Urban Planning

Open Access Journal | ISSN: 2183-7635

Volume 1, Issue 2 (2016)

Volunteered Geographic Information and the City

Editors

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COGITATIO

Urban Planning, 2016, Volume 1, Issue 2
Theme: Volunteered Geographic Information and the City

Published by Cogitatio Press
Rua Fialho de Almeida 14, 2º Esq.,
1070-129 Lisbon
Portugal

Available online at: www.cogitatiopress.com/urbanplanning

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Urban Planning (ISSN: 2183-7635)
2016, Volume 1, Issue 2, Pages 1-17
Doi: 10.17645/up.v1i2.609

Article

Revealing Cultural Ecosystem Services through Instagram Images: The Potential of Social Media Volunteered Geographic Information for Urban Green Infrastructure Planning and Governance

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Submitted: 1 March 2016 | Accepted: 5 May 2016 | Published: 6 June 2016

Abstract
With the prevalence of smartphones, new ways of engaging citizens and stakeholders in urban planning and governance are emerging. The technologies in smartphones allow citizens to act as sensors of their environment, producing and sharing rich spatial data useful for new types of collaborative governance set-ups. Data derived from Volunteered Geographic Information (VGI) can support accessible, transparent, democratic, inclusive, and locally-based governance situations of interest to planners, citizens, politicians, and scientists. However, there are still uncertainties about how to actually conduct this in practice. This study explores how social media VGI can be used to document spatial tendencies regarding citizens' uses and perceptions of urban nature with relevance for urban green space governance. Via the hashtag *#sharingcph*, created by the City of Copenhagen in 2014, VGI data consisting of geo-referenced images were collected from Instagram, categorised according to their content and analysed according to their spatial distribution patterns. The results show specific spatial distributions of the images and main hotspots. Many possibilities and much potential of using VGI for generating, sharing, visualising and communicating knowledge about citizens' spatial uses and preferences exist, but as a tool to support scientific and democratic interaction, VGI data is challenged by practical, technical and ethical concerns. More research is needed in order to better understand the usefulness and application of this rich data source to governance.

Keywords
cultural ecosystem services; e-governance; geosocial mapping; green space governance; spatial analysis; VGI

Issue
This article is part of the issue "Volunteered Geographic Information and the City", edited by Andrew Hudson-Smith (University College London, UK), Choon-Piew Pow (National University of Singapore, Singapore), Jin-Kyu Jung (University of Washington, USA) and Wen Lin (Newcastle University, UK).

1. Introduction

It is widely recognized that the presence of urban nature is indispensable for a well-functioning and hospitable city (Beatley, 2011). Today, urban nature or urban ecosystems are often conceived in relation to the concept of green infrastructure (GI). GI is a planning approach which links all types of urban nature together in a network which provides numerous benefits, or ecosystem services, such as: offering a recreational role in everyday life, playing an important part in conserving biodiversity, adding to the cultural identity of a city, easing and improving the environmental quality of the city, and providing natural solutions to technical challenges such as sewage treatment in cities (Andersson et al., 2014; Braquinho et al., 2015; Lovell & Taylor, 2013). It is also generally understood and scientifically proven that GI in cities offers health benefits such as alleviating mental, physical and social pressure—as well as being associated with economic benefits (Secretariat of the Convention on Biological Diversity, 2012; Tzoulas et al., 2007). The health benefits, aesthetic enjoyment and recreational opportunities of GI can be conceived as Cultural Ecosystem Services (CES) (Andersson, Tengö, McPhearson, & Kremer, 2015; Millennium Environmental Assessment, 2005). Thus, CESs connect nature to human values and behaviour and can act as gateways for improving urban sustainability (Andersson et al., 2015). However, the perceptions of CESs are likely to differ as they are dependent on the social context and personal values compared to, for example, the market or scientifically defined recognition of the value of food production or the carbon dioxide intake of a tree (DeFries et al., 2005). While some ecosystem service categories are more tangible which facilitates their economic and biophysical valuation, CES values are more difficult to measure and often call for the use of more holistic and innovative approaches and methods (Gómez-Baggethun et al., 2013).

However, as beneficial as GI is, it faces constant competition for inclusion in urban planning and decision-making. Competition for space, adequate valuation, and prioritisation on political agendas are just some examples of the actual and future hurdles (Braquinho et al., 2015). According to Mussachio (2013), there is currently a need to further identify the relationship between ecosystem provisions, human values and perceptions. In other words, citizens must connect with their urban nature for landscape sustainability to genuinely take root in a city (Andersson et al., 2015; Mussachio, 2013). Hence, cities will have to innovate and find ways to incrementally and aptly value urban nature, as well as better understand the complexity of ecosystems and how citizens are already experiencing the nature available to them. An enhanced understanding of the distribution of valuable urban GI features as perceived by citizens may be the key to the improved maintenance and management of natural resources. This, however, remains challenging particularly when it comes to CESs (Casalegno, Inger, DeSilvey, & Gaston, 2013) as they do not come in easily tangible measures, but are rather dependent on individual perceptions. The use of technologies such as social media and smartphones may represent a way around these challenges as they create interactive channels for broad civic participation and new ways to deliver valuable public and scientific information (Brown & Kyttä, 2014; Linders, 2012).

Volunteered Geographic Information (VGI), which is defined as the use of a range of technologies to create, assemble, and disseminate geographic information (Goodchild, 2007), makes up the dataset for this study. These data are voluntarily provided by individuals and may come from social media services, wikis, and other media, and are, therefore, often associated with Citizen Science (Jiang & Thill, 2015). This individualised and dynamic information represents a notable shift in the "content, characteristics and modes of geographic information creation, sharing, dissemination and use" (Sui, Goodchild, & Elwood, 2013, p.9). With this data source in mind, engaging citizens in governance set-ups using modern technology should not be too complicated: in this example from Copenhagen, an Instagram hashtag (#) campaign created more than 50,000 responses online on Instagram.

Instagram is an online mobile application focused on sharing photographs and providing a platform for social networking. Instagram enables its users to share pictures taken with a smartphone camera publicly with a hashtag (#), if the user wishes. Instagram is owned by Facebook© and is forming a global community that shares more than 60 million photos every day (Instagram, 2016a, 2016b).

The challenging part really appears to be the act of translating such data into useful, scientifically reliable results. This paper explores such possibilities with a particular focus on CES patterns.

1.1. Study Aim

This study explores how harvesting, analysing and interpreting user-generated geographic urban nature images stemming from social media can potentially add to a modern GI governance set-up based on digital data sharing. Thus, the study aims to demonstrate an innovative approach to analysing the character of different urban nature areas as represented by non-experts. This approach might be helpful for understanding how urban ecosystems are used and may also add to inclusive governance by visualising and attributing cultural ecosystem services to GI. In the following, we demonstrate our approach to harvesting and analysing VGI data from the Instagram API through the hashtag *#sharingcph*.

This is achieved by studying: firstly, whether shared Instagram images may be used to obtain information about urban nature in a city; secondly, by investigating spatial patterns of shared images which deal with urban nature; thirdly, by showing how this new type of spatial data relates to the formal GI in terms of public green and blue spaces, and; finally, to discuss the future potential role of social media VGI for supporting urban planning and the promotion of CES in a city (i.e., e-governance).

1.2. Volunteered Geographic Information and E-Governance

Due to rapidly developing information and communication technologies, the opportunities for broad stakeholder inclusion are becoming more numerous since these technologies can act as tools to support communication between government and citizens. Today, most citizens in the western world have access to the Internet and thanks to devices such as smartphones with online access and embedded sensors, the generation of data is unprecedented (Batty, 2013; World Bank, 2016). This shift is adding new ways and perspectives to knowledge sharing and knowledge gathering that can support the development of ideas and practices regarding urban planning and governance. Online and smartphone applications have the potential to act as media for transparent, democratic, inclusive and situation-based participatory processes of interest to planners, citizens/users, politicians and scientists.

Due to many technological advances such as ubiquitous smartphones and free applications, our societies are currently in a situation where we have the ability to "keep track of where everything (and everyone) is in real time" (Sui et al., 2013, p. 3). These advances, as poignantly expressed by Sui et al. (2013) and Johnson and Sieber (2013), have "unleashed the potential of a geographer within everybody" (Sui et al., 2013, p. 9) and created a society which can "act as sensors of their environment" (Johnson & Sieber, 2013, p. 66) or social sensing as Liu et al. (2015) puts it. Geo-referenced citizen science is part of the big data phenomenon, which has experienced explosive growth in the past few years and is "transforming all aspects of governments, businesses, education and science" (Sui et al., 2013, p. 3). The majority of this big data information is "data pertaining to activities that humans are intimately involved with", i.e. everyday actions of personal value (Batty, 2013, p. 275). Several services such as Twitter and Instagram combine geo-referenced images and short texts. Via Application Programming Interfaces (APIs), anyone can access these images and perform text and spatial analysis.

VGI is an information rich resource, which is publicly available and is shared directly by users thereby creating an enormous database (Goodchild, 2007; Jiang & Thill, 2015). Clearly this information is valuable for branding and marketing purposes, and has been used in research, e.g., tourism, disaster relief and transportation planning (Damiano, Pau, & Lehtovuori, 2015; García-Palomares, Gutiérrez, & Mínguez, 2015; Roche, Propeck-Zimmerman, & Merikskay, 2011; Sui et al., 2013), but it is also interesting for a broad base of social, spatial and behavioural sciences as it often links experiences with time and place. Its applications are just beginning to unfold and explorative research, such as this study, is harnessing this potential. Urban planners and governments are looking to incorporate new technological trends, and VGI not only provides an opportunity to connect and communicate with citizens, but this data can be further analysed to investigate behaviours, trends and issues which arise, or are already present, in a city (Tasse & Hong, 2014).

When governments connect with the VGI community it can result in a mutually beneficial relationship between governments and citizens and can in turn "support greater transparency, efficiency, and effectiveness of government services" (Johnson & Sieber, 2013, p. 65). The concept of e-governance deals with this type of interaction and is defined as technology-mediated relationships between citizens, government and businesses facilitation, i.e. communication, policy evolution, and the democratic expression of the will of citizens (Marche & McNiven, 2003; Stock, 2011). E-governance situations range from citizens influencing a government by delivering information that helps it to be more responsive and reflective, to government acting as a facilitator for citizens' actions and to situations where citizens self-organise and co-produce informal arrangements without the government playing an active role (Linders, 2012). Cities can connect with VGI communities through formal or informal processes and may involve tools and mechanisms that allow citizen participation (Johnson & Sieber, 2013).

1.3. Social Media VGI and Cultural Ecosystem Services (CES)

A special type of VGI is geo-referenced social media data originating from sources such as Twitter, Facebook or Instagram, which is sometimes referred to as ambient geospatial information ("AGI") (Stefanidis, Crooks, & Radzikowski, 2013). According to Batty (2013), inherent and intimate personal value is attached to what is shared via social media (Batty, 2013; Jiang & Thill, 2015). Thus, social media VGI reflects a connection and a shared experience with one's surroundings, while an additional strength is that it comes directly from citizens themselves (Johnson et al., 2013). VGI is creating a new medium for communicating information that circumvents traditional paths and which can help to fill a gap in available data. An example of this is social media VGI data consisting of digital photographs with geo-tags and related semantics or tags. However, the ability to quantify or even conceptualize VGI remains limited (Feik, Roche, & Sui, 2013). As such, the possibilities for analysis rest with innovative and evolving methods.

Examples of such innovative methods are studies which illustrate how social media data from non-experts can be mined (Feick et al., 2013), and studies which link CESs to VGI stemming from social media to map and reflect these services (Casalegno et al., 2013; Leetaru, Wang, Cao, Padmanabhan, & Shook, 2013; Pastur, Peri, Lencinas, García-Llorente, & Martín-López, 2016). Hence, recent studies have shown that geo-tagged online images provide an effective metric for mapping the key components of CESs, and that the concept of image sharing contains an attached value that can be spatially analysed (Casalegno et al., 2013; Pastur et al., 2016).

However, so far, to our knowledge, no studies have explored the potential of linking social media VGI to CESs in an urban setting. Combining the fact that cities and urban CESs can be considered drivers for environmental awareness (Andersson et al., 2015) and the fact that most VGI originates from urban settings (Haklay, 2013), social media VGI is, thus, a data source which is rich in spatial, temporal, quantitative and qualitative information the application of which to urban planning demands to be explored (Casalegno et al., 2013; Damiano et al., 2015; Pastur, et al., 2016).

2. Data and Methods

This section presents the geosocial data derived from Instagram, the methods applied and a classification based on images, steps in geo-processing and finally the application of diverse spatial analysis methods.

2.1. Data Acquisition and Study Area

The city of Copenhagen, defined as the administrative municipalities of Copenhagen and Frederiksberg, acts as the study area (Figure 1). As of 2015, the city of Copenhagen had an urban population of 743,564 inhabitants and an area of 179.29 km^2 (Statistics Denmark, 2015).

In 2014, Copenhagen was named the Green Capital of Europe by the European Commission. As a consequence of this award, the city of Copenhagen initiated a "sharing" concept with the purpose of promoting and communicating sustainable solutions. A Sharing Copenhagen office was established to facilitate partnerships between privates, organisations and the City of Copenhagen (Isherwood, 2013). This office launched the *#sharingcph* campaign by inviting people to share images of Copenhagen online on social media, by tagging them *#sharingcph*. The message was distributed by events, websites and posters in the city. The *#sharingcph* campaign generated more than 50.000 images online (not all with geo-location). The willingness of the citizens to participate led to the wish or idea that the rich data could be transformed into something more than just pictures online, but how exactly to do so was unclear to the Sharing Copenhagen office. The Sharing Copenhagen office expressed a wish to be able to give the data back to the citizens as well as an interest in what we, as urban researchers, would be able to extract from the *#sharingcph* images (M. Møller & B. Snizek, personal communication, January 27, 2015). Based on these motivations, we explored the possibilities of extracting, analysing and applying the data derived from *#sharingcph* to urban planning.

All Instagram images tagged with *#sharingcph* were retrieved via its API (Instagram, 2016a, 2016b) and stored in a PostGIS geodatabase (Obe & Hsu, 2015). This data included links to the images stored on Instagram, their text, the date they were taken and their geographical locations. 37,329 Instagram images taken in the period July 1st 2012 to March 25th 2015 were retrieved.

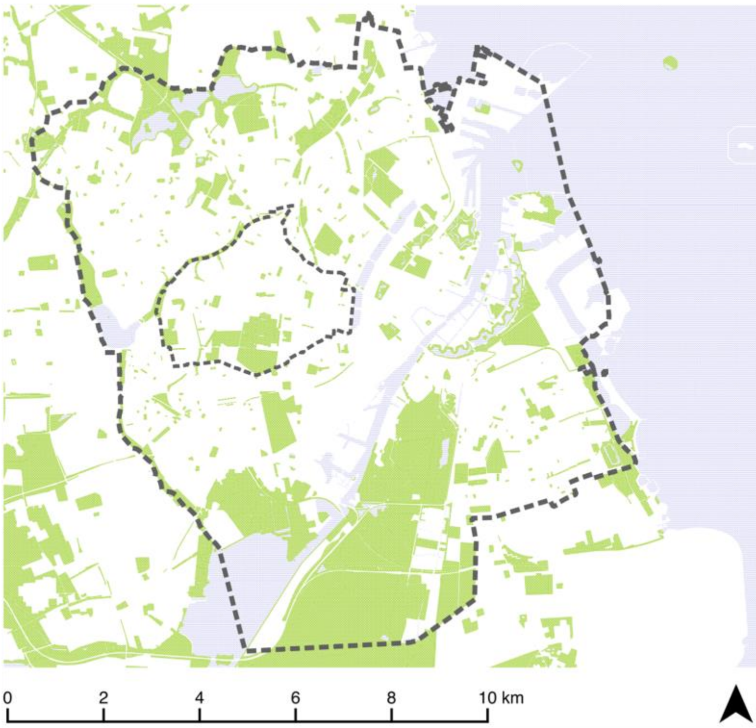

Figure 1. The study area consists of the central part of the Copenhagen region, which is defined as the administrative delineation of the municipalities of Copenhagen (outer dashed line) and Frederiksberg (inner dashed line). Officially designated blue and green spaces form the central building blocks of the city's Urban Green Infrastructure. Source: Municipality of Copenhagen.

As the search also returned images from outside the boundary of Copenhagen, only the 22,500 (N) geo-referenced images located within the study area were finally selected (Table 1). While 22,500 images make a very solid data basis, we had to select a smaller sample of these for a more detailed analysis of image content, i.e. a categorisation of the images (described below). A sample size of at least 2,397 images would allow one to make predictions about this image population with a 95% confidence level, assuming a +/- 2% margin of error and a standard deviation of 0.5. Therefore, the final categorised total number of images was 2,572 (n).

According to Statistics Denmark, in 2014, 24% of Danes were using Instagram, a noticeable increase from the result of a 2013 survey, which found that only 12% of Danes had an Instagram account (Statistics Denmark, 2015; YouGov, 2013). The 2013 survey also states that the average user spends two hours and 55 minutes on Instagram per week (YouGov, 2013). The population (N) consisted of 1,131 users who contributed between 1 to 890 images each to the dataset; the average number of images per user being 17.4. The final sample of images (n) was shared by a total of 944 individuals with an average of 2.7 images posted per user. This low average number of images per user was retrieved by setting a threshold of max. 50 images per user, thereby allowing for a more distributed sample in relation to the number of users.

2.2. Categorisation of Images

A reliable image categorisation had to be carried out to identify the shared urban nature within the city. An attempt to categorise the images automatically based on related #tags was conducted, but it did not produce a satisfactory outcome compared to a manual classification of the image content. Hence, a manual classification of the images was performed instead. As Hu, Manikonda and Kambhampati (2014) highlighted, determining the relevant image content categories is a challenge as images contain richer features compared to text. Since we wanted to study urban nature, we chose to apply a framework of lay people's nature definitions based on Buijs and Volker's Dimensions of the Prototypicality of Nature (Buijs, 2009). This category-scheme aims to be inclusive and incorporate the many ways in which nature is defined, perceived and interpreted by lay people (Buijs, 2009). Buijs and Volker's categories are: (1) Elements, (2) Spontaneous nature, (3) Productive Nature, (4) Designed Nature, and (5) Domesticated Nature (Buijs, 2009). We added a sixth category *Biocultural Nature* in order to cover situations with images of a visible human-nature interaction, such as nature-based recreation (Figure 2).

A web-based categorising interface was developed, which made it possible to categorise images into the categories mentioned fairly quickly simply by clicking on one button per image. The interface is designed to include the image that was posted, a map of the location where it was uploaded and the semantics associated with the post (i.e., in order: image-map-semantics-buttons). To be able to filter away the images that were not representative of nature and give the person conducting the classification the option to choose from the images which were not of nature or did not fit into any class, the classes (1) *Not an Urban Nature Image*, and (2) *I Don't Know* were added.

Figure 3 is an example of the online interface; in this case, the selected category was Designed Nature.

A three-step hierarchical how-to guide was produced to further elucidate the categorisation process (see Table 2). Two researchers then hand-categorised the pictures via the online medium according to the previously mentioned categorisation system. Based on this categorisation, the categorised sample size (n) was obtained.

In order to conduct an assessment of the reliability of this categorisation, two external researchers were informed about the categorisation scheme and were given the hierarchical guide and asked to categorise 498 of the pictures which had been randomly selected and previously categorised. To achieve a 95% confidence level and a confidence interval of 4, a total of 487 images had to be assessed; thus, the 498 images that were categorised for the assessment is above the required sample. This reliability assessment returned a 73.1% match with the previous categorisation, leaving 26.9% in disaccord. The majority of the images that were in disaccord (41% or 54 of the 498 images) were not categorised as urban nature, but had been categorised as green in the reliability assessment round. With 73.1% of the images categorised under the same category, this indicates that while the categorization scheme was of use for this data set, individual interpretation in any manual categorization will always play a role and will never be exact. Additionally, the number of categories could be a hindrance as this creates more options and in turn more variability.

Table 1. Basic description of Instagram images, number of users who have shared the images (i.e. Instagram users), and the range of images per user in the original, geo-referenced, and final sample of categorised images.

	Harvested	**Geo-referenced in City (study area)**	**Sample size of categorised images**
Number of images	37,329	22,550 (N)	2,572 (n)
Number of users	1,173	1,131	944
Images posted per user	Min = 1, Max = 893	Min = 1, Max = 890, Avg = 17.4	Min = 1, Max = 50, Avg = 2.69

THE ELEMENTS	SPONTANEUS NATURE	PRODUCTIVE NATURE	DESIGNED NATURE	DOMESTICATED NATURE	BIOCOLTURAL NATURE
SEA	GAME	LANDSCAPES	WOODED BANKS	COWS & PIGS	HUMANS IN NATURE
SUN	WILD PLANTS	MEADOWS	ROAD VERGES	DOGS & CATS	RECREATION WITH NATURE
WATER	MEADOW BIRDS	FIELDS OF MAZE (AGRICULTURAL)	CITY PARKS	HOUSE PLANTS	
	MOSS	OCEAN	GARDENS	ZOO ANIMALS	
	INSECTS		ALLOTMENTS		
	FUNGUS		URBAN TREES		
	CITY BIRDS		SWALES		
	WEEDS		RETENTION PONDS		
			CANALS		
			BEACH AREA		

Figure 2. The used image categorization classifies urban nature into six categories based on Dimensions of Nature. Examples of image content are shown below for each urban nature category. Adapted from Buijs (2009).

Figure 3. Example of the categorization interface showing the image, the location it was taken in, its text and the eight categorization options.

Table 2. A three-step hierarchical how-to guide was produced to clarify the categorisation process.

Step	Hierarchy Guide for Urban Nature Categorisation	Elaboration and general examples
1	Identify main focus of image and categorise based on Urban Nature or Not Urban Nature	A picture of a bike resting against a wall is not urban nature. However, a bike in a green space comes under the Designed Nature category. Puddles that reflect an urban setting are not urban nature. There must be a reflection of nature present, e.g., a tree.
2	When multiple options are possible, more weight is given to the main focus of the image.	A swan in a park is spontaneous nature (the swan) and not designed nature (the park). A tree in the foreground of e.g., a church, and as the main focus of an image, is categorised as designed nature.
3	Use location and tagged semantics as secondary support for classification.	An image of an urban scene with slight vegetation present (i.e., leaves) with semantics relating to the presence of the vegetation is urban nature, e.g., #leaf, #autumn.

Table 3. Categorisation result of the content analysis.

Description	Categorised sample (n=2,572)	Urban Nature images (n=874)
Image Content	Not Urban Nature, 64.8%	Designed Nature, 42.6%
	Urban Nature, 34%	The Elements, 27.2%
	Unable to be categorised, 1.2%	Biocultural, 13.7%
		Spontaneous, 9.8%
		Domesticated, 3.9%
		Productive, 2.7%

2.3. Spatial Data Analyses

Spatial analyses were only performed on the sample size of 2,572 images (n). The category, *I Don´t Know* representing 1.2% of the data, was omitted from the spatial analyses.

The data points, i.e., images, were processed into and analysed via GIS. A spatial calculation (spatial join) and visualisation was conducted in order to observe and compare the distribution of urban nature images in relation to all images and in relation to the official green infrastructure (with a 50m buffer to include images taken in border zones with a view of the urban nature site). Further, a hotspot analysis was conducted to reveal clusters of images. In this analysis, the radius was set to 400 metres with a threshold value of nine images; hence, all image clusters with more than nine images were considered a hotspot. Finally, a distance analysis was performed to explore the spatial character of the data in more detail. The distance of each urban nature image from the city centre—derived as the centroid from the city centre´s boundary polygon—was calculated with the Hub Distance Tool. This analysis returned a vector layer that connects each point to the specified central hub. The length of each line was calculated and this data was analysed for frequency at specific kilometres and a corresponding histogram was generated. In other words, the analysis returned the number of images found at specific distances from the city centre. This facilitated the identification of distances from the centre where a relatively high or low number of images had been shared, i.e., peaks and valleys of shared urban nature in the city.

3. Results

This section presents the results of the data analyses.

3.1. Categorisation Result of Urban Nature Related Images

The results of the categorised process reveal that Urban Nature represents 34% (874 images) of the images in the sample size (Table 3). The urban nature images were further classified according to the six perceived dimensions of nature. The ‘Designed Nature’ category, which includes parks, urban trees, and canals, represented almost half (42.6%) of the urban nature images. Further, almost 1/3 of the images were classified as the ‘Elements’, e.g. sunset, while about 10% of the images were classified as ‘Biocultural Nature’ (e.g. nature-based recreation) or ‘Spontaneous Nature’ (e.g. reflections in puddles). Logically, few images were classified as ‘Domesticated Nature’ or ‘Productive Nature’. Some examples of categorised urban nature images are shown in Figure 4.

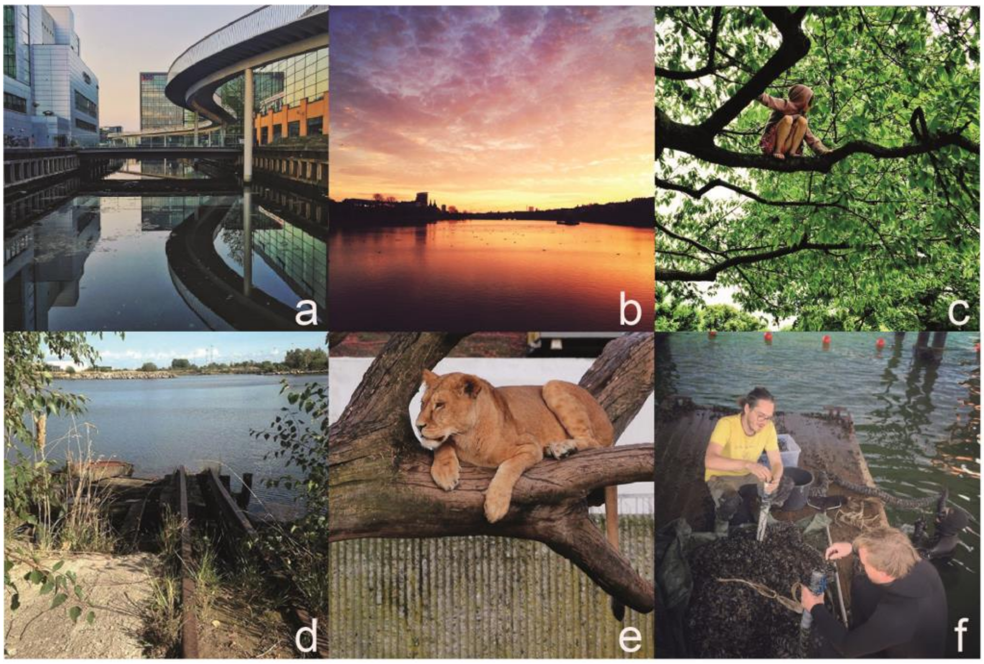

Figure 4. Examples of urban nature images as categorised. Photographer's Instagram user names in parenthesis (starting from top left): a: Designed (@tbsptrsn), b: The Elements (@might_be_wrong), c: Biocultural (@remosteen) d: Spontaneous (@copenhagen_streetlife), e: Domesticated—showing a lion from the Copenhagen zoo (@mmhenriksen), and f: Productive—showing oyster harvest in Copenhagen harbour (@maritimenyttehaver).

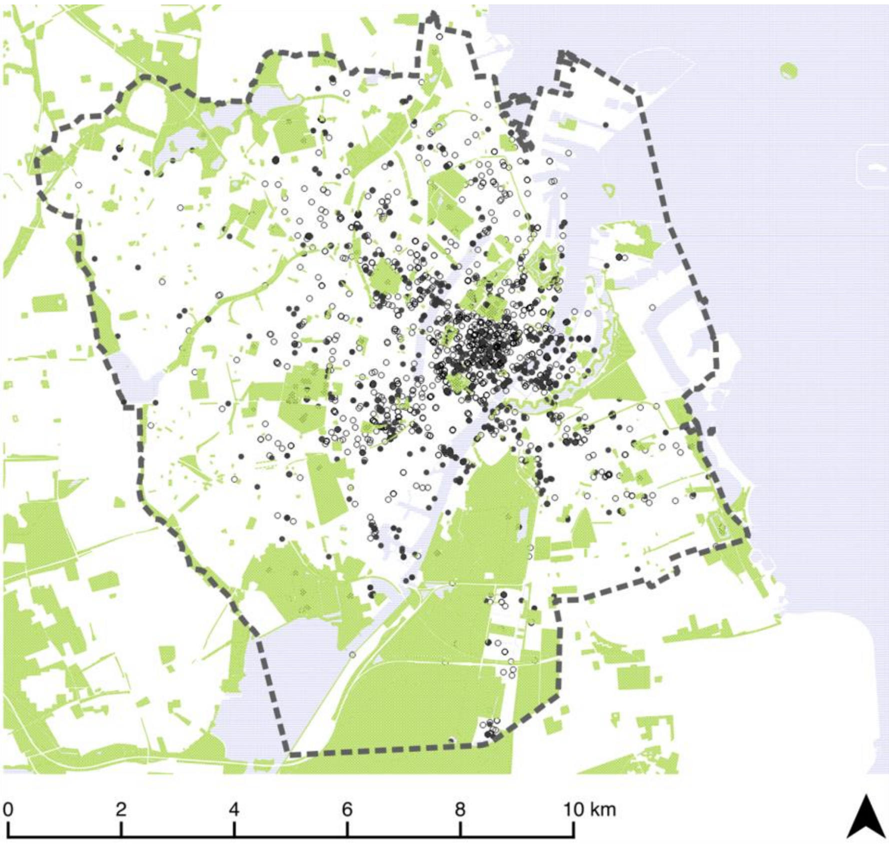

Figure 5. The spatial distribution of Urban Nature (filled symbol) and Not Urban Nature images (outline symbol).

3.2. Spatial Patterns of Urban Nature

While Urban Nature images are spatially distributed in the city and similar in distribution to Not Urban nature images, there is a pattern at certain locations to create clusters of images classified as Urban Nature (see Figure. 5).

Of the total number of images, 44.4% were located in green spaces regardless of categorisation, while 63.6% of the urban nature images were located in green spaces. Thus, the majority of the urban nature images coincided with the managed green spaces of the city; these managed green spaces contain the majority of the shared urban nature images of Copenhagen. On the other hand, 36.4% of the urban nature images, i.e., about one-third, were located outside the managed urban nature. This provides an interesting perspective as it shows that Copenhageners also share and experience urban nature outside designated public green spaces. Thus, it is of importance for the city to be aware that this nature is of value and is an asset for the city's green infrastructure.

These associations and disassociations with designated green spaces allow city planners to visualise the actual patterns of how citizens share images of the green spaces of the city. Similarly, this relationship between shared urban nature and designated green spaces provides insight which may prove valuable for the management of the urban nature of a city.

3.3. Hotspots of Urban Nature Images

A hotspot analysis was applied to identify areas with a high number of urban nature images and areas with a low number. The hotspot analysis returned 19 locations where more than nine images had been taken. To find the total number of images located at these spots, the attributes were selected by either based on the green spaces layer as borders or on the size of the hotspot. Two of these locations were found to be clusters which were probably due to a user uploading various images indoors, i.e., not at the location where the images had been taken (see upload error in limitations section). These two areas, consisting of a total of 28 images, were thus omitted. The top ten clusters with the highest number of images were then selected and individually analysed to identify their specific location and the number of images at each location. Noticeably, the top ten identified hotspots correspond to locations which are designated as green spaces, see Figure 6. The number of images taken at the top locations ranged from 13 to 33.

3.4. Distance Analysis

To analyse the data further, a distance analysis was conducted. As previously explained, there was an accumulation of 28 images, both of nature and non-nature; which in order to avoid skewing the spatial location, these images were excluded as they were clearly not spatially representative. Figure 7 is a visualisation of the distance analysis with a radial behaviour of the data with its focal point at the city centre. As the histogram shows, the distance analysis facilitates the identification of specific distances from the centre where a high or low number of images had been shared, i.e., peaks and valleys of shared urban nature in the city, see Figure 8.

Figure 6. Top 11 Nature Hotspots relative to public green and blue spaces.

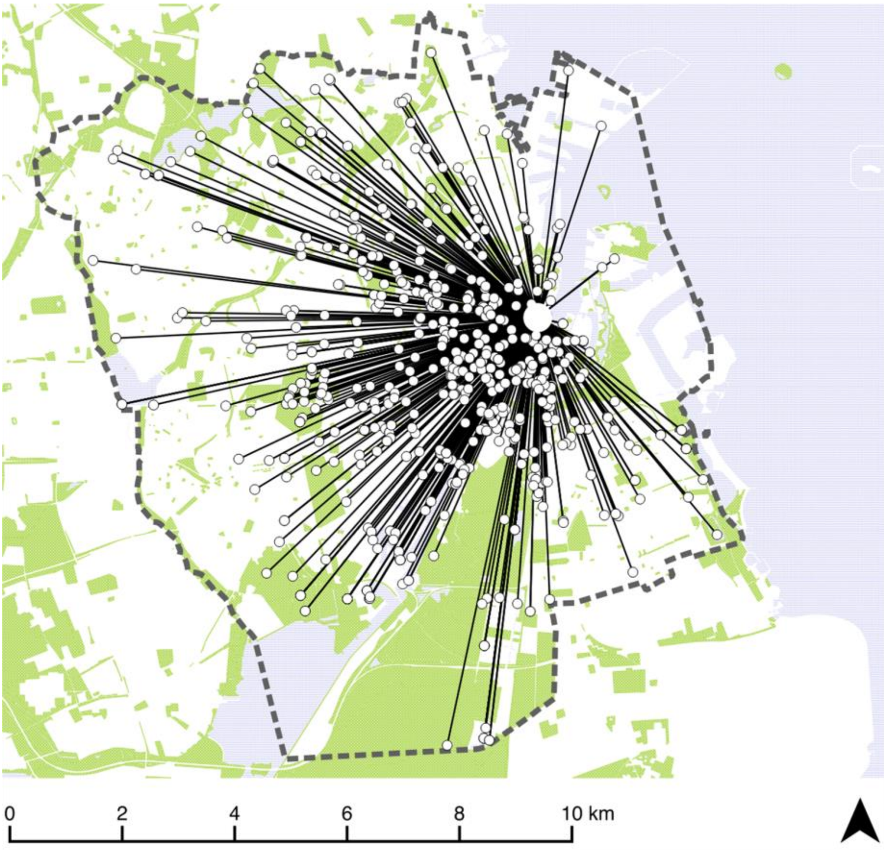

Figure 7. Images' relation to the city centre of Copenhagen.

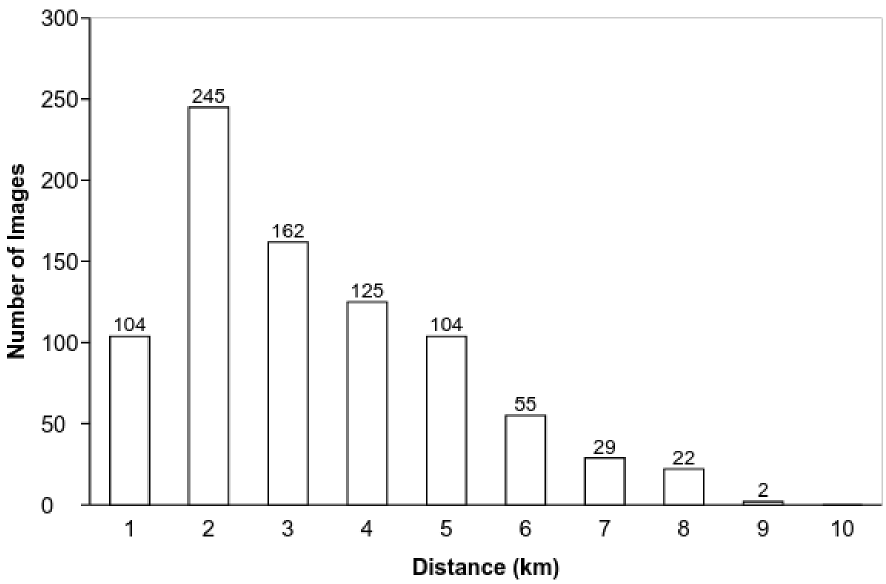

Figure 8. Urban Nature images in relation to distance from Copenhagen's city centre (r = -0.86).

The outcome of this analysis shows that more information, i.e., images, regarding urban nature will probably come from areas near the city centre rather than from the outer realms of the city. People have an affinity for sharing images from these central parks. Future research could focus on attempting to determine the causes of this affinity, which may include accessibility, park features or leisure use. As the histogram shows, the peak seen at 2 to 3 km from the centre could also be explained by the actual green space structure of Copenhagen's parks as key green spaces are located approximately 2 km from the city centre.

4. Discussion

The images from this study constitute a valuable source of VGI data and provide relevant information about the spatial representation of Copenhagen's urban nature in an Instagram dataset. Of all the aspects Copenhagen inhabitants could have shared about their city in *#sharingcph*, 34% of the images represented Urban Nature. It also shows that a general mobile application such as Instagram can be used to collect VGI content and present urban nature patterns in a city (Tasse & Hong, 2014).

Casalegno et al. (2013) showed that CES can be mapped with geo-referenced social media images and suggested that shared urban nature images, which serve as proxies for CESs such as aesthetics or sense of place, have an attached value and can be used as a tool for gathering and analysing this information (Casalegno et al., 2013: Stedman, Beckley, Wallace, & Ambard, 2004). This study supports the conclusion that CESs can be mapped via shared urban nature images.

This research is related to works of other methodologies that utilise images such as Visitor Employed Photography (VEP), in order to obtain an understanding of people's perceptions of parks and natural environments by interpreting their photographs (Mackay & Couldwell, 2004). Even though the image-taking method is controlled in VEP, this VGI method is in line with the idea that photographs can be analysed to identify a sense of place, attachment, aesthetics and other factors pertaining to the human-environment interaction in natural spaces (Garrod, 2007; Mackay & Couldwell, 2004; Stedman et al., 2004). The analysis of images can provide valuable information as photographs can be considered "representations of specific attributes of various dimensions of (an) experience" (Garrod, 2007, p. 14). According to Stedman et al. (2004), photographs offer insight into specific historical, cultural and social ways of seeing the world and these images can standalone as data sources since they are expressions of the ideas themselves. In other words, while surveys and interviews can provide great insight, images can capture certain perspectives, emotions and attitudes such as a sense of place, aesthetic value and attachment (Stedman et al., 2004).

Considering images as proxies for CES, this research supports the assertion that VGI can be used to identify places that people share due to the CES offered (Casalegno et al., 2013; Pastur et al., 2016). The MEA includes inspiration, aesthetic values, sense of place, and recreation and tourism among the CES nature provides (Millennium Ecosystem Assessment, 2005). As such VGI images, which are free expressions of people's perception of nature whether it is the inspiring, aesthetic or sense of place service provided, can be used as CES proxies. For example, the top urban hotspots of this study can be considered green spaces with high CES. A city authority can use this data as a driver for protection and investment in these areas as the information is coming from those benefiting from the services (Sherrouse, Clement, & Semmens, 2011).

This area of research and methodologies are still nascent and further explorative research focused on extended objectives must be explored to make any definite findings. For example, the fact that a low number of images were taken in a particular area does not necessarily mean that no perceived urban nature value is present, but rather indicates that other variables, e.g., accessibility issues, might be obstacles (Jiang & Thill, 2015). Further, it should be noted that spatial distributions of most activities extracted from social sensing data are positively correlated with population density (Liu et al., 2015). An overarching key consideration in visualising and analysing VGI is simply that it highlights patterns and information—here Instagram images—that are already present (Tasse & Hong, 2014).

44.4% of the total number of shared images was taken in the green spaces of Copenhagen; furthermore, 63.6% of the green images came from these locations. This city provides numerous green spaces for its citizens and aims to promote the accessibility of these spaces for its citizens in order to promote human-environment interactions. According to 2012 data, 80% of Copenhageners lived at a distance of 300 metres from a green area (European Green Capital, 2012). People have access to the green spaces in their city and, as this study shows, they share images from these locations. There is currently a call to incorporate GIS methods into urban planning as this provides a more tangible way of representing issues regarding human-environment interactions (Kabisch, Qureshi, & Haase, 2015). Through the spatial representation of urban nature VGI in Copenhagen, we use GIS to analyse these interactions and green space social values.

The distance analysis reveals a distinct centrally based radial-pattern with regards to the VGI data originating in Copenhagen, i.e., within a 2-3 km radius of the city centre. Accordingly, this study shows that urban nature VGI of Copenhagen is not evenly dispersed throughout the city; there are hotspots and specific spatial behaviours. As such, spatial patterns in the data and user-representability, among others (see limitations), need to be addressed and understood if social media VGI is to be used in decision-making.

While VGI is considered separate from public participation geographic information system, or PPGIS, it is nevertheless a related field (Brown & Kyttä, 2014). VGI analysed through GIS "research and practice remains embryonic," and consequently, this study follows the call for experimental design in methodology (Brown et al., 2014). This method of mapping CES based on a large set of publicly shared images, while notably passive, i.e., voluntary, answers the call to increase public participation rates in PPGIS ecosystem services mapping (Brown & Kyttä, 2014). The VGI data obtained from large sets of social media is "understood in the context of big data" (Sui et al., 2013, p.4). For ES mapping, this is of enormous value as the use of smartphones and social media applications will increase, which will enhance the quantity and representability of this data source for future research. As such, by exploring this field, this study aims to improve our understanding of the mapping of ecosystem services so that ecosystem services become more highly valued and to support green decision-making in urban settings.

The spatial representation of CES shows the localisation of highly valued ecosystems, as well as, the identification of "critical focal areas for cultural services management" (Plieninger, Dijks, Oteros-Rozas, & Bieling, 2013, p. 119). Additionally, the ability to map cultural— in addition to the provisioning and regulating—services of a city gives a more complete picture of ES, as well as a comparison of the ecosystem services at play (Plieninger et al., 2013). Interestingly, Pastur et al. (2016) also indicates that social media image data may potentially help to spatially visualise and monitor the medium and long-term conditions and trends of CES (Pastur et al., 2016). In the same way as remote sensing helps to identify critical areas of land use change that affect provisioning and regulatory ES, with this data we are also able to monitor changes in cultural ecosystem services by social sensing (Liu et al., 2015).

Another advantage of using geo-referenced images is that they offer a means of determining CES values that are hard to capture with just words such as aesthetics or sense of place (Pastur et al., 2016; Stedman et al., 2004). Integrating CESs into urban planning has been problematic due to their intangibility, complex relationships with biophysical variables and the difficulty connected with attributing values (Pastur et al., 2016). This research illustrates that VGI from social media provides information, in many cases unarticulated but present, about a city's urban nature and its CESs. This research complements other studies which propose methods to integrate and value CESs in decision-making processes (Casalegno et al., 2013; Pastur et al., 2016; Plieninger et al., 2013).

4.1. VGI Use for Urban Planning and E-Governance

This study seeks to provide insights into addressing the potential of using social media VGI for the assessment of CES in urban planning and governance.

In a time where a growing number of cities around the world comply to open data politics following concepts such as 'Smart Cities' and more citizens navigate and interact online, an increasing interest of mining and understanding and using these digital data is seen in science, politics and planning (Huijboom & Van den Broek, 2011; Kitchin, 2014). VGI as a volunteered, information-rich data source can help to illuminate the (nature) pulse of a city, i.e., what, where and how urban nature is 'shared'. Such information could be useful for urban planners who may be able to use it as a driver for development or maintenance projects as they could gain better understanding of how citizens 'react' to e.g. urban nature. The information holds relevance in planning and design processes because it provides a potential plethora of information regarding local and detailed knowledge about spatial conditions and characters as well as social connections. Such information can be used to better understand city dynamics, i.e. uses and preferences in given urban spaces (Seeger, 2008). Another outcome of VGI when integrated in planning and politics is that citizens may be empowered by 'sharing' if they thereby become involved in solutions to better understand, protect, and develop their environment. Relating the use of VGI to the urban CES framework may allow planners, not only to value urban nature more effectively, but also to adequately plan and protect a city's biodiversity and its citizens' well being.

VGI is a means of communication that is just starting to be used to create new responsive relationships between governments and citizens and it may lead to an increased level of citizen participation in decision-making (Johnson & Sieber, 2013). According to the 2014 UN E-government Report, both developed and developing countries are at the decisive point of embracing the potential role that mobile interaction will play in people's everyday lives (United Nations E-government Survey, 2014). In terms of social media, there is a wealth of information which is already being interpreted and used by its creators, i.e., the citizens themselves. This provides a cost-effective way for governments to engage with citizens in "e-decision making and co-creation of service" (United Nations E-government Survey, 2014). When properly planned and structured, VGI data allows governments to react to citizens' values and concerns (Johnson & Sieber, 2013).

As a dataset like this represents a quite abstract or 'free' approach as to what can be shared within the *#sharingcph* theme, one could imagine that similar campaigns could be targeted at more specific themes or places. In such cases, pre-defined hashtags could be used to getting closer to an auto-categorization of the images into themes or clusters. A simple example could be #cphpark with the sub hashtags #like or #dontlike, which would already classify images into positive or negative categories.

The concept of facilitated VGI (f-VGI) is a variation of VGI that may be of interest to planners or others who wish to get input to a predefined topic or area. F-VGI is a way to operationalize and focus VGI data into public participation in planning. As explained by Seeger (2008), an f-VGI process is facilitated by e.g. a planning professional, a local organization or government in order to feed VGI into a pre-established planning or design process (Seeger, 2008). The *#sharingcph* campaign can be understood as a form of f-VGI, as it was developed and promoted by the City of Copenhagen. However, as mentioned in the beginning of this paper, the team behind the campaign did not plan for any particular way of feeding the data into further processes regarding urban planning and design. This 'freely' formulated campaign made the dataset both interesting and challenging to work with because inputs were it not guided in any particular direction (other than "share your city").

The data is characteristic by being differentiated as each photo with the *#sharingcph* tag represents an individual person's experience somewhere in the city. In combination with other datasets that e.g. inform on participants' geo-social backgrounds, VGI holds potential as it can seemingly reach a broad audience as well as new user groups that are often weakly represented (Seeger, 2008).

In this study we focused particularly on the spatial references to map out the data while the content of the photographs and # semantics were used to back-up the understanding of the visual content. The temporal aspects of the data were not in focus of this study, but could be important in other studies when exploring use of green spaces in different seasons/over time.

VGI data can consist of highly refined, differentiated, and personal impressions from participants who share it. The challenge is to find suitable ways to analyse such data and to evaluate the impact of different levels of facilitation or steering of processes where VGI feeds in and ways to harness VGI data in combination with other datasets. VGI data could be corroborated by other established data collection methods such as surveys and interviews to create a more robust data set (Pastur et al., 2016). The distinct data sources can complement each other as the VGI has valuable strengths in that it provides large, spatially referenced and unbiased information, i.e., no potential bias triggered by interviewers (Pastur et al., 2016). Currently, in the US, younger age groups tend to use Instagram the most (Duggan, Ellison, Lampe, Lenhart, & Madden, 2015). Therefore, while not yet representative of the general public, this highlights a potential strength, as it is often difficult to involve this demographic group in governmental decision-making processes.

This study coincides with previous research on VGI and suggests that planners can use this data to: 1) uncover already present CES patterns, 2) plan and monitor future changes, 3) aid in the management and prioritisation of green spaces and, 4) establish efficient and effective communication with citizens (Casalegno et al., 2013; Johnson & Sieber, 2013; Pastur et al., 2016; Tasse & Hong, 2014).

4.2. Limitations

The use of geo-referenced, freely available social media data as a proxy for studying spatial trends in distinct fields is a rapidly growing and interesting field (Casalegno et al., 2013; Leetaru et al., 2013; Pastur et al., 2016; Tasse & Hong, 2014; Tuhus-Dubrow, 2014). However, questions relating to the limitations and reliability of this data source cannot be ignored.

This study focused on identifying spatial patterns in the data and did not aim to study individual users. Thus, because these data are publicly available, the issue of anonymity and privacy arises. It was also considered that some users might not be aware of the privacy settings or the sharing of their locations; thus, neither specific user data, nor analyses of such were generated. As no information was gathered concerning the users, no socio-economic data exist, which makes it difficult to assess representability in detail—which is a limitation of this study.

Currently, the demographic limitations of the data are quite noticeable and as such, it is not entirely representative of a population. As previously mentioned, in Denmark, only 24% of the population had an Instagram account in 2014 (Wijas-Jensen, 2014). Additionally, when working with VGI, it is wise to bear in mind that empirical research often involves 'participation inequality' with some participants contributing far more than others (Haklay, 2013). Areas with higher population densities or greater levels of outdoor activity also reflect higher geographical citizen science participation (Haklay, 2013). Tech-savvy and higher income groups are generally over-represented (Damiano et al., 2015). So while the demographics of social media and VGI participation are currently skewed, it is expected that with the predictable increase in the use of smartphones and social media, this medium of communication will indeed become more popular and more inclusive (Damiano et al., 2015).

State of the art and software have a high spatial reliability (Leetaru et al., 2013). However, sometimes there is a discrepancy between the location where an image was taken and where it was uploaded. This may be explained by people taking pictures, but waiting until later to upload and share them (Damiano et al., 2015) or perhaps their devices not being able to upload immediately due to, e.g. network problems. Unfortunately, no specific studies were found that analysed this problem. To counter this issue, the categorisation contained a map that showed the location of the images. This issue was seldom isolated in our dataset. However, regarding specific spatial analyses in this study, clusters of noticeable erroneous Instagram images with upload location errors that would skew the data were individually analysed and if needed omitted (see hotspot methodology for further information).

The data quality and locational accuracy of VGI for CES representation must be analysed and improved upon. This includes identifying location upload errors, such as identical, numerous uploads from an indoor location (see methodology section) or distance difference (i.e., range) of image to an actual feature. For example, this research made sure to view each image in a detailed content and spatial context such as 'green images located within green spaces' to ensure that only nature images were included. However, for the general population this was not implemented as there were not spatial analysis based on the population, N, and errors are to be expected. Albeit, the locational accuracy is an issue in the field of georeferenced image analysis. Solutions such as "integrating the (actual) location into the image assignment" (i.e., computing the distance difference) have been mentioned (Sun, Fan, Bakillah, & Zipf, 2013). For now, concepts such as meticulous observation of images, a sample tests to find error factors, clear categorization and boundary setting are initial solutions to overcome location errors. Where possible, buffers were included to partly compensate for some of the distance range discrepancy.

This data set was obtained solely based on the *#sharingcph* hashtag which, as previously described, was promoted by the City of Copenhagen as a part of its EU Green City campaign. This specific selection facilitated a focus on urban planning due to the city sharing motivation behind the campaign and hashtag. Furthermore, this study aimed to incorporate the e-governance and urban planning potential for cities from the outset. As such, the *#sharingcph* hashtag combined both the city planner's involvement, i.e., promotion of the hashtag, and the VGI aspect. However, the analysis focused on urban nature CESs so the hashtag of choice could have been simply #nature, or another related hashtag. Undoubtedly, scaling-up the hashtag to include more general terms would give this study a distinct focus, and it would also provide a large data set with interesting potential for CES analysis.

5. Conclusion

This explorative study shows that urban nature is indeed shared in a city, with 34% of shared images of the city representing urban nature. Additionally, the use of social media VGI to obtain this information and spatial knowledge of the city is a field that is currently growing; this study provides input to this research area.

As the name implies, an important feature of VGI data is its spatial content which when adequately analysed can provide trends and patterns about a city; in this study its urban nature. This rich data source, obtained directly from citizens, can be analysed to identify shared urban nature spatial trends and patterns. The results reveal specific behaviour in this data, i.e., hotspots and centrally based radial dispersion throughout the city. Additionally, 44.4% of the general images were taken at managed green spaces and urban nature images show a 63.6% alignment with these green spaces. The spatial tendencies of this data coincide with the official green spaces, yet there exists shared urban nature images, 36.4%, that are found in non-official green spaces. This study shows that the spatial patterns of VGI data are valuable and rich in information about urban nature and human-environment interactions, yet it is critical to first understand the data's spatial distribution in order to make further assumptions about its meaning. Urban planners can use urban nature VGI to promote CES in a city. The data helps to understand the value and interaction of humans and nature in a city and may act as a direct conduit for participation and communication between citizens and government.

Finally, as this data-set is very context specific, we would like to stress the importance of conducting future studies which attempt to determine what motivate Instagram users share urban nature images. This would include identifying the specific qualities that lead to the sharing of specific urban nature images (i.e., park accessibility, design configuration, presence of water, etc.), which is key in order to be able to utilise this source of information in city planning and governance. While some research exists regarding motivations and psychological reasons as to why people share, i.e., in order to share a personal cause, further research is needed in this area to determine, e.g. why a certain park feature has been shared, the significance of time availability or the novelty of urban nature with regards to picture sharing.

Acknowledgements

The authors would like to thank Dr. Reinhard Böcker for his guidance, the City of Copenhagen's Sharing Copenhagen office for their collaboration and the thousands of Instagrammers who provided the data for this research. This project received funding from GREEN SURGE, EU collaborative project, FP7-ENV.2013.6.2-5-603567.

Conflicts of Interest

The authors declare no conflict of interests.

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Urban Planning (ISSN: 2183-7635)
2016, Volume 1, Issue 2, Pages 18-31
Doi: 10.17645/up.v1i2.621

Article

Characterizing New Channels of Communication: A Case Study of Municipal 311 Requests in Edmonton, Canada

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Submitted: 11 March 2016 | Accepted: 10 May 2016 | Published: 7 June 2016

Abstract
City governments around the world are developing and expanding how they connect to citizens. Technologies play an important role in making this connection, and one frequent way that cities connect with citizens is through 311-style request systems. 311 is a non-emergency municipal notification system that uses telephone, email, web forms, and increasingly, mobile applications to allow citizens to notify government of infrastructure issues and make requests for municipal services. In many ways, this process of citizen contribution mirrors the provision of volunteered geographic information, that is spatially-referenced user generated content. This research presents a case study of the city of Edmonton, Canada, an early adopter of multi-channel 311 service request systems, including telephone, email, web form, and mobile app 311 request channels. Three methods of analysis are used to characterize and compare these different channels over three years of request data; a comparison of relative request share for each channel, a spatial hot spot analysis, and regression models to compare channel usage with sociodemographic variables. The results of this study indicate a shift in channel usage from traditional to Internet-enabled, that this shift is mirrored in the hotspots of request activity, and that specific digital inequalities exist that reinforce this distinction between traditional and Internet-enabled reporting channels.

Keywords
311; digital divide; mobile app; municipal government; open data; VGI

Issue
This article is part of the issue "Volunteered Geographic Information and the City", edited by Andrew Hudson-Smith (University College London, UK), Choon-Piew Pow (National University of Singapore, Singapore), Jin-Kyu Jung (University of Washington, USA) and Wen Lin (Newcastle University, UK).

1. Introduction

In recent years, spatial data has shifted from being created by paid, highly-skilled individuals, using specialized equipment, to non-expert creation (Goodchild, 2007a). This contribution of volunteered geographic information (VGI), or spatial data that is reflective of individual experience and assertion (Goodchild, 2007a), is changing the way that spatial data is collected. These non-experts, who may be contributing spatial information in their leisure time, and for a variety of reasons, are often referred to as neogeographers (Turner, 2006). Rapid advances in mobile and web-based technology is a significant facilitator of the increase in VGI (Haklay, 2013). The increased accuracy and reduced cost of Global Positioning Systems (GPS) receivers, rising availability of smartphones, and the wide spread of wireless networks have made geographic information readily obtained by handheld devices (Goodchild, 2007a; Jiang & Yao, 2006). Further, the growing demand for geographic information is also a contributing factor of VGI; in-vehicle navigation, travel planning and real-estate businesses all rely on geographic information to provide services to customers, and these location-based services have filtered into many aspects of everyday life (Elwood, Goodchild, & Sui, 2012).

A current trend in VGI generation is for citizens to support their local government in collecting information to facilitate planning and decision-making (Sæbø, Rose, & Flak, 2008). The adoption of VGI in the public sector can be conceived as a branch of e-government initiatives, and it expands e-government from one-way "government-to-citizen" (G2C) service delivery to two-way "citizen-to-government-to-citizen" (C2G2C) conversation (Johnson & Sieber, 2013; Sieber & Johnson, 2015). This bottom-up information production process can provide government with up-to-date and small-scale spatial information at low cost (Goodchild, 2007a). As citizens are closer to a phenomena and hold local knowledge that government agencies may not possess, citizens act as environmental sensors producing rich information and data that can be incorporated into management and decision-making (Goodchild, 2007b; Johnson & Sieber, 2013). The process of providing services based on citizen-generated information also impacts the relationship between government and citizens by enhancing transparency, responsiveness and accountability of governments (Wong & Welch, 2004).

Municipal 311 service, typically a direct call line or web portal, is one example of how citizens can use VGI to contribute feedback to government (Elwood et al., 2012). First implemented in Baltimore, U.S., this 311 system was initially established to alleviate 911 service congestion caused by large volume of non-emergency calls (Schwester, Carrizales, & Holzer, 2009). With the prevalence of the Internet and smartphones, phone calls are no longer the only channel that 311 services source reports from. Rather, web forms, emails and mobile apps have been developed to create additional platforms for citizens to contact the government (DeMeritt, 2011). With this rise in the variety of 311 service channels, it is critical to conduct a characterization of these methods and their use in a real-world context. With multiple 311 channels available, is there a dominant channel that is favored compared to others, and how has that channel mix changed over time and with the introduction of new channels, such as mobile apps? Are there geographic concentrations of 311 reports and do these differ by channel? And lastly, building on work done by Cavallo, Lynch and Scull (2014), are there demographic relationships with 311 channel use, highlighting existing digital divides? To answer these questions, this paper presents a case study of citizen contributions made using a 311 service in the City of Edmonton, Canada. As one of Canada's leading 'open' municipalities (both in terms of providing open data and establishing open government policies), Edmonton makes a suitable case study for tracing the development and deployment of 311 systems, providing lessons for other municipal governments currently considering or rolling out similar systems. 311 requests from 2013 to 2015 are analyzed and interpreted to identify changes in citizens' usage of multiple reporting channels, and to determine spatial patterns and hotspots of requests within the City of Edmonton. Lastly, 311 requests and channels are compared to relevant demographic variables to indicate if there are connections between residential demographics and 311 reporting.

2. The Rise of Citizen Contribution of VGI in Government

Incorporating local knowledge into urban planning and management is not a new idea. Public participation GIS (PPGIS) was initiated in the 1990s, and it refers to the use of GIS to support public participation in planning, management and decision making (Ganapati, 2011; Sieber, 2006). Technologies that enable PPGIS have evolved from traditional desktop-based GIS to Web GIS and to Geospatial Web 2.0 platforms over the past two decades (Ganapati, 2010). In addition, the increasing availability of open GIS software has removed the costs associated with installing proprietary software, which also contributes to the expansion of PPGIS (Hall, Chipeniuk, Feick, Leahy, & Deparday, 2010). Since its emergence, PPGIS has been applied in numerous areas, from "community and neighbourhood planning to environmental and natural resource management to mapping traditional ecological knowledge of indigenous people" (Brown, 2012, p.2).

The term VGI was proposed almost a decade after PPGIS was developed (Goodchild, 2007a). VGI and PPGIS are related as both of the terms feature collecting and using spatial information from non-experts (Brown & Kyttä, 2014). Tulloch (2008) argues that VGI shares common foundations with PPGIS in that both involve investigating and identifying locations that are important to individuals. Brown and Kytta (2014) compared VGI with PPGIS in terms of process emphasis, sponsors, place context, importance of mapped data quality, sampling approach, data collection, data ownership and dominant mapping technology. They pointed out that the process of PPGIS emphasizes enhancing public involvement to inform land use planning and management sponsored by government planning agencies, while VGI focuses on expanding the collection of spatial information through citizens acting as sensors, sponsored by NGOs, ad hoc groups, or individuals. In addition, Lin suggested that individuals are more likely to utilize public datasets when participating in decision-making processes in PPGIS while individuals create their own data in the context of VGI (Lin, 2013). The casualness and entertainment features in VGI are also distinct from the ways that PPGIS traditionally theorizes participation (Lin, 2013). However, the lines between VGI and PPGIS are not always clear, as Tulloch

(2008) argues that some volunteers involved in VGI have a tendency to participate in the process of decision making when creating and sharing spatial information.

PPGIS and VGI are suggested to have potential for supporting e-government initiatives, which refer to "the delivery of information and services online through the Internet and other digital means" (Ganapati, 2011; West, 2004, p.2). Moon (2002) proposed an e-government model with five stages, with political participation considered as the highest stage, suggesting that some technologies could promote public participation by enhancing two-way communications between government and citizens. PPGIS and VGI that use Web 2.0 technology can enable individuals to create spatial data and to participate in the decision-making process (Rinner, Keßler, & Andrulis, 2008). Johnson and Sieber (2013) also argue that VGI is valuable to government in providing an opportunity for citizens to collaborate on achieving social, economic, and environmental goals. Cavallo et al. (2014) suggest that the modern 311 services that provide multiple channels for citizens to report problems or complaints can be regarded as a method of direct connection with local governments, and provide citizens with the appropriate means of making contributions to community issues.

As individuals possess local knowledge that is not necessarily represented in traditional authoritative data, they can act as intelligent sensors of their surroundings and collect accurate and timely information (Goodchild, 2007b). Goodchild also points out that this method of collecting information can be much more cost-effective compared to traditional ways of collecting data that involve expensive equipment and highly-paid experts. In addition, the widespread availability of smartphones, location-based services (LBS) and social networks facilitate the creation and sharing of geographic information in real time (Chon & Cha, 2011; Goodchild & Glennon, 2010). These features of VGI imply great potential, as the location information attached to 311 reports can be visualized and analyzed to improve urban planning, management and operations processes, particularly to reveal issues that may not be detected using conventional methods, such as dead animals and unusual odors (Johnson, 2010; Naphade, Banavar, Harrison, Paraszczak, & Morris, 2011; Offenhuber, 2014).

The adoption of VGI is facing challenges despite the aforementioned values and benefits. Created by amateurs, there is no assurance of quality in VGI (Goodchild & Li, 2012). Cooper et al. (2011) suggest that the quality of VGI should be assessed through aspects of positional accuracy, attribute accuracy, currency, completeness, logical consistency and lineage, but the nature of VGI poses challenges for assessing its quality in these ways, as they argue VGI can be subjective, with quality dependent on the data user, purpose, and the context in which it is used. Further, Coleman, Georgiadou and Labonte (2009) proposed that the motivations of VGI contributors could affect the data quality, with biased information potentially being contributed knowingly.

Another critical concern about adoption of VGI in government are digital inequalities, such as uneven levels of access to computers and the Internet across a society (Compaine, 2001). Many studies focus on digital inequalities in the global context which suggests the gaps in the access to the Internet and other advanced technologies between developed and developing countries (Genovese & Roche, 2010; Goodchild, 2007a; Sui, Goodchild, & Elwood, 2013). However, digital inequalities also exist at small geographical levels. Thomas and Streib (2003) conducted a survey in the state of Georgia in the U.S. and found that the use of the Internet is associated with income, education level, age, race and place of residence; those who have higher incomes or education levels tend to use the Internet more than those who have lower incomes or education levels; younger people show higher Internet use than older people; whites and local residents are higher in Internet use than non-whites or non-locals. Similarly, Bélanger and Carter (2009) carried out a survey to explore the relationships between demographic characteristics and the use of e-government services; the results show that income, education level, age and frequency of Internet use affect the use of e-government services. Cavallo et al. (2014) conducted a case study to determine the relationships between sociodemographic status and 311 service request frequency by developing a linear regression model, and their results indicate that demographic profile plays an important role in e-government participation.

3. City of Edmonton Case Study

3.1. Study Area

The city of Edmonton, the capital city of the Canadian province of Alberta, is the study area for this research (Figure 1). Edmonton had a population of 1,206,040 in 2011, making it Canada's fifth-largest municipality (Statistics Canada, 2015a). The City of Edmonton offers 311 services for citizens to request information and for non-emergency services such as pothole reporting, drainage maintenance, and dead animal removal. Edmonton's 311 service is available through four different channels; telephone, web form, email, and a mobile app called Edmonton 311 (for both Android and iOS operating systems). The multiple 311 channels offered by the City of Edmonton make it an appropriate case study for the collection of VGI in the public sector, serving as an example to other municipalities that may be considering similar types of systems. Three methods of analysis are used on the City of Edmonton 311 request data; first, a characterization of request channels, second, a hot spot analysis to determine geographic areas of high request activity, and last, an analysis of channel use compared to sociodemographic data of area residents.

3.2. Characterization of 311 Requests

The City of Edmonton (n.d.) maintains an open data portal where all 311 service request data is provided for free public download in various formats. Each request record contains information such as date reported, request status, service category, ticket source (the channel from which a request is made), and longitude and latitude of the reported issue (Table 1). For this research, all the service requests from January 1, 2013 to December 31, 2015 were retrieved, a total of 178,691 requests.

Figure 1. Map of Canada showing Edmonton.

Table 1. An example of 311 request record in open data catalogue.

Ticket Number	**8013549449**	**Ward**	**Ward 07**
Date Created	May 20, 2015	Address	12109 80 STREET NW
Date Closed	May 21, 2015	Lat	53.5754544171464
Request Status	Closed	Long	-113.463358322629
Status Detail	Assessed—No Action Required	Location	(53.5754544171464, -113.463358322629)
Service Category	Tree Maintenance	Ticket Source	Mobile App
Service Details	Broken Branches	Calendar	2015
Business Unit	Forestry	Count	1
Neighbourhood	EASTWOOD	Posse_Number	172692468-001
Community League	Eastwood Community League	Transit_Ref_Number	239856

The percentage of requests received from each channel (telephone, email, web form, and mobile app) by month is shown in Figure 2. Percentage share for each channel is used to provide a comparison over time. This analysis shows that the share of telephone calls decreases significantly over time, accounting for 95% of 311 requests in 2013 to 80% at the end of 2015. This change in relative share is driven by the launch of the Edmonton 311 mobile app in November 2014. The Edmonton 311 mobile app capture a 6% share of requests on launch in November 2014, reaching its peak in April 2015 with 18% of request share. This percentage decreases after April 2015 and becoming stable at 12% of all requests. In comparison to these two dominant channels, email and web form requests are smaller components of the 311 request mix, with email representing 5% of requests and web form representing 7% of requests. It is noted that though the share of telephone requests has decreased significantly since the launch of web form and mobile app channels, it still remains the main channel for citizens to make 311 requests, with approximately 80% of all requests, compared to 20% for the combined Internet-based methods of mobile app, email, and web form.

The volume of requests by month is shown in Figure 3. The number fluctuates notably over time; the highest value of about 140,000 is observed in January 2014, and the lowest value occurred in December 2015, which is around 1,800. Although the volume is not constant, some similarities are seen in terms of seasonal changes. For each year, the peak value is seen in winter; the highest value is in March for 2013, in January for 2014, and in March for 2013. In addition, it is noted that the number of requests decrease from July for all the three observation years. May 2014 and November 2014, when the web form and mobile app were launched respectively, did not see significant changes in the volume of requests. For the number of annual requests, it decreased dramatically from 2013 to 2015; about 63,681 requests were reported in 2013, and the number dropped by 15.6% to 53,723 requests in 2015. The decreasing total number of requests indicate that the newly-introduced channels did not contribute to more service requests in the City of Edmonton, and the diminishing share of requests by traditional channels imply that users are turning to new channels to make requests.

3.2. Hot Spot Analysis

Visualizing the geographic distribution of channel usage can show which areas of Edmonton generate service requests via a particular channel. To avoid spatial visualization issues that are generated from using statistical units that vary in size, the study area is divided into a set of 1km by 1km grid cells. All request data are aggregated at each grid cell, and the percentage of requests from each channel are calculated for each grid cell. Cells with higher percentages indicate that users in this area are more likely to use a particular channel to submit requests than in other cells. Instead of individual areas with high or low values, spatial clusters of high or low value grids were created using the Hot Spot Analysis tool in ArcGIS. These hot spots are generated by examining the value of each feature and its neighboring features, and a statistically significant hot spot is created where a feature with high value is also surrounded by high-value features (Scott & Warmerdam, 2005). The Hot Spot Analysis tool in ArcGIS calculates the Getis-Ord Gi* statistic for each feature in the input data, resulting in z-scores (Esri, 2015). For positive z-scores, a larger z-score indicates more intense clustering of high values. For negative z-scores, a lower z-score represents more intense clustering of low values. This tool was applied for each channel, generating four hot spot analysis results (Figure 4).

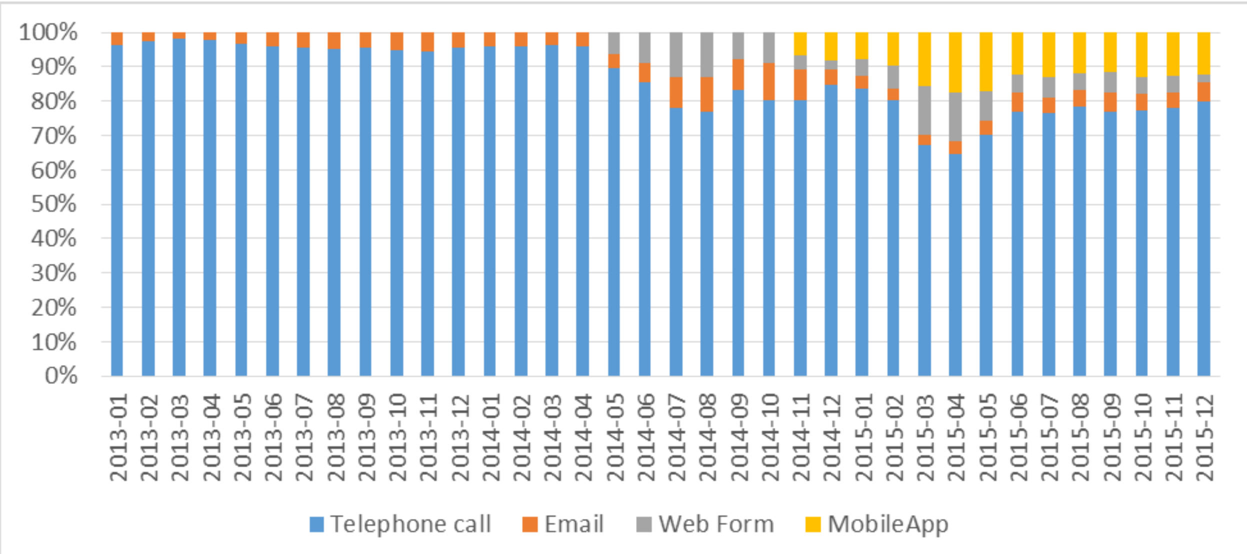

Figure 2. Percentage of requests from channels by month (From January 2013 to December 2015).

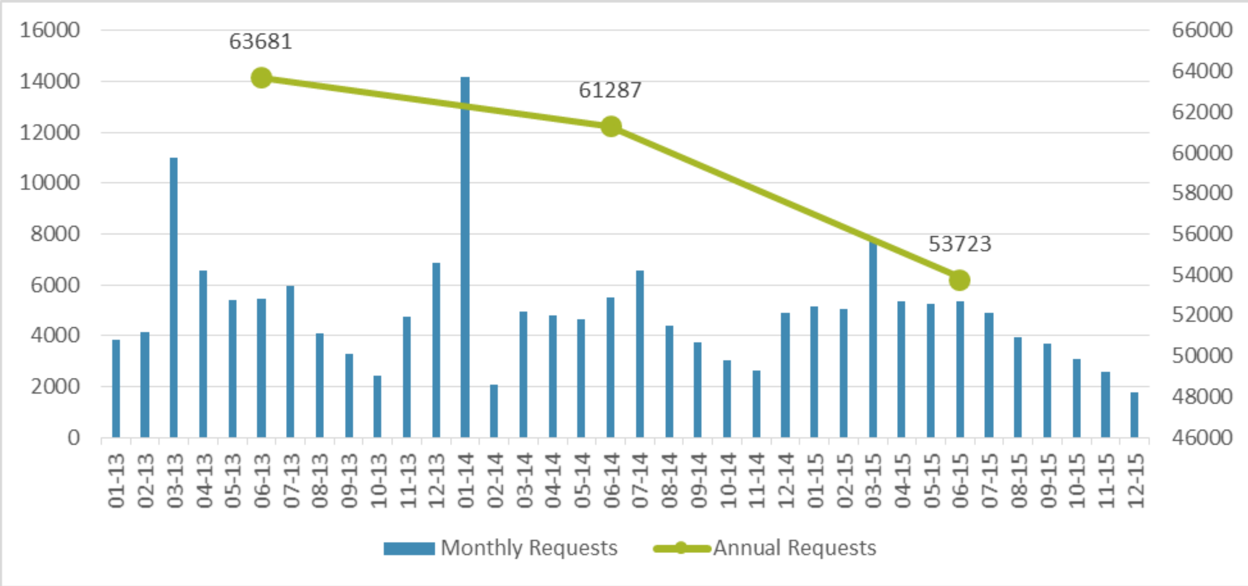

Figure 3. Total number of requests by month (From January 2013 to December 2015).

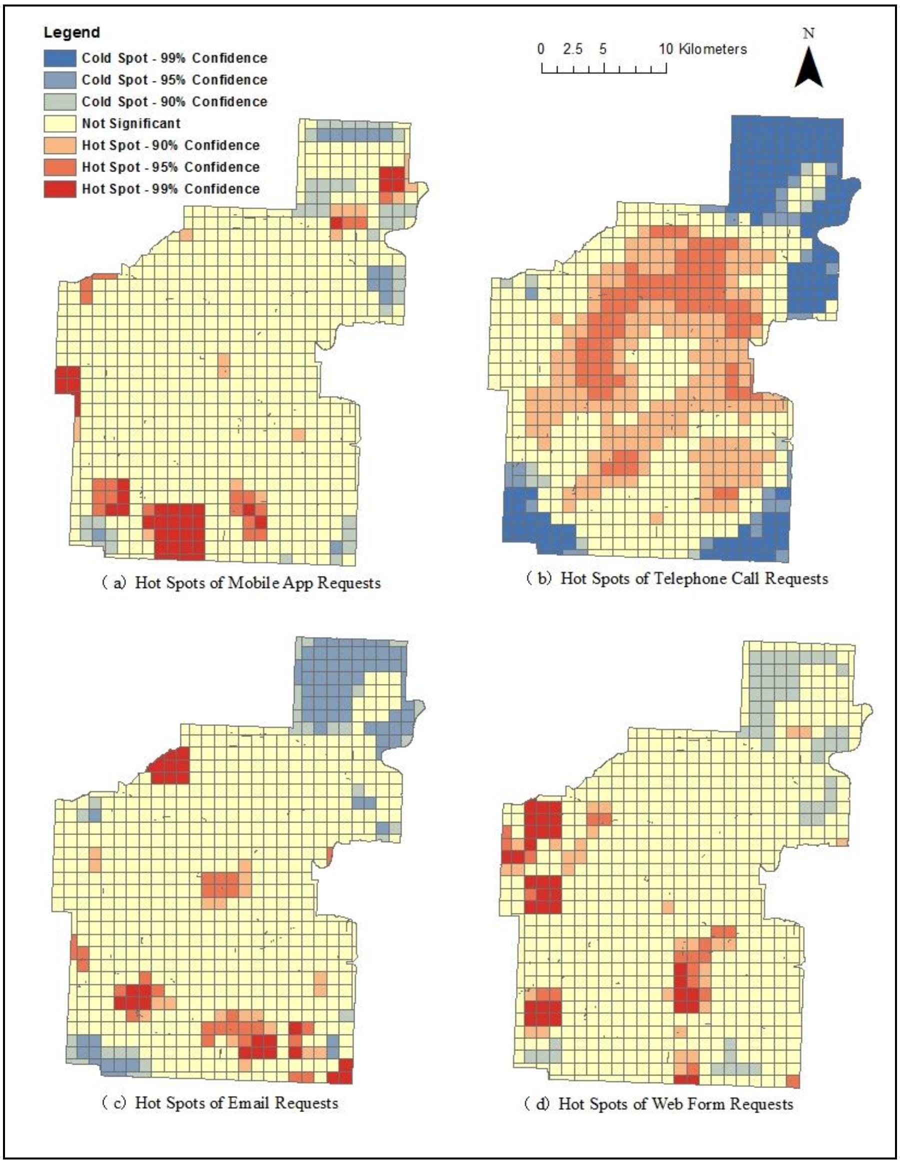

Figure 4. Hot spots analysis results based on percentages of reports from each channel.

Figure 4 shows the results from this hot spot analysis, based on percentages of requests from each channel instead of absolute numbers of requests from channels. Red indicates hot spots while blue stands for cold spots and yellow indicates no statistical significance. From map (a) which represents the requests from the mobile app channel, hotspots are mainly in the southwest of the city where a combination of agricultural land and residences are located. In contrast, the inner city which has a high density of residences and businesses shows no clustering in terms of percentage of reports received from the mobile app channel. This suggests that mobile app use is randomly distributed in the city center residences. The second map (b), represents requests from telephone calls, and shows hot spots circling the city center, with no significant clustering in the city center itself. This is despite the center of Edmonton showing the highest total volume of requests (Figure 5). It is noted that the city center is concentrated with businesses with few residences, and the disparities between the patterns of hot spots and total number of requests indicate that phone calls are possibly clustered at residential areas surrounding the city center; although the city center sees large number of requests, requests from the telephone channel are not significant. The cold spots of telephone requests are more significant than those of mobile app requests, and they are identified at the corners of the city, which also show a very low total number of requests (Figure 5). These areas are mainly covered by agriculture and undeveloped lands with a low population density (Figure 6), confirming that population plays an important role in the number of requests. However, it is observed that many of these colds spots are not similarly reflected in the mobile app requests, and even some hot spots are identified in these areas. From map (c) which represents hotspots of emails, the city center is identified as one of the hot spots. It is noted that the city center is not only concentrated with businesses, a significant number of institutions are also located in this area. The hot spots of web form reports (map (d)) shows that the two main industrial areas show some hot spots, implying that industrial areas have more use of web forms than other areas in the city. Overall, these hotspot results show the emergence of two different types of response patterns, driven by the type of technology used. One response pattern is that of the telephone—a traditional method of reporting information to municipal government. These patterns track major residential areas that have high population density. The other major pattern is generated by Internet-enabled methods, namely mobile app, email, and web form. These channels of communication show clustering in a much smaller range of areas, many of which are industrial, institutional, or have otherwise low population densities.

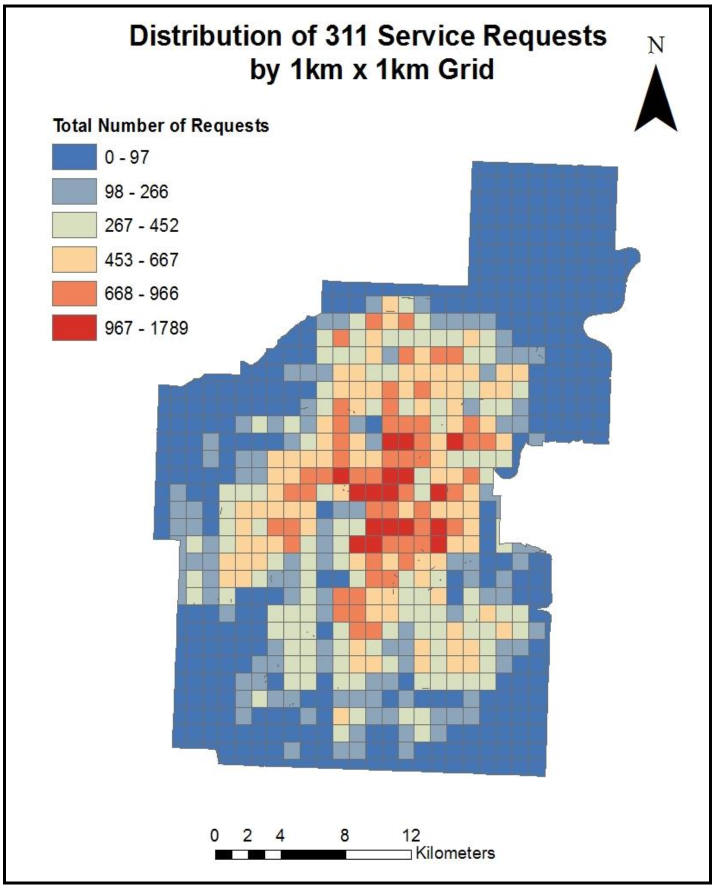

Figure 5. Distribution of service requests by 1km x 1km grid.

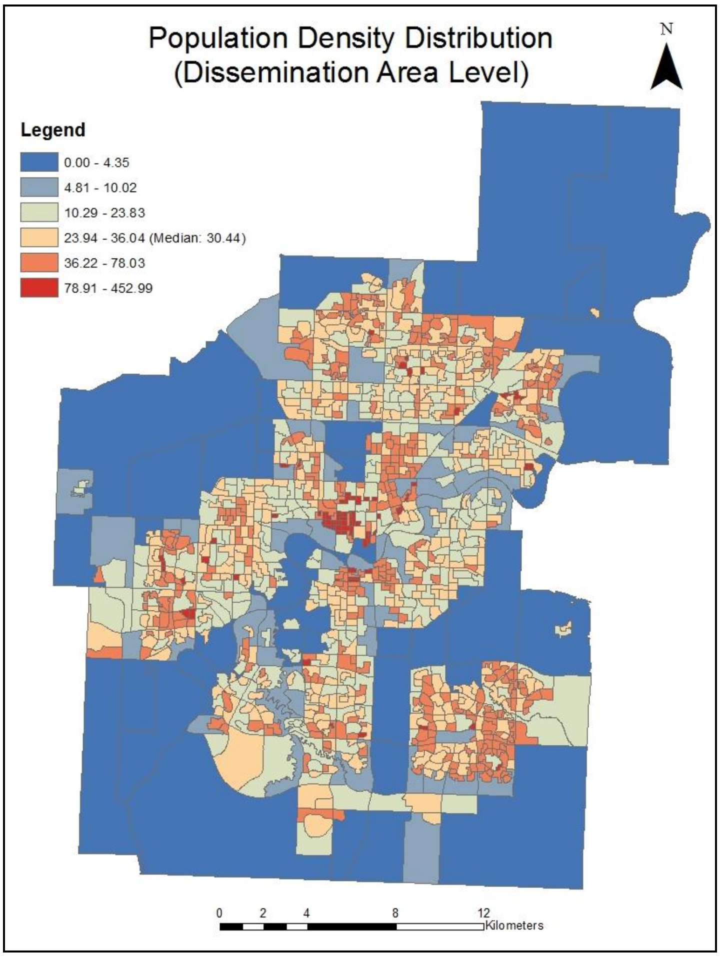

Figure 6. Population density distribution at dissemination area level. Note: Dissemination Area (DA) Level is defined as the smallest standard geographic area for which all census data are disseminated, typically with a population of 400 to 700 persons (Statistics Canada, 2015b).

3.3. Socio-Demographic Data

Inequality in access to information and communication technologies (ICTs) and gaps in knowledge and technical skills is termed as a digital inequality or digital divide (Kuk, 2003). An example of this inequality is how income and education level are found to be positively correlated with Internet adoption as individuals with higher income and education level tend to use the Internet more (Goldfarb & Prince, 2008). In addition, gender and age are also considered to be related to the use of ICT, as young people and males use new technologies more than the elderly or females (Lin, 2013). This section of the case study investigates if demographic profiles also play a role in the use of specific 311 service channels in the City of Edmonton. Key variables studied, as suggested by previous research into the digital divide include male population, female population, population by single year, percentage of population by citizenship, percentage of first language spoken (English), household income, and percentage of population 15 years or over without certificate, diploma or degree (Bélanger & Carter, 2009; Goodchild, 2007a; Thomas & Streib, 2003). This socio-demographic data is retrieved from SimplyMap, a web application from Geographic Research Inc. that provides access to Canadian federal statistical data including various demographic, business and marketing variables (Geographic Research Inc., n.d.).

Mirroring a previous study of municipal 311 services by Cavallo et al. (2014), ordinary least squares (OLS) regression is used to explore the relationships between demographic characteristics and the number of 311 service requests from each channel. OLS is a technique used to model a single dependent variable with single or multiple explanatory variables (Hutcheson, 2011). For this analysis, five regression models are built, and the dependent variables are the total number of requests and number of requests from each channel respectively. The explanatory variables are demographic characteristics along with geographic characteristics (Table 2). All the independent variables are listed in the table below. It is noted that all variables are measured at DA level. The output statistics of the five models are compared, examining the differences and commonalities in the variables that are significant (Table 3).

Table 2. Explanatory variables in regression models.

Geographic Independent Variables	Area of DA Road Length per Square Kilometers
Demographic Independent Variables	Total Population Percentage of Population without Certificate, Diploma or Degree Percentage of Non-citizens Gender Ratio of Male Population to Female Population Percentage of English Speakers Median Age Average Household Income

Table 3. Coefficients of regression models.

Variables	Total Number of Requests	Number of Requests from Telephone Call	Number of Requests from Mobile App	Number of Requests from Web Forms	Number of Requests from Emails
Total Population	0.102634*	0.088636*	0.005125*	0.001697*	0.007404*
% of Population without Certificate, Diploma or Degree	-0.457164	-0.244727	-0.078431*	-0.065716*	-0.079826*
% of Non-citizens	-0.574014	-0.581898*	-0.001987	-0.005855	0.014135
Gender Ratio	2.770114	4.494308	-1.054695	-0.276356	0.135342
% of English Speakers	0.859569	0.833315	-0.061903	-0.088039	0.202950*
Median Age	2.326921*	2.179165*	0.033151	0.054881	0.000001*
Average Household Income	-0.000081	-0.000067	-0.000008	-0.000009*	0.085558
Area	0.000022*	0.000019*	0.000001*	0.000001*	-0.000003*
Road Length Per Square Kilometers	34.041707*	29.321637*	1.474301	2.269063*	1.216818
Adjusted R-squared	0.511382	0.515259	0.348505	0.133248	0.464634

Note: Gender Ratio represents the ratio of male population to female population.

The results of the five regression models are shown in Table 3, including coefficients and R-Squared values. The explanatory variables marked with asterisks indicate that the variables are statistically significant. The significance of variables is evaluated by using a T test. In this test, the null hypothesis is that the explanatory variable is not effective in the models, and the p-value represents the probability of observing the effect in the sample data if the null hypothesis is true. P-values smaller than 0.05 indicate the statistical significance of the explanatory variable. The sign of a coefficient implies the type of relationships between the explanatory variable and the dependent variable. Positive signs indicate positive relationship, which means that the dependent variable grows when the explanatory variable increases.

In Table 3, it is observed that total population is significant in all the models and the coefficients are all positive. It can be concluded that DAs with larger populations observe more 311 requests, which is within expectations. The following discussion will not include this variable, with focus shifted on to other demographic characteristics. For the model developed with total number of requests (not broken down by channel), it is noted that only median age is identified as a significant demographic variable and is positive, which means that older people tend to make more 311 requests than younger people. For this variable, the model shows a high R-squared value of 0.511382, indicating that about 51% of variance in the total number of requests at DA level can be explained by the selected explanatory variables.

Further insight into the relationship between 311 channel choice and demographic variables can be gained through analysis of each specific channel. For the number of requests from telephone calls, the analysis results are similar to the total requests model except that the percentage of non-citizens also shows statistical significance. The negative sign indicates a negative relationship between percentage of non-citizens and the number of requests from telephone calls, thus areas with a larger proportion of non-citizens have less 311 requests made using the telephone. Note that this could also show that non-citizens (those with citizenship status of permanent resident, landed immigrant, work visa, or refugee), make less requests than citizens or they tend to use other channels to reach a 311 service. For the mobile app model, it is observed that the education indicator (percentage of population without certificate, diploma or degree) plays an important role and has a negative effect. DAs with a larger proportion of people in possession of a certificate, diploma or degree have more requests from mobile apps. Other demographic characteristics do not show significance in this model. For the web forms model, education level and average household income are identified as significant variables. The relationship between education level and number of requests from web forms is the same as the one in the mobile app model; people with a certificate, diploma or degree tend to make more requests. Household income also has a negative relationship with the number of requests from the web form channel, indicating DAs with higher average household income have less 311 requests via a web form. It is noted that the R-squared value of 0.133248 in this model is much smaller than those in other models; only about 13% of the variances in the number of requests from this channel can be explained by the explanatory variables. Lastly, for the email reporting channel, education level, percentage of English speakers and median age all play important roles. The education level has the same type of relationship with the dependent variable as discussed in the previous models; people without certificate, diploma or degree have lower tendency to make requests. It is noted that the percentage of English speakers is only significant in this model and has a positive effect, showing that English speakers are more inclined to make requests via email than non-English speakers. In addition, the median age indicator shows that older people make more use of the email channel to make requests than younger people.

4. Discussion and Conclusions

This research presents a case study of the City of Edmonton, examining its provision of municipal 311 services through various channels. The four channels provided for 311 service are telephone, web form, email, and a mobile app. These channels are each characterized for their relative share of all 311 requests over a three-year period, their geographic hotspots, and also the connection between selected sociodemographic characteristics and contributions by channel type. Overall, these three methods of analysis are used to compare the VGI contributions of individuals, showing differences based on type, location, and connections to sociodemographic characteristics.

4.1. Changing Channels of VGI Contribution

The assessment of three years of City of Edmonton 311 data reveals a notable shift in the share of service requests by channel. As described in Figure 2, with the launch of a mobile app, between 10–20% of 311 requests were received through this manner. Though traditional telephone requests still dominate, it is unknown how many of these are made through fixed landlines compared to mobile phones. Regardless, this case study demonstrates a channel shift in 311 use from the traditional voice methods requiring one-to-one interaction between citizen and municipal employee to what could be termed more passive forms of communication, with a range from 20–35% of all requests over the last year being made via a combination of mobile app, web form, and email (Figure 2). As shown in Figure 3, the total number of requests does not grow with the introduction of new channels but decreases notably over time, which confirms that there is a shift from the voice-based channel to the Internet-based channels. While it is difficult to draw a distinction between mobile uses and non-mobile uses (such as those contributions made 'in the field' when a respondent encounters an issue, compared to a request made from a fixed location, such as home or work), this shift in channel should demonstrate to government the importance of providing multiple channels for citizen input in any 311 system. For gathering municipally-related VGI in the city, multiple channels are needed, and also have the potential to be a worthwhile extension of the traditional telephone 311 system.

4.2. Uneven Contribution of VGI

The characterization of channels of contributors revealed a change from traditional telephone reporting to a greater reliance on Internet-based reporting. In conjunction with this shift, there were notable geographic differences between reports generated through specific channels. As demonstrated in Figure 4, traditional reporting methods, such as the telephone were overwhelmingly focused around areas of high residential density, excluding the city core and fringe areas of the city. This contrasted with reports from Internet-based methods, such as mobile app, web form and email that were focused on industrial areas with low residential density, and more peripheral residential areas. Additionally, this hotspot analysis showed that Internet-based methods showed more significant hotspots of activity, compared to a broader geographic range like that seen with the telephone channel. This phenomenon could indicate that Internet-based response channels are more mobile, and thus reflect reporting that is more immediate or in reaction to a particular type of experienced issue. For example, Internet-based response channels may be better placed to report issues that have just occurred, such as breakage, dead animal removal, or specific incidents. In this way, Internet-based response channels are reflective of the advantages often ascribed to VGI as being closer to an actual phenomenon, and more representative of lived experience (Goodchild, 2007a). This is a finding that requires further follow up, with a linking of type of issue, time of reporting to the reporting channel.

This hotspot analysis also presents to municipal government feedback that may help to refine municipal activities around proactive service provision, such as identifying locations within the City of Edmonton that may considered as 'problem' locations. Again, further analysis that incorporates the specific type of request could be used to determine if areas can be characterized with recurring issues and if these issues have a spatial nature to them. For example, if one road is the frequent site of dead animal removal, it may be prudent for municipal staff to investigate the potential of create safe road crossing environments for wildlife, or for posting signs to warn motorists of the potential danger. Spatial analysis of 311 requests also has the ability to be used to identify hotspots of channel usage and related gaps. For example, as mobile app diffusion accelerates, government can use 311 request channels to assess the relative merits to continued maintenance of legacy channels, as well as to target specific location-based campaigns or follow-up citizen services.

4.3. 311 Channel-Based Digital Inequalities

A critical component to understanding 311 service requests is to attempt to match requests to contributor profiles. Given the absence of personally-identifying information in 311 request information, requests are matched with sociodemographic data for the DA unit of statistical analysis. This analysis makes a major assumption in that requests are made by individuals who are living in the same place as where the request was made. Similar research, such as that by Cavallo (2014) does not expressly consider this limitation imposed by the size of the statistical areas and the mobile nature of requests. In this study, there are several interesting connections between sociodemographic characteristics and the channel of 311 service request. These connections can be interpreted as showing the presence of digital divides that are based on channel usage. The most notable of these is the link between median age and channel usage. As indicated in Table 3, median age is identified as a significant variable in the phone call requests, indicating that older people have a higher tendency to make requests via telephone than younger people. Additionally, education level plays an important role in mobile app, web form and email models but not in telephone calls. This implies that requests from the three channels are more likely to be made by people with certificate, diploma or degree. Some researchers pointed out that there is a significant gap in the use of new technologies between male and female groups. For example, Wilson, Wallin and Reiser (2003) suggested that women are much less likely to own and use computers than men based on a survey in North Carolina. Additionally, Liff, Shepherd, Wajcman, Rice and Hargittai (2004) argued that the divide between men and women exists not only in whether adopting the technology but also in the purpose of the technology use. However, gender is not identified as a significant factor in the use of 311 channel in this study. One of the reasons could be the increasing penetration and availability of the Internet that contribute to the narrowing gap in terms of technology access and adoption between genders (Dholakia, 2006).

4.4. Limitations of the Analysis

There are several areas of limitation in this paper. First, the request data obtained from the City of Edmonton covers a short time period compared to the total lifespan of the 311 service. The 311 service was started in December 2008 while the 311 request data used in this study was from January 2013 to December 2015. Therefore, the number of requests received from December 2008 to December 2012 and the channel distribution of the requests is not analyzed and interpreted. The trend of use of multiple channels presented in this paper would be more complete if the request data before January 2013 was available. Second, all the socio-demographic data such as percentage of non-citizens used in this study is based on the Canadian data from the 2011 National Household Survey, which was not an official census, but rather a voluntary survey. This data from 2011 may not reflect the socio-demographic profile of the request data, due to a 2 to 4 year gap between them. Therefore, the relationships between the use of channel and demographic characteristics identified in this paper could contain some bias. In addition, it is noted that the relationships between use of different 311 channels and demographic variables are analyzed based on aggregated data at DA level, assuming requests observed in a DA is made by the residents of this area. However, in the real world, people are travelling instead of staying at one place all the time; it is likely that a request is submitted by a person who lives in other areas. Although some DAs such as industrial areas that recorded a large number requests and very low population density have been removed in the regression analysis, the results would still have some uncertainties due to the mobility of residents.

4.5. Traditional vs. Internet-Based 311 Reporting Channels

Municipal 311 services provide a valuable way for citizens to connect with government, creating a conduit for the reporting of non-emergency issues. As the technologies used to provide 311 services have changed from traditional to Internet-based, it should come as no surprise that the patterns and nature of citizen reporting have also changed. As one of Canada's most 'open' cities, Edmonton provides a case study of 311 channel use, and tracks this change from traditional forms, such as the telephone, to a mixed 311 system involving mobile apps, web forms, and email. The differences between these two broad categories (traditional and Internet-based) are striking, with distinct spatial patterns, and connections to demographic characteristics. As a traditional method, telephone service requests largely match residential areas, and favor older individuals. Comparably, Internet-based service requests are more focused on specific areas outside of heavily populated areas, and favor younger individuals. The demographic characteristics play an important role in the use of 311 service channels, and their relationships are distinct for different channels. Education level is significantly related to the use of the Internet-based channels, and higher education level is associated with more requests from the Internet-based channels; however, education level is not significant in the number of requests from telephone calls. Citizenship status is another variable that is different between the two categories of channels; percentage of non-citizens is identified significantly related to the number of requests from telephone calls, but this variable shows no significance in the requests from the Internet-based channels. It is observed that telephone call requests decrease with increases in the percentage of non-citizens. In both instances, these service requests represent a form of VGI—these are asserted, geographically-explicit requests from citizens for a service from their government. Future work on these topics should focus on characterizing the users of municipal 311 based on their contributions. For example, are there repeated requests made by a core group of contributors? Are there specific areas and types of requests that are repeated or are there areas that are not reported? Important work remains on assessing the constraints to government adoption of requests, including a tracing of how different channels of service request are treated from within government. For example, is there preference given to a particular channel? Additionally, what is the impact of service requests made from outside the official 311 system using social media to connect with municipal or elected staff? As technologies advance the channels available for citizens to generate VGI and connect with their government, it opens up new questions, including the assessment of these systems, as well as considerations of who is favored and who may be left behind by these technological changes.

Acknowledgments

The authors thank everyone in Geospatial Innovation Lab at the University of Waterloo for their comments and advice on the data analysis process. We also acknowledge the support of Geothink, a Canadian geospatial and open data research partnership funded by the Social Sciences and Humanities Research Council of Canada (SSHRC).

Conflict of Interests

The authors declare no conflict of interests.

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Urban Planning (ISSN: 2183-7635)
2016, Volume 1, Issue 2, Pages 32-48
Doi: 10.17645/up.v1i2.623

Article

Leveraging VGI Integrated with 3D Spatial Technology to Support Urban Intensification in Melbourne, Australia

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Submitted: 11 March 2016 | Accepted: 17 May 2016 | Published: 15 June 2016

Abstract
High density residential development in metropolitan Melbourne, where contradictory imperatives of neighbourhood character and urban intensification play important roles, remains an uncertain practice. One key issue for plan implementation is the lack of consistency between authorities, developers and the community in interpreting the standards, design guidelines, and state/local strategies, especially those relating to neighbourhood character. There is currently no mechanism to incorporate community perceptions and place experiences as subjective aspects of neighbourhood character in development assessments. There is also little use of micro-scale and multi-dimensional spatial analysis to integrate these subjective aspects with objective measures (e.g. building volume and height; streetscape) to communicate effectively—and in a limited timeframe—with all stakeholders. This paper explores the potential of two emerging geospatial technologies that can be leveraged to respond to these problems. Evidence in the literature suggests that volunteered geographic information (VGI) can provide community input around subjective aspects of the urban environment. In addition, a deluge of three-dimensional (3D) spatial information (e.g. 3D city models) is increasingly available for micro-level (building- or property-level) assessment of the physical aspects of the urban environment. This paper formulates and discusses a conceptual framework to link these two spatial technological advancements in a virtual geographic environment (VGE) that accounts for micro-scale 3D spatial analysis incorporating both subjective and objective aspects of neighbourhood character relevant in implementing compact city strategies.

Keywords
3D city models; compact city; Melbourne; neighbourhood character; VGE; VGI

Issue
This article is part of the issue "Volunteered Geographic Information and the City", edited by Andrew Hudson-Smith (University College London, UK), Choon-Piew Pow (National University of Singapore, Singapore), Jin-Kyu Jung (University of Washington, USA) and Wen Lin (Newcastle University, UK).

1. Introduction

Planning is often emotionally and politically charged. This is nowhere more evident than in the push towards compact cities, where policy imperatives supporting urban intensification often conflicts with community desire to retain neighbourhood character and preserve a sense of identity (Davison, 2011). The neighbourhood is often a battleground, where community perceptions and desires around neighbourhood character drive opposition to development. This "NIMBY" (Not In My Backyard) attitude has both rational and emotional aspects and is common in confrontations between municipal governments, developers and communities (Gilmour, 2012).

Despite its significance in planning, it remains difficult to categorically define neighbourhood character because it is individually experienced, socially variable, and changes over time (Dovey & Woodcock, 2011). These attributes make it challenging to define appropriate indices that can be used in urban analytics to assess neighbourhood character to inform urban planning. There are also consequences for effective communication and engagement with the public—Woodcock, Dovey and Davison (2012) found that public opinion around development is often built on an unclear understanding of the nature and reality of development impacts.

In Australia, urban intensification has become a planning priority, particularly in metropolitan Melbourne which is the country's fastest growing city and projected to be its largest by 2030 (Victoria Government, 2014). Urban intensification seeks to cluster higher density housing around activity centres to leverage existing facilities and infrastructure: agglomerating effects are expected to attract more services, employment and facilities. The state planning system, which takes into consideration physical, social and economic aspects of the urban environment, has formalised neighbour character as a primary criterion in urban residential development. However, there is a tendency for municipal governments to implement this concept locally using objective (measurable, visible, tangible)—albeit at times simplistic—indicators such as style of construction, roof types, driveways, fencing, spatial patterns, height limits, etc.

These do not fully capture the essence of neighbourhood character. Conflicting perceptions around what constitutes 'character' and poor definition of those aspects of character under threat continue to be a central theme in community opposition to residential development aimed at urban intensification (Schwartz, Dodd, & Haley, 2014). In part, it is believed that the strength of emotion in such opposition stems from a general lack of tradition in higher density living in Australia and the desire to preserve the suburban norm of a "quarter acre block". The lack of clarity and consistency around neighbourhood character is further evident when parties pursue adjudication in the Victorian Civil and Administrative Tribunal (VCAT): it has been shown that the Tribunal tends to interpret planning schemes in an altogether different way than the council intended (Victorian Planning Reports, 2013).

Two clear issues emerge. Firstly, the prevalence of objective indicators in defining neighbourhood character ignores subjective (not measurable, not visible and not tangible) aspects of the urban environment such as sense of place and neighbourhood identity (de Jong, Fuller, & Gray, 2013). This limits the ability of planners and developers to fully consider the interaction between objective and subjective aspects in asserting neighbourhood character. Secondly, guidelines for higher density urban residential development require not only more information about the subjective aspects of the urban environment, but also greater integration of both objective and subjective elements. The ongoing frequency of opposition provides evidence that interpretation and application of urban residential development requirements still does not adequately reflect community perceptions of neighbourhood character (Dovey, Woodcock, & Wood, 2009a). In addition, a lack of consistency in interpretation between authorities, developers and the community further underscores the need to improve information inputs into development assessment to achieve broader priorities in urban intensification.

In response, this paper explores the potential of two emerging geospatial technologies that can be leveraged to respond to the problematic representation and evaluation of neighbourhood character in the context of higher-density development in Victoria. Evidence in the literature suggests that volunteered geographic information (VGI) can provide community input around subjective aspects of the urban environment (Harvey & Aultman-Hall, 2015). In addition, a deluge of three-dimensional (3D) spatial information (e.g. 3D city models and Building Information Models) is being increasingly utilised for micro-level (building- or property-level) assessment of physical aspects of urban environment such as shadow casting (Rafiee, Dias, Fruijtier, & Scholten, 2014), sky view factor analysis (Chen et al., 2012), and noise management (Herman & Rezník, 2013). 3D models can also deliver better representation and communication of real world features in an interactive virtual environment for clearer understanding of proposals by the community (Lin et al., 2013; Smith, Bishop, Williams, & Ford, 2012). Although a combination of these two inter-linked technologies can potentially satisfy the requirements of plan implementation, there has hitherto been little consideration of a formal mechanism for linking VGI and 3D spatial information in support of sustainable urban intensification.

This paper argues that a new framework that better represents and measure the subjective and objective aspects of neighbourhood character is required, particularly in the case of compact cities that are becoming vertically extended and in which complex physical, functional, and contextual relationships exist. To develop this framework, the paper first provides a background on key issues in plan implementation, specifically in Victoria. The relationship between planning and technology is then reviewed as a precursor to introducing emergent technologies that impact planning. Based on this review of the literature, a conceptual framework to enable a more holistic approach to plan implementation in compact cities that accounts for both objective and subjective aspects of the urban environment is developed. Finally, the paper concludes with a discussion about the potential opportunities and challenges of using this framework in future work.

2. Background

2.1. Neighbourhood Character: Objective vs. Subjective Indicators

Although it receives significant attention within the planning literature, the concept of place identity—or neighbourhood character—remains difficult to define precisely and consistently because it interfaces with planning, politics and social sciences (Hague, 2005). Relph (1976) emphasised the importance of understanding the significance that places have to people and this, he argued, was based on their identification of, and with, a place. This comprised three components: physical characteristics, experiences local to the setting and meaning derived through people's experiences in the physical setting. This interplay between physical, social and psychological factors as constituting the elemental definition of place character recurs throughout planning literature (e.g. Sepe & Pitt, 2014) and is best illustrated in Montgomery's (1998) conceptualisation of place (Figure 1).

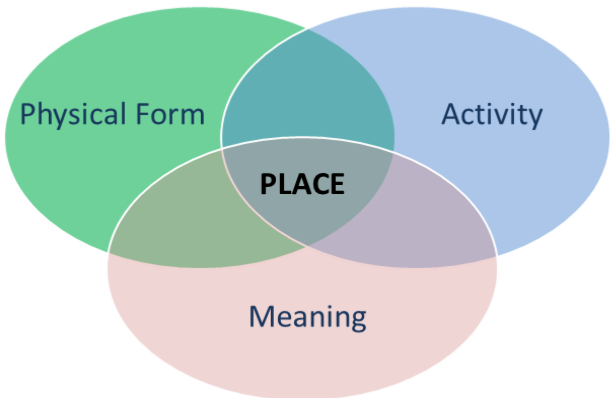

Figure 1. Montgomery's concept of place (Montgomery, 1998).

Dovey et al. (2009a) described neighbourhood character as a function of urban typology, density and street life. The authors found three key determinants: residents' experience of the place, socio-cultural outcome of urban form, and the formal spatial structure and urban morphology. This view takes into consideration the "multiplicities" and "assemblages" of residents and incorporates both subjectivities (e.g. feeling of the place, experience, socio-cultural flavour) and objectivities (e.g. building and neighbourhood form, physical and environmental aspects, streetscape). However, at times, it can be difficult to make a clear distinction between subjective and objective indicators.

The objective aspects of neighbourhood character are better understood, measured and communicated with local communities by urban practitioners and researchers (Sabri, Pettit, Bishop, & Rajabifard, 2015). These aspects can be categorised into spatial and functional indicators: building volumes, height, and density are examples of spatial indicators, and land use type, diversity, and accessibility provide functional indicators. Given that these indicators are quantitative and easily measurable (Larco, 2015), most regulatory guidelines and practical reports by governments use a range of objective indicator to measure the qualitative aspects of neighbourhood character. For instance, the Western Australian Ministry for Planning have developed urban fabric indicators (Porta & Renne, 2005) to ensure the liveability of neighbourhoods. These include land use diversity, street connectivity, number of buildings and number of lots (Table 1).

Although the physical environment contributes significantly to a sense of place (Stedman, 2003), social construction and place experience are other factors that need to be taken into consideration. These factors constitute the subjective aspects of neighbourhood character but have been neglected in most regulative guidelines pertaining to neighbourhood character and sustainability of urban design (Ewing, Hajrasouliha, Neckerman, Purciel-Hill, & Greene, 2015; Porta & Renne, 2005; Purciel et al., 2009).

Subjective indicators include social interactions—their type and the intensity of these activities through time, e.g. daily, weekly, and monthly (Bonaiuto, Fornara, Ariccio, Cancellieri, & Rahimi, 2015; Kropf, 1996; Walton, Murray, & Thomas, 2008). Other socially constructed aspects which feature in the literature as subjective indicators include people's interpretation and experience of places including positive and negative views on physical and natural features of neighbourhood (Green, 1999, 2010; Jive´n & Larkham, 2003) (Table 1). In some cases such indicators contribute significantly to constructing a sense of place independent of physical qualities embodied in the setting (Kyle & Chick, 2007). In a study of Subiaco city in Western Australia, Davison and Rowden (2012) found that residents gave equal significance to the social and experiential meaning of places as they did to physical form and appearances of streets. These subjective aspects of neighbourhood character are regarded as key factors underlying residents' resistance to urban intensification strategies and projects (Davison & Rowden, 2012; Dovey et al., 2009a; Kyttä, Broberg, Tzoulas, & Snabb, 2013; Vallance, Perkins, & Moore, 2005).

Studies have shown that the measurement of objective aspects of neighbourhood character, particularly with the application of spatial technologies, is a straightforward process (Ewing et al., 2015). Subjective aspects however, have tended to be measured indirectly using physical indicators. For instance, Harvey et al. (2015) suggested "streetscape skeleton" design variables that can be efficiently measured using geospatial information, as the sense of safety and social functionality of urban spaces at the spatial resolution of city blocks. They measured seven skeleton design variables for each streetscape including width, length, height,

Table 1. Objective and subjective indicators of neighbourhood character as derived from the literature.

Aspects	Category	Indicators	Authors
Objective	Physical	Building volumes, density, and aesthetics	Bonaiuto, Fornara and Bonnes (2006); Bonaiuto et al. (2015); Porta and Renne (2005); Walton et al. (2008)
		Green areas quantity and quality	Green (2010); Stock, Bishop and Green (2007); Glaesener and Caruso (2015); Hunter and Brown (2012)
		Streetscape, tree canopy, width, urban furniture,	Ewing et al. (2015); Harvey, Aultman-Hall, Hurley and Troy (2015); Harvey and Aultman-Hall (2015); Hunter and Brown (2012); Porta and Renne (2005)
		Building facade, private open spaces and setbacks, fences	Ewing et al. (2015); Porta and Renne (2005); Purciel et al. (2009); Victoria Government (2015)
	Functional	Land use types and diversity	Glaesener and Caruso (2015); Schwarz (2010); Verburg, de Nijs, van Eck, Visser and de Jong (2004)
		Accessibility to urban services (e.g. education, health, and recreation)	Walker, Block and Kawachi (2013); Xiao, Orford and Webster (2015)
		Street network pattern and connectivity	Brownson, Hoehner, Day, Forsyth and Sallis (2009); Dovey and Wood (2014); Fenton (2012); Porta and Renne (2005)
Subjective	Social Construction	Sociability, security, safety	Green (2010); Kyle and Chick (2007); Stedman (2003)
		Socio-cultural activities	Bonaiuto et al. (2006); Foth, Bajracharya, Brown and Hearn (2009); Smith and Phillips (2001)
	Experiential	Place attachment, cultural significant elements	Chang (2000); Jean (2015); Stedman (2003)
		Place satisfaction, microclimate, equitable access to services	Bonaiuto et al. (2015); Fleury-Bahi, Félonneau and Marchand (2008); Qin, Zhou, Sun, Leng and Lian (2013)

cross-sectional proportion, street wall continuity, buildings per length, and tree canopy coverage as an indirect measure of neighbourhood subjective aspects.

Other studies have also utilised relatively similar physical indicators for indirect measurement of subjective aspects of neighbourhood character. These include sky exposure (Samuels, 2002, p. 695), facade continuity (Meehan, 1982, p.438), softness (e.g. easement gardens indicating transparency and transitional space) (Hunter & Brown, 2012, p. 408), visual complexity, number of buildings, sedibility (measuring the number of seating opportunities) and detractors (blank walls, traffic signs, large dumpsters) (Porta & Renne, 2005, pp. 5-11). The reason for not being able to directly measure subjective aspects of neighbourhood character is stated as being the limited sample size used in audit based urban design and community perception measurement (Harvey et al., 2015). Often not enough is known about the relationship between these indictors—either singly or in combination—and people's subjective responses to them. This potentially explains why regulatory guidelines for neighbourhood character assessment by municipal governments consistently overlook subjective indicators.

2.2. The Concept of Neighbourhood Character in Victoria's Planning System

In Victoria, neighbourhood character is a primary concern in planning. The government's definition of neighbourhood character is consistent with the literature to date, mandating that developments consider both objective and subjective elements and their combined relationships. However, their description of neighbourhood character is of very little assistance to planners:

> "Neighbourhood character is essentially the combination of the public and private realms. Every property, public place or piece of infrastructure makes a contribution, whether great or small. It is the cumulative impact of all these contributions that estab-

lishes neighbourhood character. The key to understanding character is being able to describe how the features of an area come together to give that area its own particular character. Breaking up character into discrete features and characteristics misses out on the relationships between these features and characteristics. Understanding how these relationships physically appear on the ground is usually the most important aspect in establishing the character of the area." (Victoria Government, 2015)

Lack of clarity continues in the residential design code, ResCode, where neighbourhood character is used as the starting point for assessing all residential development applications, but only applies to developments up to three storeys in height. Guidelines for higher density residential developments, while continuing to refer to neighbourhood character, also demand design responses that integrate physical, social and economic aspects of the urban environment as well as consideration of the strategic prospects of the area. The issue of neighbourhood character is specifically addressed by the Neighbourhood Character Overlay (Victoria Government, 2015, section 43.05), which aims to:

- Identify areas of existing or preferred neighbourhood character;
- Ensure that development respects the neighbourhood character;
- Prevent, where necessary, the removal of buildings and vegetation before the neighbourhood character features of the site and the new development have been evaluated.

These objectives are then implemented independently by each of the state's 79 local municipal governments, who develop their own Local Planning Policy Framework (including a Municipal Strategic Statement and other local planning policies). Municipal governments must provide a schedule that contains a statement of the key features of neighbourhood character and the neighbourhood character objectives to be achieved in any affected area. However, municipal planners often describe neighbourhood character by referencing physical and functional elements of the urban environment. These include topography, street block length, landscaping and vegetation in the neighbourhood, diversity of housing, building mass and height, architecture and roof styles, street trees, and waterways (Victoria Government, 2015). These indicators do not describe the subjective aspects of neighbourhood character, such as "sense of place and community meaning".

Table 2 provides an example of a neighbourhood character description as developed for the Ringwood Activity Centre. Ringwood has been prioritised by the state government in its vision for achieving growth and has been designated as a Metropolitan Activity Centre—the highest priority centres outside of the CBD. This is an example of urban intensification policies at work. The table shows how neighbourhood character has been defined by physical elements and this conceptualisation is perpetuated by objectives that developers need to meet in proposed designs. In this instance, architectural styling, dwelling type (number of storeys) and design, construction materials, type of landscaping and even location of driveways are all used to identify elements of existing neighbourhood character. This does not change radically in the statement about future character and how this will be achieved—still relying on objective elements like building form and height as neighbourhood character objectives in design and development.

Further support of this bias towards using objective indicators can be seen in Dovey et al. (2009a). The authors found that despite the emphasis placed on neighbourhood character in planning, Victorian residents' perspectives pertaining to character were reflected only to a limited extent in regulations. Drawing on an intensive range of interviews and evidence (Dovey, Woodcock, & Wood, 2009b), the authors found that in Melbourne's inner-suburbs, when the term 'character' was raised in urban development debate, the views of stakeholders—the community, developers, politicians, and planners—tended to diverge significantly. Potentially, this could be due to a naïve image of the spatial, social, and economic impacts of urban intensification projects (Woodcock, Dovey, Wollan, & Beyerle, 2010). It remains unclear how residents' experience of their neighbourhoods can be measured and incorporated by planners and decision makers.

From the literature and contextual examples provided above, it is evident that implementation of planning policies to meet policy imperatives on urban intensification, which also attend to neighbourhood character, requires localised assessment (D'Argent, Beringer, Tapper, & Coutts, 2012; Victoria Government, 2014). Despite emerging opportunities, planners and developers still depend on paper-based information as a means of engaging with the community, disregarding readily available ICT and spatial technology applications (Houghton, Miller, & Foth, 2014). Such engagement is also limited by truncated decision-making—in Victoria, public notice periods are determined by municipal authorities although the norm is to advertise for two weeks (Victoria Government, 2014). Consequently, current planning mechanisms are severely limited in their ability to fully accommodate and consider communities' subjective perceptions of their environment. The basis for engagement and analysis is therefore fundamentally flawed (Woodcock et al., 2010).

Table 2. Neighbourhood character statement and objectives for Ringwood Activity Centre (Maroondah City Council).

Existing Character Elements	Preferred Future Character	Achieved By
• Architectural styles include simple Post War era 1950s and 1960s weatherboard and brick, 1960s and 1970s L-shaped and 1980s adaptations of the L-shaped form. • Dwellings are generally single storey and offset to one side of the lot to provide a driveway down one side. • Materials are mixed brick and weatherboard with tiled, pitched roofs. • Lot sizes vary, but are generally 500–1200m^2, with occasional smaller and larger blocks. • Established gardens are common throughout, frequently with canopy trees as features. • Multi-unit sites have been developed with dwellings aligned along the side boundary and a driveway to one side. • Generally single dwellings front the street, while multi-unit development generally front side boundaries. • Dwelling design is conventional, pitched roof, brick veneer, or in some instances timber, 2 to 3 bedrooms and garage. • Street trees are well established.	• Intent: Foster increased residential densities in preferred residential development precincts and to establish multi-level, multi-occupancy apartment style buildings as the preferred form of dwelling design and neighbourhood character. • The preferred neighbourhood character will provide for multi-level, apartment-style residential buildings that retain elements of the existing garden setting. Buildings will be larger apartment style, single buildings constructed on consolidated sites. • New development will provide for a higher intensity of site development than occurs at present. • New development will recognise the existing street pattern and create buildings that form visual landmarks throughout the precincts.	• Constructing multi-level, multi-occupancy residential buildings. • Consolidating existing lots to create larger development sites containing multi-level, multi-occupancy buildings. • Providing strategic opportunities for the planting or retention of canopy trees to maintain the existing streetscape and frame larger buildings. • Ensuring that the building form retains a human scale and is designed to avoid large, block like structures dominating the streetscape. • Providing a mix of building forms and heights that generally accord with the Ringwood Activity Centre indicative building height map. • Consolidating sites in a logical and progressive manner that avoids the creation of isolated lots of limited redevelopment potential. • Providing the opportunity to enhance pedestrian activity and contribute the creation of a sense of place. • Relating building height to lot size. • Limiting vehicle crossings to 1 per site and providing common access to sites.

3. Leveraging New Geospatial Technologies in Planning

3.1. 3D Geospatial Information and Spatial Planning Practices

Spatial information and technologies have long underpinned planning activities. In response to the limitations identified in the preceding section, we suggest two recent developments in spatial technology that might be effectively harnessed.

3D spatial information plays an important role in accurate communication of future urban developments. During the last two decades, improvements in geospatial data and infrastructure have offered a robust alternative to 3D architecture models in urban planning and design (Biljecki, Stoter, Ledoux, Zlatanova, & Çöltekin, 2015; Sabri et al., 2015). 3D city models have vastly improved and now provide a realistic representations through higher levels of detail, and provide users with greater interactivity as well as the ability to query elements of the models (Zhu et al., 2011). These advancements have added more value to sustainable information sharing and semantic representation of volumetric urban objects, such as buildings, vegetation objects, waterbodies, and other urban infrastructures (Amirebrahimi, Rajabifard, Mendis, Ngo, & Sabri, 2016; Gröger & Plümer, 2012; Zhu et al., 2011). Other improvements in 3D geospatial information including standardisation of 3D GIS formats such as City Geography Markup Language (CityGML) (Kolbe, Gröger, & Plümer, 2005), Building Information Models (Mignard & Nicolle, 2014), and web 3D visualisation (Herman & Rezník, 2013; Shojaei, Rajabifard, Kalantari, Bishop, & Aien, 2014; Trubka, Glackin, Lade, & Pettit, 2015) have all contributed to improving urban planning and management practices. Some examples include urban heating energy demand forecasting (Strzalka, Bogdahn, Coors, & Eicker, 2011), urban engineering (Borrmann et al., 2014), and future urban development scenario assessment (Trubka et al., 2015).

A recent study by Biljecki et al. (2015) reviewed the applications of 3D city models in non-visualisation and visualisation-based use cases. Different analyses and measurements such as classifying building types, and energy demand estimation are categorised in non-visualisation use cases. Other visualisation-based analyses and facilities like visibility, estimation of shadow cast, noise pollution, urban skyline, estimating population, and communication of urban information to residents are well evaluated in this comprehensive study. The majority of use cases listed in this study focused on physical and functional measurement of building and urban areas.

There are few examples of using 3D city models in a virtual environment to foster urban planning; in particular, measuring the social construction and place experience aspects of the urban environment. This is despite the fact that studies in virtual reality (VR) using 3D graphics have demonstrated the potential of these technologies for measuring subjective aspects such as safety (Toet & van Schaik, 2012) and people's behaviour and perceptions (Bishop, 2001; Chen & Bishop, 2011).

Recent literature on spatial information and urban design has also highlighted the necessity of measuring subjective aspects particularly in urban intensification projects, which include socially sensitive and vertical urban growth (Harvey & Aultman-Hall, 2015; Kytta, Broberg, Haybatollahi, & Schmidt-Thome, 2015; Schmidt-Thome, Wallin, Laatikainen, Kangasoja, & Kyttä, 2014). The next section explores the possibility of linking 3D city models with VGI and formulates a conceptualisation that fulfils the requirement of the State of Victoria guidelines and standards on higher density residential building development.

3.2. Volunteered Geographic Information in Urban Planning

Since Goodchild (2007) first proposed the term "volunteered geographic information" (VGI), it has come to encompass a broad range of citizen-based (or non-specialists) activities in the collection of information or data with a geographic attribute. This data is typically uploaded and shared using a Web 2.0 platform that, in itself, engenders participation (Kolbitsch & Maurer, 2006). Core to its conceptualisation is the context in which VGI is used, which is likely to dictate differing priorities in data quality, credibility, role of participant and participant's relationship with formal agencies (e.g. Budhathoki, Nedovic-Budic, & Bruce, 2010; Goodchild, 2007; Elwood, 2008). Participants' motivation for contributing to VGI is often discussed in the literature, where a dichotomy between intrinsic (individual desire and needs) and extrinsic (external validation or recognition) factors is often upheld (e.g. Leimeister, Huber, Bretschneider, & Krcmar, 2009; Zheng, Zha, & Chua, 2011). In the context of planning, Seltzer and Mahmoudi (2013) argued that the act of invoking citizen participation creates a distinction from more general crowdsourcing activities: the motivation of the participants has lesser impact in crowdsourcing whereas citizen participation is often associated with solicitation of specific input towards planning strategies and scenarios.

Although there is a tendency in the literature to persist with this distinction between crowdsourcing and VGI (to reflect the degree of active participation in data production by lay persons), in this paper, we adopt Haklay's (2013) proposition that crowdsourcing is a type of VGI. Haklay firstly established citizen science as a type of VGI, and within this, defined geographical citizen science as a specific subset where "the collection of location information is an integral part of the activity" (Haklay, 2013, p. 112). This, he argued, justifies the applicability of geographical citizen science in areas with a high population density or high levels of activity within the natural environment (since these are areas less likely to be affected by motivation or environmental conditions that impact upon participation). He then proposed a typology of citizen participation for geographical citizen science that is influenced by power differences between stakeholders that are implicit in any social process—of which urban planning is a prime example (Sieber, 2006). Haklay's spectrum ranged from 'crowdsourcing' (lowest level of participation) to 'extreme citizen science' (highest level of participation in which citizens are integrated with experts in problem definition, data collection and analysis) with levels of participation increasing in line with cognitive engagement, degree of integration among participants and consequently knowledge production.

Therefore, the use of VGI, echoing earlier discourses around participatory GIS (e.g. Elwood & Leitner, 2003; Weiner, Harris, & Craig, 2002), is frequently held up as a similar enabler of democratic participation in formal decision-making. We see this reflected in a range of participatory planning activities. Adams (2013) argued that VGI could be integrated with planning processes by facilitating more open channels for receiving public input. Engaging more people will lead to the provision of more useable data that is more representative of stakeholder interests, and extend spatial data resources beyond the limitations imposed by the organisational mandates of formal data producers. Brabham (2009) found that crowdsourcing public participation in planning processes appear undifferentiated from other types of participatory GIS activities up to the point where the crowd becomes engaged in the evaluation and validating of proposed solutions. In addition, there is evidence that there is growing interest from the public in engaging with planning through social media platforms (Evans-Cowley & Hollander, 2010). Indeed, Foth, Odendaal and Hearn (2007) found that participatory aspects of such platforms provided myriad opportunities for what they termed "urban epistemologies" about the urban environment to emerge.

The fact that VGI inherently has spatial attributes gives it a high degree of applicability for use in urban planning. Predicated on the concept of citizens-as-sensors (Goodchild, 2007) and with technological advances, VGI has progressively become more comprehensive and detailed, leading to increasing adoption of this data type in urban applications (Song & Sun, 2010). In addition, VGI has also been evolving to include more 3D forms of data (Goetz & Zipf, 2013). In the context of this paper, this evolution is important in terms of public engagement and participation since 3D VGI can be used to support the construction of 3D city models (Goetz & Zipf, 2013) which more accurately reflect our reality and invite greater identification from the public with proposed developments (Foth et al., 2009). This, Jiang (2013) argued, demonstrates the value of VGI in spatial analytics and computation.

There are numerous instances of 2D and 3D applications of VGI in planning in the literature. Earlier applications include CommunityViz, a GIS-based planning support system that combines 2D ArcView and 3D town building software (Foth et al., 2009). More recently, Goetz and Zipf (2013) used 3D Open Street Map data to construct 3D city models that can be used for planning purposes. In Slovenia, VGI applications are being used to improve urban cycling conditions and public spaces (Nikšič et al., 2014). In her review of 100 mobile planning apps, Ertiö (2013) found many that dealt with urban infrastructure and urban governance. Knudsen and Kahila (2012) found VGI (GPS tracking using smartphones) being applied in Denmark to understand how young people used neighbourhood infrastructure, but also to capture residents' perspectives on the neighbourhood as input into a new master plan. In another study in Finland, the authors also found VGI used to better understand aspects of the urban environment that support social sustainability. Similar applications of VGI to discern or create understanding around the more subjective aspects of spatial planning include "Place, I Care!" (PIC!) (Campagna, Floris, Massa, Girsheva, & Ivanov, 2015)

Nonetheless, there are disadvantages to using VGI in planning. Partly, this comes back to the issue of participant motivation, which in the context of planning, likely requires willingness to be coincident on two fronts: to contribute to the production of VGI, and to contribute to the planning process (Obermeyer, 2007). However, given Haklay's typology raised above, this argument may be diluted by the fact that crowdsourced data could still be leveraged as a passive input into planning processes. Rydin (2010) also questioned the effectiveness of VGI as a participatory mechanism in planning if engagement is not sustained and relies instead on ephemeral sources of input. Aitamurto, Leiponen and Tee (2011) found that the benefit of VGI can be diluted if the problem presented to the crowd is poorly defined, and subsequently, if feedback to improve the fitness of the proposed (VGI-derived) solutions is not given. However, Seltzer and Mahmoudi (2013) argued that posing a well-defined problem to the crowd may well be difficult to execute in planning since the very nature of public participation in planning is to use the public to better identify and define planning goals. In addition, the use of VGI in planning has tended to be framed around applications in strategic planning (Elmadhoun Ahmed, 2010) or urban governance (Ertiö, 2015); there are limited examples of the use of VGI in plan implementation itself.

4. A Conceptual Model to Support an Integrated Approach to Planning

To develop a response to the gaps highlighted in existing urban intensification practices in Melbourne, particularly in the plan implementation phase, this section maps the links between VGI, 3D spatial information, and subjective-objective measurement of neighbourhood character. We propose a model enabled by spatial technology that is able to facilitate micro-level analysis. By using semantic and geo-referenced data, the model can potentially enable integration of different types of data to support more effective understanding of community perceptions around current and future neighbourhood character. The model is also likely to produce outcomes that can be analysed and communicated with stakeholders to better support plan implementation.

We further propose that this integrated approach be implemented in a new generation of geographic analysis tool: Virtual Geographic Environments (VGEs) (Lin et al., 2013). VGEs focus on three functionalities: multi-dimensional visualisation, dynamic phenomenon simulation, and public participation—all of which are in line with plan implementation requirements in Melbourne. The ability of VGEs to facilitate model sharing and multi-model integration (Zhang, Chen, Li, Fang, & Lin, 2016) offers an opportunity for integrating physical-social analysis for urban planning and design purposes; further, VGEs can act as a workspace for multi-stakeholder-based collaborative planning experiments.

From a technical perspective, the advantages of utilising VGEs to support an integrated modelling and analytical paradigm for urban planners and other stakeholders can be further augmented through the use of other web-based systems. Examples include: semantic integration techniques (e.g. ontology-based spatial urban data development, ontology for planning and design), and developing application programming interfaces (APIs) for data discovery and urban analytical tools and services (Psyllidis, Bozzon, Bocconi, & Titos Bolivar, 2015). As such, a web ontology browser (WOB) and a web-based user interface can be developed to support discovery, modelling, visualisation and analysis of heterogeneous urban data types (e.g.

transport, vegetation, housing, energy) for different stakeholders. Through these mechanisms, compatibility and interoperability issues related to different data types, cross-scale analytics, and cross-discipline models can potentially be overcome.

Since a detailed technical explanation of VGEs is not within the scope of this paper, the focus of the rest of this section is on conceptualising the links between spatial information and subjective-objective measurements.

4.1. Conceptual Links between 3D Spatial Information and Neighbourhood Character

In the context of this study, micro-level analysis refers to the building envelope, building layout and design, and the streetscape. Design guidelines for higher density residential development in Victoria place significant emphasis on the physical and functional aspects of developments. Physical aspects include interior and exterior building elements such as private and public spaces and landscape design (Figure 2), energy efficiency, the space and layout of car parking, building frontages, and the relationship between street pattern and the size of the building blocks (Department of Sustainability and Environment, 2004). Functional aspects range from promotion of a focus on public transport to greater mix of land uses, while increasing the number of residents.Similar to these guidelines, development standards for medium density developments (up to three storeys), ResCode, are also focused on the micro-evaluation of building development. Overshadowing, overlooking, daylight to existing and new windows are some examples of ResCode standards.

While the application of 3D visualisation and some physical analysis such as overshadowing have been utilised in some development proposals, particularly in Melbourne's CBD (Hassett, 2014), the advantages of using multi-dimensional spatial information are not fully exploited in planning and design practice.

Figure 3 shows the potential application areas of current 3D spatial information, models and analyses in a VGE in response to the physical and functional requirements of medium-rise and high-rise residential development in Melbourne. In addition, the components of analysis and visualisation exhibited in Figure 3 explicitly cover micro-scale spatial analysis and application of 3D spatial technology in the plan implementation phase.

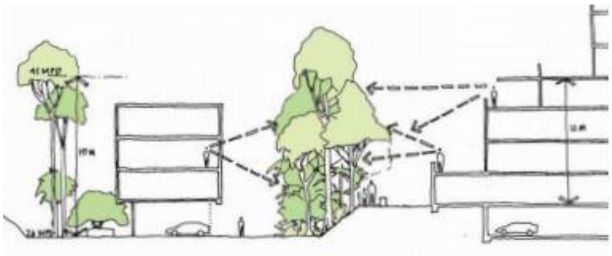

Figure 2. Landscape and outlook evaluation of dwellings. Source: Department of Sustainability and Environment (2004).

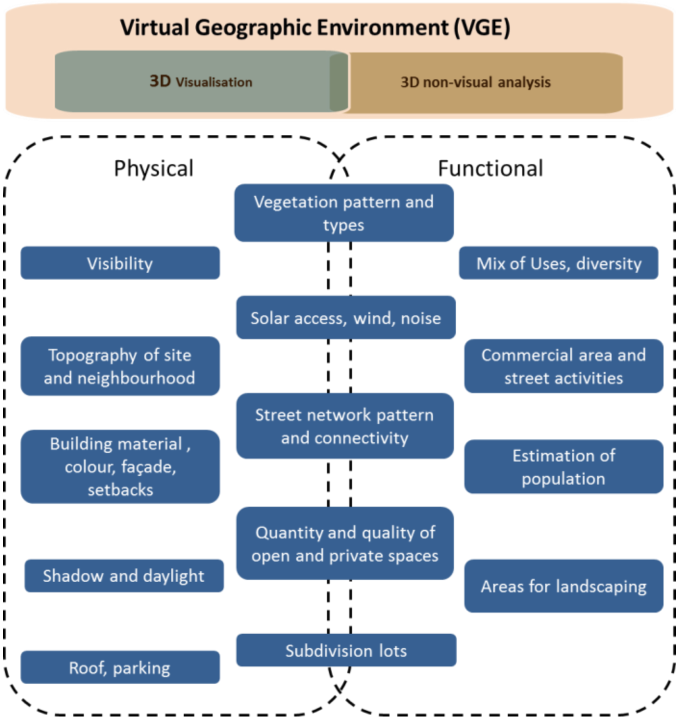

Figure 3. Measuring and visualising objective aspects of building and neighbourhood using 3D spatial technology in a virtual geographic environment.

4.2. Conceptual Links between VGI and Neighbourhood Character

There are two concerns in Victoria's planning system that might hinder an effective incorporation of dynamic community perceptions as the subjective aspect of neighbourhood character in plan implementation. First, the *Planning and Environment 1987 Act* currently dictates a two-week timeframe for allowing residents to lodge potential objections to development proposals. This process is currently mainly paper-based and has not been framed to leverage digital infrastructures for more effective communication.

Secondly, while state and local governments do communicate with the public to receive input for neighbourhood character studies and to develop guidelines for high rise residential buildings for the purposes of the strategic planning process, this is a one-off process and the community's changing preferences—often a corollary of the transformation of the socio-cultural profile of a neighbourhood—are overlooked. As such, the role of VGI, including 3DVGI, is crucial to provide not only a source of input to measure subjective aspects, but importantly to provide a data source that is sufficiently dynamic to accurately reflect changes within the community. Hence, VGI should be incorporated into a virtual geographic environment to address these issues within the planning and development framework (Figure 4).

4.3. Conceptual Links between VGI, 3D Spatial Information and Neighbourhood Character

Some subjective and objective measures overlap. For instance, street activities can be both functional and socially constructed. In addition, while landscape elements in a neighbourhood may be objective, their quality is subjective, and can be considered to be a part of place experience as well as being socially constructed. Figure 5 shows the interaction of the various indicators in a framework with 3D visualisation, 3D non-visual analysis, VGI, and 3DVGI integrated in a virtual geographic environment.

Figure 5 is an abstraction of the comprehensive range of subjective and objective measurements, and demonstrates their possible interactions in the virtual geographic environment. This framework indicates how spatial technologies would enhance the assessment of subjective and objective measures; in particular, where there are overlaps. For instance, VGI can help identify both the types of physical circumstances that make people fearful and also where they experience these fears in the existing neighbourhood. At the same time, 3D modelling can show the degree of isolation of houses, areas and people from others in a neighbourhood, which is a complementary indicator for safety in planning. Such a model will also allow people to explore proposed buildings and report areas of security concerns (Toet & van Schaik, 2012).

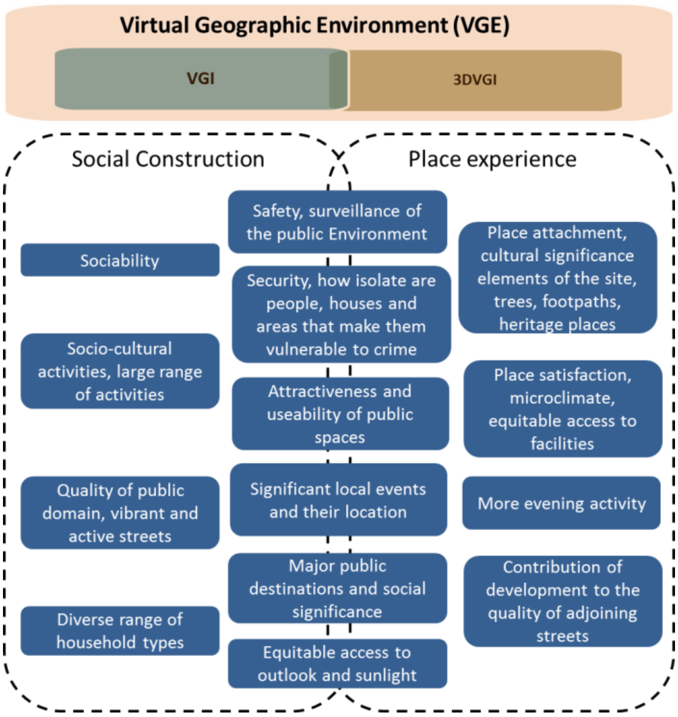

Figure 4. Measuring subjective aspects of building and neighbourhood using VGI and 3DVGI in a virtual geographic environment.

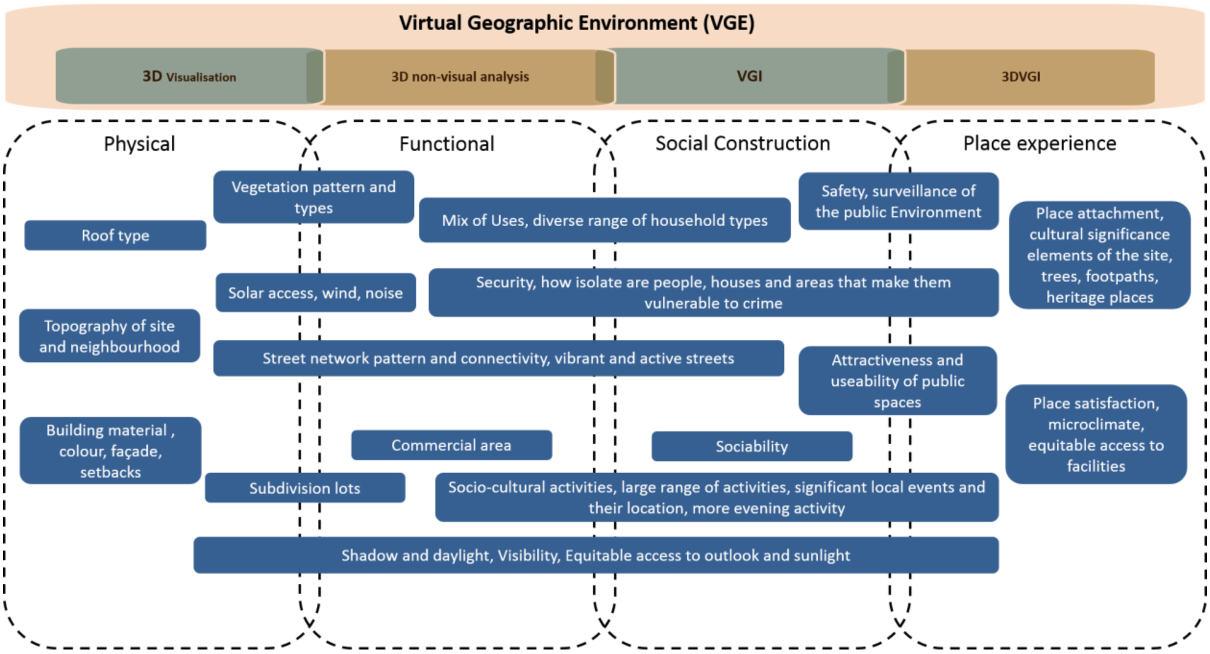

Figure 5. A conceptual framework for incorporating subjective and objective measurements of neighbourhood character in a Virtual Geographic Environment.

There are several advantages that this platform can offer within the requirements of statutory planning regulations:

- The VGE can be considered as a shared environment for all stakeholders—planners, developers and communities—to understand the real impact of developments in an evidence-based and data-driven analysis;
- Given the limited timeframe stipulated by statutory planning regulations, this environment is able to simulate the impacts of single building developments using ongoing data streams from VGI to foster a more rapid decision-making process;
- There is a possibility of generating new analytical methods in this environment by enabling the decision-makers to conduct a holistic analysis. For instance, while shadow analysis is a physical measurement of a building, the socio-behavioural impacts of a shadow cast can also be investigated;
- This platform has the ability to indicate the trajectory of neighbourhood character changes from subjective and objective points of view;
- Based on the ability to generate and store spatial data, the VGE platform is able to foster plan monitoring and strategic planning phases as well.

This is a conceptual framework that needs a proof of concept and implementation in current organisational systems, using available data in Melbourne. As such, developing such a platform in the state and local government planning systems is the next challenge with several concerns addressed in the next section.

5. Discussion and Conclusion

The concept of neighbourhood character is one that is entrenched in contemporary planning paradigms and the literature supports an unwavering view that this should constitute physical, social and psychological elements of the lived environment. This however, continues to be weakly translated into planning practices and plan implementation. Objective indicators, reflecting the physical and functional aspects of the urban environment, continue to be the dominant approach to planning assessment and analysis. This is likely due to the relative ease in collecting and measuring performance in these aspects. In recent years, attention has been turning towards the need to understand the types of subjective indicators that can be used to represent measures of neighbourhood character and these tend to cut across socially constructed and experiential aspects.

A review of applications in 3D geospatial technologies, digital geographic environments, and the mainstreaming of geographic data collection activities like VGI indicate clear potential for planning applications. In particular, the nature of VGI holds tremendous promise for collecting information relevant to subjective aspects of neighbourhood character, a mechanism also sensitive to temporal shifts in perceptions. However, it is apparent that to maximise the use of VGI, it is essential that planners and developers are able to clearly define all aspects of neighbourhood character. It therefore becomes necessary to have a comprehensive range of indicators.

Using Victoria's development standards and guidelines, this investigation extracted a comprehensive range of micro-level objective and subjective indicators that are important considerations in urban intensification. As indicated in the literature, these indicators resonate in urban redevelopment and intensification projects in other contexts such as Perth, Australia (Davison & Rowden, 2012) and Helsinki, Finland (Kyttä et al., 2013). We propose a framework that taps into the strengths of 3D spatial information for modelling and analysing objective indicators around physical and functional aspects of the environment. Similarly, VGI (and 3DVGI) is proposed as an appropriate mechanism for collecting information about the socially constructed and experiential aspects of the environment. It is likely that such an integrated approach will promote more effective understanding of communities' perceptions regarding current and future neighbourhood character. The framework is also predicated on a shift from paper-based formats to the use of a virtual geographic environment as a shared platform for communication. Such a dynamic platform for engagement is an effective way to integrate VGI and 3D spatial information. In addition, the nature of digital platforms is such that they can facilitate access more readily to different types of information, which is likely to enable a better quality of public engagement within the constraints of short statutory timeframes.

As this is a conceptual framework, the next step requires implementation of the framework to identify technical and data related issues that might challenge information interoperability, particularly in integrating structured and unstructured data, textual and graphical data, and combining data at different dimensions and scales. Subsequent future research will also need to consider the social implications of embedding this framework within planning and development processes including organisational workflows, regulatory implications and providing a structure to facilitate and normalise community participation through virtual geographic environments.

Acknowledgments

We thank the two anonymous reviewers for their constructive comments.

Conflict of Interests

The authors declare no conflict of interests.

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Urban Planning (ISSN: 2183-7635)
2016, Volume 1, Issue 2, Pages 49-64
Doi: 10.17645/up.v1i2.607

Article

Planning with Citizens: Implementation of an *e*-Planning Platform and Analysis of Research Needs

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Submitted: 29 February 2016 | Accepted: 1 June 2016 | Published: 20 June 2016

Abstract
Citizen participation should be an essential part of an urban planning process if the needs of the local population are to be addressed. Citizen participation should also improve acceptance of private construction projects by residents that live in or near such development. A complementary form of citizen participation to public planning meetings is to permit citizen engagement via Web 2.0 technologies, which also has the potential to get citizens involved that are usually difficult to reach. We aim to build a social, i.e. participatory, planning platform that allows technology savvy citizens to inform themselves of future and ongoing development projects and to also discuss them online. In this work we discuss the functional needs and context-of-use constraints of such an *e*-planning platform. A conceptual model of the technical architecture is outlined and a prototype implementation is presented. This prototype is built on free and open source software components, including a social network, to enable platform adoption in other locations. Finally, we discuss the research needs that are to be addressed if the development of participatory *e*-planning platforms should advance.

Keywords
design criteria; *e*-planning platform; open-source; participatory planning; PPGIS, social networks

Issue
This article is part of the issue "Volunteered Geographic Information and the City", edited by Andrew Hudson-Smith (University College London, UK), Choon-Piew Pow (National University of Singapore, Singapore), Jin-Kyu Jung (University of Washington, USA) and Wen Lin (Newcastle University, UK).

1. Introduction

The advent of social networks, such as Facebook.com, Google+, and renren.com, and the emergence of communication applications for mobile phones, such as WhatsApp, have changed the way people communicate, particularly in countries with high Internet uptake (Ellison, Steinfield, & Lampe, 2007; Pew Research Center, 2011). Likewise these communication tools have the potential to shape (urban) planning now and in the near future. In particular the requirement for public participation in planning processes could benefit from the engagement of people via social networks (Donders, Hartmann, & Kokx, 2014; J. S. Evans-Cowley, 2010; Mandarano, Meenar, & Steins, 2010; Staffans, Rantanen, & Nummi, 2010). Interesting to note, on the one hand, is that researchers in Participatory GIS (PGIS) have for some time developed and explored web-based approaches to public participation (Bugs, Granell, Fonts, Huerta, & Painho, 2010; Butt & Li, 2012; Kingston, Carver, Evans, & Turton, 2000; Rinner, Keßler, & Andrulis, 2008). However, agencies that want to (or are legislated to) collect and consider public opinion as part of their decision making process have rarely adopted, let alone implemented, these participatory web-based GIS—probably due to the investments that must be made (Foth, Klaebe, & Hearn, 2008; Hunter et al., 2012; Mandarano et al., 2010).

On the other hand, cities have lately recognized the possibilities that web-based feedback tools offer; particularly with respect to safe, clean cities as demonstrated by the adoption of platforms such as the international fixmystreet.org, the German "Maerker" (maerker.brandenburg.de) or the Chilean vecinosconectados.cl. However, only a small proportion of agencies and planning departments have explored possibilities that open up when using social networks for participation in planning activities (J. Evans-Cowley & Hollander, 2010; J. S. Evans-Cowley, 2010; Riggs, Chavan, & Steins, 2015). This is curious given the experience that political activists have had, who have adopted social networks to promote their cause, or that police have had, using social networks to aid crime investigation (Diehl, 2011). Probably the most widely adopted platforms for citizen-agency Web 2.0 engagement with a spatial/map-based focus have been Ushahidi.com, a participatory crisis information platform, fixmystreet.com, and shareabouts.org for street safety reporting and bike-parking allocation. We add to this list the more recent North American MindMixer platform which allows to discuss planning issues with citizens. Communitymatters.org (Horose, 2014) offers a fairly comprehensive list of web tools for online public engagement.

So while there exist (i) webpages to inform people about planning activities, (ii) platforms for citizen issue/problem reporting, (iii) general social networks that allow neighbours to discuss and organize themselves, and (iv) at least one platform that focuses on asking citizens on planning issues (with questions posed by the city government); there does not exist a platform that integrates these different functionalities. Furthermore, there does not seem to exist a (planning support) platform, which permits to present and evaluate different planning scenarios, that was designed with a focus on the citizen as user, as opposed to the planning expert.

Our work on the PlanYourPlace (PYP) project aims to address the lack of such integrated participatory planning platforms, in short, *e*-planning platforms. Our primary use case aims to implement an *e*-planning platform that aids the development of community plans within and surrounding the City of Calgary, Canada. In our development scenario, the web-based platform should inform and educate community members about urban development options, and support their participation in the planning process.

Building on earlier work (Steiniger, Poorazizi, Bliss-Taylor, Mohammadi, & Hunter, 2012) we evaluate which functionality an *e*-planning platform should provide and discuss general platform design considerations. We then present a technical architecture and a prototype platform that integrates the social network software Elgg. Finally, we discuss research topics that need to be addressed to move the development of participatory planning platforms forward.

2. Possible Activities of the *e*-Planning Platform User

For the development of an *e*-planning platform we advocate the position that it is preferable that the platform design focuses on social and collaborative aspects as adopted in a grass-roots planning approach, rather than an agency-centred perspective that focuses on controlled top-down information flows. Given this perspective, and the objective of decentralized communication, the choice of a social network-based approach for the underlying software architecture is a logical step. However, the use of social networks for participatory planning requires adaptation of social networking software. Whereas social networks provide functions for informing others, and for commenting and voting on content (e.g. articles, comments and images), they do not offer out-of-the-box planning-support functions, such as map-like display of development plans, or evaluation tools for different development scenarios, which brings us to the question: "What functionality is useful for future *e*-planning platform users?" To answer this question, we undertook an analysis of the planning and participatory GIS literature as well as existing online tools to establish a list of activities that support participation in planning, and functions that would enhance participation. The results of the literature review are documented in detail in Hunter et al. (2012) and summarized here.

When considering Smyth's ladder of *e*-participation (Smyth, 2001), which is somewhat similar to participation ladders of Arnstein's (1969), Kakabadse, Kakabadse and Kouzmin (2003), and organizations such as the International Association for Public Participation (n.d.), the lowest level of participation, online service delivery, is to *inform* the citizen (Figure 1). For planning this can take the form of plans, maps, documents, images, etc. However, as Talen (2000) and Drummond and French (2008) note, information should not flow in one direction only—from planning departments to citizens—but both ways to allow citizens to express their desires for their community. Providing community residents the ability to *discuss* planning projects with city planners, and with others from their community, elevates participation to the second rung of Smyth's e-participation ladder: online discussion. Such functionality was proposed by Guhathakurta (1999) and Drummond and French (2008), among others, and was implemented in participatory GIS platforms by several groups (Hall, Chipeniuk, Feick, Leahy, & Deparday, 2010; Rinner et al., 2008; Staffans et al., 2010; J. Zhao & Coleman, 2006) and forms also the base of the MindMixer platform that is used by several North American cities.

The next step on the ladder of *e*-participation adds *online survey* capabilities that allow users to rank (e.g.

sorting alternatives), rate (e.g. a 1-5 star rating scale as for products on Amazon.com), or vote (e.g. like or dislike) on alternative planning options (Seltzer & Mahmoudi, 2013). Carver, Evans, Kingston and Turton (2001) and Voss et al. (2004), for instance, implemented participatory GIS applications that provided ranking functionality. Similarly, tools such as OpenPlans's ShareAbouts and the Akora citizen reporting platform (VecinosConectados, n.d.) have been developed and are used to determine bike-parking stations using a participatory approach.

The three activities outlined so far (1) providing information (i.e. content), (2) allowing discussions, and (3) enabling ranking, rating, and voting on content, progressively improve citizen participation for planning. We deem the corresponding platform functions to be required for any online participatory platform, and note that these capabilities are commonly found in social networks such as Facebook and Google+. Research prototypes of participatory online GIS implemented functions (1) and (2) as well (Butt & Li, 2012; Carver et al., 2001; Voss et al., 2004).

The ultimate level of *e*-participation, as defined by Smyth (2001) is *online decision support* systems. This level of citizen participation in planning can be achieved with functionality that cannot be found in social networks. For instance Peng (2001) and Drummond and French (2008) proposed tools for the *evaluation* of planning alternatives. Such evaluations of planning proposals could be performed by calculation of indices that describe effects of a proposed planning change on demographics, transit use, resource and energy consumption, or even fiscal impacts. Hunter et al. (2012) give examples of decision support and evaluation models to be considered for the PlanYourPlace project—and have implemented models to calculate accessibility scores and crime indices for Calgary, Canada. The web-based portal of the Australian Urban Research Infrastructure Network (AURIN) has recently seen the addition of such online evaluation and decision support tools (Sinnott et al., 2015). However, these AURIN tools, such as the online What-If and EIAT, are primarily to be used by researchers and planning professionals, and only secondary have a focus on citizens as users (Pettit et al., 2013; Sinnott et al., 2015).

A higher level of *e*-participation in planning can also be achieved by developing tools that allow people to *modify plans*, or *sketch* completely new alternatives (Drummond & French, 2008; Peng, 2001). To encourage discussion about these proposals, the *e*-planning system requires that these alternative (new) plans be *shared* with city planners and other citizens.

The provision of development plans in the form of two-dimensional (2D) map-like representations can be considered part of the "information provision" functions. However, a community resident's experience of "what things may look like" is likely to be greatly improved when three-dimensional (3D) views and animations are presented (Pettit, Raymond, Bryan, & Lewis, 2011; Sheppard & Cizek, 2009). Consequently, 3D views may help reach decisions for or against a project faster, and may help to select between different planning alternatives. For example, virtual-globe technology with 3D visualization of the proposed built environment for participatory planning is presented in Wu, He and Gong (2010).

We summarize these 8 activities in Figure 2. In this figure, we have also introduced two additional functional categories: "Manage" and "Learn". "Manage" refers to a set of necessary user and document management tools, whereas "Learn" refers to a set of education tools. Why these two activities are added will be outlined next.

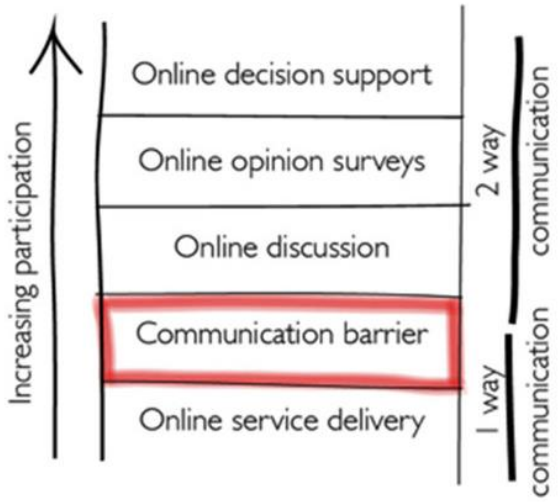

Figure 1. Smyth's (2001) ladder of *e*-participation.

Figure 2. Proposed planning support functionality for *e*-planning platforms.

3. Platform Design Considerations

When designing an *e*-planning platform, developers must consider more than simply (i) the activities that a user should preform, i.e. functions that the planning platform offers (as outlined above). One should also consider (ii) the user, and (iii) the context of use (Rubin & Chisnell, 2008). Further constraints for platform design originate from the geographic data and planning related documents that are to be provided. The following sections discuss the types of constraints that have emerged from our analysis, leading to human and technical design factors that should be taken into consideration.

3.1. The Platform User

As Rubin and Chisnell (2008) have noted, for a user-centred design (UCD) approach it is important that designers have a close look at the cohort of future platform users. We consider three general groups of users for the *e*-planning platform: citizens, city planners, and decision makers (Hunter et al., 2012). City planners shall use the platform to inform citizens about on-going planning projects and proposals, and to obtain feedback on these. Decision makers are able to gain (almost) immediate reactions on proposals, and will have the opportunity to discuss and argue for or against planning projects. The biggest user group consists of citizens, i.e. community members, who will use the website to inform themselves, discuss proposals with others, and express their opinion by voting or commenting on proposals. Given these three user groups, the set of *e*-planning-specific questions that should guide the platform design are:

User Age: What are the different age groups? High school students may already know how to use the platforms social network functions—e.g., creating a profile; adding content (images, movies, etc.); commenting on messages; and discussing with others—from their own experience with social networks. Whereas persons who have never used a social network before may be overwhelmed by the options, and they require some assistance to learn the functionality.

User Computer Literacy: What is the computer literacy of the users? Do people use a computer daily, or just occasionally? Hence, do they feel comfortable with computer use? If not, then they may need an introduction to the platform, which can be in the form of training (e.g. held in a community centre), a user manual, or an online demonstration. The provision of customized dashboards for different levels of user literacy is a further support option, as pointed out by Pettit et al. (2012).

User Planning Literacy: What do citizens know about planning processes? If they have participated in Charrettes (Lennertz, Lutzenhiser, & Failor, 2008) and community planning events before, then they may understand how the information they provide to city planners will be used. In that case, they may also understand various planning terminology, and the steps taken to move through a planning process. If not, the system needs to educate the users about these issues.

Disabled Users: How can we ensure that disabled people can access the information and participate in discussions? What are the planning issues that may interest them in particular?

User Privacy: How can we ensure anonymity and privacy? Both are important, for instance, when a user may have an opposing opinion that they wish to contribute to a discussion, but choose not to as it may bring them unwanted attention (Gutmann & Stern, 2007), or even real life attack.

User Identity: How can we ensure that votes and comments stem from a real person? i.e. how can we avoid having one person or a group of persons use several identities to sway votes and discussions?

Related to the questions about user literacy are problems identified by Nivala, Brewster and Sarjakoski (2008) and Newmann et al. (2010). Nivala et al. (2008) discovered in their usability study that while users of web maps had problems understanding, and using, zooming and panning functions—they also had problems understanding search operations, and the results produced by their search. Newman et al. (2010) found similar problems related to web page and map navigation, the understanding of map icons, and the use of seemingly simple functions such as user registration on their website.

As a consequence of the questions, activities, and issues presented above, the platform design should consider several points: (i) design of an interface that is accessible for different age groups, novice computer users, and disabled people; (ii) allow users to contribute anonymously; and (iii) ensure that each contributor has a unique identity. (iv) Finally, it is necessary to provide educational materials (online and for download) that allow users to explore and learn the platforms functionality, to learn about planning processes and planning law, and promote knowledge about sustainability criteria necessary for effective planning scenario evaluation. Points (ii) and (iii) are part of the “manage” activity in Figure (2), whereas the educational tools correspond to the “learn” activity of the same figure.

3.2. Context of Use and Data Access

While the reflections in the previous section influence functional and content aspects of platform design, the “use context” of the participatory planning platform strongly influences the technical aspects, i.e. the technical architecture. Important design considerations with respect to the context of use are:

Accessibility: Users need to be able to access the platform from home (citizen), from work (city planner and decision maker), or even from somewhere on the street with a mobile device. Hence, the platform should run on different types of devices without the need to download additional software. A web-browser solution is therefore a logical choice.

Management: The content, i.e. documents, plans, images, etc., for each development project may be managed by different entities, i.e. the responsible planning agency, be it a local government, or a community group. In addition, the data that are displayed by the map interface will likely only be partially hosted within the *e*-planning platform, and additional data will be "delivered" directly by data custodians (e.g., a city department), similar as for the AURIN platform (Barton, Goldie, & Pettit, 2015). Consequently, the technical architecture should utilize a "Data as a Service" approach that could be based on Open Geospatial Consortium (OGC) standards (Percivall, 2010; P. Zhao, Yu, & Di, 2007), for example.

Flexibility: For the evaluation of proposed plans, via various assessment models, it is beneficial to "plugin" models rather than to integrate them—as for instance realized with the Online What-If model of the AURIN platform (Pettit et al., 2013). Hence, the architecture should be designed in such a way that models are treated as, and accessed through a web service, such as the OGC Web Processing Service (Schut, 2007). In particular, one can treat the models as "Software as a Service" (Granell, Díaz, & Gould, 2010). This allows addition of further assessment models over time—without changes to the system architecture—and ensures that the integration of improvements to the models does not affect other architectural components, nor cause website downtimes. Using a service-based architecture will also enable installation of a particular model on different computers so that distributed processing can be employed during high-demand times.

Security: In social networks people usually have a profile that contains personal information. Such information should not be accessible by others, unless approved by the profile owner. Hence, an authentication model (i.e. authentication manager) that controls access to data and user information is a critical component of the architecture.

Licencing: Licenses for software and geographic data need to be considered when building the system. For instance Carver et al. report on efforts that were required to license mapping data from the British Ordnance Survey for their participatory GIS, at a time when free map services such as OpenStreetMap did not exist (Carver et al., 2001). License restrictions may have two different types of effects for *e*-planning platforms: First, licences for data may prohibit the presentation of certain types of data/information to certain user groups, e.g., a decision authority may see more information than a community leader, or vice versa. In addition, data licenses may restrict access based on where the platform user resides. Second, licenses and the related pricing for software can restrict the ability to set-up and customize the platform. Hence, budgetary limits as well as restricted access to under-the-hood software functions can hinder the adoption of the platform by communities and cities. For this reason the project strives to employ a free and open source software strategy (Steiniger & Bocher, 2009).

In summary, the five points above require that the participatory platform architecture: (i) be web-based, (ii) be (OGC service) standard-based for data and assessment model access, and (iii) has a software module that manages user access to ensure data security and conformance with data licenses.

An additional issue that falls between the UCD categories of user, user actions, and context is that of *ownership* over the data created in the *e*-planning platform by the users (see Hunter et al., 2012). Content that can be created includes text comments, votes, photos that may be uploaded, etc. Depending on what is decided by the platform provider, i.e. all or some created data will be owned by the platform provider or, alternatively, will be made accessible under an open data license, ownership may affect platform functionality (data access options) as well as platform architecture (e.g. service types used).

4. Detailed *e*-Planning Platform Functionality

Having defined the activities that *e*-planning platform users will likely perform, and having outlined several user-based and context-based design constraints, we have derived a detailed list of recommended platform functionality—shown in Table 1. This list contains 10 different groups of functions, whereby including the *e*-planning activities of Figure 2: (1) management tools, (2) visualization tool, (3) 3D visualization tools, (4) information tools, (5) discussion tools, (6) survey tools, (7) evaluation tools, (8) sketching tools, (9) sharing tool, and (10) learning tools.

We then compared this list with standard functionality offered by social networking software, specifically the social network software Elgg (Costello, 2012). One can see from Table 1 that a large number of the recommended functions are readily available in this social network. As Sani and Rinner (2011) noted in their comparison of Web 2.0 and PGIS functions, the existing functions are S-L-A-T-E-S functions (McAfee, 2006), i.e. functions that permit Searching, Linking, Authoring, Tagging, Extension/recommending, and Signalling. "Authoring" functions enable neighbours to comment on a development project, and are necessary for city planners and community members to write project news and articles. "Linking" to further, perhaps more detailed, information is possible with the same authoring tools. "Signalling", in an *e*-planning sense, relates to

Table 1. Detailed functionality recommended for an *e*-planning platform.

Tool Group	*e*-planning Functionality	Elgg Social-Network Functionality
Manage	User authentication	●
	User social network profile	●
	User anonymous login and commenting	
	Create development project	
	Subscribe to development project	○
Visualize 2D	Display topographic map with communities	
	Display planning projects	
	Display reported issues	
Visualize 3D	Dynamic 3D explorer	
Inform	Search information, projects, and documents	●
	Informing about new projects in area of interest	
	Posting project news and articles	●
	Uploading documents (text, video, images, etc.)	●
	Reporting issues to the community	
	Informing about latest project news	○
	Informing about hottest discussions	
	Creating events	○
Discuss	Comment on issues and documents	●
	Messaging to other platform users	●
	Live-chat with others	●
	Forum / group discussions	●
Survey	Rating (1-5 stars)	○
	Like & Dislike	●
	Preference survey tool	
	Ranking alternatives	
Evaluate	Provide functions for indicator calculation via assessment models for planning scenarios.	
Sketch	Modify development plans	
	Create new plans	
Share	Sharing documents (text, images, videos etc.)	●
	Sharing modified and created plans	
Learn	Provide education tools on: (i) platform use, (ii) planning processes, (iii) sustainability, and (iv) assessment tools.	

Note: ● Elgg out of the box (i.e. standard) functionality; ○ functionality provided by an additional Elgg plugin/module.

functions that permit users to notify other users of new development projects or project-related content. Tools that enable citizens to report positive and negative comments about locations within their neighbourhood can be considered a form of geo-"tagging".

Hence, given the existence of these social network functions it appears to us at least that the best approach is to add *e*-planning functionality to a social network platform. From a developer's perspective, this will avoid re-inventing the wheel and save development effort. From a user's perspective, there is the added benefit that many *e*-planning platform users are likely to be social network users. Therefore they will be comfortable with using standard social network user interfaces and functionality—reducing the need for additional user introduction and training.

5. Technical Architecture of an *e*-Planning Platform

To develop an *e*-planning platform it is necessary to give some thought to the technical architecture that is required to offer all the functionality in Table 1. We speak here of a technical architecture since different software modules, on perhaps different servers, need to work together. The architectural design needs to address in particular the context-of-use related constrains that we identified earlier: (1) users can have access from different locations; (2) data are stored in different locations; (3) data may be processed with different models maintained at different locations; and (4) user access rights and data security are addressed. Interestingly, all these constraints are well known from the Spatial Data Infrastructure (SDI) literature (GSDI, 2009; Percivall, 2010; Rajabifard & Williamson, 2001). It is therefore beneficial to build on the implementation experiences and robust technical standards that are used for SDIs when developing an *e*-planning platform architecture. An important set of standards for the implementation of SDIs was, and continues to be developed by the Open Geospatial Consortium (OGC).

These standards allow transfer, manipulation, analysis, and display of geographic data. Building on those existing standards, we have developed a conceptual model of the technical architecture shown in Figure 3.

This conceptual representation distinguishes between four functional architectural components: First, a *presentation layer* that presents information to the user and that allows the user to interact with the platform via the user interface (UI)—e.g. by navigating the map, or pressing buttons. This layer has two base components: a social network UI and the map viewer UI. Second, an *application layer* that integrates the services that are offered to users and allows communication between users, e.g. allows chats and messaging, and use of services, e.g., trigger services and present results. In the application layer we account again for two different application components: one that handles social-network related functions, including also user management, and one that handles planning and mapping related functionality.

Third, a *service layer* that consists of the different types of (web) services that provide data search, data processing, data access and display functions. We suggest for example a (1) "view service" that generates map like images, a (2) data "download service", to retrieve data or subsets of data, (3) a "processing service" that will handle evaluation of development plans using predefined models, e.g. a walkability model or an environmental impact model, (4) + (5) two "discovery services", one for planning data and one for social network data, which allow searching of both data streams, and (6) a "social data mining service". The social data mining service(s) should analyse incoming data and user profiles to notify users of the hottest discussions, new project information, etc., and support platform administrators in evaluating survey data and user comments.

Finally, the fourth conceptual layer is the *data layer*. Its function is to store and deliver data needed for view, download, and processing services. One database will handle in particular the data from the social network, and another exclusively the mapping-related (GIS) data. The third data module, denoted simply "Data Service" in Figure 3, will connect to external data that are not stored as part of the platform, such as topographic data from mapping agencies or demographic data from statistic departments (e.g., base map data provided by web map servers such as a WMS or WMTS).

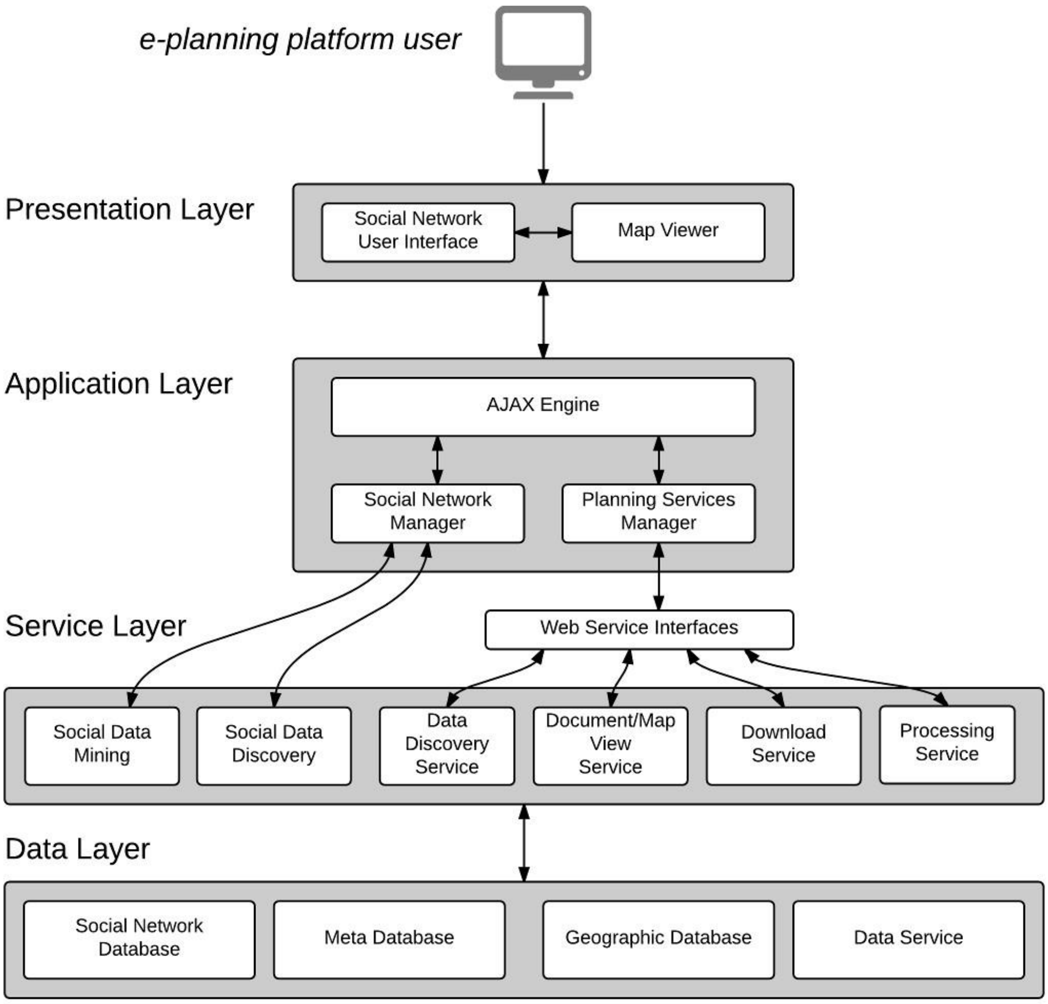

Figure 3. Conceptual four-tier architecture for an *e*-planning platform.

A fourth module, the "Meta Database", contains a database that stores metadata needed to enable search functionality for external and internal web-services and data. The Meta Database is used by the two discovery service modules in the service layer.

As mentioned earlier, the ability to transfer planning data and evaluate plans using specified models via web-processing services should function within a standardized web-service environment—which is why we included a "web service interfaces" component in the diagram. Poorazizi, Steiniger, and Hunter (2015) outline in detail how existing web service standards, such as OGC's Web Feature Service (WFS) for vector data transfer, and OGC's Web Processing Service (WPS) for running evaluation models can be used (Percivall, 2010; P. Zhao et al., 2007). However, non-OGC standards for data and processing can be utilized as well. For instance the AURIN platform utilizes the GeoJSON standard that describes a fairly simple data schema for data web-services (Sinnott et al., 2015).

6. PlanYourPlace, an *e*-Planning Platform Prototype

The PlanYourPlace project was established to develop a rich web-based resource for community planning, education and collaboration. The prototype of that platform aimed at providing data and information to residents, planners and decision makers for a handful of neighbourhood communities in the City of Calgary, Canada. The implementation of the prototype is and was to be performed in a modular and iterative fashion. That is, after generation of a new or selection of an existing, suitable base platform the new *e*-planning functionality was added. We added new functionality based on internal priority and resource evaluation—similar to the SCRUM software development approach (Schwaber & Sutherland, 2011).

6.1. Software Used

The social-network Elgg (Costello, 2012) was chosen as the base platform following an evaluation of existing social-network software. Important evaluation criteria were: that the software be open source; has well-sized developer and user communities; is stable; allows extension of the platform using modules and plugin mechanisms; has a data access and security handling system; and, comes with a basic set of communication and document handling tools, e.g. SLATES functionalities. Limiting the selection of software to software that is distributed under free and open source licenses was done to ensure that we are able to customize the software components to any degree we deem necessary, and to be able to re-distribute it later without any restrictions to testing and improvement in future research work by us and others (Hunter et al., 2012).

To extend Elgg with *e*-planning functionality, and in particular, to add capabilities for the display, storage and management of spatial data, we first utilized OpenLayers and later Leaflet as the map viewer, and employed PostgreSQL/PostGIS as the spatial database (Steiniger & Hunter, 2013). Elgg itself uses the database MySQL to store user-related data.

The software GeoServer was used to setup spatial data processing workflows as OGC Web Processing Services (WPS), which permit the evaluation of current urban infrastructure and urban development plans, for instance the evaluation of urban accessibility. Most of this software was installed on one server running on a LAMP (Linux-Apache-MySQL-PHP) configuration. However, a further server is employed to run evaluation models as remote web-services and to deliver customized community base-maps using the software TileMill and PHP TileServer. External data sources are also included via standard web protocols, such as base-maps from Google Maps and MapQuest, and location geocoding services from Google.

6.2. e-Planning Functionality Implemented

To test out the functionality implemented so far the reader is referred to the prototype at www.planyourplace.ca/elgg. We note, however, that most of the tools are only accessible after registration (the reader may use "ijgiuser" with "ijgitest" for exploring the platform)—and that navigation may be slow due to limited resources of the hosting server. From the 10 different functionality groups shown in Figure 2, the prototype implements 6 functionality groups: tools to inform, discuss, survey, evaluate, share and manage content (see Figure 4). A particular survey tool that we developed is the MapYourPlace tool, which allows users to create map-based comments on what they like or don't like in their community (see Poorazizi et al., 2015). The first evaluation tool developed is WalkYourPlace. It evaluates accessibility and/or walkability of the user's neighbourhood based on the number of public services, parks, shopping, etc. within a given walk-time (see Steiniger, Poorazizi, & Hunter, 2013). The tool also evaluates the level of crime within the same walk-time area to estimate a crime-index. We also implemented and evaluated approaches for the provision of interactive learning support tools for sustainability education (Bliss-Taylor, 2014). How to design a set of (interactive) learning tools, tools for scenario/plan modification, i.e. the sketching of completely new scenarios, and intuitive 3D visualization of planning scenarios needs to be researched further. As such, we will discuss related research needs below.

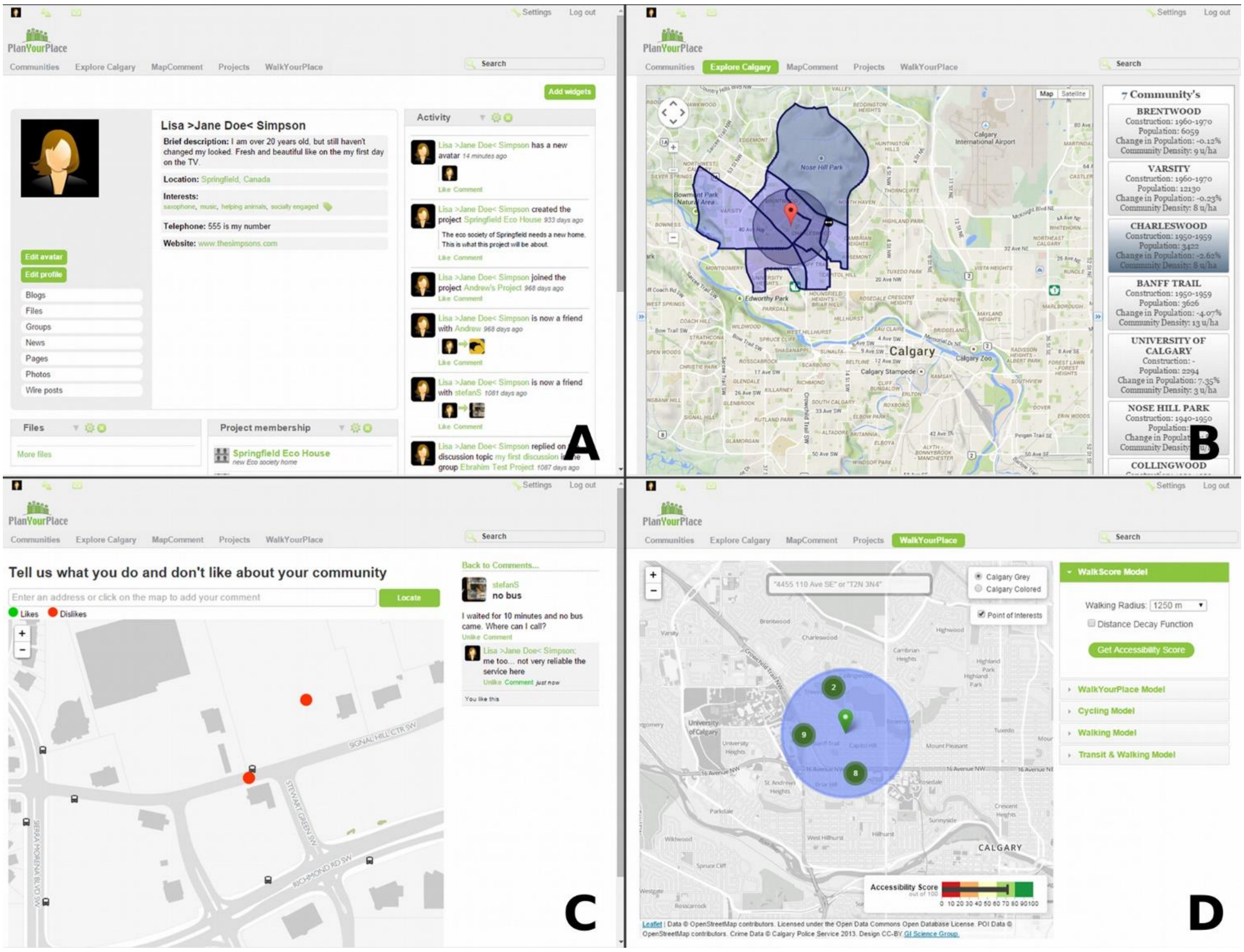

Figure 4. Screenshots of the *e*-planning platform prototype for PlanYourPlace.ca. Image A: user profile view; Image B: "Explore Calgary" a community information tool; Image C: "MapYourPlace" a community feedback tool; Image D: "WalkYourPlace" a tool to evaluate accessibility, here shown with www.walkscore.com concentric model with 1 mile walking radius.

6.3. Fulfilled Development Constraints

The current prototype covers most of the seven constraints that emerged from the platform's user profile and context-of-use. The three context-of-use constraints defined the basic architecture: First, the prototype platform is web-based so that information can be accessed from anywhere. Second, the prototype utilizes OGC Web service standards for data exchange (e.g. OGC WMS, OGC WMTS) and data processing (e.g. OGC WPS). Third, it has an access handler that can restrict and permit certain user groups to access data in the platform.

Looking at the four user induced constraints, the current prototype ensures that each user has a unique identity. Some prototype functions permit the submission of anonymous contributions so that people can speak freely. However, education material still needs to be developed. This is, as outlined above, an area of ongoing work (see Bliss-Taylor, 2014). Also the question of whether or not the design of the user-interface is user friendly and perceived as useful, across a range of diverse user groups, has yet to be answered. This requires the completion of a usability evaluation study in the future, perhaps in a similar fashion as the AURIN usability evaluation (Barton et al., 2015). For such a study the implementation and use in two or three real-world scenarios (i.e. communities and development projects) is necessary. However, performing and reporting on the usability study is not the focus of this paper, as our objective is to present the design criteria and a first prototype that embraces these design requirements. Or, as Rykiel (1996) formulates: the development of a model is one task, while validation of a model, in our case the platform, may be done by the research community.

7. Discussion—Or What We Have Learned

We gained three major insights during design and development of the *e*-planning platform. The first insight is that platform development should adhere to the principles of user-centred design (UCD). Following a

UCD approach made us aware of the different types of user groups that the platform should serve, and the different contexts in which a user might interact with the platform. Applying a cyclic approach to development—entailing design, develop, evaluate (by users), and refine steps—as recommended by usability (Nielsen, 1993; Rubin & Chisnell, 2008) and software development experts (Cohen, Lindvall, & Costa, 2004; Laanti, Salo, & Abrahamsson, 2011), should ensure that the platform is understandable to first-time users and can support citizen engagement. Within the domain of participatory (web) GIS, Haklay and Tobón (2003), Jankowski, Robischon, Nyerges, Ramsey and Tuthill (2006) and Rinner and Bird (2009) have also pointed out the advantages and need for UCD and usability evaluation.

Second, investigating functionality requirements for the *e*-planning platform made us aware that social networks possess a lot of the functionality that we believe a participatory *e*-planning platform should offer. In our case, the social networking software Elgg (Costello, 2012) provided functionality for communication among citizens, and between citizens and planners, and functions for sharing, commenting on, and voting for or against "content". Hence, when it comes to the implementation of an *e*-planning platform we would argue for the use of a social network as a base platform, instead of adding SLATE functions to (existing) mapping platforms. However, it has been pointed out that utilizing social platforms as a source of knowledge, such as Twitter, Facebook etc., will also require development of tools to filter relevant messages from uninformative messages (see Haworth & Bruce, 2015), and to develop mechanisms that prevent that groups can sway discussions and votes (see above).

The third insight came when we studied the constraints related to platform-users and context-of-use. The constraints that we found were similar to requirements for implementation of an SDI. The need for distributed data storage, data processing, and security measures suggests that *e*-planning platforms can be seen as a specialized and extended version of an SDI. Thus it makes sense to build the participatory platform based on open standards (OGC, ISO, W3C) and principles that have been developed for SDIs (see GSDI, 2009; Percivall, 2010). Subsequently, the *e*-planning platform prototype for PlanYourPlace uses OGC standards and adopts SDI principles (for a more technical perspective see also Poorazizi et al., 2015).

However, related to the choice of OGC standards we like to add two comments: First, the AURIN architecture tries to avoid the use of OGC compliant internal components in favour of more recent and more flexible data access methods such as REST and GeoJSON (Tomko et al., 2012). Although this offers more flexibility, it requires additional customization to use and connect to a new particular data service—which is exactly what OGC standards try to avoid (see detailed explanations in Poorazizi et al., 2015). Second, it is apparent that Google Maps and ArcGIS are used by thousands without support for OGC standards, using proprietary protocols instead. However, avoiding OGC standards means that users have to stay within a particular software vendor "ecosystem" that have the tendency to "lock-in" the data into this system. The effect is that a service provider dependency is established. This usually involves that moving data out of the system can become very costly (with respect to time and money). It also comes at the risk that such service may at some day not be offered anymore after some business evaluation, like it happened with the Google Maps Engine (King, 2015).

8. Research Needs for Participatory Planning Platforms

Given our work on the platform design and the practical implementation we have also explored the limits of the knowledge available for building *e*-planning platforms. Hence, below we outline where we see what the research needs are, particularly from a technical perspective.

The prototype for an *e*-planning platform as presented is missing functionality that permits modification of existing infrastructure plans. It still needs to incorporate sketching of new development scenarios, and 3D visualisation of scenarios. Furthermore, prototypes for interactive educational support tools have been studied—but are not included, and we have "only" two indicators for scenario evaluation implemented. The reason for not having advanced further on these functionalities is a dearth of general knowledge on how to implement such fairly complex tools best. In the following we detail seven topics that we think require dedicated research if *e*-planning platforms should advance in a manner useful for citizens, planners and decision makers.

User Support tools (education): There is a need for the development of content, presentation concepts and support tools for the support/education component of *e*-planning platforms. Support should enable participation at high levels on the participation "ladder" (Arnstein, 1969), and provide help with the use of sustainable urban development strategies (Schwilch, Bachmann, & de Graaff, 2012). There is little literature concerning potential sources of support for public participants. Numerous participation and/or decision making tools already exist to aid urban planning participants (Cinderby, 2010; Tippett, Handley, & Ravetz, 2007). But, most of these are intended for use in in-person processes. These applications cannot address the need for support when public participants are gathering online. As Poplin (2012) asks "How can one create a pleasant virtual environment in which citizens learn about current situations?".

The tool should consider all perspectives, providing information that would interest those with diverse perspectives. Qualitative and quantitative, short-term to long-term, small-scale and whole-system, political, social, economic, and environmental factors should all be considered. Support tool communication should focus on issues that are important to intended users, and work with their existing understanding of sustainability, urban planning, and related issues. In general, public understanding of sustainability varies in depth from the use of simple definition to avoid engaging with the concept, through appreciation of resource use implications, to recognition of the equity and justice issues involved (Reid & Petocz, 2006; Reid, Petocz, & Taylor, 2009). To compound the problem content must be written in a language that caters to the "average" citizen (if there is such a thing). Development of educational support tools also requires research that considers different user groups, interaction design, and instructional design (Sandars & Lafferty, 2010).

User Interface Design/Visualization: For *e*-planning platform functions that allow users to report issues to the city (e.g. areas they like, where they feel unsafe, or a pot hole, etc.), the prototype offers a reporting user interface that is map based. That is users "simply" place a pushpin on a map and describe what they have encountered, or their concern, in a text box. This appears straightforward, but Nivala et al. (2008), Roth and Harrower (2008), and Newman et al. (2010) found that some users of web maps had difficulty navigating the map and did not understand, or misunderstood map symbols. This makes us question if a purely map-based approach is useful. An alternative to a map-based user interface is a text-based version, as commonly used in social network websites, and adopted by the German reporting platform Maerker.Brandenburg.de that lets citizens report street maintenance issues.

However, as Rubin and Chisnell (2008) have pointed out, the best approach is probably in the middle of the two different designs. Hence, user evaluation of each design (map-based vs. text-based) is needed to obtain directions towards a "most usable" user interface. This includes also the need for research on the usability of navigable 3D visualizations of planning scenarios, as pointed out by Sheppard and Cizek (2009). Connecting interface design and learning we suggest that only a simple interface, i.e. dashboard, with some very basic functionality is presented to the "rookie" user of the platform. After some time of using the platform, and perhaps after "graduating" from tutorials, more complex functions and tools with analysis and sketching functionality would extend the users' dashboard. This way one can probably avoid that the user gets overwhelmed after logging in for the first time.

Assessment Models and Metrics: *e*-planning platforms need to provide tools to evaluate existing infrastructure and planned developments based on economic, environmental or demographic indices. Several indices and models have been developed as components of planning support systems in the past. Hence, it will best to develop (simplified) interfaces that will connect to these tools instead of developing models from scratch (see Pettit et al., 2013). However, it is important to choose metrics that are understandable to, and resonate with community members so that users can make sound decisions. For instance, in the PlanYourPlace workshops "cost" was raised as an important and understandable metric (Hunter, Sandalack, Liang, Kattan, & Shalaby, 2011). As a result such metrics, among others, should probably be featured. Research in this area is needed to identify metrics that citizens understand well and that account for individual perspectives, but also for societal long-term impacts.

Planning Scenario Tools: Sketching functions of *e*-planning platforms should allow (i) creation of markups and annotations to existing development plans, (ii) creation of new plans, and (iii) modification of proposed plans. Central questions for developing the sketching tools are: (1) How should the user be able to mark-up plans and how is this information attached to plans? (2) How and what objects of an existing plan/map can the user edit? (3) How should the sketching be done? For instance, is it better to adopt the approach of planning-like games such as SimCity/Micropolis where the platform provides a set of objects (e.g. a house or a road segment) that can be added to a plan by drag & drop, or is it better to allow free-form drawing, as one would with pen and paper?

An important component of the research and development on sketching is most likely object and object-context recognition. This is necessary, since free form sketching by the user requires the platform to recognize what the user wants to draw and, eventually, provide drawing support. The generation and utilization of ontologies together with Bayesian inference methods may yield a promising approach for such object and context recognition (Alvarado & Davis, 2004; Lüscher, Weibel, & Burghardt, 2009; Yin, Chang, & Forbus, 2010).

Mining Tools: User will be able to vote (like/dislike), rate (5-star rating scale), rank, and comment on content. Here, the term "content" refers to images, development plans, other comments, news, etc. Mining tools are necessary to evaluate what preferences users have and summarize these in reports. These tools should be able to be used by community administrators or city planners. Hence, by users that may not have strong computer skills. Subsequently the interfaces of the evaluation functions should be simple and understandable as well. Research should address the development of methods to combine voting data, user profile and network data. These methods will allow to identify user groups with particular preferences and to identify trends in preferences.

Mobile Tools: The wide spread use of smart phones brings new challenges but also a lot of opportunities to participatory planning (J. Evans-Cowley, 2012). On the one hand, an *e*-planning platform should allow users to access the planning information "in the field" so that a neighbour can explore right at the spot how a development proposal may look like and what it effects may be. Such possibility calls for augmented reality tools that can display planning scenarios (e.g. a new building) in virtual manner over existing terrain as demonstrated in Allen, Regenbrecht and Abbott (2011) and Oksman, Väätänen and Ylikauppila (2014). It also calls for place-based evaluation models and tools that take the current users positions, such as walkability or bikeability scores. On the other hand, mobile phones offer the opportunity for data collection (Bohøj, Borchorst, Bødker, Korn, & Zander, 2011). For instance, the *e*-planning platform can profit from mobile photo uploads that present the current situation, or users can geo-tag their favourite or disliked places in the neighbourhood. The utility of these three uses (visualization, evaluation and data collection) of mobile tools will be in solving and identifying current and local problems. They will, however, be probably less useful when one considers long term, and citywide or regional planning.

Institutional Integration: Government at this point has little experience extracting innovative knowledge out of exchanges on social media sites. It is unclear to what extent the information that flows into government is governed, processed, used and how government acts on information that is created with and among their audience members in conversations on social media platforms. Online deliberation research needs to become more attendant to outcomes—not simply in terms of whether participants trusted the process, but in terms of the political efficacy of citizens and of policy outputs. As Bang & Esmark (2009) suggest, new modes of governance have placed emphasis on the democratization of citizen input, but without outputs, no form of collective action, including talk, amounts to much. The political process does not stop when the talking stops. Online deliberation is not an alternative to political decision-making, but a means of enhancing it. In any representative democracy, deliberation by the public, stakeholders and decision makers is but one stage in the complex process of turning preferences into implementable policy. We know very little at the moment about how online deliberative talk turns into institutional decision making. How, technically, can *e*–planning content creation and deliberation be integrated into existing planning decision making processes. To this end, there is a need for the mapping of institutional process through which online deliberation must connect with to increase the efficacy of citizens (Coleman & Moss, 2012).

Apart from these seven main research themes there are of course further research and development topics that address augmentation of platform capabilities, for instance the development of tools that allow to compare two or more planning scenarios *vis-a-vis*. However, our personal top-three priority list for future research consists of education support tools, the development of assessment models, and the work on planning scenario-sketching tools. Because the education tools and assessment tools are indispensable for platform adoption by citizens, and both can further the probability of platform use directly in public participation planning meetings *to demonstrate things and invite people.* Finally, the scenario sketching tools are useful to planners and citizens to explore different planning scenarios.

Acknowledgments

We thank Ehsan Mohammadi and Coral Bliss-Taylor for their work on the "Explore Calgary" tool and the educational support tool design, respectively. We are grateful for funding from the Canadian NEPTIS Foundation and GEOIDE (Grant TSII 202). Stefan Steiniger has also been supported by the Centro de Desarrollo Urbano Sustentable (CEDEUS), Conicyt/Fondap/1511 0020, and the project "AccesoBarrio" (Fondecyt 1150239).

Conflict of Interests

The authors declare no conflict of interests.

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Urban Planning (ISSN: 2183-7635)
2016, Volume 1, Issue 2, Pages 65-74
Doi: 10.17645/up.v1i2.627

Article

Civic Hackathons: New Terrain for Local Government-Citizen Interaction?

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Submitted: 16 March 2016 | Accepted: 8 June 2016 | Published: 21 June 2016

Abstract
As more and more governments share open data, tech developers respond by creating apps using these data to generate content or provide services that citizens may find useful. More recently, there is an increase in popularity of the civic hackathon. These time-limited events gather tech enthusiasts, government workers and interested citizens, in a collaborative environment to apply government open data in developing software applications that address issues of shared civic importance. Building on the Johnson and Robinson (2014) framework for understanding the civic hackathon phenomenon, Canadian municipal staff with civic hackathon experience were interviewed about their motivations for and benefits derived from participation in these events. Two broad themes emerged from these interviews. First, through the development of prototypical apps using municipal open data and other data sets, civic hackathons help put open data into public use. Second, civic hackathons provide government staff with valuable feedback about municipal open data sets informing and evolving future open data releases. This paper concludes with reflections for urban planners about how civic hackathons might be used in their practice and with recommendations for municipal staff considering using civic hackathons to add value to municipal open data.

Keywords
civic hackathon; civic technology; geospatial web; open data; open government; volunteered geographic information; web 2.0

Issue
This article is part of the issue "Volunteered Geographic Information and the City", edited by Andrew Hudson-Smith (University College London, UK), Choon-Piew Pow (National University of Singapore, Singapore), Jin-Kyu Jung (University of Washington, USA) and Wen Lin (Newcastle University, UK).

1. Introduction

For some, the term "civic hackathon" might conjure concerns about computer savvy individuals with malicious intent trying to disrupt power supplies or play games with traffic signals. The reality is refreshingly different. In the new world of open government, civic hackers use their coding skills to work with municipal open data to program apps and find solutions that improve ordinary people's quality of life. From Mayor Bloomberg's 2011 "reinvent NYC" civic hackathon to the City of Paris' 2016 urban security focused event to Toronto, Canada's 2015 traffic jam event, local governments worldwide are using civic hackathons to deploy open data to fix their cities.

The ubiquity of the internet and internet-enabled mobile devices in our everyday lives serves as the foundation for this connection between civic hackathons and open government efforts to make governments more accessible, accountable and transparent (Brown, 2007; Chang & Kannan, 2008; Longo, 2013; Yildiz, 2007). At its heart, the open government movement seeks to redefine the relationship between governments and citizens by, among other things, making information about government services, activities and spending more available and understandable. One way in which governments demonstrate their openness is through the release of government data through open data portals. Here, open data is generally understood to be data "that can be freely used, shared and built-on by anyone, anywhere, for any purpose" (Open Knowledge Foundation, 2013).

But making data "open" is only the beginning of making *governments* open. Governments can only be considered truly open when their citizens have access to the information they need to inform their understanding of government processes, policies and decisions (Open Government Partnership, 2011). Open data is part of the information citizens need but it is not, in and of itself, necessarily easy to understand, use, or work with. When citizens begin to work with data to answer questions, address concerns and to advocate for change that open data becomes part of a participatory open data process and it begins to actively serve the open government movement.

This paper broadly considers how municipal government staff, including urban planners, might begin to seize new opportunities that new forms of data, such as open data, present. For example, what new interactions and engagements with citizens can be facilitated through the use of data? More specifically, this paper focuses its attention on civic hackathons—time intensive, civic-focused topic events convened to put data sets, often municipal open data, into active use through the creation of mobile device applications with civic/community intentions. Building on the Johnson and Robinson (2014) framework for evaluating the impacts of civic hackathons, this paper asks the question: do civic hackathons provide a new forum for local government-citizen interaction? Drawing from interviews conducted with Canadian municipal staff who have direct experience convening civic hackathons, the research found civic hackathons connect government and the citizen in two broad ways. First, through the development of prototypical apps using municipal open data and other data sets, civic hackathons help put open data into public use. Second, at civic hackathons with government staff present, the hackathon participants act as sensors, by sharing and providing feedback on data sets to the government data custodians. This paper presents these findings and concludes with reflections on the importance for municipal staff in general, and urban planners specifically, to consider their role in the emergence of a participatory open data movement.

2. Literature Review

2.1. The Changing Nature of Open Data Provision: Moving from Data Provision to Participatory Open Data

The provision of open data, that is, data collected by government to support service provision and decision-making, is rapidly becoming commonplace in many municipal governments throughout North America and Europe (Höchtl, Davies, Janssen, & Schieferdecker, 2014). Open data, typically provided in a raw format, through a web interface, and with a permissive license encouraging use, can consist of infrastructure data, such as roads, buildings, land use, service provision (garbage collection schedules, recreation programs), and transparency or accountability data (council minutes, expenditures, voting records).

Though this raw open data may be accessed directly by a citizen end user, there is frequently an infomediary role played by private sector companies, NGOs, journalists, and even other government levels or jurisdictions (Janssen & Zuiderwijk, 2014). These entities take open data and use it to create products that may have wider impact. For example, a private sector mobile application developer may rely on access to municipal transit scheduling information, provided as open data, to feed a mobile transit app accessed by citizens. Another example is the use of water quality data to feed a community group portal on local water management and drinking water safety issues. These examples represent outcomes of open data provision by government, taking raw data, providing it to a select group of tech-savvy users, who take this data, combine it with other data sources, and make a product that has impact with a specific community of users. However, this one-way process of data provision by government and access by infomediaries and/or citizens, can also be a two-way form of input, contribution, clarification, or editing, for example with citizens being asked to provide requests and input to government via a 311 request application (Johnson & Sieber 2013; Offenhuber, 2015). This move represents a culture shift from government data as product to data as a starter for conversation between government and citizen (Sieber & Johnson, 2015). This shift is mirrored in the evolution of the open data portal from simply a library or repository of raw government datasets, towards a meeting point where citizens may also access information prepared by municipal staff through data analysis, and to provide comment or input through a web form or companion mobile application (Sieber & Johnson, 2015). For example, an open data portal may contain both the raw dataset and a map-based viewer through which citizens can filter, explore, download, and even comment or edit specific pieces of municipal data (Johnson, 2016a). In this way, a government open data portal aims to diversify its user base to include a range of users, all with an interest in accessing and exploiting the civic potential of government data. These could include technically-savvy developers who want access to raw data, community groups or not-for-profits that are looking to support their community-support mandates with information about their specific populations, journalists looking to find facts to support their stories, and also average citizens looking for specific answers or information. This change from data provision to engagement through information sharing approach shows a maturation and evolution of the role of open data, opening the possibility of a more participatory conversation with citizens (Janssen, Charalabidis, & Zuiderwijk, 2012; Sieber & Johnson, 2015).

This evolution in open data provision provides an opening for the citizen contribution of information, and also shows government interest in supporting the use of open data, either through their own activities as data analyst and service provider, or through specifically encouraging and activating others to act as 'infomediaries' (Janssen & Zuiderwijk, 2014). In both cases, this more active role of government as open data users or champions echoes Janssen et al's (2012) comments that open data must be used to be of value. One specific way that government encourages the use of open data is through the hosting or sponsoring of hackathons, developer contests, or codefests—all events designed to bring together diverse teams of individuals to work with municipal open data, often on a targeted issue of civic interest, in pursuit of a variety of goals—networking, prize money, opportunity to vend a product to government, or simply out of fun and enjoyment (Johnson & Robinson, 2014).

2.2. What Is a Civic Hackathon?

Code for America, a leading organization in the civic technology sector, defines civic hacking as people working together quickly and creatively to make their cities better for everyone (Code for America, 2013). Code's focus on the "civic" element of a hacking is key here—that there is an assembly of people gathering to focus their efforts on improving their community sets civic hacking apart from app development with entrepreneurial goals.

Johnson and Robinson (2014) offered the following description of civic hackathon:

> "The civic hackathon is a time-limited (typically hours or days) event, launched at a specific venue, where enthusiasts, government workers, interested citizens, and members of the private sector meet in a collaborative environment to access government open data. The goal of a civic hackathon is to leverage government open data to develop software applications that address issues of shared civic importance. Civic hackathons are often coupled with prize money or other material rewards for participants, and typically involve the release or promotion of new or potentially highly-valued government data. Civic hackathons often present a specific problem or theme (such as transit, or engagement), to which the sponsoring government aims to direct participant efforts toward the development of an app serving some sort of public and/or market need." (Johnson & Robinson, 2014, pp. 350-251)

As civic hackathons have grown in popularity, the community of practice has further refined what distinguishes an entrepreneurial app contest from a civic hackathon (Baccarne et. al, 2015; Dawes, Vidiasova, & Parkhimovich, 2016). The entrepreneurially-focused app contest places greater emphasis on the end-product (the app), claims of innovation, and market potential of the app (Baccarne et. al, 2015). In contrast, at a civic hackathon, the convenor or host is typically a government department or public agency and the data used are often government open data, (Harisson, Pardo & Cook, 2012) with goals of the event reflecting a public or civic need. As the frequency civic hackathons being held increases, we are witnessing them as a new venue for government and the public to interact. In this regard many scholars and practitioners are asking: are civic hackathons a new form of civic engagement?

2.3. Are Civic Hackathons a Form of Civic Engagement?

Zuckerman's (2013) two axis framework (Figure 1) is commonly used in discussions about how to evaluate civic technology and its contribution to civic engagement writ large (Sifry, 2015). On the x-axis, civic engagement activities are considered for their meaning ranging from symbolic events to ones with measurable impacts. Johnson and Robinson (2014) flag the need to differentiate the impacts of hackathons given that some are high tech stunts with free pizza, beer and t-shirts while others claim to offer a deep dive into important civic issues using municipal open data.

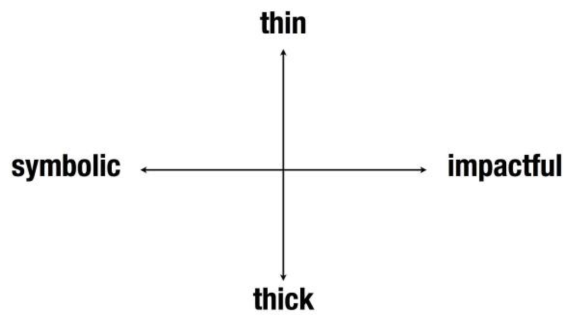

Figure 1. Zuckerman's 2-D matrix for thinking about civic engagement activities. Source: Zuckerman (2013).

On Zuckerman's y-axis we see a transition of civic engagement activities ranging from thin to thick. Building on this framework, Leighninger (2015) offers that "conventional" engagement includes the kinds of activities municipal governments commonly use to seek public input into their processes like public meetings and deputations to Council. Next he frames "thin" engagement as activities in which individuals participate like voting and signing petitions. With new online capacity he adds tweeting, a Facebook "like", map contributions, and online feedback on government projects to the "thin" list. "Thick" engagement "enables large numbers of people, working in small groups, to learn, decide, and act together" (Leighninger, 2015, p. 190). Using this taxonomy, civic hackathons share the characteristics of "thick" engagement, yet despite this, many questions can be raised about the fit between civic hackathon goals and public need, the cross-section of society present at these events, and the overall impact of the civic hackathon, particularly as an event that is often run 'outside' of formal decision-making channels (Sieber, Robinson, Johnson, & Corbett, forthcoming).

This tension between "thick" and "thin" forms of engagement makes framing the civic hackathon wholly as a civic engagement exercise a challenge. As with Leighninger (2015), and Johnson, Corbett, Gore, Robinson, Allen, & Sieber, (2015), questions of value exist when assessing the outcomes of largely digital, selective engagement exercises. To develop a better understanding of where civic hackathons fit as some combination of outreach, service provision, extension of open data platforms, training, or even as civic engagement, we use interviews with municipal staff responsible for convening civic hackathons. Their perspective on the civic hackathon as potential engagement is critical for uncovering the motivations for launching a hackathon and also the perceived benefits derived from these activities. Despite rhetoric that civic hackathons have significant impacts, liberate data and offer a new form of civic engagement, it is time to move from speculation to gathering evidence.

3. Method

Given this project's focus on how governments are making use of open data, to assess the role of the civic hackathon as civic engagement, we identified municipal staff working in Canadian municipal governments as research participants. Key informant interviews are useful when trying to evaluate the outcomes of particular activities (USAID Center for Development Information and Evaluation, 1996). For this project, key informants were drawn from participants in a cross-Canada open data research project, and included representatives from many of the most developed municipal open data programs in Canada, as well as relative newcomers to open data provision. All key informants were considered to be experts in the subject of civic hackathons, having developed, planned, and/or hosted a municipally-sponsored civic hackathon. This particular focus on municipal staff was deliberate as this research sought to evaluate the potential use of civic hackathons from the perspective of municipal government staff. This internal focus on open data program evaluation is important, as building internal feedback mechanisms has been identified as a central way in which government can support the case for continued delivery of open data (Johnson, 2016b). Similarly, capturing staff perceptions of hackathons can provide not only a frame for evaluating the event itself, but reveal the underlying motivations and goals that drive government-citizen connections.

In total, six key informants were interviewed, representing the municipalities of Toronto, Ottawa, Edmonton and the Edmonton Public Library, and Kitchener. The small number of staff interviewed signals that civic hackathons are still not widely used by Canadian municipal government staff and thus the potential pool of interviewees was small.

Open-ended interviews were conducted, with the interviewer allowing respondents to elaborate and go into detail on a variety of aspects of hosting a civic hackathon, including motivations and outcomes, but also technical, procurement, and civic engagement issues. Interviews were recorded, transcribed, and then coded based on an open approach (Bain, 2003) which facilitated comparison between interviews on key themes. These interviews are used to define the key outcomes of civic hackathons from the municipal staff person's perspective.

4. Analyzing Civic Hackathons: Significant Outcomes for Data Providers

Through our research with Canadian municipal governments who have conducted civic hackathons, three main themes emerged in response to questions about motivations for holding and outcomes generated by civic hackathons. These three themes are; civic hackathons help to activate open data use, at the civic hackathon municipal staff participation is critical to help animate the municipal open data, and civic hackathons form a useful method of direct feedback from data users to government staff. We examine each of these themes in turn, providing evidence from interviews and comparison with existing literature.

4.1. Civic Hackathons Help to Activate Open Data Use

There is a common perception of the civic hackathon as a forum for the creation of mobile device applications with commercialization potential from government open data (Longo, 2013). In contrast, the local government staff interviewed for this research relayed that in the beginning, the "civic hackathon" was first conceived of as a way to help municipal governments to get their newly released open data into use by getting it out of the portal and into the community. The interviewee from Toronto shared "in early days people were asking questions like: where do I find the data?".

This comment shows that local government staff were using civic hackathons for two purposes—first to draw attention to the data sets themselves and second to help create awareness about where and how to find data. Kitchener staff had a similar experience, with early efforts focussed on getting data into the portal, raising public awareness about the data's existence, with hackathons being identified as a way to accomplish this goal. Similarly, in Ottawa, municipal staff showed leadership by connecting the need to release open data with additional efforts to get people to actually use it.

By hosting or supporting civic hackathons, municipal government staff are acknowledging that making data open, in and of itself, is only the first step in a broader program of supporting open data use. This demonstrates a desire on the part of government employees to move quickly beyond what Sieber and Johnson (2015) termed the 'data over the wall' model of open data provision, where data is 'dumped' in a portal, towards a more activist role of government as a supporter and even convenor of civic engagement activities related to open data use. We also see parallels with research on the deployment of technology tools, such as geospatial mapping, for civic engagement purposes. Sieber et al (forthcoming) signal in their work that when tech staff are asked about the potential for online tools to improve discussions between local governments and their citizens, they have an "if you build it they will come" mentality meaning that developers sometimes believe that great online, interactive tools, including open data portals, will draw users by their very presence. Yet research tells us otherwise, as many tools developed to support engagement become lightly or rarely used, and also inflict a range of structuring issues on the process of engagement (Johnson et al., 2015). It is clear from these experiences that the provision of open data and data management tools are only one step in broader engagement through data sharing, and simple provision does not relate to use or to any guaranteed desirable outcome.

4.2. Municipal Data Animation Efforts Benefit from Having Government Staff Present

The second common theme that emerged across the interviews is that staff realized, as their experience with civic hackathons deepened, that if municipal open data was going to be used in a civic hackathon, then it was important and advantageous for municipal staff to be involved with and present at the event(s) when the data was being used. In these events, staff responsible for a variety of roles within the local government were needed to provide support to hackathon participants. Data savvy staff are needed to "speak to the data" (City of Kitchener interviewee 1) regarding the technical characteristics, such as the structure, nature, limitations, and format of the data set and other data elements. The City of Toronto interviewee shared an experience from a civic hackathon at which participants were in need of a particular data set that wasn't available in the portal. The City of Toronto staff were able to quickly locate the data in spreadsheet format and share it with the participants. Without the staff present to respond quickly, the event would have suffered, with participants becoming stuck. In a different situation, participants encountered a technical problem with a data file. The City staff at the hackathon were able to call another staff person at home and solve the problem quickly, which is important in a time limited event like a civic hackathon. By having technical data staff present "it really enables the hack to go on" (City of Toronto interviewee), providing key assistance to hackathon participants and allowing data custodians within government to use their expertise to support the broader goals of open data, moving simple provision to actual use.

The interview respondents from Toronto, Edmonton and Kitchener consistently noted that civic hackathons helped municipal staff better understand the open data needs of their residents. Hackathons, according to the Toronto respondent are a space for staff to advocate for data use and to draw attention to the data but they have more potential to engage more municipal staff in addition to the municipal open data teams. Subject area staff (e.g. urban planners, municipal transportation engineers) are also needed at hackathons to help participants understand the context of the open data: "At the hackathon events you want the people that know the data but also it would be helpful to have the staff who work with data and practice....So I can...to some degree, help them navigate the website (open data portal). But if they're really looking for nitty gritty, then it's really helpful to have someone from the division there" (City of Toronto interviewee). In Edmonton, public library staff realized there was a resonance between the "open data movement" and the mission of their public library to "make information openly available to the public" (Edmonton interviewee 1). By having library staff attend, Edmonton forged connections between the open data team and the library staff. Despite the overall strength of this finding, as reported by our sample, it is important to remember that this research did not query the perspectives of hackathon *participants* about the presence of municipal staff. This issue will be addressed in the conclusion in a framing of future research needs.

4.3. Civic Hackathons Provide Important Feedback to Local Governments about their Open Data

Interviewees relayed that as their experiences with civic hackathons deepened their understanding of how to work with and improve their current provision of municipal open data expanded. For Edmonton, Toronto and Ottawa, the first hackathons with municipal staff in attendance were different in terms of expectations and structure than the ones that followed. As the Toronto interviewee shared "in the early days we didn't really have much data at all. So we weren't really able to help them [hackathon participants] really do anything". While in the case of early events, local governments may have imagined civic hackathons as a way of publicizing their open data portals, helping the public learn more about open data and its potential, by hosting or participating in civic hackathons, municipal staff are engaged in a more reciprocal working relationship with data users. According to the City of Toronto interviewee: "all of that kind of learning…I don't believe you get it unless you engage and participate". Now that more municipal open data is available and more feedback from data users is being received through hackathon events, municipal staff are learning too about how their open data might better achieve its civic potential.

Through participating in civic hackathon events, open data staff reported receiving valuable feedback about the structure and accessibility of their open data sets. In some cases (e.g. Toronto), at a civic hackathon, participant questions signalled to staff that some existing data sets were hard to find. During one event, participants wanted access to Council minutes and agendas. In Toronto these data are available through the City of Toronto Meeting Management Information System (City of Toronto, n.d.) but staff learned, first hand, that the public was not intuitively able to find this information set and the municipal staff present were able to help connect the need with the information quickly. In another Toronto civic hackathon a participant, who was a coder with extensive technical expertise, questioned open data staff on how and why particular data files were structured and bundled a particular way. His questions led staff to make changes that resulted in open data files that were faster to download and easier to access on mobile devices. These resident-staff interactions also help staff quickly identify conflicts between data sets. The staff from Kitchener also specifically discussed how beneficial this kind of feedback on data structure and format was, allowing them to make changes and to learn for future data releases. Here having government staff present at civic hackathons facilitated reiterative learning that informed the early days of open data releases.

When City staff are able to participate directly in civic hackathons they also learn more about what kinds of data users want and need. Given that a 'large' open data catalog may contain one hundred datasets, there is an immense amount of data collected by government that is not provided via an open data portal. Municipal staff reported feeling the pressure of wanting to get more data out but they were clear that their hope is to get the data out that people actually needed and wanted and they "don't want a fire hose where they just put it (data) all up there". But through participating in civic hackathons, the municipal staff interviewed here reported gaining valuable feedback about which data sets are desired yet not yet shared on municipal open data portals. This allows data users to request priority data, giving municipal staff a specific reason to approach data custodians internal to government, and to work with those departments to make a given data set open. The City of Toronto staff person specifically noted "But we like evaluations. We like to see evidence of people's reactions". Similarly, the Kitchener staff also reported benefits from the in-person discussions about data: "We talked to different groups in terms of what sort of things they would be interested in. And it's like "what do you want?", "What do you have?"" Well, what do you want? We got a lot of stuff." "Well, what do you have?" (...) But then there's the odd ball things that you don't even think about, and until you put it up there, and people start asking questions and giving you some feedback on what you've got, what's missing. You know, geez, if it only had this then we could, you know—I got an idea but I need this other piece. It allows us to tweak what (data) we're putting out." And the Edmonton staff members also reflected on receiving the same benefits: "we wanted people to give us a sense of how we could move forward engaging the open data movement in the community of people and the city who are invested in it. And we got a lot of feedback that helped give us that kind of direction". Here the face-to-face contact provides valuable feedback for City staff about how to prioritize future open data releases.

This process of working directly with the public at civic hackathons, outside of formal public meetings, is a different point of connection for municipal government staff. These changes require shifting mindsets about what it means to share information rather than keeping it from public access. In the words of one interviewee: "Now I'm starting to get into it (open data) and now it's like, well, let's see what we can put out there. That's not easy to do when you've had twenty years behind you of hoarding data". Early participation in civic hackathons has lasting impacts on how government staff conceived of their working relationships with the public:

> "We're directed not to create, not get into the apps contest or whatever, but be involved as part of our crowd sourcing concept, which was accepted. In other words, as we're doing this, let's go out and ask the community what they need and not sort of define it ourselves. So that's where actually going and participating in the *hacks*, sort of, *became our methodology*. And we learned quite quickly that you know what, we're not—we wouldn't be really good at creating these kinds of events because the sort of ethos, the culture, if you like, is very differ-

ent to, to what we are more accustomed to. So if we were going to do a hack, likely, back then especially, right, likely we would have said, oh, it's got to be on a Monday between 8:30 and 4:30. So we observed that. And said, well, you know, this is amazing. And how are we contributing? How do they seem to want us to contribute? It looked like more or less as the people presenting some of the data, that that's what they were asking us, where do I find this?" (City of Toronto interviewee)

And civic hackathons have put different staff into direct contact with the public. In the past, GIS and data staff have been behind the scenes "serving the needs of the Corporation" yet now, with civic hackathons, these staff are in rooms with members of the public. This change is welcome by staff and it is significant.

Another reciprocal benefit that staff report from their engagement in civic hackathons is that staff perceive them as events that help residents learn about their community and how their local government functions. One interviewee shared:

> "You know, it's just a very different means of operation than traditionally what you get out of government. And I've seen evidence of it being successful with the community. And I found the community to become more tolerant of our delays for whatever reasons there are, they respect us/ because we're there. If we were less inclined to participate and be visible then I think you would see more blow back and who knows what kind of even editorial you might get in the blogs and the tweets/ and whatever media coverage there is." (City of Toronto interviewee)

The same participant also noted:

> "And I'd argue too that it's a way of teachable moments. It's all part of civic engagement. It's getting people to understand how the government works and why it works. And does it work well for them? And I mean, think of it, it's a two way street. We could come back easily and talk about issues".

5. Conclusions: Are Civic Hackathons a Gateway to Broader Civic Engagement?

Ultimately, staff report that they perceive civic hackathons to be a step in the direction toward new resident-government relationships. Civic hackathons have, in one way, helped government staff see how keen residents are to engage with open data beyond the hack events themselves: "There's been a strong appetite for people to just give them a time and a place and a reason to come together, to see what each other's working on or interested or learn about new tools or new data sets or meet people at the city and ask them questions about the data. So it's more about setting them up for work that happens outside of those events" (interviewee). And in Edmonton, the library staff interviewed reported that from their experience, the civic hackathon "idea was civic engagement, just putting people face to face and giving them the opportunity to work together".

As open data communities mature we are seeing the emergence of additional types of events at which open data are used and explored. In Ottawa, community members started an open data book club where people meet monthly to discuss a data set—here the focus is on the data and its use rather than on app development. In Toronto there is an open data book club and a weekly civic tech hack night which combines discussions about data sets with ongoing work on app development. This range of activities at which municipal open data is considered and sometimes used in app development demonstrates that residents have an interest in open data and its application beyond tool development. And as these kinds of beyond-civic-hackathon activities emerge, questions will arise for local government staff. The City of Kitchener staff interviewed shared "the people who did get engaged were looking toward the next thing. So, you know, again, how far do we (the City) take it with that? And at what point does our role stop in that and does the community take it on?".

A municipal government bringing in outside actors, in this case citizen hackers, to work on apps that have civic benefit could be argued to be form of outsourcing consistent with trends toward neoliberalization. Johnson and Robinson (2014) asked whether hackathons were a form of backdoor procurement? In some ways, a civic hackathon represents one step towards the implementation of the neoliberal rhetoric of open government—with its attendant challenges generated by shift of power from centralized to decentralized (Bates, 2014). If the civic hackathon movement continues to be popular, these concerns are important to track and evaluate. However at this particular moment, civic hackathons appear to be more valuable to local governments as a tool for engagement than as a technique for getting free or subsidized labour in the form of app building. Furthermore, increasingly, civic hackathons are being grouped with other activities like Open Data Book Clubs and data sprints at which the focus of the meetings is more about the discussion of the data and its potential than on the production of the app itself.

These interviews conducted for this research begin to shed light on the impacts of a relatively new phenomenon for local governments: the civic hackathon. These findings confirm that civic hackathons are different from entrepreneurial app contests in that their "value" and impact focuses more on sharing, animating and generating feedback on civic open data sets than it does on producing a ready-to-use mobile device app. These findings signal the importance of municipal open data needing stewardship in the form of municipal staff familiar with the data, their format and structure and also municipal staff with knowledge and experience in the areas of application related to the data. Through participation in civic hackathon events, municipal staff reported gaining receiving valuable feedback about what kinds of data residents want, how well the data sets are structured, and how these data sets might inform actions taken by residents. This feedback opportunity reinforces the importance of municipal staff needing to participate at the events, acting as infomediaries that can facilitate the creation of information from the raw open data (Janssen & Zuiderwijk, 2014). These findings also help position civic hackathons as an event that contributes to broader participatory open data efforts and that also may serve as an entry point for residents to participate in other civic engagement efforts.

When this research began, the distinction between app contests and civic hackathons was less clear than it is now, with questions arising about whether the hackathon phenomenon was a trend that would taper off. In 2016, governments worldwide continue to sponsor hackathons with a variety of goals including possible app development, and these findings signal that organizers might think beyond prizes, having robust participation numbers and publicizing outcomes to what the role of civic hackathons is in connecting the public with civic open data. This research on civic hackathons helps to demonstrate that there is civic and local government value in having staff attend these events, though one challenge that many local governments face with civic hackathons is that they often take place outside of regular working hours for municipal staff (e.g. on weekends and into the evening) but given the learning and knowledge exchange between municipal staff and participants, there is an institutional argument to be made for having staff present. Civic hackathon organizers should consider, from the outset, what feedback mechanisms they can create to allow the useful feedback provided at these events to shape and influence municipal open data practice moving forward—who needs to be present and what kinds of note taking, and post-event evaluations might be developed to gather this feedback in a way that is useful and durable? And, given that civic hackathons appear to lead to other open data events and engagement and civic engagement more broadly, how can local governments take full advantage of the civic engagement potential of these events to harness that energy and put it to future use?

Urban planners, as municipal staff, may also take particular note of the civic engagement potential of civic hackathons. It is a "normal" part of their work for municipal planners to be directly engaged with the public. As professionals who direct and implement local land development processes, urban planners are commonly legislatively required to hold mandatory public meetings. Yet civic hackathons are a markedly different event—there are no formal, local government decisions taken, there are no proponents of a development process. Civic hackathons are more informal and collaborative than typical land use planning public meetings. In civic hackathons there are myriad forms of expertise with people working voluntarily and collaboratively. Given the popularity of civic hackathons and the findings presented here that signal their potential to add a new dimension to the relationship between residents and their local governments, municipal planners should become familiar with the civic hackathon event and begin to consider what points of meaningful contact there might be with urban planning practice.

In developing this project, the research team wondered whether civic hackathons would be a flash-in-the-pan trendy event whose time would have come and gone before the findings were shared. Instead the interviews conducted here reveal that hackathons continue, at least in the short to medium term, to provide a valuable forum for municipal staff and a broad diversity of data users including citizens, private sector, non profits, and journalists, to explore open data. Rather than reliably producing civic-minded apps for mobile devices, civic hackathons in their current form are useful events in a participatory open data ecosystem and they appear to add value to municipal open data through taking this data and putting it into action within a specific community of data users, closely working with government representatives. In this way, the process of a civic hackathon becomes much more important as outcome compared to a specific app that could be developed. As a re-framing of government-citizen relationships with open data access and use at the center, a civic hackathon exists as a manifestation of the potential for engagement.

Despite this potential, many critical questions for future research emerge, most notably asking what are the specific outcomes for civic hackathon participants? What kinds of people participate or critically, do not participate (e.g. age? gender? background—technology, urbanist?)? What motivates the participants to come (e.g. fun? wanting to make a difference? entrepreneurial aspirations? new form of volunteerism?)? What do participants think about having local government staff present and does this presence enhance or hinder interest in participating? Do the participants share the government staff's enthusiasm for the new space that hackathons create for citizen-government staff interaction? And how do residents feel when their politicians participate? One could imagine tension emerging if a hackathon investigated topics such as council expenditures or other potentially sensitive transparency data with representatives of the government in question. As open data portals grow, the feedback loop between hackathons and municipal open data efforts should be further explored. How does government go about incorporating and acting on diverse feedback, and are there specific obstacles that may be blocking the further development of both open data and the civic hackathon? And most critically, what is the long-term future of the civic hackathon event? Is there a limited appetite for this type of activity, and without evidence of real engagement or changes driven through participation, is the likelihood of further investment from governments destined to falter? Or, is as hinted by the key informant interviews presented here, could a civic hackathon a potential new conduit through which government and citizen can connect? Finally, is the hackathon an entry point for disruptive action, such as a launch pad for entrepreneurial activity that may appropriate government roles to the private sector?

The interviews conducted from this modest sample of Canadian local government staff form findings that contribute to the nascent body of literature focused on the civic impacts of hackathon events. Research that builds up and broadens the focus on civic hackathons is encouraged. A web search of "city hackathons" shows upcoming events in cities like Amsterdam, San Diego, and Dublin among many which signals the civic hackathon, as an open data engagement event continues to be popular. While there is more research attention devoted to the entrepreneurial app contests and their impacts, this research shows there are marked differences in intent, structure, expectations and outcomes between app contests and civic hackathons. Furthermore, as open government and open data movements continue to build momentum, additional research is needed with a civic or public focus because, as this project demonstrates, the impacts and outcomes of civic hackathons do appear to offer a new terrain for local government-citizen interaction.

Acknowledgments

The authors would like to thank the participants for sharing their experiences and the reviewers for their valuable feedback. The research reported here is funded by the Social Sciences and Humanities Research Council (Canada) and the authors are part of the geothink.ca research team.

Conflict of Interests

The authors declare no conflict of interests.

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Urban Planning (ISSN: 2183-7635)
2016, Volume 1, Issue 2, Pages 75-87
Doi: 10.17645/up.v1i2.608

Article

‘Sensor’ship and Spatial Data Quality

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Submitted: 4 March 2016 | Accepted: 16 June 2016 | Published: 24 June 2016

Abstract

This article describes a Los Angeles-based website that collects volunteered geographic information (VGI) on outdoor advertising using the Google Street View interface. The Billboard Map website was designed to help the city regulate signage. The Los Angeles landscape is thick with advertising, and the city efforts to count total of signs has been stymied by litigation and political pressure. Because outdoor advertising is designed to be seen, the community collectively knows how many and where signs exist. As such, outdoor advertising is a perfect subject for VGI. This paper analyzes the Los Angeles community's entries in the Billboard Map website both quantitatively and qualitatively. I find that members of the public are well able to map outdoor advertisements, successfully employing the Google Street View interface to pinpoint sign locations. However, the community proved unaware of the regulatory distinctions between types of signs, mapping many more signs than those the city technically designates as billboards. Though these findings might suggest spatial data quality issues in the use of VGI for municipal record-keeping, I argue that the Billboard Map teaches an important lesson about how the public's conceptualization of the urban landscape differs from that envisioned by city planners. In particular, I argue that community members see the landscape of advertising holistically, while city agents treat the landscape as a collection of individual categories. This is important because, while Los Angeles recently banned new off-site signs, it continues to approve similar signs under new planning categories, with more in the works.

Keywords

categorization; landscape; outdoor advertising; spatial data quality; VGI

Issue

This article is part of the issue “Volunteered Geographic Information and the City”, edited by Andrew Hudson-Smith (University College London, UK), Choon-Piew Pow (National University of Singapore, Singapore), Jin-Kyu Jung (University of Washington, USA) and Wen Lin (Newcastle University, UK).

1. Introduction: Outdoor Advertising and the Los Angeles Landscape

To outdoor advertisers, Los Angeles is “the largest outdoor advertising market in the United States” (JCDecaux, 2007). To community activists, the city is “ground zero of billboard blight” (M. Ashburn, personal communication, 2011). Los Angeles has a landscape of suburban sprawl designed for automobile travel, and it is the home of the entertainment industry—factors that led to a density of billboards greater than other cities (Gudis, 2004). In the 1920s, the city began requiring permits for off-site signs, signs that advertise a product or service not available on the same site and commonly called “billboards” (1 L.A.M.C. 4.4 § 14.4.4(B)(11)). Yet the city enacted nearly no regulations as to the location and amount of billboards that could be erected. Years later, the Department of City Planning (2009) opined that the city’s lax regulations: “have shaped the way signage has been incorporated into our streetscapes, in a way that can now in retrospect be described as excessive. A proliferation of signage adds significantly to the visual clutter for which Los Angeles has become well-known, and points to the need for stricter sign regulations.”

In 2002, the City of Los Angeles made two important steps toward regulating signage. It banned new off-site signs, and it created the Off-Site Sign Periodic Inspection Program, which charged the Department of Building and Safety (LADBS) with creating a comprehensive inventory of existing off-site signs. Almost immediately, outdoor advertising companies challenged these laws in court. The three corporations that own the lion's share of billboards in the city held up the inventory program for years, and even after the city was legally cleared to restart the program, political pressures kept the city from commencing work and, later, releasing its results (Sedano, 2016). This article describes a project to employ volunteered geographic information (VGI) to map off-site signs in Los Angeles. The project was begun during the years that the city's inventory program was stymied and was designed to aid regulation by gathering data that the city was legally and politically unable to. Off-site signs are a perfect subject for VGI in urban settings because signs are made to be seen by the public at large, and there are a lot of them. While governing bodies may not have specific knowledge of the changing landscape of signs, collectively, residents do.

This article studies how urban residents mapped the landscape of off-site signs in Los Angeles and, as such, is positioned within the emerging field of VGI and its concern with the quality of spatial data created by non-professionals. Yet the article arrives at its key finding—that residents understand signage far differently than the professionals who make and enforce the zoning code—by way of landscape theory. Landscape is the field of social life, the land that we develop or choose not to develop, and the structures we build, mold, and maneuver around. The urban landscape is a "palimpsest", a concatenation of the old and the new rather than layer upon layer (Schein, 1997, p. 662). The guiding principle of modern landscape theory is that landscape is both a material and a cultural construct (Olwig, 1996). The landscape is primarily a visual field, but not an objective one (Cosgrove, 2003). Following art historian Berger (1972), who identifies the power inherent in the gaze and employs the phrase "ways of seeing" to capture the idea that perception is a learned skill, Cosgrove (1984) posits that the landscape is seen differently by different viewers. He studies the role of 18th and19th C. British landscape painting in remaking both the cultural conception of landscape and the material landscape to match this ideal of aristocratic property owners. The relationship between the material and the cultural is thus dialectical, and the movements of this dialectic as they play out on the landscape are deeply political (Mitchell, 2003). In urban settings, scholars note the often wide disparity between the landscape conceived by planning and that of lived reality (Mustafa, 2005; Scott, 1998). Expert ontologies of particular landscapes are a key site of contestation; the power to create the categories by which landscape is defined and regulated underwrites the making and remaking of the material landscape (Robbins, 2001).

In the following section I discuss recent examples of VGI in urban settings, highlighting municipal governments' tendency to engage residents as sensors for simple data and issues in spatial data quality that arise with VGI. Next, I describe the design of the Billboard Map website, how volunteers used the site, and the results of a field audit of the first 326 entries on the site. I analyze these results using traditional spatial data quality factors, and I find that the data was spatially accurate but that over-completeness of the dataset was an issue as users entered more types of signs than the city inventory enumerates. I then turn to the landscape of Los Angeles to consider why residents might have mapped more signs than city agents, and I find that the landscape is suffused with off-site signs that the city permits under a variety of new categories beyond the categories of traditional billboards. I argue that city agents see the landscape as a composite of individual items, distinctly categorized. Residents, however, see the landscape as a unified, cohesive whole. I argue that the VGI map of signage pursuant to this vision of the landscape shows fidelity to the landscape and to the law, and I suggest that the limited inventory created by the city is a tactic to obscure the true number of off-site signs in the city.

2. Literature Review: VGI in Municipal Settings and Spatial Data Quality

Together, the Internet, global positioning systems, mobile devices equipped with spatial locators, and apps for capturing and sharing spatial data now let persons untrained in GIS or cartography easily create and share spatial data and maps (Haklay, Singleton, & Parker 2008). The public has responded enthusiastically, and the result is vast amounts of VGI—locationally referenced data created by non-professionals. Much of the data is spawned as the unplanned, individual moments of sharing that are ubiquitous to Facebook and Instagram, but some data is borne of civic and community-minded projects, such as Cyclopath, a website for the biking community of Minneapolis, MN, USA, to share routes and road conditions (Priedhorsky, Jordan, & Terveen, 2007). Viewing urban residents as "citizen sensors" (Goodchild, 2009), local governments are interested in VGI as a fount of community data. Years of neoliberalization have left local bodies with decreased funding for service provision, making VGI an attractive option as residents become potential sources of free labor (Johnson & Sieber, 2013). Ganapati (2011) identifies this type of citizen engagement in three areas: transportation information sharing, service management, and community mapping. This speaks to a broader use of social media by governments for data sharing with citizens. Linders (2012) offers a typology for citizen participation using social media by: "Citizen Sourcing (Citizen to Government)", "Government as a Platform (Government to Citizen)" and "Do it Yourself Government (Citizen to Citizen)". Though the examples and types are not strictly VGI, many rely on spatial data sharing, such as Chicago's Snow Portal for sharing and accessing road conditions.

A key impediment to government use of VGI is mistrust of non-expert data (Johnson & Sieber, 2013). This topic encompasses both the traditional issues of spatial data quality as well as the more ontological questions of whether the quality of VGI should be judged differently than professionally created geographic information. In the last few decades, the judgment of spatial data quality advanced along with the methods of data creation (Devillers et al., 2010). Traditionally, spatial data quality was considered solely by positional accuracy, how closely the placement of a data point on a map matches its actual location on the face of the Earth (Van Oort, 2005). Spatial data quality assessments now judge attribute accuracy, the validity of all information associated with a data point besides its position, such as the name of a river; temporal quality, the data quality over time, with an assessment of the rate of change of the source material and the rate at which the dataset is updated; and completeness, the exhaustiveness of a dataset, considering both whether data is missing and excess data is included (Van Oort, 2005). Spatial data may now be easy to create, but these many factors of quality are not easy to assure, especially in formal institutional settings (Johnson & Sieber, 2013). Metadata is also an issue: the quality of professionally created datasets is well tested and documented, while the quality of VGI is generally not (Mooney, Corcoran, & Winstanley, 2010). Further, VGI often involves the mashing up of varying data types from varying sources, undermining quality and making it more complicated to judge (Hall, Chipeniuk, Feick, Leahy, & Deparday, 2010). Due to these reasons for mistrust, the reliability of VGI is a major concern (Delavar & Devillers, 2010).

The largest and most comprehensive dataset of VGI is OpenStreetMap (OSM); correspondingly, it is also the most studied (Koukoletsos, Haklay, & Ellul, 2012). The spatial data quality factors of positional accuracy, attribute accuracy, and completeness OSM data of England (Haklay, 2010), France (Girres & Touya, 2010), and Germany (Zielstra & Zipf, 2010) have been analyzed. In each case, researchers found positional accuracy was very good, attribute data was incomplete, and the completeness of the data varied widely, with nearly complete datasets in urban areas but broad swaths of unmapped areas outside cities. Girres and Touya (2010) and Haklay (2010) suggest that OSM should issue more stringent specifications in place of its current informal rules for data collection and tagging, which they note are often more suggestions for data collection and tagging than rules. However, they caution that OSM should still allow for contributor freedom, in order to maintain its volunteer base. Similarly, Van Exel, Dias and Fruijtier (2010) argue that even for a seemingly traditional type of dataset, such as OSM, traditional spatial data quality indicators may need to be retooled. For example, semantic accuracy may be hard to judge: predefined schema for attribute data is uncommon in crowdsourced datasets to allow volunteers' "creative input" but has a negative effect on spatial data quality. These scholars argue that the use of the dataset be considered before judging the quality of VGI. For instance, creative and personal data should not be judged by the same rigorous accuracy standards as a traditional spatial dataset such as OSM.

Johnson and Sieber (2013) also find that local governments use VGI as a participation platform to dialogue with residents rather than simply gain or share information. In this vein, the field of VGI aligns with public participation GIS (PPGIS) and its concern with democratizing the tool of GIS. PPGIS is a broad field, incorporating a wide variety of peoples, contexts, and methods to achieve the goal of community empowerment (Elwood, 2008; Sieber, 2006). "At its heart, the overlap between PPGIS and VGI relies on the investigation by individuals of locations that are important to them" (Tulloch, 2008, p. 164). The fields diverge, he argues, in that, "VGI is more about applications and information while PPGIS seems more concerned processes and outcome" (Tulloch, 2008, p. 170). The critical work of PPGIS is directly relevant to the analysis of VGI and in many ways is the necessary precursor and backdrop to its analysis (Elwood, 2008). Key in PPGIS is to "conceptualize data as socially produced and embedded" (Elwood, 2008, p. 177) and acknowledge the "difficulty of integrating spatial data that originate from different epistemologies, as 'local knowledge' and 'official knowledge' often do" (Elwood, 2008, p. 180). Still, implementations of VGI systems by planning and other government agencies to engage with the public in what might be deemed participation rather than simply information sharing are "sparse" (Rinner, Kumari, & Mavedati, 2011), if not "few and far between" (Ganapati, 2011). In the vast majority of VGI literature, urban residents are understood as "sensors", whose unique experience of the urban landscape is only recognized for making them "expert sensors" of the landscape than as potential partners in planning deliberation (see, e.g., Karimipour & Azari, 2015). Governments' failure to use VGI for community participation reflects the failure of official planners and decision-makers to sustain community participation generally. Brown (2012) argues that improvement in PPGIS technologies and techniques have not resulted in meaningful participation, because government agencies do not accept it. In an evaluation of ten years of PPGIS projects, Brown "has yet to observe any tangible evidence that PPGIS data has been used in agency decision making, let alone influence and improve the substantive quality of decisions in planning outcomes" (Brown, 2012, p. 14).

3. The Billboard Map Website: Description

Weeks after the billboard inventory ordinance was passed in 2002, the largest outdoor advertising companies in the area brought actions in state and federal court to halt the program. The cases settled in early 2007, but the city did not restart the program. When asked by the media why the program was stalled, LADBS personnel stated that litigation prevented the program from being restarted; however, the City Attorney's office admitted that no current litigation was preventing the program (Pelisek, 2008). The Billboard Map website was envisioned to fill this data vacuum. The goal was to create a map that might match the inventory of off-site signs that that the city had planned but, at that time, had neither completed nor released due to political and legal pressure. The design imperative was to collect data that the city could use in its regulatory effort.

Google is a common basis for VGI projects due to the ubiquity of Google Maps and the availability the Google Maps API. Similar to this project's goal, Johnson, Belblidia and Campbell (2011) create a publicly accessible urban dataset using Google mapping tools. They employ Google Earth's satellite imagery to map vacant lots in Detroit. This project employed the Google Maps API for the site's base map and the Google Street View (GSV) interface rather than satellite imagery to locate signs. Billboards have a relatively small footprint compared to their sign faces, and they are difficult to identify from above, making satellite imagery ineffective for locating signs. GSV is a feature of Google Maps that shows street-level photographic imagery of streetscapes within the context of a map (Anguelov et al., 2010). The GSV interface provides full pan, tilt, and zoom capabilities from a user's perspective. A user can rotate the current view to turn the view a complete 360 degrees, zoom the camera in and out at a particular location in front of the camera, and increase or decrease the pitch of the view to move the field of view up or down and towards or away from the horizon. The user can proceed down a street by clicking to the next available camera position or by clicking on a location in the distance. Google updates its GSV dataset at specific locations approximately every eighteen months (Badland, Opit, Witten, Kearns, & Mavoa, 2010).

Since its inception, scientists have tested GSV for usability and relied on its growing dataset as a basis of research. On point for this project are studies that use GSV as source for streetscape audits. Badland et al. (2010) find GSV audits to be faster and less expensive than physical site visits and that efficiency improves rapidly with user experience. Curtis, Duval-Diop and Novak (2010) use GSV to audit New Orleans to identify neighborhood patterns of return and rebuilding after Hurricane Katrina. Although video was available from local community groups, the authors find that GSV is just as effective and chose to rely on GSV as their data source so that their methods could easily be replicated. The design of this project was inspired their work. The design of the Billboard Map pushed beyond the existing literature on GSV streetscape audits by relying on non-experts.

As with other community-minded VGI websites, the desire for broad-based participation was countered by the desire for accurate data. I followed the lead of the Cyclopath designers (Priedhorsky et al., 2007) by favoring open access over site control that might enhance spatial data quality. The site thus operated as a Wiki: users were responsible for creating the data and maintaining the quality of the entries through edits and deletions of errors. Steps to promote more accurate data collection, such as in-person training, online training, and mandatory online instructions will invariably discourage some potential users from participating. I opted to make instructions available on the site but not to require them for participation. Requiring users to register with the site prior to usage was also seen as a way to increase data quality, on the assumption that if one cares enough to register with the site then one will tend to be more careful in entering data than an anonymous visitor. Differing from Cyclopath here, I opted for open access and chose to allow users to add map points without registering. However, registration was required to edit and delete existing billboard entries.

The home page featured a map frame that opened on the extent of all current sign entries, above a table listing the entries (Figure 1). The user could scroll and zoom with the standard Google Maps controls. To the left of the map was a bar with instructions on using the system, which a user could click to hide for a larger map view.

To begin the process of recording signs, the user clicked on a location in the main mapping interface. This action launched a pop-up window with three main features: (1) a window with the GSV viewshed directed northwards from the point selected by the user; (2) a map window centered on the point; and (3) attribute information fields including the approximate address of the point, estimated using employed using the latitude/longitude supplied by the Google Maps API and a reverse geocoding process described by Goldberg and Cockburn (2010) (Figure 2). In the viewshed window, a red rectangular box overlain on the image was used to identify the location of a sign in 3D space. Users panned and zoomed the GSV image until the red rectangle surrounded the sign of interest. When the user saved the entry, the program computed the 3D spatial location of the billboard, and the map updated in real-time to show the new entry.

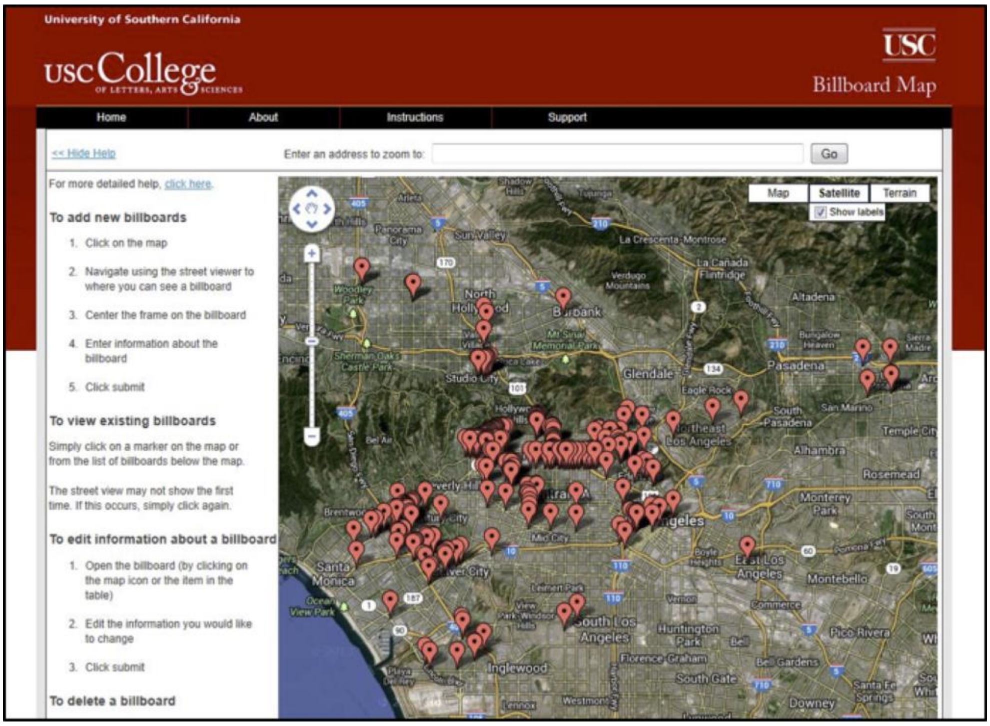

Figure 1. The home page of the Billboard Map website, featuring a Google Maps base map and points of signs entered by users.

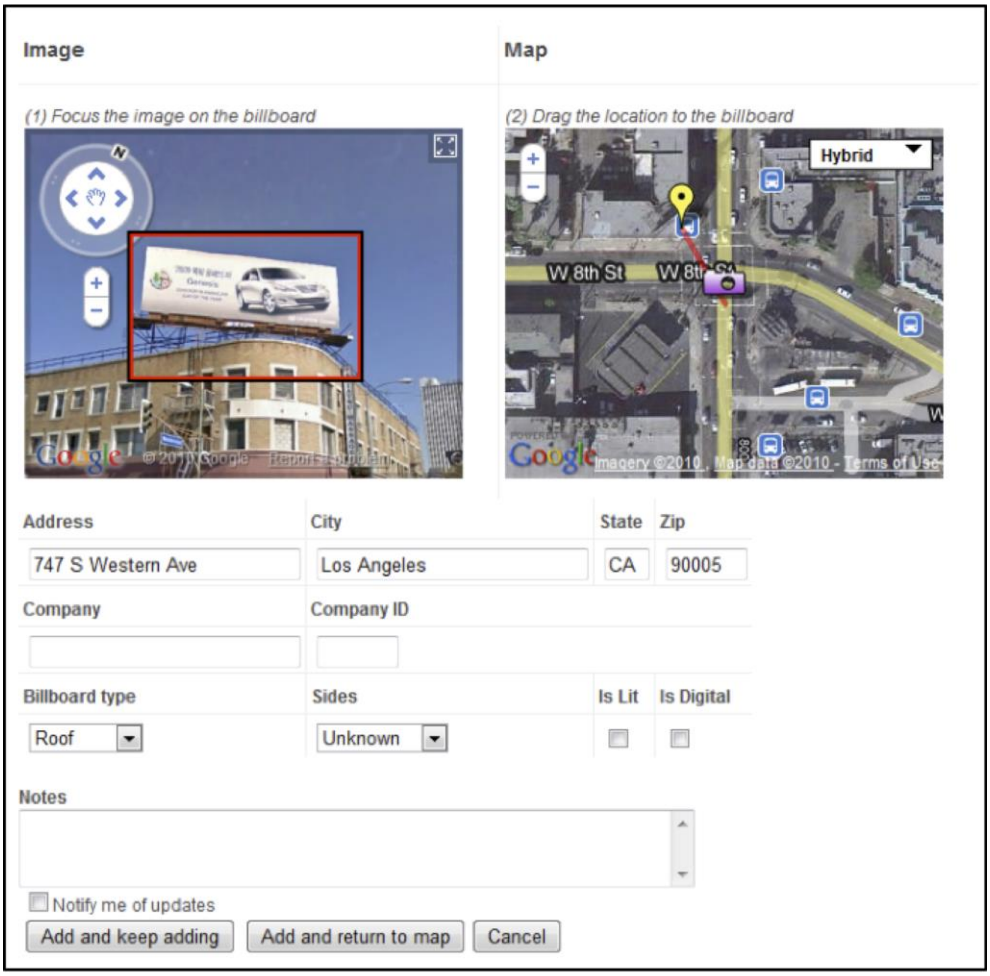

Figure 2. The Billboard Map's pop-up window for data collection, featuring a Google Street View window, a map window, and fields for attribute data.

The pop-up window also provided fields for users to record the sign attributes that were collected by city inspectors during their fieldwork. These attributes, identified by the head of the city's inspection program, included: (1) number of sign faces (many signs are double-faced, with sign faces on the front and back); (2) lighted or unlighted; (3) digital or non-digital; and (4) type of sign: pole, wall, roof (L. Zamperini, personal communication, April 13, 2010) (Figure 3). Finally, the window provided a "Notes" space for users to provide free-form comments on the sign.

I reached potential users by notifying online media venues of the project, and a variety of these venues publicized the site. The Coalition to Ban Billboard Blight (CBBB) described the project in a blog post. Their subscriber list is relatively small compared to the other venues, but the audience is directly interested in the topic. Curbed LA, a website covering local real estate development, and the website of the Los Angeles Times, the main regional newspaper, both covered the project. According to Google Analytics, the majority of visitors to the Billboard Map who entered at least one sign on the map linked to the page from either CBBB or Curbed LA. This finding was not surprising as the project relied solely on user interest in the topic to generate engagement: unlike VGI studies that offer gifts (Brown & Kyttä, 2016), the Billboard Map offered users no monetary or material reward. From February through April, 2011, 31 users registered with the site, and many used the site without registering. In this time period, 326 entries were added to the map. 326 entries provided a sizeable enough collection to test the usability of the initial incarnation of the site for its intended purpose—supplementing the official inventory of signs. In the following section, I describe the spatial data quality of these entries.

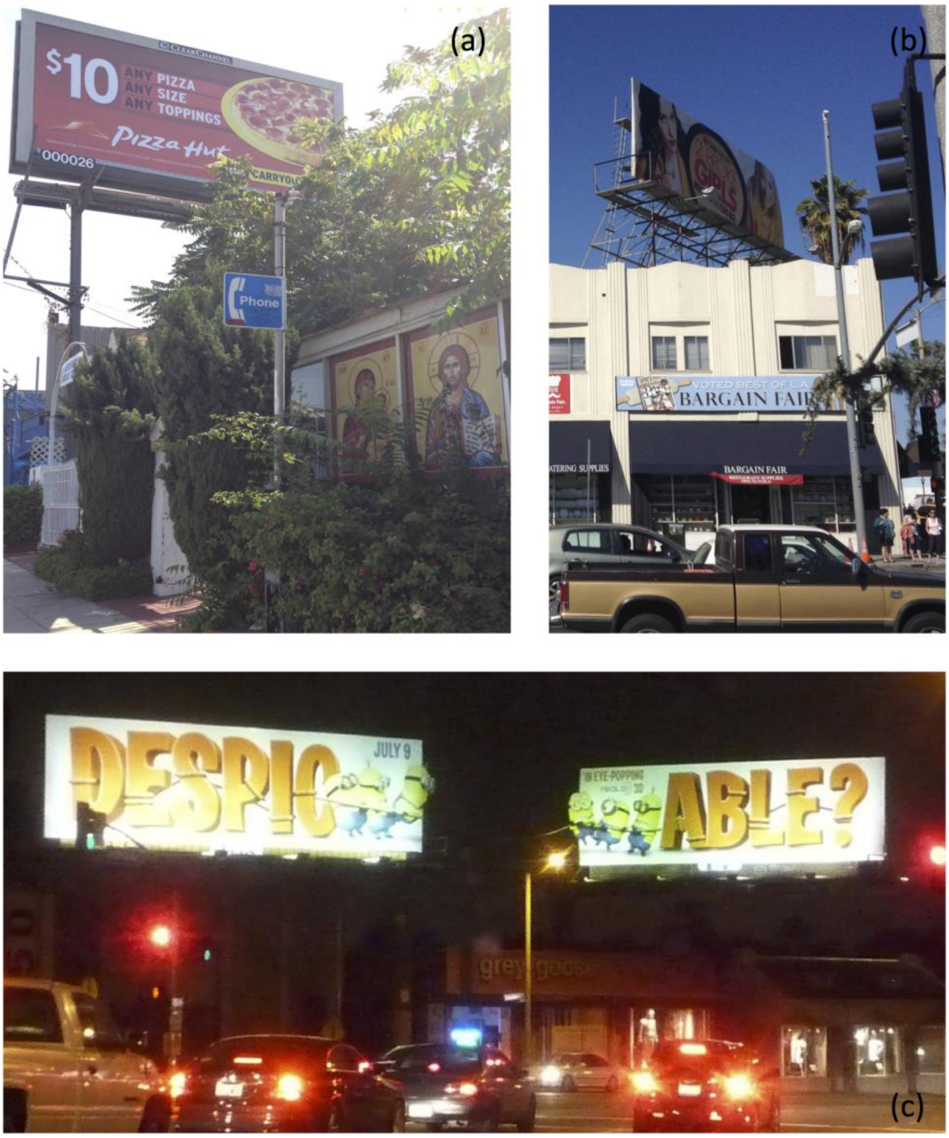

Figure 3. Examples of types of signs and sign attributes collected by the city inventory and the Billboard Map, including (a) a double-sided pole sign; (b) a lighted roof sign; and (c) two digital pole signs.

4. The Billboard Map Website: Results and Analysis of Spatial Data Quality

The Billboard Map, like most existing VGI systems currently employed in municipal governance (Ganapati, 2011), envisioned the residents of Los Angeles as sensors rather than as partners or participants in planning or policy deliberations. The site was intended to collect data useful for regulation, specifically to help the LADBS catalog signs. City agents charged with the day-to-day tasks of regulation, for example with maintaining permits and enforcing municipal codes, require accurate data for their work. To consider the utility of the Billboard Map for this purpose, testing the traditional spatial data quality parameters of the VGI data against the expectations of the city inspectors is key.

The spatial data quality of the 326 volunteered entries in the Billboard Map was based on ground-truthing of the data rather than a comparison against a reference data set as used in other tests of VGI accuracy (see, e.g. Haklay, 2010). Because the city had not yet released its inventory in 2011, and no other public dataset of existing signs existed, there was no reference data set against which to compare the VGI entries. A field test of the 326 entries was therefore required, and it was completed using a Trimble GeoXH GPS receiver to record location and attribute data. After the city's inventory was released in late 2012, I was able to confirm my findings against the city's dataset (Los Angeles Department of Building and Safety, 2014).

The first result sought was the positional accuracy of the web entries. Using ArcMap, I calculated the distance between the location of web entries with the location of corresponding field entries using the "XY to Line" tool, chosen because it yields the desired distance calculation, as well as a visual confirmation of the process (Figure 4). Prior to running the process, I corrected the location of the field points using 4" pixel resolution natural color orthophotography from the 2012 Los Angeles Regional Imagery Acquisition Consortium dataset. This test showed that 43% of web entries were within 20 feet of the intended sign, 75% were located within 50 feet and 91% were located with 100 feet. The city's inventory was not used to confirm these findings because, though it provided coordinate information for each sign, the coordinates are to a point randomly sited within the parcel containing each sign, not to the sign's exact location within the parcel. Hence, my field location points were more accurate.

Given that urban planning is focused on individual parcels, the second result sought was whether web entries were sited within the correct parcels. ArcMap is capable of determining if a point is within the boundary of an areal feature or an adjacent areal feature, but parcels are often separated by streets and sidewalks. To assure the findings were accurate, a manual analysis was necessary. For this, I used Los Angeles County's parcel dataset, visually comparing the parcel that contained a web entry and the parcel that contained the corresponding field point (Figure 5). Even with 91% of web entries within 100 ft. of the correct location, this test revealed that only 50% of web points were sited within the correct parcel, 88% were located in the correct parcel or within one parcel of the correct one, and 98% were located in the correct parcel or within two parcels of the correct one. The disparity between positional accuracy and correct parcel placement is explained by the urban setting of Los Angeles, as the commercial corridors which host outdoor advertising are often lined with narrow parcels. This level of accuracy is likely not good enough to be considered viable for LADBS's purposes in regulating signage, as signage is permitted based on parcel.

Figure 4. Sample image of ArcMap with line measurements between web and field data points.

Figure 5. Sample image from ArcMap with web point separated from corresponding field point by one parcel.

The Billboard Map relied on users to manually enter attribute information including the number of sign faces, and whether a sign was lighted or digital. In the majority of cases, these fields were left empty. The finding is in line with existing studies of VGI. OSM's positional quality far exceeds the quality of other attributes (Girres & Touya, 2010; Haklay, 2010; Zielstra & Zipf, 2010).

The temporal quality of the website's data was in large part dependent upon the temporal quality of the GSV data. Although the website allowed a user to enter a sign whether or not it was actually shown in GSV, no users during the test period did so. Although GSV data is updated, on average, every 18 months, a review of GSV in Los Angeles shows that the data has been updated every three to six months for the last three years. The inventory of billboards created by the City of Los Angeles, on the other hand, is conducted every two years.

The spatial data quality assessment was run on 326 signs, and, given that the estimated number of off-site signs in Los Angeles at the time was 10,000, it was clear that the Billboard Map data was incomplete. However, the entry rate of the data suggests that completeness would be an on-going issue. According to the city's 2014 inventory, there are 8,814 off-site sign faces within the municipal boundaries. In the first three months of operation, the Billboard Map contained 431 sign faces (105 of the 326 signs were double-faced signs). At a rate of 431 in three months, it would take years for the public to map the nearly 9,000 sign faces in the city.

As in OSM datasets, the Billboard Map's completeness varies over space. Whereas OSM coverage drops from urban to rural areas, the Billboard Map dataset varies across the urban setting. Most users entered only one sign, but a few users entered many signs along one stretch of roadway. Accordingly, most parts of the city were unmapped while a few corridors have near complete coverage. For instance, one registered user entered 56 sign faces along a 2.2mile stretch of Melrose Boulevard, making the coverage in this area much more complete than in other parts of the city.

The spatial data quality factor that separates the Billboard Map most noticeably from other VGI studies is over-completeness. Unlike OSM users, the users of the Billboard Map entered excess data points. First, they mapped signs that were outside the municipal boundary of Los Angeles. The city of Los Angeles comprises a large, awkwardly shaped area, with numerous smaller municipalities within its bounds or adjacent to it. Some of the cities, such as West Hollywood, which contains the famed Sunset Strip, and City of Industry, have much more lax regulation of signage than the city of Los Angeles. With the proximity of the cities and the size of signage, outdoor advertising that sits in, and is therefore regulated by, one city can easily be seen from other cities.

The aspect of over-completeness that is most striking is the type of signs mapped by volunteers. Billboard Map users mapped signs that were not of the type identified in the city inventory. City inspectors recorded only the traditional style of off-site signs, the pole, wall, and roof signs known in the vernacular as "billboards" (Figure 3). The VGI dataset of the Billboard Map includes many types of signs beyond these traditional billboards. These include massive signs integrated within new architecture (Figure 6a), supergraphics wrapped around older structures (Figure 6b), signs posted on fences (Figure 6c), and wall signs of larger dimensions that older wall billboards (Figure 6d). Judged against the city's inventory, these signs are excess data that undermine the spatial data quality of the dataset.

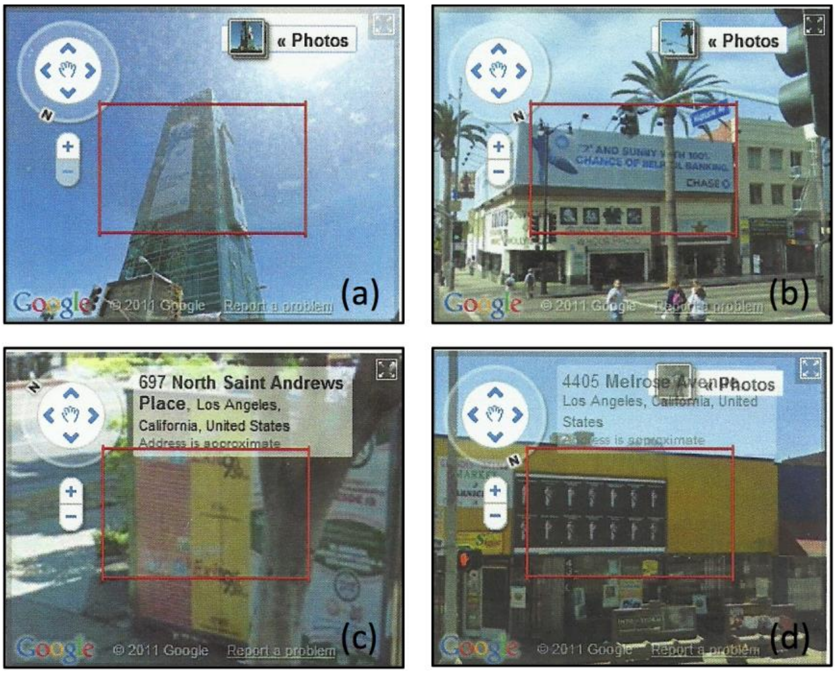

Figure 6. Sample Google Screen View images of Billboard Map entries, showing "excess" data points of signage not collected by city inspectors.

5. The Ontology of Off-Site Signage and the Ontology of the Landscape

Though LADBS limited its inventory to traditional pole, wall, and roof billboards, the legislation creating the program does not so limit its scope. The inventory ordinance states, "All off-site sign structures as defined in Section 14.4.2 of the LAMC and subject to the provisions of Chapter I of the LAMC are subject to regular inspection" (Off-Site Sign Periodic Inspection Program, 2014). Chapter I of the LAMC regulates development on private property but not government-owned property, hence the inventory is only of signs on private property. Section 14.4.4 defines an off-site sign structure as, "A structure of any kind or character, erected, used or maintained for an off-site sign or signs, upon which any poster, bill, printing, painting, projected image or other advertisement may be placed" (Sign Regulations, 2008). Notably, this language does not limit an off-site sign to traditional pole, wall, and roof signs. According to the language of the statute, therefore, the inventory should include any structure used for an off-site sign.

On closer inspection, the "excess" Billboard Map data appear to fit within this broad definition. These signs show ads for banking services draped down the sides of an office tower (Figure 6a) and wrapped around the top of a touristic gift shop in the heart of Hollywood (Figure 6b); they show ads for phone service on the fence around a car repair shop (Figure 6c) and liquor on the exterior of a butcher shop (Figure 6d). Therefore, these signs are "off-site signs" according to the city's definition and thus within the mandate of the city's inventory.

The discrepancy between the city residents' and inspectors' compilations of off-site signs appears to be based on differing ontologies of the two projects. The users of the Billboard Map website had a different conception as to the scope of signs to be mapped than that of the expert field inspectors working for the city. Somewhat ironically, inspectors for the city's "Off-Site Sign Periodic Inspection Inventory" only mapped a limited collection of off-site signs. For the Billboard Map, city residents mapped all kinds of off-site signs.

In fact, many types of off-site signs exist throughout the Los Angeles landscape in addition to traditional billboards. As noted, the city banned new off-site signs in 2002. Also in 2002, the city signed a contract with global outdoor advertising company JCDecaux for street furniture adorned with off-site signage (JCDecaux, 2002). Soon after, hundreds and then thousands of new off-site signs appeared across the city pursuant to this program. Because the inventory ordinance limits its scope to private property, these signs are not technically within its scope as they sit on public sidewalks. In addition to the ban on new off-site signs and the inventory program, the 2002 sign laws enacted a new zoning mechanism entitled Sign Districts, and the city soon enacted the first such district, the Hollywood Signage Supplemental Use District (2004). In the following years, the city permitted more than fifty off-site signs, most of which were supergraphic signs, spanning whole building walls. Billboard Map users mapped many of these signs, including those shown in Figure 6a and 6b. In 2007, the city allowed off-site signs on walls placed around construction sites and undeveloped lots, under the deceptively entitled Graffiti

Abatement Program (2007). These walls are intended to be temporary but without enforcement by the city and because they give a financial incentive to property owners to keep their parcels undeveloped, these often become permanent fixtures of the cityscape. Figure 6c shows one such signed mapped by a resident. Not long after the temporary construction wall sign ordinance was passed, the owner of the company that lobbied for the signs began erecting off-site signs under the cover of a law that permits temporary promotional signs. These signs feature small text along the sign frame stating "Come into (name of on-site business) and enter our sweepstakes for a chance to win these or related prizes". The sign faces, however, always display off-site advertisements, and are never images related to an on-site sweepstakes or other promotion. A number of these were also identified in the Billboard Map, such as that shown in Figure 6d. In 2011, the city entered into a contract with Martin Outdoor Media for bus benches adorned with off-site signs, and thousands of these signs now fill the city. The image in Figure 6d shows two such benches in the foreground. Like the JCDecaux street furniture signs, these sit on public property and are thus beyond the scope of the inventory mandate.

This list reveals the vast difference between the scope of the mapping project as understood by the Billboard Map users and the scope the city inspectors were tasked with. The discrepancy is due not just to different ontologies between the two mapping projects but to different ontologies as to the landscape itself. The Billboard Map data reveals that city residents view the urban landscape very differently than do city agents: urban residents view the landscape as a cohesive whole, while city agents view a landscape of categories. Landscape scholars argue that landscape is a "way of seeing" (Cosgrove, 1984), as much cultural as material. Landscapes are therefore open to interpretation as well as contestation. The disparity between the lived experience of landscape and the expert, planned conceptions of landscape (Mitchell, 2003; Mustafa, 2005) might explain why urban residents view the landscape differently than the city agents who regulate it. LADBS inspectors are tasked with enforcing specific code provisions, granting permits for individual projects, counting and cataloguing each of the thousand of off-site signs. They labor in the minutiae of the municipal code, and, in their working lives, the landscape is a categorical one.

The broader issue, though, is with the setting of the categories themselves. "Where competing accounts of what constitutes the categories of landscape exist, the fixing of those categories is an inherently political exercise" (Robbins, 2001, p. 162). The power inherent in the setting of landscape categories derives from the dialectical relationship between the cultural and material. Those who set the categories can remake the landscape accordingly. This dialectic, and the power to remake the landscape according to a changing ontology, is evidenced in the Los Angeles landscape. In 2002, Los Angeles banned new off-site signs following years of community protestation against the landscape of advertising (Pelisek, 2008). In the years following the ban, the city approved new categories of signage including street furniture, temporary construction wall, and bus bench signs, and then outdoor advertisers added thousands of new signs to the urban landscape pursuant to these categories. The city created the Hollywood Sign District in 2004, and it thereby permitted fifty massive new off-site signs to adorn development projects that are visible for miles outside of the sign district itself. By remaking the categories of landscape, the city decision-makers have remade the landscape itself.

In 2010, the Hollywood Sign District was effectively cancelled due to public backlash against the changes to the landscape. Yet the city's creation of new categories of signs continues. In 2011, the city approved a new sign district in the heart of its downtown that will allow a massive new development project adorned with off-site signage. At a public hearing before the City Council's Planning and Land Use Committee (2011), then-City Council member Jan Perry stated in support of the project, "What is being proposed by the developers is not a billboard", thereby distancing the proposed signs from the cultural baggage associated with the traditional categories of off-site signs. However, the Billboard Map shows that the residents of Los Angeles understand the landscape as a cohesive field of advertising, not as the collection of regulatory categories under which these signs are permitted. Whether the City Council deems these new signs "billboards" or not, residents see them as more off-site signs.

6. Conclusions. VGI for Improving Expert Data and Community Knowledge

The Billboard Map website was envisioned as a method of collecting data for the city's off-site inventory in the years that the program was politically stalled. The head of the inventory program was skeptical at the outset about the utility of the data for the city's purposes (L. Zamperini, personal communication, June 22, 2011), a common governmental response to VGI (Johnson & Sieber, 2013). On first look, Mr. Zamperini's skepticism is borne out by the results of the spatial data quality analysis, as the non-expert mappers did not understand the scope of the city's inventory project and mapped far more types of signs, yielding a dataset with excess data. To make the Billboard Map's data match the scope of the city's inventory, a future iteration of the project could employ a filter on sign type to limit the types of signs mapped by users or to require volunteers to complete a tutorial prior to mapping. Scholars note that stricter rules for collection of VGI can improve the quality of spatial data (Girres & Touya, 2010; Haklay, 2010), yet scholars also suggest caution in applying rules so as not to stifle creative and unconventional map-making (Van Exel et al., 2010). The Billboard Map VGI shows that the creativity of non-professionals reveals itself in unlikely ways. The spatial data sought here—off-site signs—is straightforward. Signs are large, material structures, not ephemeral happenings. The project was not designed to collect opinions or ideas about signs (Rinner et al., 2011); it was not designed to map emotions about signs (Kwan, 2007); it did not ask residents to envision future spaces with or without signs (Seeger, 2008). Yet from the simple mapping task undertaken by so-called sensors, we learn an unexpected insight about how residents experience the urban landscape. This finding supports the argument for caution in applying filters or other rules for data collection in VGI projects.

Further, by inadvertently ignoring the city's categorical distinctions, the users of the Billboard Map have pointed out that the so-called "Off-Site Sign Periodic Inspection Program" is a vastly incomplete record of off-site signs in the city. It may be that the discrepancy between the city's actual landscape of off-site signs and the city's inventory of off-site signs is an inadvertent error. Just as we can imagine technical rules for improving the quality of the Billboard Map dataset, we can imagine instructing LADBS inspectors to correct the scope of the project to match the language of the ordinance. Yet the scope of the inventory appears quite intentionally limited; in fact, a number of off-site signs beyond pole, wall, and roof signs were listed in the 2012 inventory but removed in 2014, including the massive off-site signs on the "Hollywood and Highland" development that is now home to the Academy Awards show and an upscale shopping mall. The outdoor advertising industry has great influence in Los Angeles City Hall, and legislators repeatedly push for growth of signs and lack of transparency at the behest of the industry (Pelisek, 2008; Smith, 2012). The creation of new sign categories to avoid the ban on off-site signs has been a tactic of urban and industry decision-makers. The inventory itself obscures the fact that many of the pole, wall, and roof signs in the city are unpermitted and illegal (Sedano, 2016). The limited scope of the inventory to only a handful of the many types of off-site signs that now adorn cityspace appears to be another tactic in this overall strategy.

The political backdrop of outdoor advertising inspires a different viewpoint on the question of whether to include spatial data quality rules to improve the volunteers' mapping of signs. Asking residents to map signs according to the city's limited ontology is to engage them in the Sisyphean task of helping a city appear to regulate without actually regulating. Much more useful is for residents to continue to map signs according to their experience of cityspace. A map of the actual extent of off-site signage in the city could be incredibly useful in countering the conjoined efforts of capital and state to grow the advertising landscape, offering a rebuttal to the city's categorically limited yet politically acceptable inventory.

As outdoor advertising grows in Los Angeles cityspace, it spreads in cities around the world. Indeed, companies such as JCDecaux, which have remade the Los Angeles landscape, are remaking the urban landscape globally by coordination with local agencies (Iveson, 2012). Los Angeles residents have alerted us to the fullness of signage that is obscured by categorization. The global nature of the industry requires future study to discover whether these tactics are employed throughout the world to spread signage, perhaps uncovering the growth of advertising obscured by the local nature of sign regulation. Engaging urbanites to map the full extent of signage is a counter-tactic available when officials lack the political will to regulate the advertising landscape.

Acknowledgments

Many thanks to John Given, Daniel Goldberg, Dennis Hathaway, Karen Kemp, Su Jin Lee, Reid Priedhorsky, Kaveh Shahabi, and John Wilson for their support of this project.

Conflict of Interests

The author declares no conflict of interests.

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Urban Planning (ISSN: 2183-7635)
2016, Volume 1, Issue 2, Pages 88-100
Doi: 10.17645/up.v1i2.620

Article

Ensuring VGI Credibility in Urban-Community Data Generation: A Methodological Research Design

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Submitted: 11 March 2016 | Accepted: 5 June 2016 | Published: 27 June 2016

Abstract

In this paper we outline the methodological development of current research into urban community formations based on combinations of qualitative (volunteered) and quantitative (spatial analytical and geo-statistical) data. We outline a research design that addresses problems of data quality relating to *credibility* in volunteered geographic information (VGI) intended for Web-enabled participatory planning. Here we have drawn on a dual notion of credibility in VGI data, and propose a methodological workflow to address its criteria. We propose a 'super-positional' model of urban community formations, and report on the combination of quantitative and participatory methods employed to underpin its integration. The objective of this methodological phase of study is to enhance confidence in the quality of data for Web-enabled participatory planning. Our participatory method has been supported by rigorous quantification of area characteristics, including participant communities' demographic and socio-economic contexts. This participatory method provided participants with a ready and accessible format for observing and mark-making, which allowed the investigators to iterate rapidly a system design based on participants' responses to the workshop tasks. Participatory workshops have involved secondary school-age children in socio-economically contrasting areas of Liverpool (Merseyside, UK), which offers a test-bed for comparing communities' formations in comparative contexts, while bringing an under-represented section of the population into a planning domain, whose experience may stem from public and non-motorised transport modalities. Data has been gathered through one-day participatory workshops, featuring questionnaire surveys, local site analysis, perception mapping and brief, textual descriptions. This innovative approach will support Web-based participation among stakeholding planners, who may benefit from well-structured, community-volunteered, geo-located definitions of local spaces.

Keywords

community participation; data credibility; geo-spatial quantification; participatory methods; quality of data; urban planning; volunteered geographic information

Issue

This article is part of the issue "Volunteered Geographic Information and the City", edited by Andrew Hudson-Smith (University College London, UK), Choon-Piew Pow (National University of Singapore, Singapore), Jin-Kyu Jung (University of Washington, USA) and Wen Lin (Newcastle University, UK).

1. Introduction

Effective urban planning must reflect citizens' experiences of socio-spatial inequalities (cf. UN-Habitat, 2009, p. xxiii), which relate to place-specific factors of social distinction and cultural identity (Cassiers & Kesteloot, 2012). Such inequalities are widening due to major economic and infrastructural changes in many cities around the world (cf. UN-Habitat, 2012, p. 83), and reveal uneven distributions of economic, social and cultural resources (cf. Marcuse, 2002, pp. 11-34; UN-Habitat, 2009, pp. 31-39). The effects of spatial inequalities include the urban population's uneven levels of access to their city's resources, resulting from both physical barriers and social exclusions (cf. Grant, 2010, pp. 5-9).

Communities as urban forms are distinguished by their network interactions at spatial, social and semantic levels. This means that people in a segregated spatial enclave, for example, develop bounded networks that sustain the community, based on proximity, needs and resources and cultural affinities. Spatial inequalities are apparent in community environments as people's quality-of-life capabilities are affected by, for example, their self-identification or sense of entitlement relating to a place; yet these inequalities are not always directly visible to community participants (discussed by Dorling, 2012, pp. 220-222).

Community participation may assist urban planners in understanding the non-discursiveness of community formations, especially in highly localised spaces. There has been renewed emphasis on empowering community participants to articulate their positions in terms of their localized definitions (Chambers, 1995). Many indicators of inequalities that are highly salient relate to visible urban-fabric or socio-cultural differentiations (cf. Chokor, 1991; Veiga, 2012). Less salient, however, are information-based indicators such as social connectedness and access to economic opportunities (cf. Morsey, 2012; United Nations, 2013, p. 77). Current analyses of spatial inequalities are generally based on broad (and costly) economic and social surveys (e.g. at the city level). Community participation based on volunteered geographic information (VGI) provides a cost-effective means of gathering a wide range of data relating to localities and their inter-relationships with urban infrastructures and political agencies (Haklay, Antoniou, Basiouka, Soden, & Mooney, 2014).

While participation based on VGI offers benefits to both researchers and participants in urban planning, it also poses challenges in its uptake and use in professional and scientific domains (Tulloch, 2007). One challenge relates to the diversity of community among data producers, who diverge in their levels of expertise and the nature of their motivations for participating (Coleman, Georgiadou, & Labonte, 2009). Another challenge relates to the credibility of using volunteered information, which has been addressed by Flanagin and Metzger (2008). Credibility as a quality may stem from the data *accuracy* of scientific enquiry, or from its *believability* for social or experiential engagement. However, believability based on perception of quality may result from the participant's 'rule-of-thumb' cognitive heuristics, rather than a well-defined rationale for evaluation (Flanagin & Metzger, 2008). The authors maintain how information abundance, resulting from Web participants' multifarious engagements with geolocation technologies, is associated with paucity in credibility and a so-called 'context deficit' for data management. Hence, the range of data sources and styles of metadata generation (for example, of image tagging) have resulted in low credibility of voluntary data overall. This paucity has, in some cases, been overcome by 'credentializing' participants in the required domain of expertise (such as, for example, in wildlife identification; cf. Goodchild, 2007).

Upholding data quality may thus place a burden of responsibility on data providers in geospatial data-sharing communities (Goodchild, 1995, pp. 413-425). Hence Lush, Bastin and Lumsden (2012) have outlined a requirement for providing standard indicators of geospatial metadata credibility. The authors have offered a range of indicators to uphold data quality in decision-making domains, including possibilities for credentialing the data provider through a so-called 'community advice' process. In such a process, peer review of geospatial data could allow users and experts to provide commentary on datasets provided, including any limitations and problems associated with the data.

2. "Visualizing Community Inequalities"

The work outlined in this paper stems from a broader project at University College London, "Visualizing Community Inequalities" (VCI) (supported by the Leverhulme Trust), which aims to integrate an urban model of local community identities in their urban-network and geo-demographic contexts. The challenge is to integrate into the model urban communities' definitions of their local spaces, based around composite or multi-dimensional markers of these spaces. The investigators also found that a major challenge of integration relates to the variability in VGI participants' levels of engagement, confidence and skill, which we addressed through a structured workshop format (outlined below). Through this we have sought to identify what spatial structures are employed by urban communities to define their local spaces. Our approach is in contrast to a notion of local community spaces being formed around distinctive boundaries or binary definitions of what lies 'inside' and 'outside' the community space. Instead, we surmise that local markers of community spaces stem from 'relational artefacts' of physical and conceptual inter-dependencies, which underpin spaces for connectivity, separation or interaction. Such local spaces form around community foci and street-network functionalities within spatial-structural and geo-demographic contexts. The overarching research challenge is to integrate urban structural, demographic and semantic layers into the urban model.

The research design of the VCI project has similarly addressed the need for data credibility by including in the methodology a stable and rigorous format for participatory point-data generation. Here point data has been gathered in terms of well-defined socio-economic and urban structural contexts. In this approach, we aim to develop a Web-enabled platform for credible, volunteered point-data generation. Yet the process of characterizing urban communities for integrated digital modelling has posed a challenge of complexity to the investigators. This led us to develop a 'pen-and-paper' prototyping methodology (based around participatory workshops). The aim of this was to generate diverse data pertaining to socio-spatial characteristics of the communities sampled at both the community (aggregated) and individual (disaggregated) levels. We subsequently selected only the most relevant and salient of the data for inclusion in the platform's data model. Here we report on the qualitative participatory methods and quantitative analytical methods for ensuring the quality of data capture. We present a case study of our research in Liverpool, (Merseyside, UK), which provides a compelling background for research into urban community formations in highly contrasting socio-economic contexts.

3. Deriving Urban Community Data for Planning

Urban communities involve subtle and irresolvable interplays of social meanings and spatial structures, forming their physical and symbolic boundaries (Logan, 2012). Community spaces also include effects from within the broader urban network (Hillier & Vaughan, 2007; Sampson, Morenoff, & Gannon-Rowley, 2002), positioned with multiple layers of spatial, social and effective properties (Grannis, 2009), thus posing a significant challenge to consistent data gathering.

Community spaces are special features of the urban environment, formed through the socio-spatial configurations by which people achieve 'nearness' at many levels of the home, street and public space. Community spaces comprise relational complexes of object and abstract artefacts (Hillier, 2007, pp.67-68), which we term physical and conceptual artefacts respectively. Homogeneity and separateness in the urban environment can enforce stereotypes of 'self' and 'other' (Sibley, 1995). These may also be reflected in socio-spatial structures and behaviours, including neighbourhood boundaries and place-bound identities or values (Mckenzie, 2015).

Community spaces that are conceptualized and defined as neighbourhoods afford the benefits of family life, social experiences and economic opportunities (Kearns & Parkinson, 2001). Yet neighbourhood identities are not spatially or temporally fixed. Community members' concepts of their neighbourhood vary according to, for example, their age, gender, level of ability, socio-economic standing or stage in life (Lupton, 2003).

The intermediaries of community spaces, their topo-geometric and topographic properties, provide the means by which urban actors both *think of* and *think with* their environments (Hillier, Turner, Yang, & Park, 2010). For example, the theoretical and methodological field of space syntax has shown how cities are arranged topo-geometrically into foregrounds of economic movement and backgrounds of controlled, residential zones. In these contexts the observer sees the 'other' city (whether background or foreground) relative to his or her position (Hillier & Vaughan, 2007). We *think of* these networks in terms of theoretical and professional discourse; we *think with* them in terms of quotidian actions based upon spatially embedded meanings.

Elsewhere the anthropologist Tim Ingold has similarly outlined an epistemological split between professional and 'inhabitant' spatial cognitions, stemming from distinctions of analytic and embodied knowledge respectively. Ingold has argued provocatively for a notion of 'way-faring' in spatial cognition, whereby the inhabitant develops his or her local and embodied knowledge through tangible encounters with flows of environmental information (Ingold, 2011, pp. 146-155). So too, various urban sociologies have described the embeddedness of local structures in community formations. For example Grannis (1998) has highlighted the importance of supposedly 'trivial' streets that interconnect blocks of tertiary streets, thus providing a path for novel community links to form. Elsewhere, Power and Houghton (2007) have identified spaces of community connectivity and urban innovation, which are not always visible to the official planner (Power & Houghton, 2007, pp. 158-159), and can lead to separation from social cores such as family homes (Power & Houghton, 2007, p. 55). In this way the authors observe how infrastructural projects have undermined or replaced 'community anchors', such as places for stopping and chatting or for children's play (Power, 2007, pp.58-59).

Considering the embedded, embodied or non-discursive nature of community formations around physical artefacts at a more theoretical level, Conroy and Bafna (2003) have drawn on seminal work of Lynch (1960) to re-define urban taxonomies in terms of their 'imageability'. In a similar vein, Palaiologou and Vaughan (2012) have offered a synthesis of urban structures that control movement among individuals and communities, namely those of *boundary*, *threshold and interface,* and their potential role to *divide*, *connect* and *allow interaction.* The VCI project sought to address these themes to case-study sites in areas of polarized socio-economic inequalities, with a view to revealing how communities in these contrasting areas variously employ local features to demarcate their local spaces.

4. Case Study

In our current work, we invited urban communities in Liverpool to volunteer information about their local spaces in terms of connectivity, separation and interaction. Liverpool is the UK's third city by regional population. While enjoying higher than-average economic growth in the period 2009–2014 (Liverpool City Council [LCC], 2016a), the city has among the highest levels of multiple deprivations of any UK local authority (LCC, 2015). The Liverpool region is 'a place of contrast and social and spatial disparities', bearing a range of spatial inequalities reflected in zonal concentrations of wealth and poverty (Sykes, Brown, Cocks, Shaw, & Couch, 2013, p. 6). It can be characterized historically as an area of prolonged industrial decline, reflected in overall above-average unemployment (5.7% at the time of writing), neighbourhood dereliction (cf. Hilditch, 2014), and low business density (LCC, 2016b). The Mersey estuary region is now attracting massive brownfield infrastructural investments, with groundwork currently under way. Within the Liverpool region, community inequalities within neighbourhoods at the peripheries of these developments present among the UK's most polarized spatial inequalities (findings of a study by Dorling et al., 2007). The region's transport authority has also advanced a progressive policy agenda, 'Connected Communities', which highlights the crucial importance of transport in revitalizing the urban region. A round of stakeholder consultations with urban practitioners and policy makers in Merseyside revealed the suitability of focusing on secondary schools in the city region, as they provide a stable environment and baseline for community-based research within a (planning) domain-sensitive context.

5. Area Characterization Methods

A preliminary characterization of all possible target schools in Merseyside area was carried out with the objective of creating a solid quantitative contextual background for the research. This preliminary step created a well-informed sample of schools and produced general contextual data, against which the much more detailed and contingent data gathered at the workshops could be compared and interpreted. The complete population of 79 state-sector secondary schools in Merseyside was characterized according to two broad sets of attributes: one covering demographic and socio-economic aspects, and another covering urban-structural characteristics.

Demographic and socio-economic attributes were quantified for the Lower Super Output Areas (LSOAs) where each school is located, using the 2015 Index of Multiple Deprivation (IMD). Super Output Areas are geo-located units devised by the UK's Office of National Statistics (ONS) to represent population aggregations by place of residence. In the present context, LSOAs represent locations of around 1500 people in small residential areas. IMD provides a measure of relative deprivation, by which LSOAs are scored and ranked from least- to most-deprived. IMD is constructed by weighting indicators covering seven aspects of deprivation, namely: income, employment, health deprivation and disability, education skills and training, barriers to housing and services, crime and living environment. IMD and its separated sub-domains are provided as open data sets by the ONS.

Urban form and structure attributes were computed in a GIS from Ordnance Survey (OS) data, including layers representing the full road network hierarchy and the footprints of all buildings. Access points to public transport modes were also reckoned, using the UK Department for Transport's NaPTAN data set. The various urban-form and road-network structure indicators were computed through vector manipulation and quantified for the areas within circular buffers of 1 km radius, centred on each school's postcode centre point. These morphological indicators cover six aspects of urban form and structure, namely: geometry and topology of the street network (e.g. total length, number and type of junctions), geometry and topology of blocks (e.g. number of blocks, area/perimeter ratio of blocks), density and grain of buildings (e.g. number of buildings and total built-up area), network centrality measures (e.g. maximum betweenness centrality value) and density of public transport access points (e.g. number of bus and taxi stops).

Regarding the demographic and socio-economic characterization of Merseyside schools, we have made use of a set of geo-statistical clustering methods known as Local Indicators of Spatial Association (LISA), applied to IMD values encoded into the geography of LSOAs in the Liverpool Region. More than just quantifying the level of deprivation of each single LSOA containing a school, we were in fact interested in the *embeddedness* of such LSOAs within potentially larger geographical patterns of relative deprivation. Indeed, it is well known that the shape and size of the spatial units into which data is aggregated, has an unavoidable biasing effect (known as the 'modifiable areal unit problem') on the resulting aggregated value. Therefore, to merely collect the IMD values (or of its sub-domains) for each LSOA containing a school, would produce only coarse and not very reliable data.

LISA methods allow researchers to evaluate the variability of geographical attributes not only for each feature, but also for the features within a given neighbourhood around each one. In other words, LISA tell us the degree to which a feature has a particularly high or low value, according to the attribute itself *and* the location of the feature in question. Therefore, one may evaluate the degree to which a school located within a high-, medium- or low-deprivation LSOA is also located within a larger area of relative deprivation respectively. If, for instance, high deprivation is verified across a reasonable range of distances (e.g. 0.5 km, 1 km, 1.5 km and so on) around a deprived LSOA containing a school, one may say with a very high level of certainty that such a school does indeed lie within an area of consistent and systematic deprivation. Using this method, we have made a characterization of the socio-economic embeddedness of every public-sector secondary school in Merseyside, targeting those lying in areas of consistent deprivation patterns, as described by IMD and its sub-domains.

The sampling of schools using as criteria their contrasting socio-economic characteristics also results in a strong variability regarding the morphological characteristics of the urban environments where those schools are located. To account for such variability becomes a fundamental step, in order to control for its potential impacts on the phenomena studied through the data gathered in the school workshops. The general physical and spatial morphological characterization of the schools' environments is therefore expected to provide complementary information to their socio-economic characterization, and also to serve as benchmark by which the information gathered in the workshops may be evaluated.

The morphological indicators mentioned above will be fed into a methodological data-flow model (which we present in Section 8, below) at a later stage of the research project. These indicators were chosen for their acknowledged support in distinguishing relevant aspects of urban form (such as building and network densities or network connectivity and geometry), which change significantly across urban areas and historical periods. Each morphological indicator results in a single figure for each area surrounding each school; together, they can be analysed through multivariate statistical methods in order to obtain summarized but consistent morphological descriptions and classifications. The use of network centrality measures allows us to generally characterize the urban movement potential of a given area, and therefore to make basic inferences about the probability of co-presence and social interaction on that area. Finally, the reckoning of the number and type of public transport access points, provides information about an area's accessibility degree, exposure to city-wide social networks and of the affordance of public space.

6. Participatory Research Methods

Once the sampled areas had been characterized, the investigators sought to understand how local populations made use of urban structures within socio-economic contexts to formulate the demarcations of their community spaces. In other fields, geographers have highlighted the significance of people's mental maps of urban landscapes (cf. White & Gould, 1986). There seems to be a task outstanding to identify the relational complexity of community spaces resulting, that is, from the conceptual subsuming of physical artefacts into locally embedded or everyday processes (cf. O'Brien & Psarra, 2015).

In order to study this complex field and to ensure data credibility in a participatory VGI context, the investigators devised a workshop format whereby participants would work creatively within a structured framework. The workshops focused on themes of affordances for connectivity, separation and interaction in an area of 1 square mile surrounding the school, with the school located at the centre of the area sampled. Participation was invited from all state-sector secondary schools (excluding special schools) across the Metropolitan County of Merseyside, via an invitation submitted to teaching staff located across the county (Figure 1). Our intention was to include in the study schools representing the range of multiple deprivations in the city, while maintaining a broad balance in gender profile.

In total, 14 secondary schools participated, representing the range of areas in Liverpool by various indicators of deprivation (Figure 2). Approximately 360 participants engaged in the workshops, comprising 51% male and 49% female students. Around 230 participants were aged 13–14, around 80 aged 15–17, and a far smaller number aged 18. As most participants were children, it was not possible to gather data about individual circumstances relating to deprivation. However, an assumption was made that participants have general experience of typical social, structural and environmental characteristics of these areas.[1]

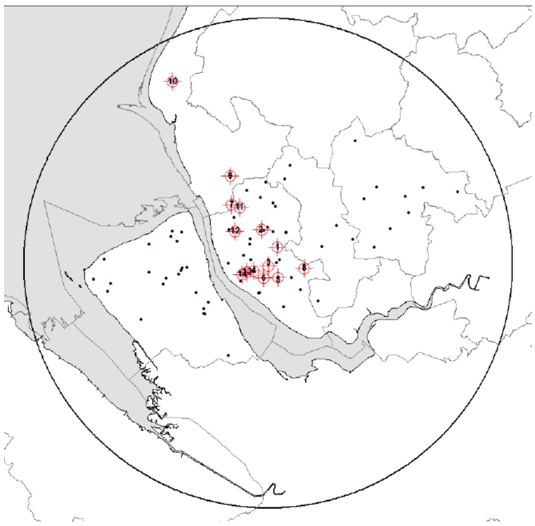

Figure 1. Locations of schools invited to participate in the workshops located within Merseyside. The schools selected for the sample (highlighted) were limited to contrasting areas within the city of Liverpool. The outer circle demarcates the geographic scope for statistical sampling (radius=25 km).

[1] Workshops were organized with the assistance of an external partner, Placed, a non-profit creative enterprise based in Liverpool (http://www.placed.org.uk).

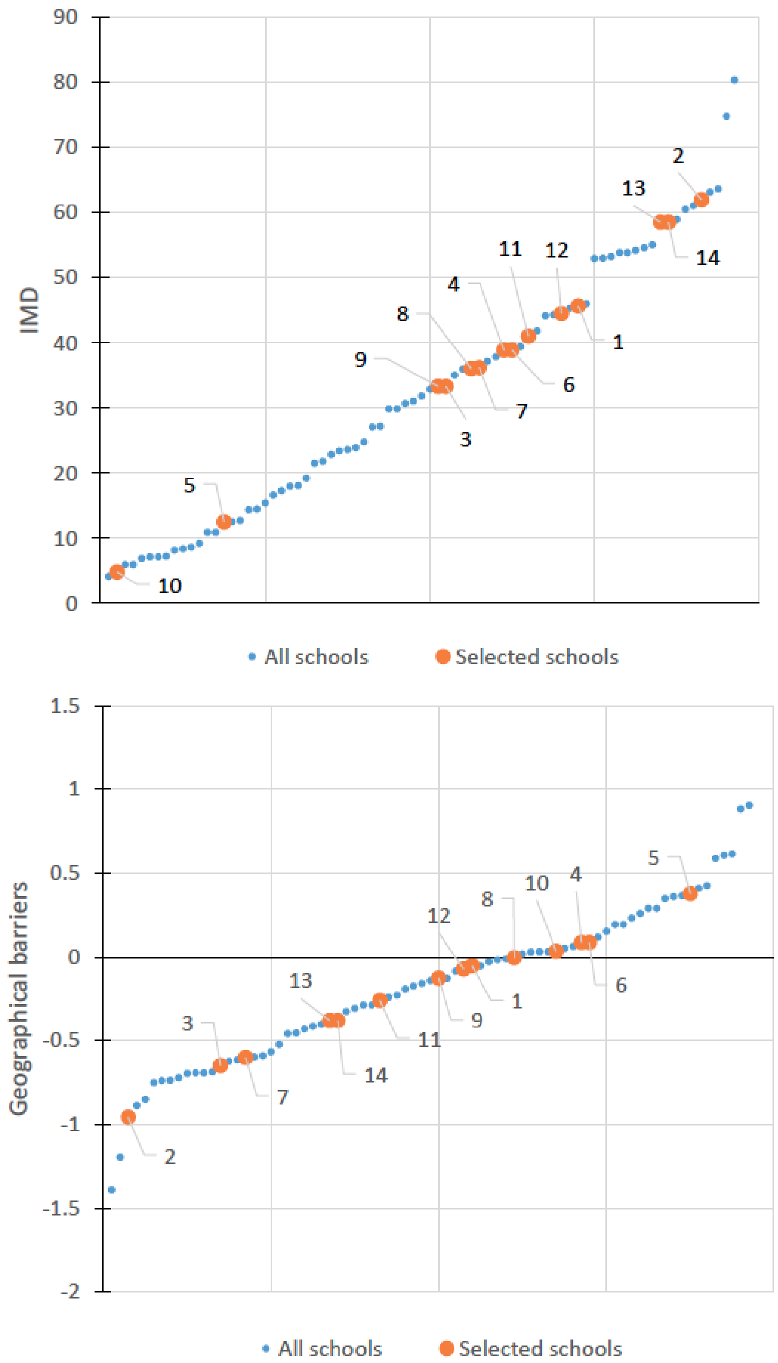

Figure 2. Two rank plots of the 14 Liverpool schools participating in the workshops (highlighted points) and of all state secondary schools in Merseyside (non-highlighted points). The y-axis denotes the values of the Index of Multiple Deprivation (IMD, top) and of the Geographical Barriers sub-domain (bottom), with high values meaning highly-deprived LSOAs; the x-axis denotes each LSOA rank value. IMD reveals a cluster of schools located within LSOAs of moderate IMD scores, with outliers in low- and high-deprivation areas. IMD sub-domains such as Geographic Barriers (bottom) reveal a more even distribution of sampled schools, although deprivation levels generally correlate to accessibility levels.

The investigators followed a methodology of community participation that seeks to equip the participants to analyse and describe their own 'realities' (Chambers, 1997). The aim was to bring about a 'transformative' participatory experience, whereby unfamiliar concepts are introduced and barriers to understanding are surmounted through close dialogues with facilitators (cf. Meyer & Land, 2006). Hence, participants received basic 'class-room' training in the impact of the urban fabric for community connectivity, separation and interaction. Participants were arranged into age-based groups of 3–4 people, including groups of 12–13, 14–15, 16–17 and 18–plus year-olds. The session used image-based case studies of urban fabrics, and involved participants in simple evaluation exercises. Following this, the participants undertook an evaluation of their local school area using A1 maps, colour-coded sticky dots to demarcate significant places and string to demarcate paths.

Participants then made use of their individual packs of workshop materials. An important element for capture of metadata was a questionnaire survey (extracted from a format devised by Scholes, Boniface, Stockton and Mindell (2016). This was devised to capture:

- Basic personal details;
- Level of social engagement;
- Sense of difficulty getting to/from school;
- Sense of the local area (weighted scale: positive-to-negative);
- Knowledge of local proximity to amenities and services;
- Range of districts visited in previous 12 months;
- Range of travel modalities employed.

The investigators also included in each pack a person character card, selected from a set that was devised by the researcher to reflect some typical experiences of people living in deprived areas (e.g. relating to health, employment, personal relationships, hazards and disorders). The purpose of this was twofold. Firstly, we wished to avoid the possibility of stigmatization (i.e. facilitators were restricted by the school Head Teachers from introducing themes of 'deprivation' in describing the local area during the workshop). Secondly, we encouraged the participants to reflect on the broader needs of the community. For example, character scenarios invited the participants to think about local structures from another's perspective, which also fits a 'dialogic' model of relational complexity (O'Brien & Psarra, 2015)[2]. Participants filled out a brief questionnaire about that character's needs in the local area, from which we may draw a set of broader community requirements.

Participants worked individually with A3 local maps representing 1 square mile (1.7 km^2) surrounding the school (Figure 3). This sample represented typical distances between local amenities and services proximal to the school, such as shops and transport links. These distances are set within a radial scale relating to walkability, or to 'velo-mobility', that is typical of participants' everyday mobilities. Participants were invited to apply emoticon stickers to any number of local structures that they deemed significant for affordances of connectivity, separation or interaction among people in the local area. Participants could select from a constrained set of up to 14 emoticons. Sets of emoticons comprised representations of primary emotions by a standard psychological schema, basic hand gestures and abstract signs for 'hazard' or 'barrier'. Each participant was given one sheet of 5x sets of 14 emoticons. Participants made their own, individual interpretations of emoticons' meanings.

[2] The psychologist James Wertsch (1993) has outlined how children use such 'dialogic' imagination to construct their sense of reality by thinking with the experiences of another.

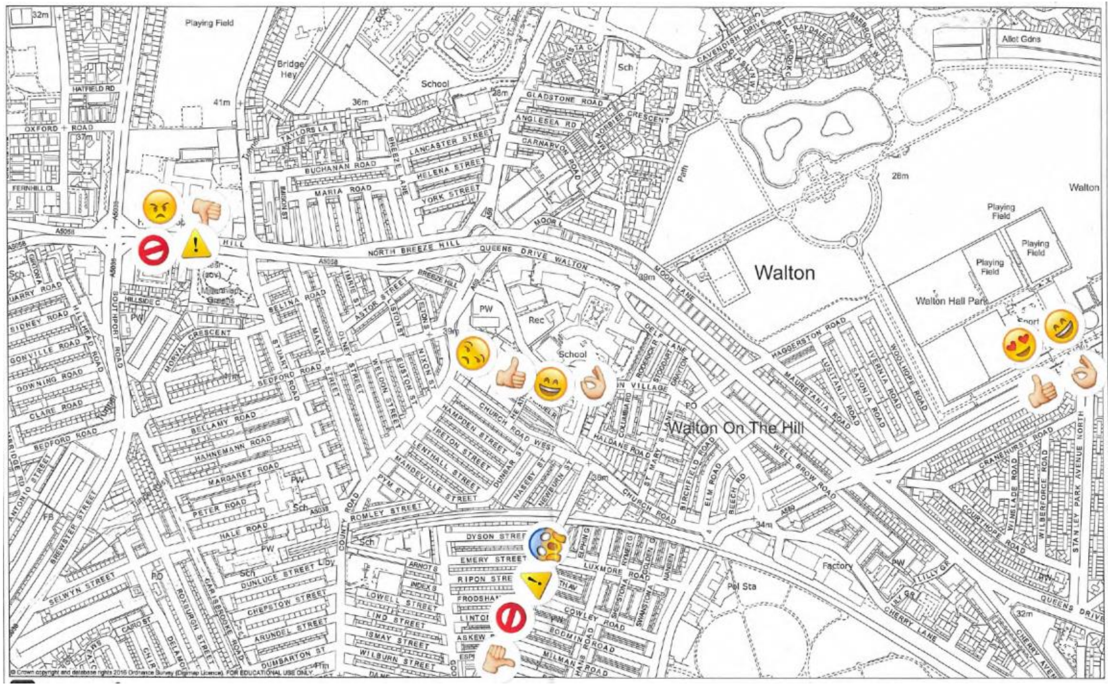

Figure 3. Example A3 map of local area (not to scale). Here a 13 year-old, female participant has selected four features that she regards as being significant for local community formations (including the school she attends, in the centre for the map). She has used several emoticon stickers to represent her range of thoughts, feelings or experiences, and so on, about these.

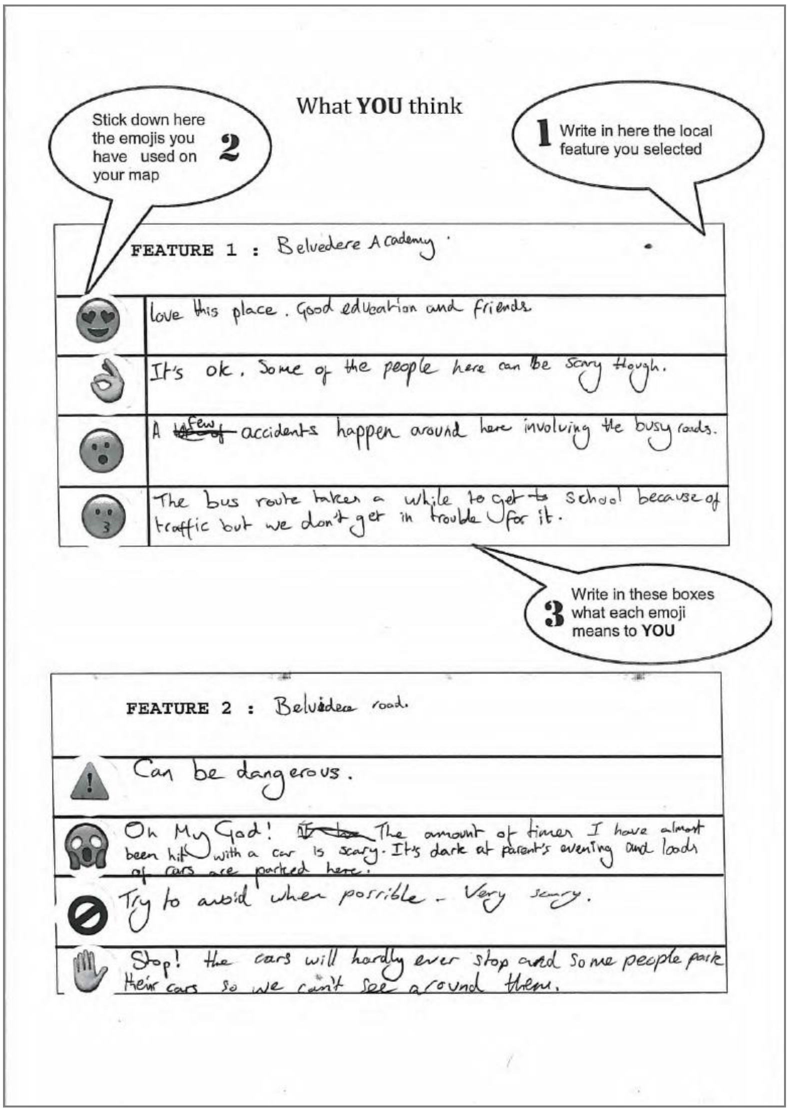

Figure 4. Example of completed emoticon table, with brief descriptions of each emoticon (not to scale). Here the participant has selected her school as being the local 'feature' most important for connectivity, and the local main road as that most important for separation. The participant has listed four emoticons for each feature, and written a text description of each emotion.

Participants were then invited to select two 'features' in the local area: one most important for connectivity and one most important for separation among local people. Following this, they were invited to fill out a table to list and describe the emoticons they used on their maps (see Figure 4). This involved listing the two most significant features for connectivity and separation, and sticking examples of four emoticons they had used down a left-hand column. Participants then filled in each table field with a brief description of what each emoticon meant to them with reference to the selected local feature (for example, 'fear' emoticon relating to a local park might be described as 'scary after dark').

The table was refined after four completed workshops to improve the quality of texts gathered. This was achieved by supplying the word 'because' in each field, compelling the participants to construct complete sentences around a causal factor (for example 'I was scared at the park gates *because* a gang was there'). These refined tables also included a list of example sentences, which helped improve the quality of texts gathered, while resulting on only occasional 'parroting' of the supplied examples.

7. Assessing Quality of Context for Data Production

The investigators' intention was to bring all participants, no matter their profile and background, to a broadly similar level of engagement in the data-gathering activity. This was measured through entry and exit surveys, which invited all participants to report on the impact of the workshop on their awareness and knowledge of urban design and communities, as well as their level of confidence and 'domain' knowledge in these areas (323 entry and 275 exit surveys were collected from 340 participants). Entry surveys demonstrated stark differences in the confidence levels and aspirations of students; only 21% overall reported any prior experience in working with built environment themes. Yet after training and practical work the majority of participants reported improved knowledge, awareness and confidence overall in addressing matters of formation and intervention in the built environment.

Comparing entry and exit surveys among participants revealed the overall positive impact on skills and knowledge resulting from engagement in the workshop (albeit our counting was biased by the lower return rate of exit surveys). On entry 32% of participants agreed and agreed strongly that they were aware of the impact of urban design on people, increasing to 91% upon completion of the workshop. Similarly, 68% of participants reported being aware of their local urban community environments at entry, rising to 94% upon exit. Confidence in talking about architecture and the built environment rose from 17% to 79% upon completion of the workshop. The exit surveys revealed a generally improved levelling of participants' knowledge of the built environment, perhaps reflecting the criticality of the community training exercises as part of the workshop format. This general levelling helped us to ensure that the data produce through the workshops was from a stabilized basis of skills, knowledge and awareness of our study's key areas of focus.

8. Methodological Data Model

In generating a research design for the VCI project, the investigators surmised that all urban communities comprise three informational layers: urban-structural, geo-demographic and 'semantic'. Hence, the urban-structural layer relates to street-network functionality in terms of movements; the geo-demographic layer relates (in the present context) to distributive patterns of socio-economic deprivations; the 'semantic' layer relates to locally embedded and inter-dependent definitions of community spaces. Modelling the semantic layer has posed an outstanding challenge for research and we have described our approach to this through data gathering via a series of participatory workshops. These have comprised a wide-ranging prototyping phase, from which we have gathered high-dimensional data. The complexity of the model being tested benefits from a diagrammatic model (see Figure 5).

The project data model reveals data gathering from urban spatial sources (structural and distributive) and local semantic sources. The local semantic data pertains to community definitions of local spaces, categorised as points (the location of emoticons) and weights (the type of emoticons applied). Points data may be processed algorithmically to reveal clustering around significant local features (such as community foci and street-network functionalities), and these may be taken as 'markers' of local structures for community life. Both weight and points data may be applied to take sections of the urban data; hence, horizontal sections may be taken at the city scale from categories of emoticons (for example, the section of data relating to all 'angry' emoticons), or vertical sections may be taken at the local scale relating to significant local structures. Once data sections have been taken, the investigators can then extract text descriptions of these markers. From these we may generate taxonomic categories of urban community localities. For example, where a park entrance has been widely demarcated with 'hazard' and 'angry' symbols, and described in terms of 'gang' activities, so we may taxonomize this as some kind of *barrier* to accessibility and community life.

9. Discussion

The phase of work reported in this paper forms one part of a broader project, which intends to develop a participatory, Web-enabled platform to support planning-domain processes. We adopted a 'pen-and-paper' prototype method for point-data capture, which allowed us to iterate rapidly a system design, to improve participants' levels of engagement, and to stabilize the data-generation environment. This prototype method would be readily transferable to any digital platform featuring, for example, Web-mapping capabilities and meta-data capture. The outstanding task for the investigators is to devise a 'linked' data model, which allows for the recombination of point- and meta-data so as to produce novel, localized definitions of community spaces.

Fortunately some current developments in open-source platform technologies support this kind of participatory map-making. For example, GeoKey is an open source platform that provides server-side, customizable geographic data components, allowing modellers to build a framework for participatory map-making and to manage volunteered data[3]. Elsewhere, various libraries within the R programming environment support overlays of geo-spatial and graph-theoretical network analyses, which are publishable to the Web (such as, for example, Spatial R, iGraph and Shiny). Used in combination, these allow the modeller to observe or simulate urban communities' dynamic inter-relationships.

Urban community formation is a multiple-layered, super-positional process, involving urban structural, geo-demographic and semantic components. Urban communities also make use of a range of artefacts in their built environments to define their local spaces. The 'relationality' of these artefacts involves their incorporation into locally embedded frameworks, whereby

[3] Developed by the Extreme Citizen Science Research Group at University College London (http://geokey.org.uk).

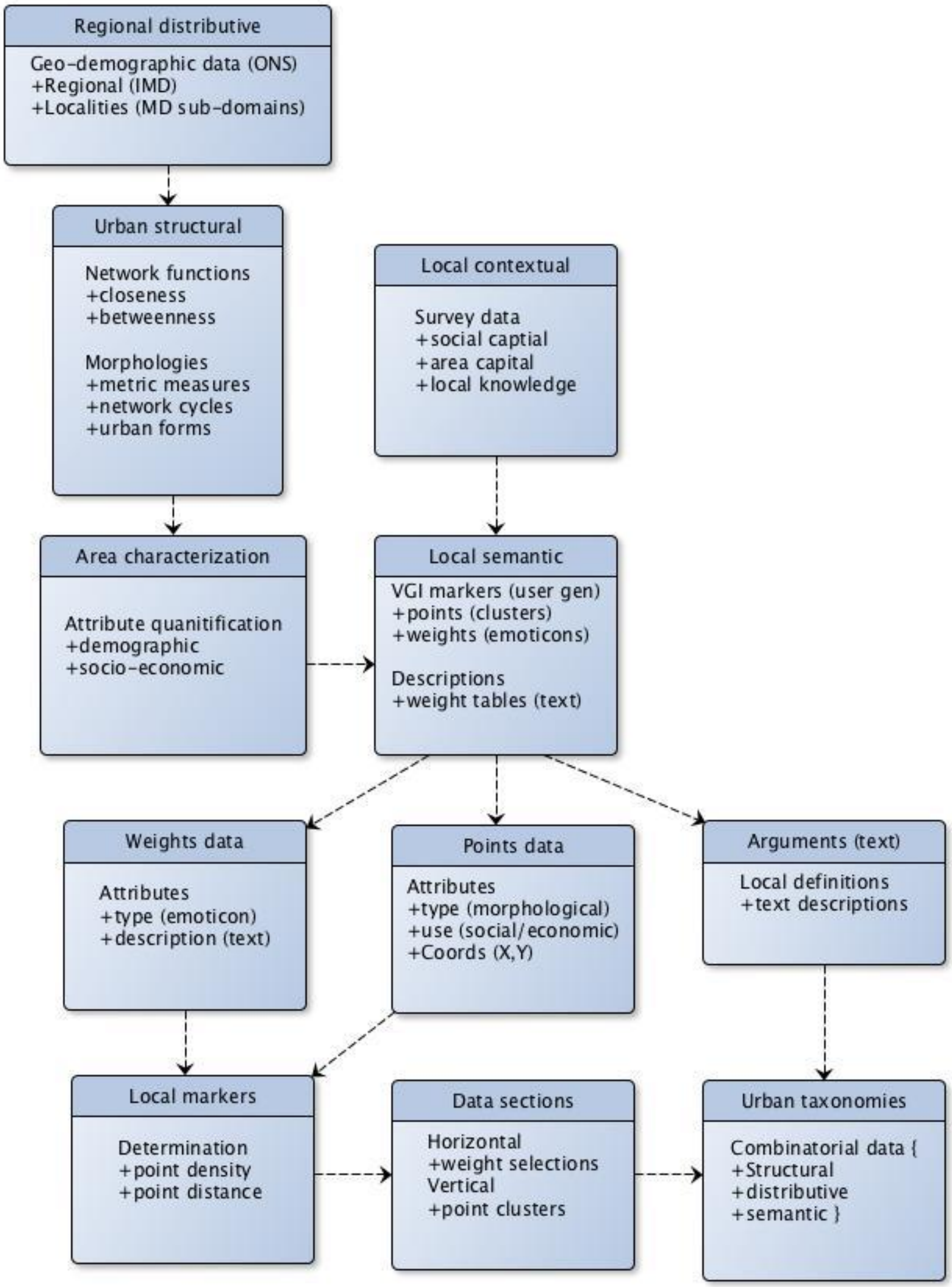

Figure 5. Methodological data model ('VCI project'). The model shows how a range of data flows into the study's urban community analysis, forming the basis for gathering voluntary point data and text data. It shows how 'local semantic' data is gathered from the participatory workshops, including the geo-locations (points) and characteristics (weights) of the emoticon stickers, the urban artefacts they represent, and their text descriptions. Finally, the processed points data will be used to taxonomize the range of artefacts selected in terms of comparative demographic and structural characteristics. In this way, the VGI data is captured traceably within a well-defined, multi-layered framework.

separate communities (or sub-groups within a community) may use the same physical artefacts yet attribute to them different sets of weights. Hence, one group's space for connectivity may be another's for separation.

Understanding how 'relational artefacts' are embedded in localised, everyday processes has posed significant challenges to the investigators. Firstly, we face the challenge of complexity in the multiple layers of urban community formations. Secondly, we face the problem of ensuring quality of VGI-derived data. In meeting these challenges, we have employed two contrasting modes of data capture, one based on quantitative structural and demographic characteristics, and one on qualitative or participatory generation of VGI data.

The workshop format we adopted attended to the need for credibility in data capture stemming from 'credentialization' of data producers. Hence, the workshop included a training component that helped to bring all participants to a broadly even level of knowledge, skill and capability in working with urban affordances and possible interventions, which we measured on broad terms via entry and exit surveys. The population sample comprised a range of secondary state-sector schools, providing us with a stable and well-defined baseline for study, as well as participant segmentation based on gender and age, and community profiling based on based on transport and mobilities categorizations. Further analysis may recombine the sample sub-populations more subtly, based on their personal and community profiles in combination with their selective 'weights' (such as, for example, the group of pedestrians in high-deprivation areas who experience overall negative feelings towards their local environments). Where the capture of VGI data has presented a problem of quality and consistency in geospatial analysis elsewhere, we have found that a voluntary approach framed within a well-defined and 'transformative' participatory context serves to maintain quality. Moreover, the participatory context has also benefitted from systematic analysis of area characteristics, meaning that highly diverse weightings and descriptions of local community formations are traceable to their specific socio-economic and structural contexts.

10. Conclusion

The investigators set out to ensure credibility in VGI-based data generation in urban planning through an iterative research design. Our intention was to achieve credibility by framing the enquiry. We focused on accuracy through a systematic urban spatial analysis, which served to formulate the structural contexts of our sample populations, including morphological affordances for community life in often challenging urban environments. We focused on believability by stabilizing the participatory data-production environment through comparative evaluations of participants' levels of engagement, which served to formulate their experiential contexts based on these generative affordances. This dual approach to VGI data credibility has allowed us to address the core concern for the inclusion of participants' experiences of socio-spatial inequalities in urban-planning processes.

We propose that the various datasets generated for the study may flow into an integrated model, which will underpin a connective (Web-enabled) platform intended for participatory urban planning. The employment of a participatory selection and weighting method means that we can show how community members are connected to their local spaces through various kinds of localised mediations. Hence, we intend to develop a layered graph data model of weighted and defined structures, which will comprise our next phase of work. Finally in the current project, the investigators intend to validate the study's multiple-layered model of urban community formations in a formal urban-planning domain.

Acknowledgment

The authors are very grateful to Jo Harrop, Director of Placed CIC, for providing additional information about workshop outcomes.

Conflict of Interests

The authors declare no conflict of interests.

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COGITATIO

Urban Planning (ISSN: 2183-7635)
2016, Volume 1, Issue 2, Pages 101-113
Doi: 10.17645/up.v1i2.645

Article

Data-Driven Participation: Algorithms, Cities, Citizens, and Corporate Control

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Submitted: 16 April 2016 | Accepted: 10 June 2016 | Published: 4 July 2016

Abstract
In this paper, we critically explore the interplay of algorithms and civic participation in visions of a city governed by equation, sensor and tweet. We begin by discussing the rhetoric surrounding techno-enabled paths to participatory democracy. This leads to us interrogating how the city is impacted by a discourse that promises to harness social/human capital through data science. We move to a praxis level and examine the motivations of local planners to adopt and increasingly automate forms of VGI as a form of citizen engagement. We ground theory and praxis with a report on the uneven impacts of algorithmic civic participation underway in the Canadian city of Toronto.

Keywords
big data; civic engagement; data-driven; local government; participation; smart city; urban planning; VGI; volunteered geographic information

Issue
This article is part of the issue "Volunteered Geographic Information and the City", edited by Andrew Hudson-Smith (University College London, UK), Choon-Piew Pow (National University of Singapore, Singapore), Jin-Kyu Jung (University of Washington, USA) and Wen Lin (Newcastle University, UK).

1. Introduction

Governments, from the municipal to national levels, are transitioning from the now "old" to "new" way of administering services to and engaging with their publics (Schmidt & Cohen, 2013). Such changes to city planning and policy-formation are driven by big data, which is viewed as the datafication of socio-behavioral observations (Brabham, 2009). Many fields of geography and urban planning have shifted to big datasets that are rapidly increasing in availability and being accessed by software solutions with a promised ease-of-use (Graham & Shelton, 2013). For this paper, we consider a specific type of big geographic data called volunteered geographic information (VGI). VGI is the "widespread engagement of large numbers of private citizens, often with little formal qualifications in the creation of geographic information" (Goodchild, 2007, p. 212). Goodchild (2007) argues that VGI, can broaden the numbers and types of people participating due to the ease of contributing. He further asserts that "citizens as sensors" could augment government datasets, datasets once considered the responsibility of expert-collection by the municipal and state governments. Today, VGI acts as "a predominant source of information about scores of geographic features (i.e., cities, towns, national parks, landmarks)" (Hecht & Gergle, 2010, p. 229).

Simultaneously, social technologies and digital service providers are fundamentally altering the way in which we go about our daily lives (cf., Castells, 2009). The transformational force of these algorithmically encoded apps are impacting how we work, interact with one another, and are becoming the digital markers of public opinion (Croitoru, Crooks, Radzikowski, & Stefanidis, 2013; Kwan, 2016). Indeed, corporate providers of "smart city" solutions like IBM, Facebook, and

Cisco offer to bring a suite of monitoring and analytical data-services which furnish insights on the needs of citizens and answer the demands placed on cities (Maillet, 2012). Where once urban planners, geographers, and statisticians were responsible for extracting actionable insights from primary-data like national censuses, the heterogeneous nature and massive volumes of VGI has mandated the use of big data analytics like machine learning algorithms and data-driven approaches for knowledge discovery (Kitchin, Lauriault, & McArdle, 2015). It is important to remember that the collection of VGI is often instrumentally regulated through software and, as we argue, analysis. As Sieber and Haklay (2015, p. 2) note: "there are structural (software coded) mechanisms to dictate what and how information is collected". Issues of assertiveness and accuracy were primary barriers to the use of VGI by planners and policy-makers, but these are increasingly being assuaged by hidden "software solutions" (Wiig, 2015).

Municipal governments increasingly look to VGI from local residents to improve public participation in local government (civic participation). The combination of location-aware mobile devices and Internet connectivity allow for easy reporting of infrastructure problems or provision of feedback on events. Elwood (2008) speaks to the potential of VGI to expand engagement because of the spatial narratives enabled by the heterogeneous platforms. VGI also makes claim to increase transparency in government decision making via the medium of Internet technology. These claims have created a "web of expectations" where the democratic process can be extended to everyone (Johnson et al., 2015). Elwood and Lesczynski (2013, p. 559) are less sanguine. If anyone can use the app, then it might be concluded that everyone is using it. If they are not, then people may be blamed instead of structural digital divides or discriminations. Elwood and Lesczynski add that VGI is often presented "as easy or fast, emphasising how undemanding it will be to participate" (Elwood & Lesczynski, 2013, p. 559). Despite VGI being relatively new to both city interests and as a form of participation, it is often situated as a technological solution to the "messiness of democracy" (Baack, 2015).

The way in which VGI becomes a form of civic participation is often not entirely "active and deliberative" unlike the way participation is commonly seen in approaches such as Public Participation Geographic Information Systems (PPGIS). With VGI, participation becomes a largely passive act through automated service of data collection and analysis. VGI also responds to the requirements of active participation (e.g., direct interaction at public hearings or citizen panels), which people seem increasingly unwilling to engage with on a municipal level (Clifford, 2013; Putnam, 1995). This passive participation enables a seemingly boundless information space where city officials could effortlessly scrape public opinion from citizens' twitter feeds and interactions across the city (MacEachren et al., 2011). These repurposed contributions present the public as data—without the need of "distracting" people from their daily lives in order to actively engage with political activities (Cardone et al., 2013, 2014).

We argue that VGI enacts a form of passive civic participation that is attractive to cities, corporations, and busy citizens, while conveying a host of contradictions. We begin by discussing the rhetoric surrounding digitally enabled paths to participatory democracy in current and future cities. This leads us to interrogate how the city is impacted by a rhetoric of harnessing civic participation through data science. We move to a praxis level and examine the motivations to develop automated forms of citizen engagement. We ground theory and praxis with a report on the uneven impacts of algorithmic civic participation underway in the Canadian city of Toronto.

2. Civic Participation and Its Digital Enablers

Civic participation is considered a cornerstone of democracy (Hoffman, 2012). It has promised to keep "community life vital and public institutions accountable" (Roberts, 2015, p. 3), to ensure "the have-not citizens…be deliberately included" in policy-formation (Arnstein, 1969, p. 216), and to have "citizens as coproducers of public services" (Whitaker, 1980, p. 240). Despite these benefits, effective implementation of civic participation remains difficult and the ultimate role it has in city operations remain in a state of ambivalence (Innes & Booher, 2004). Many commonly mentioned reasons for this apparent ambivalence on part of policy-makers range from it proving difficult for governments to assure citizens they are being heard (Rowe & Frewer, 2005), civic participation rarely appearing to influence decisions of public officials (Chess & Purcell, 1999), and civic participation generally failing to capture a sufficiently broad spectrum of the public opinion (Lowndes, Pratchett, & Stoker, 2001a, 2001b). Common participatory methods used in cities have been considered to antagonize participants, pitting individuals or interest groups against one another, and rendering the duties of city officials more difficult to accomplish (Innes & Booher, 1999). Such issues with the implementation of citizen-government engagement have left many institutionalized mechanisms of civic participation, like public hearings and citizen surveys, "to be nothing more than rituals designed to satisfy legal requirements" (Innes & Booher, 2004, p. 419).

The purpose of participation is often positioned as a defining aspect of the concept itself. For example, Innes and Booher (2004) identify several purposes for civic participation. First, civic participation provides a mechanism to inform decision-makers, determining public preferences that play a part in decision outcomes. Second, participation seeks to improve decisions by incorporating the "local knowledge" of citizens into decision processes. A third purpose of civic participation is to foster goals of social equity and justice. This position often manifests through the mechanism of political power dynamics and may require a redistribution of power to achieve those goals. A fourth purpose of participation focuses on legitimizing an outcome from policy or planning decisions. Having the public involved in the process (although not necessarily influencing an outcome) justifies a government's decisions. Finally, participation is often legally mandated, making it "something planners and public officials do because the law requires it" (Innes & Booher, 1999, p. 218).

Over the past few decades, local governments have looked to the "use of information and communication technologies (ICT) to foster citizen engagement" (Cegarra-Navarro, Garcia-Perez, & Moreno-Cegarra, 2014, p. 660). Their pervasiveness and *de rigueur* have caused technologies to evolve from being a tool for mass communication, to being seen as a digital window into the activities and perceptions of urban populations (Kavanaugh, Carroll, Rosson, Reese, & Zin, 2005). To Kingston (2007, p. 138) the opportunities presented by the Web 2.0 changed "how citizens can participate in the delivery and management of everyday services in their neighbourhood". As our lives become more integrated with social technologies, we as citizens inexorably adopt the role of VGI producers. We produce our participation through VGI by our passive actions, and play into the discourse surrounding the "development of e-society as an effect of new technologies development (that) is connected with accessibility of data concerning planning issues" (Hanzl, 2007, p. 291). ICTs, including geospatial technologies and location-aware devices, can impact civic participation approaches to adapt to information age demands (Greco & Floridi, 2004). Similarities can be found with PPGIS, which concerns the use of spatial technologies to facilitate citizen influence on governance (Sieber, 2006). Like claims for other ICT and now with the Web 2.0, PPGIS has often positioned technology as an approach to empower people, while carrying unintended social implications (Sieber, 2006). Geographic information systems (GIS) provided a platform for dialogue between the local knowledge of a community and the knowledge of experts and officials, although not always evenly or accurately with all those involved (cf., Pickles, 1995). PPGIS processes involve public contributions of geographic information with established goals to map, build, and develop participants' communities. PPGIS is considered a bottom-up approach (Jankowski, 2009), even though implementation of PPGIS is often more "top-down" and serves government interests. Like PPGIS, VGI may be created from "the bottom"; it is increasingly being adopted in "top-down" approaches motivated by corporate interests that complicate the usage of VGI for meaningful public participation (Portugali, 2011; Söderström, Paasche, & Klauser, 2014).

Carver (2001) provides an early commentary on the transition of PPGIS to online technologies. According to Carver, Evans, Kingston, and Turton (2001, p. 907), traditional means of participation in the planning process require prolonged engagement between city officials and the public. They note numerous barriers like: "It takes time, familiarity, and confidence with bureaucratic procedures, personal contacts in key places, money for campaigns, and private transport in order to attend meetings." Trust in local knowledge, that is the non-expert opinions of citizens, poses key problems for the PPGIS adoption cycle in official capacities, while there are growing needs to interrogate the many social barriers and implications born from the GIS (i.e., technology) and participation merger (cf., Elwood, 2006; Sieber, 2006).

3. Data-Driven Participation

Passive civic participation extracted, aggregated, and analyzed through algorithms posits a different approach to citizen-government relationships by using indirect interaction methods (i.e., asynchronous, automatic, and repurposed content). Participation becomes the product of harvested public opinion from VGI (e.g., sentiments and topics from the text of a tweet) that then would be used within municipal decision-making. Inherent in these methods of participation are techniques that can utilize unstructured data, behavior-analytical algorithms, and distributed computing infrastructures to collect, transform, and extract relevant social signals from massive datasets from a variety of sources.

Predictive algorithms and big data software solutions are strongly associated with the spread of interactive web capabilities and mobile-sensor technologies (Beer, 2009). There is a presumed suitability of big data like VGI to represent the local knowledge and interests of a community, which is largely unconfirmed speculation (Lin, 2012). A rapidly growing level of availability for VGI datasets continues to propel these claims of access to local knowledge (Tulloch, 2014). The localness attributed to VGI is often seen as stemming from the ability to track our day-to-day interactions and movements through distributed sensor areas that are now found everywhere, from the GPS-enabled phones in our pocket, to the video cameras adorning cities' transportation corridors, buildings, and streets. Coupled with a growing stockpile of VGI, the introduction of many "software solutions" has only augmented a widespread credence in using VGI as a form of participation in city operations (Lin, 2012).

The futurist Duperrin (2014) makes a case for VGI as part of prospective citizen-government interaction models. He argues that a shift to digitally mediated forms of passive participation both suits the ongoing societal convergence with Internet technologies because these practices are preferred by citizens:

> "It is not participation that wearies people, nor its lack of sense but its active nature. It requires time (without being sure to get anything in return) and attention. No one denies the advantages of information sharing but employees do not understand why it requires extra work and citizens are happy from the benefits they get from the use of collective data (even unconsciously) but won't spend their life behind their screen to provide a predictive, analysing and proposition machine with ideas, feedbacks and experiences." (Duperrin, 2014)

An active, engaged citizen is the prescription of the day, but that prescription is increasingly difficult to fill. Four characteristics advance this approach to passive engagement and participation in governance matters through VGI, namely 1) removal of the requirement for deliberation and education on multiple political issues (Albrecht, 2006), 2) power of data-driven analysis to abduct relevance and context of inputs from disparate datasets (Provost & Fawcett, 2013), 3) ability to offer a qualitative representation of collective public opinion and documentation relative to its formulation, and 4) improvement of transparency in the democratic process by clearly documenting these processes (Afzalan & Evans-Cowley, 2015; Anderson, 2011).

Enabling users to contribute their own content (i.e., VGI) also has altered the concept of expert. An expert is not necessarily the primary content "producer", nor is the amateur (i.e., public or citizen), but merely a passive "user" (Bruns, 2008). Part of this "produsage" model allows users (i.e., amateurs) to contribute actively, transform, and even "analyze" all kinds of content for their own purpose (Bruns & Schmidt, 2011). The pervasiveness of easy-to-use technology is sometimes seen as having effectively removed the need for any form of expert facilitation (Turner, 2006). For example, planners, technicians, or scientist in most PPGIS projects retain a level of oversight on the collection to use of the spatial data. Seeger (2008, p. 200) notes that most VGI is deemed an ontologically different kind of data collection than that through facilitated public engagement "because of the way in which the collection of volunteered gathered information is shepherded by a facilitator, as part of a pre-established planning or design process." With public participation increasingly seen through VGI, the planner and specialist may eventually have no part in what some consider an entirely user-driven process (Ali & Fahmy, 2013). In certain cases, communities have deliberately limited any outsider involvement or purposely regulated the sharing of their collective knowledge with officials who use Web 2.0 technologies. These sorts of "gatekeeper techniques", although not totally unprecedented prior to the VGI, are increasingly worrying to officials as well as the decreasing influence public participation may have on a decision's outcome (Johnson & Sieber, 2013).

Recently, researchers have been investigating similar forms of gatekeeping as the pruning and restriction of information access are increasingly done by coded functions in computer software (i.e., algorithms) (Napoli, 2015). In other words, with the increasing reliance on data-driven participation, this sort of control (i.e., be it the production of VGI by citizens, or how or where it is used by city officials) is now being delegated to the coded decisions of algorithms and by the available "solutions" a particular software is capable of performing (Bozdag, 2013; Winter, 2015).

Another major shift with Web 2.0 is that active participation methods hold less influence on a particular engagement method (e.g., random opinion survey cards versus citizen panels). Rather than the level of involvement by citizens, a data-driven model emphasizes numerous participants indicating or justifying that they exert influence over official decision-making (Craglia & Shanley, 2015). Many crowdsourcing and citizen-science projects like OpenStreetMaps are heralded as examples of an ever-present "crowd" that is always willing to engage and relevant to the needs of a particular city. The public is considered to be an omnipresent crowd and participation is the digital contribution that enables change in social, environmental, and political environments (Vesnic-Alujevic, 2012). It is also becoming clear that the level of influence exerted by data-driven participation will increasingly be evaluated in terms of how big a scale it achieves (Sieber & Tenney, n.d.). This is a scale arguably out of reach for any single municipal department, expert, or community of citizens to process without additional software analytics furnished by private companies (Bucher, 2012).

Proponents claim that new civic tools facilitate direct citizen-to-government (C2G) connections, enhance citizen-to-citizen (C2C) interactions, and should eventually lead to an "automated democracy" (e.g., Cardone et al., 2013). That is, the ideals of direct-democracy (i.e., civic participation) are merging with data-driven methods of a "fourth paradigm in science" and are ushering in an era of governance by algorithm (Esty & Rushing, 2007). According to Esty & Rushing (2007, p. 14), this era uses:

> "Robust data collection and analysis to illuminate problems and enable policymaking that is more nimble, tailored, and experimental. Closes gaps in knowledge by harnessing new technologies to collect, analyze and disseminate key data. Focuses on results by setting quantitative, outcome-focused goals, measuring policy performance, and comparing results among peers. Develop systems to ensure data are used to guide policy priorities and solutions." (Esty & Rushing, 2007, p.14)

A common goal in numerous big data projects is to automate aspects of municipal operations (cf., Kitchin,

2013) that create a "recommendation system" for choices in governance. This is a form of data-driven participation, where the future of participation promotes an understanding of the city as a complex system. In this system, both physical and social operations can: 1) be reduced to the calculation of variables that represent actualities of human existence and lived geographies (Mattern, 2015), 2) the system can then be optimized through these derived indicators (i.e., data) and a series of algorithmic tweaks (Hollands, 2008), 3) that in turn will inform city officials and policy-formation to better serves its public (Tang, 2015). It is not just the power of big data (or VGI) that offers many of these opportunities; the tools (i.e., the algorithms) used to collect, process, and analyze patterns and relationships purportedly inform policymaking.

4. Algorithms, Planning, and Governance

One can simply define an algorithm as a set of procedural steps that solve a particular problem. However, all algorithms must have some form of input and output, "two openings that can be manipulated to help shed light on the algorithm's functioning" (Diakopoulos, 2015, p. 405). In practice, algorithms exist in complex realities where they are commonly hidden from sight (cf., Manovich, 2013). These procedures are also interconnected to such an extent that it becomes difficult to determine where one function ends and another begins. For example, it is rare to find an individual algorithm or procedure that stands alone without being used in tandem with another algorithm (e.g., a function used for the prioritization of some content without the content first undergoing algorithms of categorization and association). Further, many algorithms come with various levels of transparency and control over their parameters. Such cases are exemplified by proprietary and closed-source services when the actual code becomes buried inside larger software packages (e.g., IBM's InfoSphere). In cases of closed-source or proprietary software, it is common to describe the inner-workings (i.e., the algorithms and impacts over their input to garner an output) as black boxes (Diakopoulos, 2014).

> "Deconstructing the black boxes of Big Data isn't easy. Even if they were willing to expose their methods to the public, the modern Internet and banking sectors pose tough challenges to our understanding of those methods. The conclusions they come to—about the productivity of employees, or the relevance of websites, or the attractiveness of investments—are determined by complex formulas devised by legions of engineers and guarded by a phalanx of lawyers." (Pasquale, 2015, p. 6)

Algorithms are realized through computer code and software systems that guide a widening array of public-private spheres, urban mobility, logistics, and service systems (Kwan, 2016). Kitchin and Dodge (2011, p. 246) argue that algorithms have permeated the seams of nearly every aspect of modern life, and have birthed an unintended yet "vital source of social power". This has only recently become a topic for discussion in legal and public policy discourse. Such discourse often emphasizes adapting government operations to a form of algorithmic governance, which is a digital form of decision-making that relegates duties (and perhaps liability) of governments to computerized processes (Diakopoulos, 2016).

Algorithmic usage varies in form and function depending on how the acted-upon data was created, collected, and eventually employed within urban planning contexts. The use of computational or algorithmic methods arose in various areas of city planning through spatial analytical functions of GIS. In the 1970s and 1980s, the use of positivistic techniques of spatial analysis like destination-allocation models relied on rational, objective perspectives on urban dynamics and planning policies (Lake, 1993). For example, Balling, Taber, Day, & Wilson (2000) developed mathematical optimization functions rendered through multiobjective genetic algorithms. This plan was thus a product of rules-based and automated heuristics from land-use zoning and policy variables to create the "optimal" layout for a city.

Planning departments mediated their stance by utilizing "stakeholders". This approach, common throughout the 1990s, envisaged urban form based on "the desired image of a city" amongst a consulted group of citizenry (Fainstein, 2000). As Fainstein (2000) details, this planning perspective stressed direct civic engagement and often would utilize web-based discussion portals or citizen feedback systems. In these cases, an algorithm for decision-making may be within the particular software or technology, but was seen as a social process where the "input" to planning processes aimed to co-produce an "output" of a planned city according to the desires of a citizen. Brown, Kelly, and Whitall (2014, p. 2) reviewed PPGIS methods of engagement with "amateur" citizens and "expert" planners in environmental assessment projects. They find that most of these projects lead to "better results for environmental quality and social objectives". However, the identification and inclusion (or exclusion) of stakeholders in these PPGIS projects is problematic in many of the areas PPGIS was applied. Brown et al. (2014) describe the issue as PPGIS sampling bias, which tends to benefit the majority stakeholders. This further disenfranchises minority groups who are pushed to the periphery of influence or, at times, completely excluded. Big data (and by proxy VGI) claims to solve these sampling problems by harnessing massive datasets, which are situated as being representative of entire populations (Kitchin, 2014).

VGI and big data algorithms are injected within the current planning era, are often called "new urbanism".

Fainstein (2000) describes this as the culmination of both the “planned-city” and “desired-city” models that holds a strong emphasis on equity, that is, the “just-city model”. As we argue, the primacy of control in this data-driven realm of big data analytics is bestowed onto the algorithms that often act behind the scene, out of sight from both the citizen and the city official.

Data-driven participation relies on the use of large volumes of citizen-contributed data harvested from various sources and sensors, which are integrated through Internet based services and the physical infrastructure of a city. This VGI stands as the datafication of human activities and social life where our movements, interactions, and opinions become coded through digital services and transubstantiated by an array of algorithmic treatments (Richter & Winter, 2011). It is rare that an end-user has total control over a VGI dataset from the collection to its use in any particular capacity (Budd & Adey, 2009). Rather, it is often argued the adopting data-driven approaches and computational methods remove the requirement of getting too involved with dealing with the “raw” VGI. According to Diakopoulos (2015, p. 401), the “intrinsic crux of algorithmic power: (is) autonomous decision-making”.

> “Regardless of an algorithm’s function, their application employs a transformative perspective to viewing the world of municipal operations that “problematize(s) public life, including how they necessitate the datafication of the world, create complex feedback loops with social data, or encourage the creation of calculated publics.” (Diakopoulos, 2015, p. 401)

Many of the algorithms used for big data are seen as being predictive, acting in real-time, and learning from existing observations to better interpret future events (Winter, 2015). The decisions being made by software and algorithmic treatments of VGI fundamentally challenge old practices of decision making in urban planning and policy-formation by becoming condensed decision points fitting on a computer monitor. These new practices of political regulation become ensconced in the realm of what media mogul Tim O'Reilly has deemed “algorithmic-regulation”. To O’Reilly (2013, p. 300), using data-driven techniques for guiding decision-making at the municipal level delivers four unparalleled advantages over traditional means of engagement. They are: 1) creating a deep understanding of the desired outcome; 2) providing an ability to utilize real-time measurements to determine successes or failures when attempting to accomplish a determined outcome, 3) using “unbiased” algorithms or computer software that can both manage the volumes of real-time data and make needed adjustments based on new scenarios, and 4) utilizing periodic “deeper analyses” to further refine the functioning of these algorithms as a means to ensure they are performing as expected.

Visions of a city that operates on the back of algorithmic policy and planning regulation contradict theories of a city as an assemblage, which emphasize social-production by human and organizational dynamics. As Chandler (2015, p. 841) warns: “Unfortunately, what works for Google does not work so well for marginal and vulnerable people and communities that desperately need to transform their circumstances”. For Chandler (2015), big data does not empower those most in need social change, but instead can only assist in the management of what already exists. In other words, determining what exists, what becomes interrelated, and what *will occur* depends on the observable properties of available big data. Therefore, the algorithms trained from and unleashed upon the available observation space in VGI datasets do little to identify or benefit those communities that exist on the margins or are entirely excluded (i.e., the uneven digital divide and social inequity).

Another issue regarding the use of or reliance on algorithmic-regulation stems from the control withdrawn from the citizens generating the data and from the city officials wishing to use VGI. The ability to interpret the meaning of VGI datasets is argued as transcending the cognitive capacities of any single human. These beyond-human barriers are seemingly tackled by software solutions that are modeled after (both in terms of our neural processes and trained by our very thoughts, activities, and normative behaviors observed from training datasets) human facilities. For example, the renowned IBM artificial intelligence (AI) software called “Watson AI” already are marketed to and used in municipal operations:

> “Watson is a lot like us. Watson can read and understand natural language and can draw conclusions from it. Whether it’s twitter feeds, websites, or traditional data sets, Watson can make sense of it and present it in a way that makes sense to you. Through your interactions with Watson, Watson learns, tracking feedback from you about its successes and failures and becoming smarter the more you interact with it. Watson can analyze huge amounts of data and reduce it down to critical decision points. For each conclusion Watson reaches, it provides a confidence level. Watson learns from us. The more we interact with Watson the “smarter” Watson gets.” (elementblue, n.d.-a)

Such discourse suggests Watson surpasses our limited human-capacities (the very same it emulates) and enters a plane of infallible clarity for principled decision-making. Paradoxically, Watson is trained on our limited faculties, which means it will always be subject to “learn” from the available collections of knowledge that we contribute or can dataify. A prudent omission regards the fact that what makes Watson and other similar systems "smarter" is the often irrational, illegible, or incorrect data that is represented through an uneven access to VGI. This VGI may have limited or no relevance to the conditions of a specific geographic context. Crampton et al. (2013) note that a preoccupation with "location" (i.e., the distinguishing characteristic of VGI from other forms of user-generated content) ignores the complexity of a mediated reality; greatly limits our observation space, thus missing the opinions of "others"; and ultimately reduces our ability to truly *know* a geographic locality:

> "Content is not produced solely by human users, but is the product of a complex, more-than-human assemblage, involving a diversity of actors, including automated content producers like Twitter spam robots." (Crampton et al., 2013, p. 231)

Early concern surrounding the use of VGI in municipal operations focused on quality aspects of the data and proxy measures like "credibility" and provenance to attest that any given contribution was fit for use. Per Elwood, Goodchild, and Sui (2012, p. 584), these forms of data "can be said to be asserted, in contrast to the authoritative products of traditional sources that derive their authority from their creation by highly trained experts." In turn, this raises questions about the nature of truth and data quality aspects that VGI can have when used in "official capacities". Stephens (2013) and Haklay (2010) note divisions between gender, race, and social class representation available in data from the Web 2.0, reinforcing the inequalities of social justice prevalent in modern society. Discrepancies in power, representation, and processes (i.e., in data collection, data quality, and effects of data analysis) found across web-enabled participation methods and crowd-sourced systems remain largely unknown, prompting the need for further research in these areas (boyd & Crawford, 2012). Graham, Hogan, Straumann, and Medhat (2014), advise:

> "It will now take much more sustained quantitative and qualitative inquiry into locally contingent challenges, barriers, inequalities, and deliberate exclusions for us to understand how to work toward more inclusive, more just, and more equitable representations and digital layers of our planet." (Graham et al., 2014, p. 763)

Whereas these aspects of uneven representation have also been longstanding issues in active participation, they are exacerbated by the "uncertainty" of transitioning to a form of data-driven participation (Kwan, 2016). This largely due to a limited ability to examine or explore such uneven processes that data undergoes, which are locked behind *coded-doors* (Diakopoulos, 2016). Institutional policy has begun to collectively trust the "ghost in the machine" and it marginalizes concerns regarding the quality of VGI that is instrumentally corrected and cleaned.

> "Instruments are a critical source of knowledge. They are seen as more reliable than humans in VGI by relying on GPS signals that provide technological information about the location. The same is true with the embedded coordinate information in the header of digital photos taken by a cellphone. The information is captured automatically by machines of which uncertainty and precision can be quantified and therefore it is trustworthy." (Sieber & Haklay, 2015, p. 2)

Algorithmic procedures on VGI presume to act as corrective lenses for our ability to see the contours of the digital divide. Any remaining concerns seem to be negated by the promises of unparalleled insights furnished by the use of big data (boyd & Crawford, 2012).

5. Myopic Algorithms Guiding a (Non-)Responsive City in Canada

Frictionless participation through technological innovation depends on software and algorithms to make sense of a deluge of social data. By using this data a city seemingly becomes "smart", or "intelligent", or "responsive" (Hollands, 2008). Endless supplies of fuzzy concepts like the "smart city" are rarely used consistently. There is neither a single template for framing the datafication of the city, the types and capacities of data and algorithms running through it, nor any examples that can be generalized from current practice (Albino, Berardi, & Dangelico, 2015). Instead, there is widely uneven reach to the role and implementation of algorithmic-regulation and "smart governance" when it comes to civic participation in municipal operations. There remains a strong connection to century-old cybernetic theories that place public trust in computational systems and mechanical controls of public administration. Goodspeed describes these machine systems as:

> "The fundamental unit of cybernetics (that) is the control loop used to monitor and control a specific system. The loop is made up of sensors to detect conditions, actuators that can make changes and an intelligent controller." (Goodspeed, 2015, p. 81)

The fundamental unit of the algorithmically-regulated city thus expands beyond the control loop. The complexity of these control-loops is obfuscated by a proprietary shroud of software solutions. Data-driven participation occurs through these algorithms and enables a city to become truly responsive to newly minted *intelligent communities* (Williams, Goodwin, & Cloke, 2014).

An example of uneven reaches and control shift in planning practices and citizen engagement is the "Intelligent Community" initiative within Canada's largest city, Toronto. The Waterfront Toronto Corporation is an established public-steward that launched an "Intelligent Community" in 2013. This broad action plan was designed to enhance the lives of those who live and work in Toronto's waterfront communities (Figure 1). By enlisting a series of private companies (e.g., IBM, Cisco, and Element Blue LLC), public investments have aimed for a cloud-based community platform "designed to use data to support smarter decision-making for waterfront residents and businesses about everything from daily commute to health and wellness, energy and water use" (www.newblueedge.ca).

Facilitating the civic participation efforts of the Intelligent Community initiative is a hybrid system provided and operated by the private company Element Blue LLC. Element Blue operates around the world as an IBM partner to provide various software solutions to government operations. The company's flagship software solution is called CitizenReach, which is described as "a web, mobile, and tablet enabled public comment platform designed to effectively and efficiently facilitate the dialogue between citizens and government entities." (elementblue, n.d.-b) CitizenReach claims to offer citizens an ability to voice their opinions and present an opened window for government entities to hear from them. Underneath the CitizenReach solution (Figure 2), is a system of components and algorithmic functions that can "integrate with unstructured data such as SMS, and major social media sources…(with) complete pre-processing (capture, analysis, validation) to this unstructured and incomplete data before it is forwarded to other systems" (elementblue, n.d.-b).

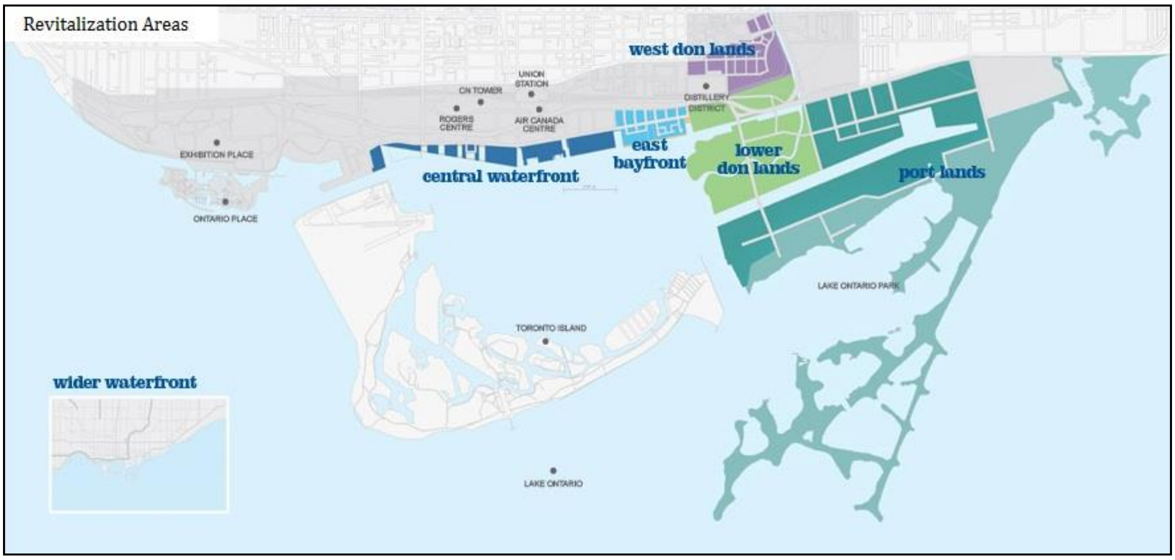

Figure 1.Map of Waterfront Toronto Communities. Source: Waterfront Toronto (n.d.-a).

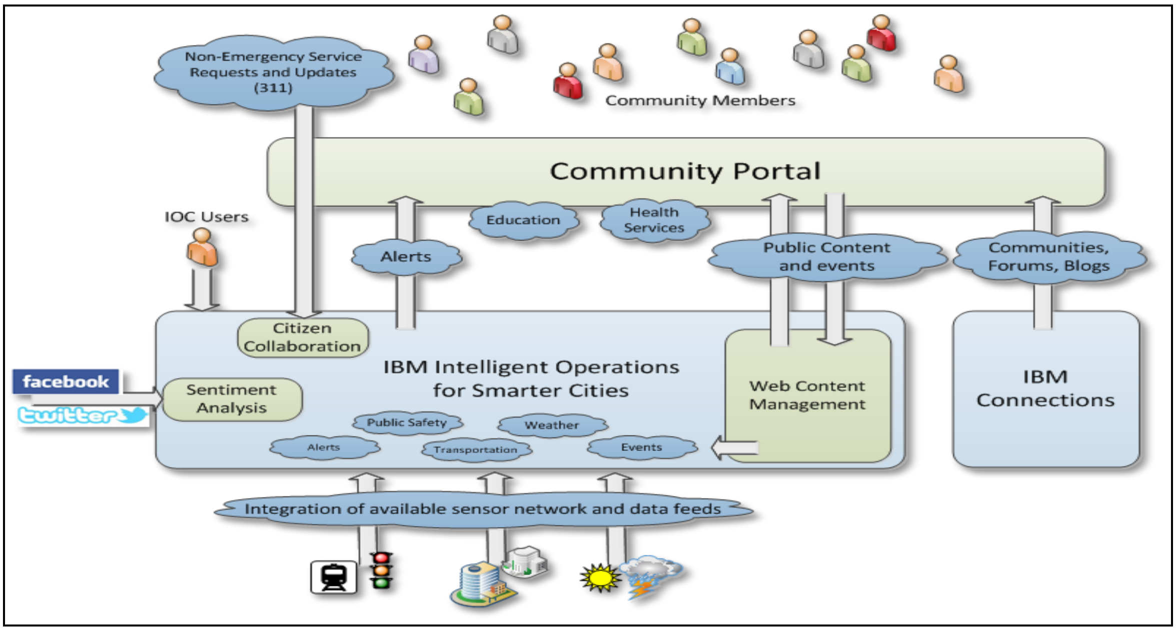

Figure 2. The CitizenReach platform being deployed in Waterfront Toronto communities. Source: elementblue (n.d.-b).

The New Blue Edge project started in 2014 and was quickly supported through municipal funding. Despite considerable enthusiasm, the project has yet to progress much further than the development phase. In fact, many citizens living in the Waterfront community are unaware of the multimillion dollar contract that had been made between these corporate service providers and Waterfront Toronto, let alone informed as to any of the services they provide. Services of this software stating it can correctly identify the community members and other stakeholders to provide them a seamless "integration (that) deepens the previously passive web experience into an integrated, geo-aware, and interactive experience" (elementblue, n.d.-a). However, the rhetoric has seemingly yet to be practiced.

From the onset of the New Blue Edge project, many Toronto citizens and planning officials were cut out of the loop as most of the project's implementation was delegated to corporate control (Lorinc, 2013). After several years and over $1.2 billion dollars of public investment into the Waterfront Toronto initiatives, many of the proposed intelligent enablers have yet to leave the "development phase" (Starr, 2014; Verner, 2015). Much of the New Blue Edge community portal remains inoperable and it remains unclear whether companies are already harvesting VGI data to both citizens and planning officials that do not have access to the "behind the scenes". This lack of control by citizens and municipalities over the data-driven participation efforts erodes the very notions of empowerment, transparency, and efficiency the project is argued to provide. Further, the abdication of already limited public resources through investment in private companies to collect and manipulate potentially-sensitive datasets being harvested could be perceived as encroaching on the privacy rights of citizens. It also limits the role of local planners and governments, and fuels a multi-billion dollar data-commodity market that aims to resell this valuable data to other private interests (Campbell & Carlson, 2002; Medway & Warnaby, 2014)

6. Conclusion

We argue that data-driven forms of civic participation increasingly become the modern approach for municipalities to engage with citizens. Data-driven participation relies on the use of large volumes of data (i.e., VGI) that are handled through complex assemblages of computer software and algorithmic treatments. The promised capabilities of these tools include: 1) remove key aspects of deliberation and education that often seen as imperative to more active forms of civic participation, 2) bring the power of data-driven analysis to extract hidden insights from unruly datasets, 3) condense the complexity of urban life to consumable graphics on a screen, and 4) provide greater transparency in the democratic process via clear documentation.

As mentioned above, the purpose of civic participation is often conflated with its ontological definition. In the case of VGI, large amounts of citizen-contributed data are algorithmically harvested and repurposed, which render citizen-government relationships into passive forms of indirect interaction (i.e., asynchronous, automatic, and repurposed content). It has been further argued that the suitability of both VGI and big data analytics becomes a matter of concern because VGI "does not work so well for marginal and vulnerable people and communities that desperately need to transform their circumstances" (Chandler, 2015, p. 841). Data-driven participation consequently shifts from its primary purposes in cases such as PPGIS and active deliberation methods that seek to empower citizens and influence government decision-making. Instead, datafication of participation via VGI propels the integral process of democracy into data-market economies that are largely driven by corporate interests outside those held by government officials and citizens. Further, much of the "how" and "what" behind data-driven participation remains hidden in proprietary black boxes. Diminished access to the data constituting participation not only negates the promises of transparency commonly attached to the use of Internet technologies but also obfuscates who retains control and responsibility for outcomes of such approaches (i.e., removed from the citizens producing the data and planners wishing to use it and placed into the hands of private companies).

Motivations for a data-driven participation seek to harness the participatory aspects of governance with data produced by this ubiquitous technology. However, the sheer volume of data suggests VGI can be harnessed only through the "intrinsic crux of algorithmic power" that will effectuate "autonomous decision-making" (Diakopoulos, 2015, p. 401). In addition to streamlining the participation process in cities, algorithmic procedures carried out on VGI supposedly assuage any concerns and generate a corrective lens to see the contours of the digital divide. Any remaining concerns are negated by the promises of unparalleled insights furnished by the use of big data (boyd & Crawford, 2012).

We provide an initial accounting of a form of coded engagement by data-driven participation methods at the municipal level. Our suggestion is we should look beyond the discourse of technological solutions offered by corporate storytelling (Söderström et al., 2014). In addition to issues of privacy, which data-driven approaches to participation will certainly exacerbate, the black box algorithms may do little to address issues of quality surrounding VGI. We should also be concerned that these data-driven approaches will diminish the role of civic participation in municipal operations as they increasingly supplant more active forms of participation. As Elwood and Lesczynski (2013, p. 559) put it, "it is imperative to examine whether these practices emerge alongside other more collective and presumably demanding modes of engagement and action, or whether they signal a decline in these modes of political and social practice". That being said, there are ample opportunities for VGI to operate in participatory capacities within cities. Restraint should be practiced in adopting a technological solution to the "messiness of democracy" that operates behind *coded-doors*.

Acknowledgments

We are grateful for the support from the following funders: SSHRC grant 895-2012-1023 "How the geospatial web 2.0 is reshaping government-citizen interactions" and Mitacs Accelerate PhD fellowship co-funded by Esri Canada Inc.

Conflict of Interests

The authors declare no conflict of interests.

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Urban Planning (ISSN: 2183-7635)
2016, Volume 1, Issue 2, Pages 114-127
Doi: 10.17645/up.v1i2.617

Article

Citizen-Centric Urban Planning through Extracting Emotion Information from Twitter in an Interdisciplinary Space-Time-Linguistics Algorithm

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Submitted: 8 February 2016 | Accepted: 9 June 2016 | Published: 5 July 2016

Abstract
Traditional urban planning processes typically happen in offices and behind desks. Modern types of civic participation can enhance those processes by acquiring citizens' ideas and feedback in participatory sensing approaches like "People as Sensors". As such, citizen-centric planning can be achieved by analysing Volunteered Geographic Information (VGI) data such as Twitter tweets and posts from other social media channels. These user-generated data comprise several information dimensions, such as spatial and temporal information, and textual content. However, in previous research, these dimensions were generally examined separately in single-disciplinary approaches, which does not allow for holistic conclusions in urban planning. This paper introduces *TwEmLab*, an interdisciplinary approach towards extracting citizens' emotions in different locations within a city. More concretely, we analyse tweets in three dimensions (space, time, and linguistics), based on similarities between each pair of tweets as defined by a specific set of functional relationships in each dimension. We use a graph-based semi-supervised learning algorithm to classify the data into discrete emotions (happiness, sadness, fear, anger/disgust, none). Our proposed solution allows tweets to be classified into emotion classes in a multi-parametric approach. Additionally, we created a manually annotated gold standard that can be used to evaluate *TwEmLab*'s performance. Our experimental results show that we are able to identify tweets carrying emotions and that our approach bears extensive potential to reveal new insights into citizens' perceptions of the city.

Keywords
integrated space-time-linguistics methodology; participatory planning; semi-supervised learning; Twitter emotions

Issue
This article is part of the issue "Volunteered Geographic Information and the City", edited by Andrew Hudson-Smith (University College London, UK), Choon-Piew Pow (National University of Singapore, Singapore), Jin-Kyu Jung (University of Washington, USA) and Wen Lin (Newcastle University, UK).

1. Introduction

Traditional urban planning processes typically take place in offices and behind desks, and thus oftentimes neither fully comply with citizens' needs nor sufficiently account for neogeographic and Web 2.0 phenomena like participatory planning or online participation (Brenner, Marcuse, & Mayer, 2012). This is increasingly problematic as citizen participation initiatives become more demanding and clearly articulate their claim for participation in urban planning and decision-making processes. The recent developments mentioned above are highly suitable for assessing citizens' subjective emotions and observations, which are a key element in participatory planning (Nold, 2009). In this context, participatory sensing approaches like "People as Sensors", Collective Sensing and Volunteered Geographic Information (VGI) (Resch, 2013) can undoubtedly play a key role, but their potential has not been fully exhausted so far.

These citizen-centric approaches are critical for the future of urban planning because the weighting process of all public and private interests is one of the core elements of urban planning (Zeile, Resch, Exner, & Sagl, 2015). It ideally considers all public and private parties and minimises conflicts to achieve optimal planning results, preferably for all citizens. Thus, all available information and knowledge sources should be considered in the planning process (Pahl-Weber, Ohlenburg, Seelig, von Bergmann, & Schäfer, 2013).

The sources of user-generated data introduced above are therefore potentially of significant interest for urban planning processes. In fact, they have been used in a variety of disciplines throughout the last decade, ranging from urban planning and sociology to geoinformatics, computer science and computational linguistics. This is because these data inherently cover a range of information dimensions such as, for instance, spatial and temporal information, as well as the textual content. In previous research these dimensions were generally examined separately in single-disciplinary approaches. As such, text analysis, geospatial interpolation, time series analysis, etc. have not been combined into a single joint method. However, using such separate research approaches severely limits the significance of the results as no holistic conclusions can be drawn for urban planning (see Section 2).

A further issue in capitalising on user-generated data such as social media posts in urban planning is that previous approaches do not work reliably because they have been designed for edited text. Examples of these approaches include Capdevila, Arias and Arratia (2016), Kouloumpis, Wilson and Moore (2011), or Hauthal and Burghardt (2013). These previous approaches do not perform well with social media posts like Twitter tweets as these data are characterised by a higher level of uncertainty and dimensionality (Steiger, Resch, & Zipf, 2015). More concretely, social media posts contain a large portion of slang words, abbreviations, emoticons, irregular punctuation, "yoof speak", or other words that cannot be found in standard dictionaries, which most previous approaches work with (Eisenstein, 2013).

In consequence, new approaches need to be found to analyse user-generated text content. Rather than analysing text in traditional ways, such as like rule-based methods, string comparison, word-matching, or phrase detection, more intelligent ways have to be designed to reliably analyse social media posts. In this context, self-learning systems (neural networks, semi-supervised labelling mechanisms, etc.) seem to be the most promising approaches (Eisenstein, 2013). This shift towards more complex text analysis algorithms also necessitates close collaboration between researchers from urban planning, geoinformatics, and computational linguistics.

This paper introduces a citizen-centric urban planning approach that uses tweets to assess citizens' perceptions of the city and associated emotions in an interdisciplinary manner. More precisely, we extract emotions from tweets in geo-space, time, and linguistic space in a semi-supervised learning algorithm by labelling posts, i.e. by assigning a distinct emotion class (see next paragraph) to each post. Therefore, we leverage the concept of similarity, which exists in all three dimensions. Our proposed solution, *TwEmLab* (Twitter Emotion Labeller), constitutes a full-fledged implementation pipeline that allows for the classification of tweets into emotional classes in a multi-parametric approach. Our experimental results show that emotions can be conditionally detected in an integrated space, time, and linguistics method (validated through a gold standard) and that the approach can potentially significantly enhance urban planning processes. In contrast to numerous previous approaches, our research does not aim to use conventional ways of assessing emotions or purely map them (see Section 2). Thus, our paper does not deal with the general topic of emotion mapping, but rather presents a specific approach for extracting emotions from social media for use in urban planning. Furthermore, our integrated space-time-linguistics approach goes beyond previous research methods, which have oftentimes been presented as "spatio-temporal analysis", while merely being methods for emotion extraction and subsequent spatial or temporal analysis.

As a basis for extracting emotions we use a modified version of the emotion model by Ekman and Friesen (1971), which defines six basic emotions. However, recent research found that two pairs of emotions can be merged into only two emotions due to their high similarity. This results in four basic emotions: happiness, anger (including disgust), sadness, and fear (Jack, Garrod, & Schyns, 2014). In addition, our research defines the class "none" (no emotion is present or can be unambiguously detected in a tweet). Furthermore, we use the subdivision of these basic emotions by Shaver, Schwartz, Kirson and O'Connor (1987), which assigns more granular emotions to the four emotion classes. The structure of this paper is as follows: This introduction is followed by a section on related work in emotion detection in social media posts and citizen-centric urban planning. Thereafter, we present our approach from a theoretical viewpoint, i.e., the process of generating a set of labelled tweets from unlabelled ones. Section 4 then lays out the case study and our results, before Section 5 presents the evaluation of our results together with a discussion of the approach and the results. Finally, the paper ends with a set of key conclusions.

2. Related Work

Our presented approach addresses the overarching topic of citizen-centric urban planning, for which we concretely developed a method for extracting emotions from user-generated data, leveraging the concept of "similarity" in three dimensions (geo-space, time, linguistics). The following paragraphs describe related work in these areas.

2.1. Citizen-Centric Urban Planning

Jane Jacobs was one of the pioneers of a bottom-up and citizen-centric planning approach (Jacobs, 1961). The central questions are: *How is it possible to integrate all heterogeneous interests into the planning process? How can citizens' perceptions of urban spaces be measured? How can new technological approaches improve the entire process?* The Urban Emotions approach addresses these questions by using "human sensor" data, generated by social media, wearable sensor technology, and participatory sensing approaches, to develop a method set that creates a new point of view, viewing the "city as an organism" (Resch, Summa, Sagl, Zeile, & Exner, 2015). This approach is clearly influenced by the work of (Castells, 1996). Batty et al. (2012) state that, effectively, only citizens can make a city truly "intelligent" (in contrast to technologically driven understandings of Smart Cities), where "collective sensors" (e.g. social media channels or the cell phone network) are used to create a better understanding of humans' interactions and mobility in cities. Derived spatial, temporal, and spatio-temporal patterns help to identify urban processes and to characterise special social-cultural movements and developments.

2.2. Emotion Mapping

Emotion mapping is an emerging way of collecting and visualising citizens' feelings and perceptions. This field of research has its origins in the 1970s and tries to explain the relationship between the perception of the natural and the built environment (R. M. Downs & Meyer, 1978). In a cartographic representation, which is called "mental maps" or "cognitive maps", the subjective perception of people in (urban) space segments are visualised (R. Downs & Stea, 1974). The "Image of the City" describes the concepts of a cognitive representation of space: "We are not simply observers of this spectacle, but are ourselves a part of it, on the stage with the other participants. Nearly every sense is in operation, and the image is the composite of them all" (Lynch, 1960). "The steadily rising importance and the use of these maps in urban planning is addressed in the well-known 'Mappiness Project' or the work on Emotional Cartography" (Nold, 2009). A new approach, which is driven by the "quantified self" movement and the increasing availability of wearable sensors, is the analysis of physiological measurements to derive emotion information (Zeile, Resch, Loidl, & Petutschnig, 2016). However, the main goal of these efforts is to map and visualise emotion information, which is in contrast to our work where the aim is to extract emotions from social media for use in urban planning.

2.3. Extraction of Emotion Information from User-Generated Data

The field of "sentiment analysis" typically deals with a word's, sentence's, or document's polarity, i.e., whether it conveys a positive, negative, or neutral sentiment. Additionally, research has been conducted to determine the expressed sentiment's strength (Liu & Zhang, 2012). For our purpose we need a more sophisticated emotion model because knowing a tweet's polarity is not sufficient to convey the type of emotion, which is vital to understanding urban processes.

Detecting emotions from tweets focuses on classifying Twitter posts according to a number of distinct emotions. The two approaches by Roberts, Roach, Johnson, Guthrie and Harabagiu (2012) and Bollen, Mao and Pepe (2011) analyse the results of large-scale events and their influence on Twitter traffic for one or more days. In doing so, singular small-scale variations of Twitter traffic might be overseen. These smaller events may be important for urban planning as they affect smaller, local areas. Additionally, both approaches lack the geographic component, which is essential to our approach. Also, these previous efforts neglect the possibilities that arise for emotion detection from emoticon analysis.

Another approach by Hauthal and Burghardt (2013) aims to detect emotions in VGI, and to map emotional hot spots in a city. However, the approach works on the basis of a simple syntactical word-matching algorithm that is not able to cope with the complexity of unstructured text data like Twitter tweets and other social media posts. The same applies to López-Ornelas and Morales Zaragoza (2015) and McGuire and Kampf (2015) who only analysed Twitter hashtags, and Do, Lim, Kim and Choi (2016) who pursue a lexicon-based approach that aggregates the weighted tweet-frequency values of words.

Strapparava and Mihalcea (2008) evaluate different algorithms that work in an unsupervised manner or with automatically obtained training data. Although the news headlines analysed by the authors share certain properties with tweets, such as brevity and partially incomplete sentences, they cannot be directly compared. While newspaper headlines are a source for short but edited text, tweets are not. Although news headlines can be considered as having a spatio-temporal dimension because they generally refer to current events, tweets are explicitly georeferenced and tagged with a timestamp. Thus, their approach inadequately takes the spatio-temporal dimension into account.

2.4. Linguistic Similarity

As mentioned in Section 1, our approach uses spatial, temporal, and linguistic similarity. Agirre, Cer, Diab and Gonzalez-Agirre (2012) define semantic textual similarity as "the degree of semantic equivalence between two texts". The main difference between their approach and ours is that they define a similarity rating of zero between two texts as "on different topics". In contrast to this, the topic does not influence the similarity score in the similarity metric proposed in this paper. In other words, the two definitions of similarity serve a different purpose and therefore the definition above is not applicable to the task at hand. To emphasise this contrast, we do not define textual similarity in terms of semantics, but with respect to a text's linguistic properties.

Many common similarity metrics for documents are defined on the documents' vector representations (Baba et al., 2015; Hill, Reichart, & Korhonen, 2015). However, because the data in our approach are not represented as vectors, geometric metrics are not applicable. This is due to the fact that the representation as a vector encodes the use of one dimension per feature, which would undermine the idea of a three-dimensional analysis based on the different dimensions of Twitter data. Furthermore, a vector would result in a bias towards the linguistic dimension as we define numerous linguistic features, but only a single parameter for the temporal and spatial dimensions, respectively. Consequently, a completely new approach to similarity computation is necessary in order to leverage the multiple dimensions.

3. Method for Extracting Emotions from Unedited Text

This section introduces our method for extracting emotions from unedited text like tweets. Figure 1 illustrates the stepwise method overview, in which we produce a set of labelled tweets from raw tweets, i.e., tweets are assigned a distinct emotion class. This is achieved by a semi-supervised learning approach, which labels tweets on the basis of a subset of the gold standard ("seeds"). The following subsections describe the single steps in more detail.

3.1. Data Preprocessing

The preprocessing step removes all tweets from our dataset that are not useful for our actual research goals. Furthermore, we apply a part-of-speech (POS) tagger (Owoputi et al., 2013) and a lemmatisation method (Manning et al., 2014) to optimise the dataset that is used for the subsequent analysis.

To eliminate non-relevant tweets, we first delete URLs and mentions of other users. This needs to be done because URLs are oftentimes abbreviated through services like bit.ly or goo.gl, and mentions, i.e., user names, are not unambiguous carriers of a tweet's emotion. If tweets are found to be empty after this first step, they are excluded from the dataset.
Second, we remove all tweets that do not contain any English words. According to Lui and Baldwin (2014), language identification of tweets is a complex problem, for which no perfectly accurate solution exists so far. To account for this shortcoming, we assessed the implications of wrongly classified tweets for the gold standard production (see Subsection 3.2) and similarity computation (see Subsection 3.3). Two cases have to

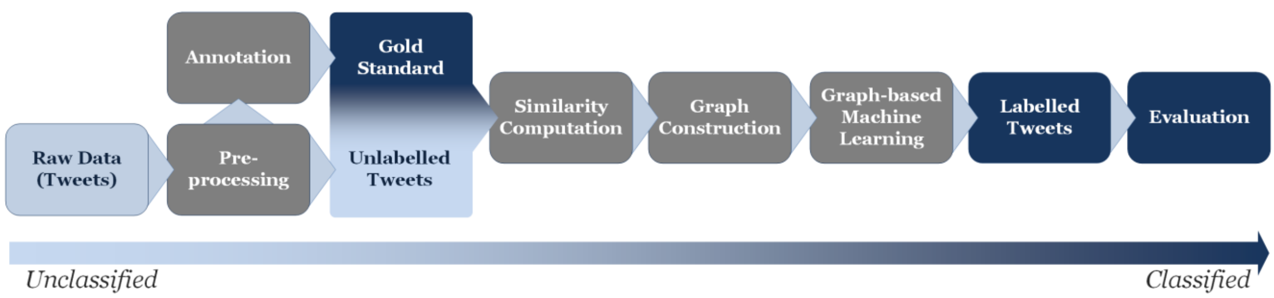

Figure 1. Workflow of the method for extracting emotions from unedited text.

be distinguished when considering the case of English versus all other languages. i.) tweets written in a different language are wrongly classified as English, thus remaining in the dataset. Consequently, if tweets are written in different languages they are probably not linguistically similar to each other. ii.) tweets written in English are wrongly classified as any other language and consequently discarded from the dataset. To reach the goal of eliminating non-English tweets, we combined two freely available state-of-the-art language classification tools in a voting architecture as proposed by Lui and Baldwin (2014): lang-id.py and compact language detector (cld2).

3.2. Annotation—Producing the Gold Standard

The production of a gold standard is necessary as we use a semi-supervised learning (SSL) approach for labelling the tweets. The SSL method requires a subset of ground-truth data to train the system and to evaluate the results. We base our annotation procedure on the work of Roberts et al. (2012), but adapted their approach to our environment and goals. Concretely, we employ more annotators (5 rather than 3) and we select annotators with little pre-knowledge in computational linguistics to avoid biases. In a related approach, Balabantaray, Mohammad and Sharma (2012) use seven emotion categories (Ekman and Friesen's six categories plus "no emotion"). We leverage new research results from emotion psychology, which defines four emotions, as stated in the introduction (see Section 1). Furthermore, the authors of the related study download tweets and user information randomly. In contrast, we use tweets originating from a particular place and time, which makes our data more homogenous in space, time, and user base, and hence easier to annotate.

In the actual annotation follows a three-phase process. The first annotation phase is the initial instruction phase to achieve a general agreement on the standard of the annotation procedure. Before the actual annotation, all annotators receive an annotation manual, providing all participants with the necessary information to understand the task and to standardise the resulting annotations, including a tree-like emotion structure that contains "sub-emotions" to each of the basic emotions (Shaver et al., 1987). The second phase constitutes a test phase in which the annotators individually label the same set of tweets. The results are then evaluated using the kappa metric for measuring the inter-annotator agreement. Concretely, we use the Fleiss Kappa index (Fleiss, 1971), which generalises the original Cohen's Kappa (Cohen, 1960) to more than two annotators and classes. The basic idea behind the kappa metric is to not simply measure the percentile agreement between two or more annotators, but to normalise this value by the expected agreement (produced by chance). The basic formula is $(p_o-p_e)/(1-p_e)$, wherein p_e is the expected (chance) agreement and p_o is the observed agreement. The larger the kappa value is, the higher the probability that the result was not produced by chance (Bortz, Lienert, & Boehnke, 1990). The second phase is completed if the kappa results are sufficiently high (at least 0.68). It shall be noted that the value of 0.68 represents broad agreement in the domain of computational linguistics, but further investigation is needed as to whether a lower threshold can be used when annotating emotions in tweets.

The third phase is the main annotation phase, in which all annotators individually annotate a different large set of tweets. This procedure provides a good compromise between ensuring high-quality annotations and reducing the load on each annotator. For the actual annotation we used the Crowdcrafting platform, which was chosen because of its free and open source nature and because of the promise of handling the task distribution correctly. Annotators were asked to label the same 400 randomly chosen tweets, which is a significant number to be used as a gold standard for the semi-supervised learning method, as widely agreed upon in existing literature.

3.3. Similarity Computation and Graph Construction

As a basis for classifying tweets according to contained emotions in a graph-based approach (see Subsection 3.4) we first need to perform a similarity computation. In our case, the concept of similarity is defined as the likelihood that two tweets contain the same emotion. The similarity computation comprises three dimensions, namely linguistic similarity, spatial similarity, and temporal similarity, which are combined to a single similarity value. As the details of the similarity computation are described in a separate research paper (Summa, Resch, & Strube, 2016) and because of its complexity, the following paragraph only provides a basic description of this process.

The similarity in the spatial and temporal dimensions are both formulated in exponential decay functions (see Subsection 4.1), in accordance with existing literature (Li, Goodchild, & Xu, 2013; Sakaki, Okazaki, & Matsuo, 2010). The computation of linguistic similarity uses the following "feature groups": hashtags, POS tags, word properties (word length, uni-, bi- and trigrams), emojis, spelling (e.g., recurring letters), and punctuation (e.g., several exclamation marks). More details on how these feature groups were defined can be found in Summa, Resch, & Strube (2016).

After the similarity between two tweets has been computed, the graph, which constitutes the input for the semi-supervised learning approach, is constructed. The graph is defined by the tweets (nodes) and the pairwise similarity values between tweets (weighted edges). If two tweets are not considered similar at all they receive an overall similarity score of zero, and no edge between the two respective nodes is established in the graph. It is evident that the graph's density strongly depends on the edge weight threshold, which defines how many edges the graph contains. This is important because the graph's density (number of edges) clearly influences the SSL algorithm's running time and memory consumption. Finally, a node without any edges will not be part of the graph. This property is relevant for the evaluation because there is no guarantee that all seed and test tweets will actually be included in the graph.

3.4. Graph-Based Machine Learning for Labelling Tweets

For labelling the tweets (assigning an emotion to every tweet), we use the graph-based SSL algorithm Modified Adsorption (MAD), which has been found to be the most suitable method because "MAD is most effective for graphs with a high average degree, that is, graphs where nodes tend to connect to many other nodes" (Talukdar & Pereira, 2010). This is the case in our experiments as we initially calculate connections between all tweets. Generally speaking, graph-based SSL algorithms operate on a graph that is formally defined as $G = (V, E, W)$. The entities that are to be classified (tweets) are represented as nodes V, whereas possible connections between them are represented as edges E. Additionally, a matrix W stores the edges' weights (Bengio, Delalleau, & Le Roux, 2006). MAD is an example of transductive learning, i.e., no distinct training and test phases are conducted, but all instances are instantly labelled (Zhu & Ghahramani, 2002).

3.5. Evaluation Procedure

The evaluation of our results is difficult as no comparable approaches (integrated space-time-linguistics methods) exist so far, which in turn means that no standardised evaluation procedures have been defined yet. Furthermore, traditional evaluation metrics can only be applied conditionally, as they only work for single-disciplinary approaches from geoinformatics or computational linguistics, not for integrated methods. Thus, we propose a two-step evaluation setup to evaluate our results: i.) measuring a single feature combination's results, and ii.) comparing it to the other results. Furthermore, we selected a significance test that compares our results against two baselines. These procedures are described in more detail in the following paragraphs.

First, we chose a suitable evaluation measure: In general, classification tasks are evaluated by an approach to record correctly (true positive, true negative) and wrongly (false positive, false negative) labelled instances per class and to construct a confusion matrix (CM) accordingly. From the CM, precision, recall, and f-score values are calculated. After this has been completed for all classes, micro and macro averages are computed (see the next paragraph for details).

We chose to use precision, recall, and f-score as they are invariant towards a "change of true negative counts" and thus do not require a well-defined negative class (Sokolova & Lapalme, 2009), which is the case in our approach as laid out in Subsection 5.1. Additionally, our evaluation measure is applicable to a multi-class environment like our emotion classes, which we achieve by taking two averages over multiple classes: micro and macro averages (van Asch, 2013). The micro average constructs a confusion matrix from all classes' results and evaluates it like a single class. In contrast, the macro average evaluates all classes individually and the results' average is taken. Consequently, micro averaging is highly influenced by the larger classes' results, which contribute a larger fraction of the confusion matrix's counts. In contrast, macro averaging treats all classes alike, not being dependent on the number of test samples.

Next, we selected a suitable significance testing method, which computes the difference between our results and i.) a random baseline (assigns emotions randomly to tweets), and ii.) a majority baseline (assigns most frequent class label to all tweets). In our case, McNemar's test is the best choice for testing the significance, as underpinned by Dietterich (1998): "Given two classifiers C_A and C_B and enough data for a separate test set, determine which classifier will be more accurate on new test examples". This definition encompasses our setting (enough datasets and several runs). Furthermore, McNemar's test has an acceptable type 1 error ("false positives") while being computationally inexpensive, and it can handle data that are not normally distributed (Japkowicz, 2012), as in our case.

4. Case Study and Results

To test our approach presented in Section 3 we applied it in a case study, analysing about 200.000 Twitter tweets for the greater Boston area. The time period covers one week before and one week after the Boston marathon bombing. Table 1 summarises the properties of our dataset.

4.1. Experiments

In conducting our experiments, we followed three main steps in accordance with the methodological setup described in Section 3. The label distribution of the gold standard (manually annotated tweets) is illustrated in Table 2. It shows a strongly skewed class layout as the negative class ("none") is much larger than the other ones – this is discussed in more detail in Subsection 5.2. The first column indicates the number of agreements, i.e., how many annotators labelled a tweet with the same emotion.

Table 1. Dataset description summary.

Data Description Summary	
Geographic Bounding Box (WGS84)	-71.21°, 42.29°, -70.95°, 42.45°
Time Period (UTC)	08 April 2013–22 April 2013
Number of Georeferenced Tweets before Pre-processing	222,089
Number of Georeferenced Tweets after Pre-processing	195,380
Number of Unique Users	16,099

Table 2. Gold standard: Emotion labels and number of agreements.

	Emotion Labels					
Number of Agreements	Anger/disgust	Fear	Sadness	Happiness	None	Total
3	21	5	20	37	64	147
4	21	1	19	50	90	181
5	24	2	4	57	231	318
Total	66	8	43	144	385	646

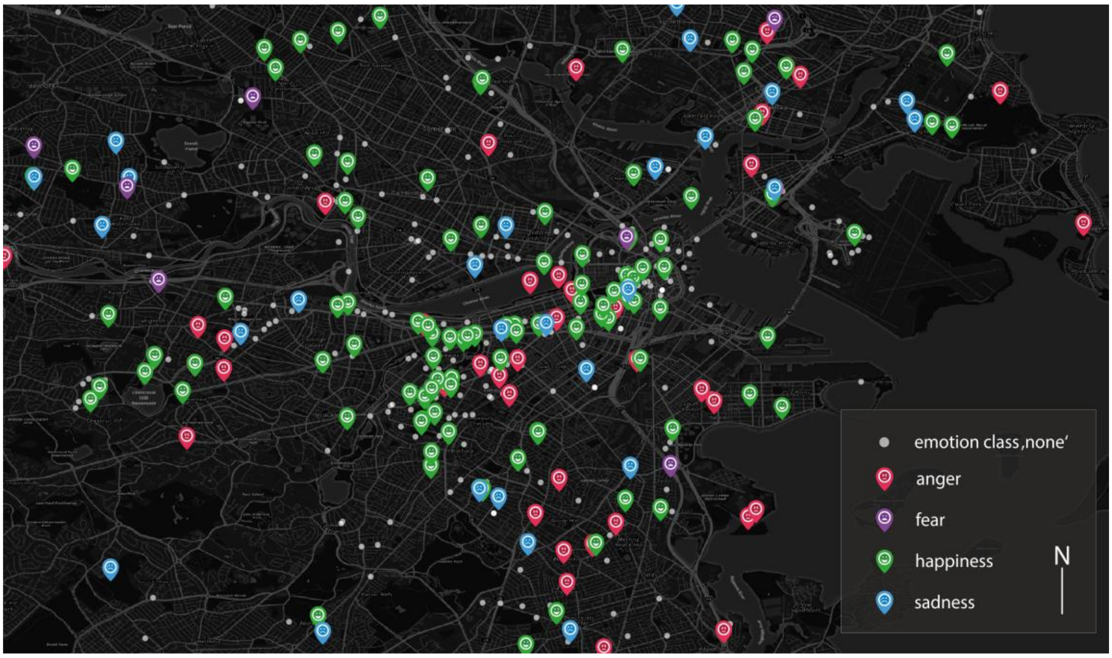

Figure 2. Spatial distribution of the gold standard.

First, we performed a seed selection, i.e., a random selection of seeds from the gold standard, to make sure that all runs in one experiment use the exact same training and test dataset. Second, our algorithm calculated the optimal combination of feature groups. The linguistic features are selected in an iterative approach, i.e., feature groups are added one by one, and the best combination between feature groups is finally applied, where "best" means the highest evaluation result (see Subsection 3.5). Then, the optimal parameter settings for spatial and temporal similarity are computed analogously. Third, we carried out the labelling procedure with the following parameters: amount of unlabelled data (5,000), the number and distribution of seeds (happiness: 70, sadness: 20, anger/disgust: 30, fear: 4, none: 70), the edge weight threshold (0.5), and the weighting parameters for the three dimensions linguistic (1.0), temporal (5.0), and spatial (5.0) similarity. These parameter values turned out to be the best ones with respect to the evaluation results (see Section 4.3), which were obtained by comparing different parameter combinations in our empirical optimisation.

4.2. Results

Figure 2 shows the spatial distribution of the tweets contained in the gold standard, where the icons indicate each tweet's emotion label. It can be seen that the gold standard is randomly distributed over space, where the tweet density correlates with the population density (e.g., higher density in the inner city). This is expected as we drew a random sample from the entire Twitter dataset for the annotation procedure. The map displays the gold standard tweets that we used for our analysis.

Applying our developed method to the Twitter dataset using the parameters described in Subsection 4.1 produced a result that is characterised by a high concentration of the labels for the emotion classes of "happiness" and "none". This is not surprising as a consequence from the skewed dataset (see Subsection 5.2 for a thorough discussion). The maps shown in Figure 3 reveal strongly clustered "happiness" tweets (left) while "none" tweets (right) are more evenly dispersed over space—again with an apparent correlation between tweet density and population density. These results are discussed in more detail in Subsection 5.2. The number of unique users in our dataset is high enough to avoid clusters that are generated by only one person, which has oftentimes been a shortcoming in previous research.

4.3. Evaluation Results

The statistical evaluation results, which were obtained according to the procedure described in 0, show that we can reliably detect the emotion classes "happiness" and "none", and that our approach performs better than the baselines. Table 3 summarises the evaluation results for each of the measures. It shall be noted that precision, recall, and f-score are computed for every emotion class, whereas micro and macro averages are an integrated measure that consider all emotion classes, as described above. Following this rationale, it is evident that the averages are lower than the individual numbers of the "happiness" and "none" classes as no tweets have been labelled with the other three emotion classes. These evaluation results are discussed in Subsection 5.2.

The most significant method to evaluate the difference in the performance of our approach versus the baselines is to compare *macro averages*. The majority baseline by definition scores low according to the macro-averaged evaluation metrics because the macro-averaged metrics give equal weight to all evaluated classes. The fact that *TwEmLab* outperforms the majority baseline with respect to macro-averaged metrics is satisfying, but the comparison with the random baseline is even more meaningful in this case. This shows that the results are not produced by chance, but that meaningful similarities have been found between pairs of tweets.

5. Discussion of the Approach and the Results

This section discusses *TwEmLab* in two ways: First, in terms of the strengths and weaknesses of the methodological approach (Subsection 5.1), and second with respect to the obtained results (Subsection 5.2).

5.1. Discussion of the Approach

One central advantage of our approach is that it is virtually **language-independent**. It does not depend on specialised language resources and can work with languages other than English—given that a gold standard is available and the dataset exclusively contains text in one single language. This characteristic is important because it makes our approach transferrable to other study sites, as only 40% of tweets are written in English language. Furthermore, our approach is generic enough to be applicable to georeferenced posts from **other social media networks** like Flickr, Instagram, Panoramio, Facebook, etc.

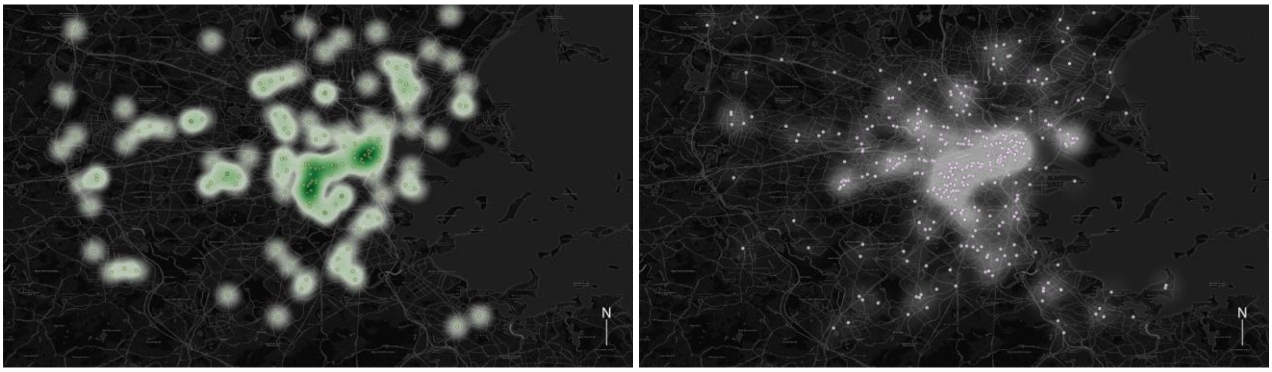

Figure 3. Spatial distribution and density of the tweets labelled with "happiness" (left) and "none" (right).

Table 3. Statistical evaluation results.

Evaluation Measure	Happiness	None	Random Baseline	Majority Baseline
Precision	0.65	0.68	n/a	n/a
Recall	0.24	0.98	n/a	n/a
F-score	0.35	0.80	n/a	n/a
Micro average precision	0.68		0.22	0.64
Macro average precision	0.27		0.23	0.13
Micro average recall	0.68		0.22	0.64
Macro average recall	0.24		0.14	0.20
Micro average f-score	0.68		0.22	0.64
Macro average f-score	0.25		0.18	0.16

Even though the evaluation of our approach shows promising results (see Subsection 3.5), a number of simplifying **assumptions** had to be made. First, we assume that exactly one emotion is present in a tweet, or none at all. From a psychological viewpoint, this may not necessarily be true, although the brevity of tweets makes them less vulnerable to changes in emotion compared to longer texts. Second, we assume that the tweets' textual content actually refers to the time and place from which they were sent, which has been a known restriction for most previous research efforts using Twitter data. Finally, we assume that there is a causal relationship between the expressed emotion and the user's environment.

A major challenge is the **construction of the gold standard**. Although our approach using human laymen annotators is scientifically justified, the resulting data set is still not unambiguous. This is rooted in two causes: i.) the way tweets are written, which makes them difficult to understand for other people; and ii.) the implications in Twitter users' abbreviated way of expressing themselves through 140 characters long messages, which are hardly suitable for conveying clear and unambiguous messages. Thus, labelling tweets with an emotion from a given set is a highly subjective task with considerable uncertainty. For instance, tweets may be understood and interpreted differently because of ironical language or use of slang; they may contain more than one prevalent emotion.

Another challenge that needs further research is the process of **computing similarity between tweets**. Here, we face a number of critical factors like defining the edge weights and finding appropriate thresholds for the weights. This is a particular and use case-dependent research challenge as no generic weights can be defined. The value of the weights of the single dimensions (space, time, and linguistics) obviously influences the results, which needs to be accounted for in the interpretation.

5.2. Discussion of the Results

Our results show that we can generally **detect emotions in tweets** using our approach in an integrated space-time-linguistics method. In Figure 3, the "happiness" tweet map is characterised by two **clusters** in the inner city. When looking at these particular clusters we can see that most of these tweets are related to the Boston marathon bombing, as they were written in the days after the marathon event. From a semantic viewpoint, it is interesting to observe that these tweets are classified as "happy", which results from a particularity in the characterisation of the dataset. Many of these tweets contain words like "proud", "supportive", "thanks", "love", "strong", "pride", etc., which are sub-emotions of happiness in the model by Shaver et al. (1987).

This special characteristic in our results arises from the **skewed nature of the dataset**: The "none" and "happiness" classes are dominant (see above), and in many cases only "none" and "happiness" labels occur in our results, depending on the parameter settings. This is a specificity of Twitter tweets, as confirmed by a number of psychological and sociological studies (Dodds et al., 2015; Wojcik, Hovasapian, Graham, Motyl, & Ditto, 2015). This effect arises because a high fraction of sad statements are oftentimes expressed as positive thoughts, as shown above. This distorts the input dataset and the results for emotion extraction.

Furthermore, the emotion classes of "none" and "happiness" can be more easily distinguished from each other compared to the other emotion classes because they are "more different" from each other. This may be due to the fact that "happiness" is the **only positive emotion class** in the used emotion model and thus in the gold standard annotations.

These distortions can probably be mitigated by a larger gold standard (allowing for the use of more seeds in all emotion classes) and by defining an appropriate number of seeds for each emotion class. Furthermore, while the emotion classes themselves are clearly specified, the **"none" class captures different phenomena**, such as "no emotion", "I didn't understand the tweet", and "I cannot decide". Consequently, the negative class is not of much interest for the project's evaluation.

From a purely quantitative viewpoint, our results prove that *TwEmLab* performs **better than the baselines**. This is a remarkable output given that our research constitutes the first approach towards a **joint metric** of computing similarity with respect to two tweets' emotional content along three dimensions (linguistic, temporal, and spatial), which clearly advances the state-of-the-art compared to previous single-disciplinary approaches or sequential methods.

Furthermore, our results show that it is possible to **generate a gold standard** through manual annotation of tweets, where the actual annotation is a subjective interpretation of a tweet's emotion by the annotators. Just like previous approaches, we assume that a high inter-annotator agreement (in our case 5 agreements among the 5 annotators) is considered a valid output. Furthermore, the actual annotation procedure is laborious and a high kappa index can only be achieved through distinct and unambiguous communication of the annotation task. Here, one essential research question will be the definition of a threshold for a sufficiently high kappa index, as current agreements (0.68) have been defined for edited text analysis, not for social media posts. Furthermore, the annotated tweets could then be used in a semi-supervised learning algorithm to label all tweets. We have shown that our trans-disciplinary similarity metric is not only theoretically possible, but also proven to be suitable for emotion classification. Yet, it is still to be proven how the results of our method can be applied to spatial planning processes.

6. Use in Urban Planning

We are confident that our results are directly usable in urban planning processes. Apart from proving the general ability of our approach to detect emotions that are associated with places, we investigated a number of concrete examples. The first one is traffic-related. Here, we observed a number of tweets carrying different emotions, including “Traffic awful today (@ Kendall Square)”, “Tourist traffic at Fenway already terrible”, “Holy shit the traffic on Comm Ave is ridiculous. Thanks to those goddamn shit sox or whatever that soccer team is called #fenway”, “So. Much. Traffic. #fuck”, “At this rate, I might never make it to MNSB….I hate Red Sox traffic”, “traffic on Mass Ave from Central Sq into Boston is gridlock. Avoid!”, and many more. As all of these messages are associated with a geolocation and a timestamp, concrete traffic hot spots can be identified.

Another example is related to the Boston marathon bombing event itself. After the marathon bombing, the hashtag #BostonStrong was heavily used and oftentimes infused with emotion. Interestingly, we observed two different kinds of emotions. First, citizens expressed their sadness and sorrow in their tweets: “All of the aftermath from last week is still heavy, still brings tears.”, “A crowded T of heavy hearts and sad faces, it hurts to see how shaken we are.”, or “Still digesting the events from yesterday. Will be sad for the victims, their families & loved ones and our city for some time.” Second, we observed a large number of positive tweets, which appear in the emotion class of “happiness”. This is due to the fact that terms like pride, hope, love, optimism, and others are subsumed under happiness according to the emotion model by Shaver et al. (1987). Examples of such tweets include “A week ago our lives here in Boston changed forever. Always be thankful for the love in all of our lives. #blessed #bostonstrong”, “Moment Of Silence In The Quad Was Amazing, Thank You EC #bostonstrong”, or “I absolutely love all the #BostonStrong support around town!”. These different ways of expressing one’s emotions towards a tragic event need to be accounted for when interpreting the results of our research. Additionally, we were able to attribute emotional tweets to a wide variety of concrete planning issues like dog faeces on the streets, damaged pavements, or dangerous bicycle lanes.

This shows that social media constitute a valuable, open source of information for urban planning. This is particularly so as urban planning is oftentimes still a closed communication process between local governmental actors, and not an open, transparent procedure that integrates, discusses, and considers the requirements of citizens and civic interest groups. In an ideal planning workflow, all arguments should be collected, weighed against each other, and discussed in workshops, charrettes or other open formats to gather opinions and needs from citizens. However, in current deductive processes, which are typically initiated and installed by the government, citizens often do not feel that their requirements are heard and considered enough. This may be due to the fact that sectoral interests, diffuse goals, and unrealistic demands characterise the process (Olk, Somborski, & Stimbel, 2011). In contrast, public participation is increasingly promoted by politicians because it encourages democracy, increases acceptance through higher transparency, creates a more accurate repository of wishes and suggestions concerning the planning topic, delivers better results, can produce a legitimation of a specific planning approach, and reduces the costs of a planning process (Fürst & Scholles, 2008; Senatsverwaltung für Stadtentwicklung und Umwelt Berlin, 2012).

This is specifically important in emerging discussions about how stakeholders and politicians can foster participation and integrate the public into decision-making processes. The main question is how more people can be engaged in these processes and how new target groups can be involved in alternatives to traditional means of participation. The results of the research presented in this paper, i.e., a reliable method for extracting emotions from social media and correlating them with precise urban planning issues, will be a helpful mood sensor in future, to complement traditional surveys with a dynamic layer in planning processes. We clearly see the possibility of creating daily snapshots of citizens’ remarks on planning aspects in cities. As an example, the growing problems of railway project “Stuttgart 21” were reflected in social media before 2010, but politicians and planners did not realise this at an early stage.

In addition, it will be helpful in the future to compare the results of the Twitter maps with government expenditures. As a result of citizens’ protests, the State of Baden-Württemberg installed a State Counsellor for Civil Society and Civic Participation whose duty it is to improve civic participation on every level in the state and to integrate it into administrative processes (Erler, 2015). Against this background, the *big data* source of social media can be seen as an invaluable complement to traditional planning and participation processes as they contain plenty of potentially useful remarks concerning urban planning issues.

In this regard, our approach can deliver new insights into peoples’ thoughts and expectations concerning their city. In contrast to top-down processes, *TwEmLab* pursues a bottom-up and inductive approach. The advantages are obvious: Bottom-up processes are self-organising, where the data acquisition of urban phenomena is done by interested people, mostly laypersons, and not by institutions (Streich, 2011). If the citizens as "gatherers" of urban phenomena are not only data producers, but also provide an impetus for new planning issues, our approach is at the core of such self-organising processes of assessing phenomena in urban spaces. A simple example for such an inductive process is the hashtag used in Twitter messages and other social media posts. People use these hashtags to mark a specific annotation to a special event. This dynamic, together with more latent patterns like punctuation, spelling, words' properties, and others, allows us to gain up-to-date information about citizens' emotions and thoughts. Through this it is possible to obtain citizens' direct feedback for urban planning and as a supplementary decision support tool for ongoing planning processes using contextual emotion information.

One particularity of this approach is that it is not understood as a general tool of solving all planning issues, but that it can help to create another view and a more accurate understanding of the city as an organism. From a current viewpoint it would be beneficial if this new knowledge could be integrated as indicative information in official planning processes (Zeile et al., 2015). From a planning perspective, the annotations of the emotion labels "anger", "fear", and "sadness" seem to be a valuable information source of the future. Our experiences show that explicit comments concerning problems of the urban environment, like traffic jams or pollution, can be detected in tweets carrying this emotion. At this point, this kind of information helps to filter and identify planning-relevant tweets. In the future, we expect more accurate and reliable results using our method that can, for instance, be used in special planning processes or in combination with large-scale projects like Boston's "big dig"—the Central Artery/Tunnel Project (CA/T)—or "Stuttgart21", Stuttgart's controversial re-design of the area around the main station.

7. Conclusions

This paper presents the innovative, interdisciplinary method "*TwEmLab*" for identifying emotions in social media posts such as Twitter tweets, constituting a new approach towards jointly analysing the linguistic, spatial, and temporal dimensions of the data. To this end, we constructed a set of gold standard annotations for tweets with a set of discrete emotion labels. *TwEmLab* assigns similarity scores to pairs of tweets according to their three dimensions. It constructs a graph with the tweets serving as nodes and the similarity scores as edge weights between the respective tweets. After performing graph-based semi-supervised learning in order to label all tweets with their appropriate emotion classes, it evaluates the results through precision, recall, and f-score, as well as micro and macro averages.

Our results show that *TwEmLab* is able to generally detect emotions in tweets with some restrictions (see Section 5). Although this work is the first attempt to combine tweets' textual and spatio-temporal dimensions into a single metric for emotion detection and classification, its performance is better than the baseline's. A central challenge revealed by our results is that the "happiness" and "none" labels are disproportionately overrepresented. While this is not surprising, as several studies from the fields of sociology and psychology confirm, it still poses a significant challenge in identifying the other (negative) emotion classes in tweets.

Concluding from the discussion of our approach and our results (see Section 5), we identified a number of open future research issues: the development of a structured method for defining spatial, temporal and linguistic weights; the definition a formal method for determining the required size of the gold standard tweets used as seeds; the exact influence of the skewed dataset; the derivation of a suitable kappa index threshold for the inter-annotator agreement when annotating tweets; and research on how to improve the macro-averaged f-score to increase reliability of the results. Finally, the influence of the dataset size on our results needs to be further investigated, as it is not yet clear if and how larger datasets correlate with better results.

Conflicts of Interest

The authors declare no conflict of interests.

Acknowledgements

We would like to express our gratitude to the German Research Foundation (DFG—Deutsche Forschungsgemeinschaft) for supporting the project "Urban Emotions", reference numbers ZE 1018/1-1 and RE 3612/1-1. We would also like to thank Dr. Wendy Guan from Harvard University's Center for Geographic Analysis for her support through providing us with the Twitter data for our study. Furthermore, we would like to thank Günther Sagl, Enrico Steiger, René Westerholt, Clemens Jacobs and Sebastian Döring for supporting the annotation procedure. Finally, we would like to thank the Doctoral College GIScience (DK W 1237-N23) at the Department of Geoinformatics—Z_GIS, University of Salzburg, Austria, funded by the Austrian Science Fund (FWF) and University of Salzburg's Open Access Publication Fund for their support.

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Urban Planning (ISSN: 2183-7635)
2016, Volume 1, Issue 2, Pages 128-140
Doi: 10.17645/up.v1i2.614

Article

Kilburn High Road Revisited

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Submitted: 4 March 2016 | Accepted: 28 June 2016 | Published: 8 July 2016

Abstract

Drawing on John Agnew's (1987) theoretical framework for the analysis of place (location, locale and sense of place) and on Doreen Massey's (1991) interpretation of Kilburn High Road (London), the contribution develops an analysis of the notion of place in the case study of Kilburn High Road by comparing the semantics emerging from Doreen Massey's interpretation of Kilburn High Road in the late Nineties with those from a selection of noisy and unstructured volunteered geographic information collected from Flickr photos and Tweets harvested in 2014–2015. The comparison shows how sense of place is dynamic and changing over time and explores Kilburn High Road through the categories of location, locale and sense of place derived from the qualitative analysis of VGI content and annotations. The contribution shows how VGI can contribute to discovering the unique relationship between people and place which takes the form given by Doreen Massey to Kilburn High Road and then moves on to the many forms given by people experiencing Kilburn High Road through a photo, a Tweet or a simple narrative. Finally, the paper suggests that the analysis of VGI content can contribute to the detection of the relevant features of street life, from infrastructure to citizens' perceptions, which should be taken into account for a more human-centered approach in planning or service management.

Keywords

content analysi; Kilburn High Road; place; VGI

Issue

This article is part of the issue "Volunteered Geographic Information and the City", edited by Andrew Hudson-Smith (University College London, UK), Choon-Piew Pow (National University of Singapore, Singapore), Jin-Kyu Jung (University of Washington, USA) and Wen Lin (Newcastle University, UK).

1. Introduction: Volunteered Geographic Information and the City

The domain of geographic information has been recently challenged by the availability of large quantities of crowdsourced information, namely volunteered geographic information (VGI) (Goodchild, 2007; Sui et al., 2012), which is created by individuals more or less voluntarily thanks to Web 2.0 applications that enable information co-creation (social media, photo-sharing platforms, wiki projects, etc.) but mediated by people's values, perceptions and experiences. As with any other innovation, VGI combines technology and social practice. The technology consists of the many location-based devices used by ordinary citizens who become sensors, and of Web 2.0 technologies, while the phenomenon of user-generated content is part of a cultural change which very recently has led to the adoption of open access and a collaborative and sharing approach to information resources. This cultural turn has been defined as *collective intelligence* by the French philosopher Pierre Levy (1994) who explains that that "the collective intelligence tries to articulate in a new way the individual and the collective domains in a new space of knowledge" (Levy, 1994, p. 33). In this context contributors are engaged in knowledge production processes, which are grounded in social structures and norms, and then in its turn, physical place (Hardy, Frew, & Goodchild, 2012).

Recently the appeal of VGI has grown steadily and created a wide scientific community involved in the harnessing of these new sources of geographical information. The main drivers of its success relate to:

a) The features of this information (the non-expert producers, the participatory approach, the huge quantity, the real time accessibility, the finer grained resolution and the scalability);
b) The extremely diversified fields of potential applications (disaster and crisis management, environmental monitoring, planning, land use, mobility, people's behavior and so on) which are more and more employed in governance and in the management of public services;
c) The experiential and perceptional nature of the content embedded in VGI which can be distilled both to achieve a better understanding of beliefs, practices and habits and potentially challenge the dominant narratives since VGI is built on the understanding of the social world mediated by people's conversations and contributions (Capineri, in press; Capineri & Rondinone, 2011; Elwood, 2008, 2010).

For the domain of urban studies, VGI is a rich source of information since the settings of such data are mainly urban: most crowdsourced information—particularly data coming from social media—is produced in urban areas which combine connection facilities (internet, free wifi, hotspots, etc.) and the concentrated critical mass of city users (residents, tourists, business people, commuters, students, visitors, etc.) (Roche, Nabian, Kloeckl, & Ratti, 2012). Indeed recent literature shows many applications of VGI dealing with different topics related to urban enviroments, such as the management of disaster relief (Zook et al., 2010), the identification of tourist flows (Girardin, Calabrese, Fiore, Ratti, & Blat, 2008), the evaluation of the attractiveness of urban space (Crandall, Backstrom, Huttenlocher, & Kleinberg, 2009; Teobaldi & Capineri, 2014), the dynamics of urban cores (Aubrecht, Ungar, & Freire, 2011; Jiang & Jia, 2011; Sagl, Resch, Hawelka, & Beinat, 2012); the definition of cities' boundaries from geocoded social media data (Jiang & Miao, 2015); participatory urban planning (Campagna, Floris, Massa, Girsheva, & Ivanov, 2015; Campagna, Massa, & Floris, 2016); public transport management (Attard, Haklay, & Capineri, in press) and even people's affective responses in different urban contexts (Huang, Gartner, & Turdean, 2013; Resch, Summa, Sagl, Zeile, & Exner, 2015).

Besides the applications briefly mentioned above, local knowledge deriving from VGI has notably been applied to vernacular geography which "encapsulates the spatial knowledge that we use to conceptualize and communicate about space on a day-to-day basis" (Hollenstein & Purves, 2010 p.22). In urban studies it is particularly interesting when contexts which can be considered "vague" need to be tackled, such as "downtown" (Hollestein & Purves, 2010) or "neighborhood" (see livehoods, n.d.). More recently considerable attention has been given to the integration of perceptions and emotions in planning since they may be applied to identify aspects and areas where the citizens' wellbeing is not optimal and where action is necessary (Crooks et al., 2014; Foth, Bajracharya, Brown, & Hearn, 2009; Resch et al., 2015).

This article reflects on the exploitation of VGI sources for qualitative and place-based analysis by using a selection of georeferenced data from Twitter and Flickr concerning Kilburn High Road in London. After this introduction, which has addressed the cultural and scientific background that has nurtured the recent development of VGI, the paper discusses the potential of VGI for place-based analysis in Section 2; then methodology, data and the case study are explained in Section 3; the following Section 4 develops the content analysis of the VGI sources selected for the case study and presents the results. Finally the concluding remarks discuss the potential benefits of using VGI content for the formulation of policies and planning improvements.

2. VGI and Place

The purpose of this section is to concentrate upon place rather than space in relation to the exploitation of VGI sources. Indeed the crowdsourcing revolution has offered scientists new opportunities to apply their skills for the ever-changing discovery of the relationship between society and environment by reviving the sense of place, the idea of 'localness' and the dimension of perception which had been obscured by the quantitative revolution. In particular, VGI enables us to combine the two fundamental dimensions of the human relationship with the environment, namely space and place. Space is measure dependent and more objective in nature; place has a more subjective component which derives from its perception and from experience (consumption, use, representation, etc.). The concept of place is characterized by recurrent inconstancy throughout history, culture and communication, but generally a place can be represented or referenced according to many perspectives/points of view, dependent on what is intended to be communicated (e.g. its function, its physical properties, its values, its relationship with the subject) (Cresswell, 2013). In this way the perception of place is not trivial and perception is a fundamental feature of crowdsourced information (Capineri, in press). When utilized as a form of qualitative geographical information, the fragmented individual-level pieces of content from VGI provide a powerful source of information on the experiential dimension and on sets of values for specific places with a precision which was unattainable in the past through traditional time-constrained investigations (e.g. surveys, interviews, etc.) or official data (e.g. census).

This paper will refer to John Agnew's theoretical basis for place-based exploration of VGI since it embraces both the geographical dimension and the meaning that objects or functions have for individuals and possibly communities. The three dimensions of place (location, locale, and sense of place) can be addressed by using VGI components (as in Purves & Derungs, 2015). In fact, VGI consists of two main components:

a) A geographical reference (i.e. geotag, coordinates, geoname) which allows spatial representation on a map and thus addresses the notion of location, the anchorage of the information. This component consists of the digital footprints that can be represented in space as the manifestation of the producers' activity on the Web: thanks to the geocoding attributes (geotags, geonames, coordinates), the geographical origin (location) of the data can be identified. The geographical reference offers a preliminary source of information which reveals both digital activity or inactivity and the citizens' appropriation of place by naming or tagging it.
b) A stock of content which enables us to transform these data into information and eventually knowledge. The content may take different forms: images, texts, symbols, maps, check-ins, etc. Content may be either neutral/locational if it simply carries positional information (i.e. an address) or qualitative if it takes the form of descriptions, comments, images, drawings, videos. Content analysis allows us to address both the dimension of locale which expresses the settings of different experiences at locations and reveals the where of social life (workplace, shopping malls, churches, vehicles) and the sense of place expressed by feelings, emotions, statements contained in the annotations. When using VGI sources it must be kept in mind that they are digital footprints, or byproducts of human/machine interactions (Graham, 2013), generally produced by a relatively young population with skills in using Web applications.

3. Methodology, Data and Setting

Here we aim to use VGI to analyse Kilburn High Road (KHR) not from a space perspective but from a place perspective using VGI content since it is perceptional and experimental in nature, capable of revealing the daily routines and elements that characterize place. The aim is to compare a singular view point structured source—Massey's description of Kilburn High Road in London—with multiple viewpoint unstructured and fragmented content from VGI sources to arrive at the multiple identities suggested by Massey. The comparison will show manifestations of the locale (urban functions, services, etc.) which emerge in the context of KHR at different times, their evolution and the sense of place obtained from citizen's comments in the VGI data.

A qualitative approach for the analysis of the VGI content was selected since it was considered the most suitable both to explore a relatively large amount of unstructured data and to interpret VGI content and build explanations, not spatial patterns, from data about KHR as place such that potential explorations are 'grounded' in people's everyday experiences and actions. As with any systematic empirical investigation, VGI content analysis must proceed only after adequate preparation and organization. The preparation phase consists in collecting suitable data for content analysis and selecting the records of analysis, namely texts and annotations included in the VGI data. The organization phase includes first the classification of the data into the categories of location and locale and then extracting emotions and feelings from the texts and linking them to the locale in order to explore the sense of place, making sense of the data. This phase is important since data can be reduced to concepts that describe the research phenomenon—here KHR—by creating a conceptual system.

The data selected for the analysis are the description by Doreen Massey of Kilburn High Road which is a text of approximately 850 words (Massey, 1991, pp. 24-29), and two VGI data sets including:

a) 1493 georeferenced photos published on Flickr and collected from 2014 to 2015 with the tag "Kilburn High Road" and published by 362 users (19 users contributed 48% of the sample; 1 user accounted for 10%). Only 701 records were selected since photos with identical or incomprehensible comments were removed from the analysis. The comments attached to the photos are a rich source of information because people who take a photo choose to turn their gaze into a photo and the gaze is a socially constructed action: "Gazing is a performance that orders, shapes and classifies" (Urry & Larsen, 2011, p. 2).
b) 691 georeferenced Tweets collected from Twitter using API from 2014 to 2015 with the tag "Kilburn High Road" produced by 423 users. Only 521 Tweets were selected for the analysis since some of them contained incomprehensible comments. Tweets are the digital footprints of KHR's users, who talk about multiple topics from trivial ones to more focussed ones about Kilburn, a sort of "stream of consciousness" as in these two Tweets: "we made these memories for ourselves" or "monkey wandering lonely as a cloud".

These two data sets are interesting but present some limitations as it regards information about the users which must be taken into account: social media data are generally created by young people, and no reliable information about gender can be obtained from the users' profile since they often use nicknames. Nevertheless the sample of Tweets may reveal several nationalities if we consider that texts are written in 27 languages in total, of which 50% in English and 23% in Arabic, followed by French, Portuguese, Spanish, Italian, Dutch, Russian and Romanian.

After collecting the data, the analysis was organised in three steps. First, content analysis was carried out by enumerating the frequency of words (either single words or 2–3 word combinations recurring more than 3 times) in Tweets and in comments included in the Flickr photos to work out what kinds of terms emerge most frequently (e.g. road, theatre, railway bridge, etc.). Secondly, the selected terms were classified according to the three dimensions of location, locale and sense of place. The location category includes place names related to the concepts of road, neighbourhood, city and country such as "Kilburn High Road", "North West London", "Camden borough", etc. which have been used to check how users define the geographical context of KHR. The locale category includes three different groups of terms, identified by consulting the Urbamet Thesaurus: urban functions (such as transport, recreational facilities, shopping facilities, public services, built environment), street furniture (such as postbox, phone box, platform, traffic light, mural, graffiti, bridge, etc.) and activities (such as work, food, sport, events). Finally the sense of place category includes records which refer to emotions, feelings extracted from the Tweets and the photos' descriptions and associated to the selected groups of terms (e.g. unhappy → transport; useless → phone box). Linking emotions, perceptions and feelings to the locale allows us to put into context the groups of terms identified. For example, the word *bus,* which is one of the most frequently recurring words in the urban functions group, has been associated to records which express feelings of people travelling on them, such as this Tweet: "Have been on the bus for 30 mins. Still not out of Kilburn". This step is important because limiting the analysis to frequencies carries the risk of neglecting the wider social context that gives rise to convergences (Dittmer, 2010; Hay, 2000); moreover, the extraction of emotions highlights citizens' perspectives, preferences and needs which can be used by planners to adopt a more integrated, timely and human-centered approach (Resch et al., 2015). Indeed the sense of place includes sense of belonging, which is a prerequisite for social solidarity and collective action (Figure 1).

The setting of the analysis is an "ordinary" road, namely Kilburn High Road, located in the north west of London, more precisely in the borough of Camden.

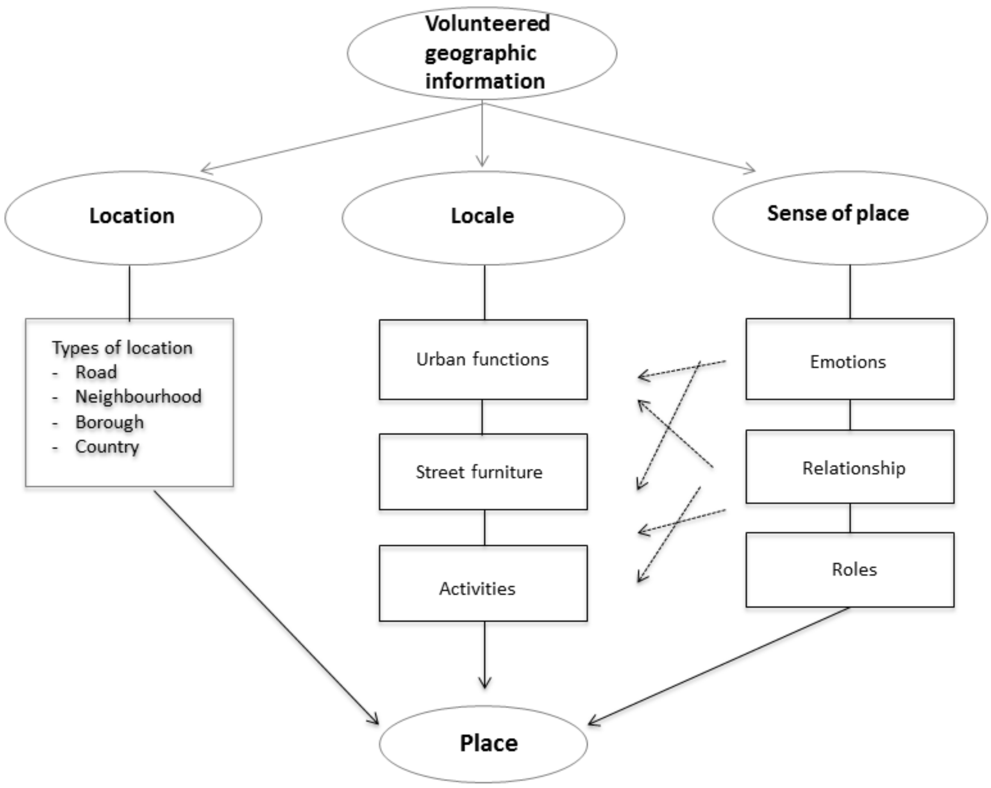

Figure 1. VGI and place: A conceptual schematic representation.

The choice of a road as analytical setting is explained by the fact it is a conventional element of urban morphology, which is a particularly suitable laboratory for place analysis since roads are theatres of public life where objects and people are moving at different speeds and for different purposes. Elements like buildings, bus stops, gardens, lights, cars, signs, shops, houses, dogs, pubs, residents, workers, students and so on, endow the road with its distinctive essence and vitality whose analysis enables us to grasp the social life and the changing forms of the road itself (Fyfe, 2006). Here the road will not be considered as a piece of urban infrastructure but as theatre to explore the notion of place.

When Doreen Massey in her *Global Sense of Place* (Massey, 1991) described Kilburn High Road in London and its variegated features (the bridge, the newspaper kiosk, the Indian shop, etc.), she explained that a place has "multiple identities" which can either be "a source of richness or a source of conflict, or both". Massey argues that place should not be seen as a closed, coherent entity but as an open, complex and interconnected entity through links associated with travel, migration, culture, leisure, as well as personal biographies and memories. Doreen Massey's definition of place makes explicit some of the implications of Agnew's (1987) work: for Massey places are "networks of social relations" (Massey, 1994, p.120), that are dynamic over time; a place is a product of its linkages with other places and not just a matter of its internal features and it has a temporal dynamic. Jane Jacob too described in sharp detail the rhythms of daily life in Hudson Street in Greenwich Village, arguing that streets play a central role in establishing urban communal life (Jacobs, 1995, p.93); to achieve this it is important for the street to be 'multifunctional', not the exclusive realm of traffic or trade.

4. The Results: From a Singular View to Multiple Identities

Once the three steps of the analysis described in the section above have been performed, the emerging features of KHR were identified and explored also by comparing Massey's description of the 90s of the last century with the present time VGI data (Tweets and Flickr photos). Table 1 shows the distribution of the records (Tweets and Flickr descriptions) in the groups identified and the codes used to classify the records.

4.1. Location: The Geographical Reach of KHR

The notion of location refers to a site in space where an activity or an object is in relationship with other sites. In the text by Doreen Massey, Kilburn High Road is simply placed in "the north west of the centre London" but the VGI data offer a wider locational framework.

First of all, the distribution of the georeferenced VGI data has been mapped to represent the setting of the analysis which highlights the even distribution of VGI data along the road's course (Figure 2).

As it regards the location, the data used in the analysis reveal several other terms which place KHR in relationship to the neighbourhood and to the London area: the most frequent items in the location category are the road name (KHR) and "Kilburn", followed by "London" and "North West London" and England (Table 2). This highlights that the local scale is the most relevant and then the metropolitan one which gives a sense of belonging to a larger space.

In addition, there are several street names which occur quite frequently in the texts considered and their representation shows a sort of gravitational area around Kilburn Hgh Road, as Figure 3 illustrates. People mention these streets and roads for different purposes (meetings, cinema shows, offices, etc.) but all in all they are part of the larger KHR "espace veçu".

VGI producers also mention other locations which have a global reach such as Canada, Argentina, Palestine, Brazil, Italy, Ohio, to show that for one reason or another (sport, family, friends, work, etc.) they have links with other places: this simple fact demonstrate what Massey argued about the connections that places have at different scales.

Table 1. Distribution of Tweet and Flickr photos' records in the conceptual categories.

Dimension	Category/Groups	Category/ Code	Term samples	Records	%
LOCATION	Location	Site	Kilburn, London, Camden	510	41
LOCALE	Urban function	Shopping facilities	shop, department store, store, Tesco, Evans	51	4
LOCALE	Urban function	Recreational services	restaurant, cinema, theatre, McDonalds, park	143	11
LOCALE	Urban function	Built environment	flat, terraced, cobbled, murals	55	4
LOCALE	Urban function	Cultural heritage	Gaumont Theatre, Tricycle	89	7
LOCALE	Activities	Events	party, match	62	5
LOCALE	Urban function	Transport facilities	bus, railway, metro	245	20
LOCALE	Activities	Food	club sandwich, curry, sausage	19	2
LOCALE	Street furniture	Infrastrucures	phone box, postbox, platform, lights, bench	17	1
LOCALE	Activities	Weather	sunny, cold, windy	61	5

Table 2. Most recurring terms in the location category.

Location/Site	Terms	Occurrences (n.)
Road	Kilburn High Road	218
	Kilburn	138
	High Road	7
Neighbourhood/borough	Camden	5
	Hampstead	5
City	London	102
Country	England	9

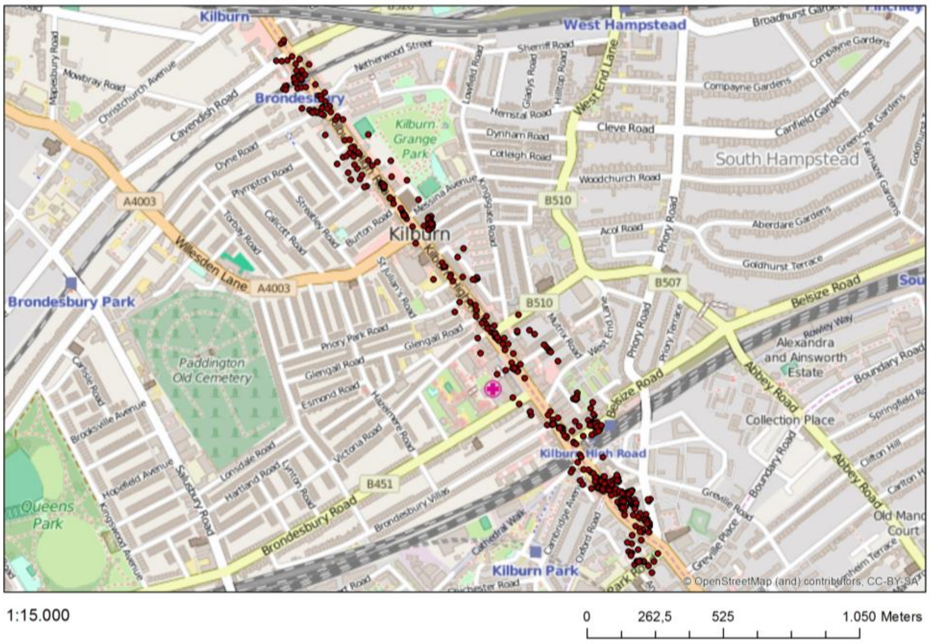

Figure 2. The distribution of georeferenced Tweets and Flickr photo along Kilburn High Road.

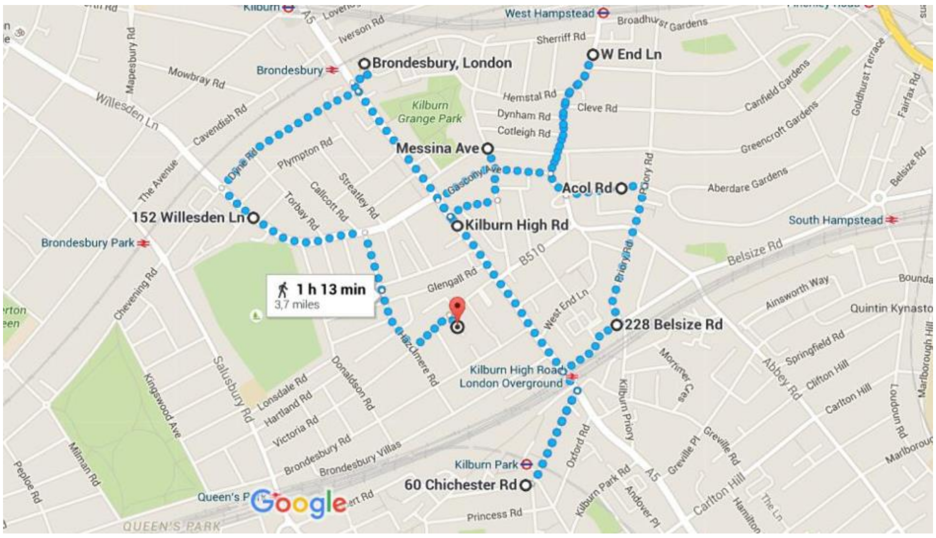

Figure 3. Emerging paths around KHR from VGI content.

4.2. Locale: Everyday Life in KHR

The notion of locale, which serves to discover settings where everyday life takes place, was analysed by grouping the most frequent terms in three categories: urban functions, street furniture and activities.

4.2.1. Urban Functions

As regards urban functions, Massey defines Kilburn as her "local shopping centre" and her description focuses on the newspaper kiosk run by a Muslim, on the Indian clothes shop and on a few leisure facilities such as the Black Lion guesthouse, the "local theatre" (The Tricycle) and the National Club. From this "sketch", the idea of both the multiethnic and dynamic atmosphere of KHR is conveyed, together with the value of the services such as the historic guest house built in the XIX century and the theatre performances.

The other significant function relates to transport: Kilburn High Road is an important node in the London metropolitan area, as Massey comments "this is one of the main entrances to and escape routes from London, the road to Staples Corner and the beginning of the M1 to 'the North'". The transport function seems to be a problematic feature of KHR since the traffic is defined as "stationary" and "snarled up".

When the two VGI data sets are considered, the urban functions that emerge are more diversified, as the following table shows. The selection of the most reccurrent terms (single word or up to 3 word-strings with > 3 occurrences) converge on: recreational facilities (like theatres, cinemas, live music) and on transport facilities (see Table 3).

It is also interesting that famous global chains such as McDonalds, Starbucks and Tesco appear in the list as an effect of the globalization process in food retail which will also appear in the activities category later in this paragraph. The other "shops" seem quite ordinary ones as the many photos from Flickr show through landscape snapshots of the shopfronts along KHR (see, for example, Figure 4).

The two most cited recreational facilities are the Gaumont Cinema and the Tricycle theatre which can be considered as part of the local cultural heritage for their architectural and artistic value: the first is an art deco building and second is an innovative theatre. The fact that "conversation" converges on these items shows that they are part of Kilburn High Road's cultural identity (Figure 5).

On the other hand all the terms concerning transport are due to the fact that city mobility is an important and often problematic part of daily urban life. Kilburn High Road is served by several railway lines, linking the area with the city centre and the north-west suburbs. Most Flickr photos show the traditional red buses or double deckers and the iron railway bridge built in 1852 as icons of local transport (Figure 6).

Table 3. Most frequently recurring terms in the urban functions category.

Locale/Urban functions					
Recreational services	**Occurrence (n.)**	**Transport facilities**	**Occurrence (n.)**	**Shopping facilities**	**Occurrence (n.)**
The Black Lion	39	bus	34	shops	33
Gaumont Cinema	38	stations	19	store	9
Tricycle Theatre	38	train	12	laundrette	3
Kilburn Park	22	Kilburn High Road railway station	8	Tesco food	3
theatre	19	car park	6		
cinema	18	Bakerloo Line	6		
Cock Tavern Theatre	18	Metropolitan Railway	6		
pub	15	Kilburn High Road Station	4		
Luminaire music hall	13	North London Line	3		
Queens Park	8	Kilburn High Road tube station	3		
restaurant	6				
hotel	6				
McDonalds	5				
Sichuan restaurant	5				
Grange Cinema	4				
North London Tavern	4				
cafe	3				
club	3				
Red Lion	3				
Starbucks	3				

Figure 4. A panorama of KHR shopfronts. Source: Flickr, The Creative Commons.

Figure 5. The Gaumont Cinema (right) and the Tricycle theatre (left) in KHR. Source: Flickr, The Creative Commons.

Figure 6. Kilburn High Road railway bridge. Source: Flickr, The Creative Commons.

4.2.2. Street Furniture

Moving on to the street furniture category, another aspect of street life is taken into consideration. All the items (e.g. postboxes, phone boxes, traffic lights, traffic signs, bus stops, etc.) are utilitarian in nature but also have a symbolic value which builds the identity of the street and relates more generally to the national culture: an example could be the British red phone box. As Jane Jacobs pointed out: “a sidewalk life arises only when the concrete, tangible facilities it requires are present….If they are absent, public sidewalk contacts are absent too" (Jacobs, 1961 p. 93).

In Massey's sketch, street furniture consists of posters on the wall relating to political and social conflicts (such as references to the Irish Free State, letters from the IRA), notices recording lottery winners or announcing forthcoming concerts, with many postboxes along the road. The flow of VGI, in contrast, offers a strong convergence on street murals and graffiti, a recent expression of street art, and on items linked with transport (e.g. the platform, the junction), street lights and the traditional phone boxes (Table 4).

In particular the phone box, which seems to be a relic of the past but is without doubt a traditional item in the British urban landscape, produces some nostalgic feelings as will be demonstrated later. These terms emerge particularly from the georeferenced photos on Flickr.

4.2.3. Activities

The terms selected in the activities group refer to actions or behaviours of different kinds which are performed by VGI producers. This category includes terms related to everyday activities, from work to transport and food, sports and free time (Table 5).

The activities which emerge from the VGI data refer to very common habits like eating out with friends, going to parties and concerts, or doing paperwork. In particular, terms concerning food highlight, as with the shops, typical globalized items like burgers, sandwiches or the appreciation for ethnic food like kebabs or Indian and Chinese dishes (e.g. pitta bread, noodles); moreover people's comments also converge on some comfort foods, like the chocolate-coated bananas or the vanilla icecream. It is interesting that the drinks mentioned include beer and coffee but omit the more traditional English tea.

5. Sense of Place

The last category to be addressed is sense of place. Massey describes KHR from an affective point of view, "Kilburn is a place for which I have a great affection; I have lived there many years" which embodies the features of place by presenting it as a community with its inhabitants and their relationships with the street environment.

Table 4. Most frequently recurring terms in street furniture category.

Locale/Street furniture	Occurences (n.)
murals and graffiti	52
junction	25
side platform	14
sign	11
stairs	8
lights	7
phone boxes	4
building dates	5
island platform	5
station name	5
gardens	4
bench	3
neon lights	3
traffic light	2
street art	2

Table 5. Most recurring terms in the "activities" category.

Locale/Activities							
Food	**Occurences (n.)**	**Sport**	**Occurences (n.)**	**Events**	**Occurences (n.)**	**Work**	**Occurences (n.)**
beer	10	World cup	22	match	8	work	50
coffee	9	football	20	film	7	job	10
beefburger	5	jogging	6	concert	6	watch	6
chicken	5	tennis	5	music	5	write	5
club sandwich	4	walking	3	home parties	4	dissertation	3
shish kebab	4	yoga	3	parties	3	paperwork	3
chicken pitta	3	Wimbledon	2	garden parties	3	workshop	3
vanilla ice cream	3	play	3			office	3
noodles	3						
lamb	3						
chocolate coated banana	2						
lolly	2						
salad	2						
rice	2						

In order to grasp the sense the of place at KHR, records with terms or expressions revealing emotions and feelings have been manually selected and linked to each category (transport, street furniture, etc.) trying to collect at least 3 records containing terms or expressions related to emotions. The selection is rather difficult because the analysis of VGI sources shows that feelings and emotions are not always expressed by single words like happy, unhappy, love or hate but rather with expressions of more that one word that reveal the state of mind. For example the sentence "I am single again", may convey the idea of loneliness but this feeling is not clearly stated in the annotation; or does the Tweet "Club sandwich in front of me on the bus" mean the traveller is hungry or annoyed?

Furthermore, only a limited number of records contain emotional expressions which can be linked to the categories, as Table 6 shows.

The combination of categories and emotional contents highlight the recurring feelings on the emerging terms identified in the analysis on Kilburn High Road, as the samples in Table 7 explain.

Table 6. Records containing emotional terms and expressions extracted for each category.

Category	Records containing emotional terms & expressions
Location /Site	40
Urban functions	
Recreational services	8
Built environment	12
Transport	40
Activities	15
Street furniture	12

Table 7. Samples of records selected for exploration of emotions & feelings.

Dimension	Category	Records with emotional & perceptional contents (samples)
Location	Site (KHR)	"I really **love** Kilburn". "**Enjoying** too much here I don't wanna go home". "Kilburn High Road has always been a **bustling** and **vibrant** place and a couple of recent visits has shown me it still is". "I took this walking along Kilburn High Road after going to a football match. I liked the **atmospheric feel** that the streetlight gave to the bricks and cobbles". "A **bland-looking place** alongside Kilburn High Rroad station" "I love **the old people**, even the grumpy old crows! They're **amazing**" "The southernmost part of the road, south of the junction with Marylebone Road, is noted for its distinct **Arab flavour**". "all Hindus are cordially invited" (Massey, 1991).
Locale	Transport	"oh dear a truck **broken down**". "I **hate** strangers sitting next to me on the bus". "have been on the bus for 30 mins.Still not out of Kilburn". "**Erratic** is the only way to describe driving in London". "I don't know **what's worse**, driving in London or using Londons public transport. Both will eventually cause me a **heart attack**".
Locale	Recreational facilities	"You can see **Nandos** on the left. **Woody Grill** on the right". "There are many **pawn brokers** on the street as well as **pay day loan shops**, gambling machine shops and betting shops".
Locale	Street furniture	"Using phone boxes is **still a thing**?". "I cannot imagine how long this mural has been here, advertising matches, so different in its **faded glory** from the glossy flashy ads that have superceded it". "By contrast, large murals under rail bridges near Kilburn Station. Part of the aim of the Kilburn murals was **celebrate** the "vast multiculturalism" of that part of London. Also to involve members of the **local community** as the murals were painted". "I think there's a very clear line between **street art** and graffiti". "dust, dog poo". "pigeons should get fined...". Yet, the flashy lights attract me—the neons, the fluorescents and the ever changing traffic lights.This city is always lit. A bit too well lit sometimes.
Locale	Activities	**"Club sandwich** in front of me on the bus". **"#fish and #chips** #fincity #kilburn#london". "@NandosUK #nandos [restaurant] KILBURN". "#hotChocolate #Starbucks #myJob @KilburnHigh Road". "Woke up to a **kabanos** in our bathroom. And a mini version of those smooth **Turkish beef sausages**. Our cats are such cultured scavengers".

After reading these annotations, some remarks may be made on the emerging sense of place of KHR: a busy and vibrant road characterized by heavy and congested traffic, with a multiethnic population which seems to be comfortable in the neighbourhood despite the typical drawbacks of the urban environenment such traffic congestion, litter or light pollution. The comparison with Massey's description also reveal some changes, particularly in the shopping facilities (the local shops replaced by department stores) and in street furniture (the posters replaced by murals) but also the permanence of problematic features (the congested traffic) and of cultural heritage (such as the Gaumont Cinema, the Tricycle theatre). The explorations of the sense of place derived from VGI annotations could be developed further, but the aim here has been to concentrate on the most relevant aspects of the road while giving examples of the potentialities of VGI in dealing with urban matters. The lessons learnt from the analysis could certainly be used to improve the quality of life and to finetune planning initiatives in those fields which emerge from citizens' footprints: the case study identified, for example, traffic, light pollution, litter as relevant features on which conversation converges. As argued by recent literature (Campagna et al., 2015; Crooks et al., 2014; Foth et al., 2009), VGI can complement existing authoritative geographic information in giving planners near real-time information not only about rapid changes in the physical environment but also about social processes in space and time. In addition, such sources offer unprecedented potential in the investigation of community perspectives, preferences and needs (Resch et al., 2015).

6. Conclusions

The paper has shown some of the potential of volunteered geographic information when an urban context has been analyzed from a qualitative point of view.

The singular point of view of KHR by Doreen Massey has been supplemented by the palimpsest of information derived from VGI sources which has brought together the informal knowledge of the content and become a collector of multiple points of view. This multiplicity of identities has highlighted the many emotional relationships within KHR such as appreciation, criticism, sharing and reacting and so on.

In addition, the identification of emerging terms has revealed the "sticky features" in the fluid space of digital information: the categories identified are clusters of information which not only tell stories of location (the *where*) but collects the added value generated by the producers' annotations that build the sense of place.

In this context VGI enables a better understanding of place identity and dynamics since place is a process that is continually reproduced through a distinct mix of wider and social relations.

The exploitation of VGI has so far been characterized by a preoccupation with representing crowdsourced information on maps that often all look the same, since patterns are strongly biased by the heavily concentrated production areas of crowdsourced information. Maybe narratives should go beyond the map to address territoriality and place (Roche, 2015) and exploit the inner meaning of the crowdsourced content, highlighting conflicts, convergences, power relationships, values and practices, as we have tried to do in this paper.

In conclusion, the VGI sources produced more or less voluntarily by non-expert people have shown two important qualities that could also be employed in urban planning: a) content created or edited by individuals will eventually converge on a consensus on features, preferences, values; b) they may tell 'stories' about places, unknown to the wider public, and consolidate knowledge, mainly at local level, which could remain unseen because it is remote from the places where decisions are made. As Jane Jacobs wrote: "Designing a dream city is easy; rebuilding a living one takes imagination" (Jacobs, 1958).

Acknowledgments

The author would like to thank John Agnew (University of California, Los Angeles), Gilles Falquet (University of Geneva), and Rob Lemmens (University of Twente) who provided insight and expertise that greatly assisted the research, although they may not agree with all of the interpretations/conclusions of this paper. The other acknowledge the support of COST Action IC1203 European Network Exploring Research into Geospatial Information Crowdsourcing: software and methodologies for harnessing geographic information from the crowd (ENERGIC).

Conflict of Interests

The author declares no conflict of interests.

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Urban Planning (ISSN: 2183-7635)
2016, Volume 1, Issue 2, Pages 141-154
Doi: 10.17645/up.v1i2.644

Article

The V in VGI: Citizens or Civic Data Sources

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Submitted: 13 April 2016 | Accepted: 17 June 2016 | Published: 12 July 2016

Abstract
Volunteered geographic information (VGI), delivered via mobile and web apps, offers new potentials for civic engagement. If framed in the context of open, transparent and accountable governance then presumably VGI should advance dialogue and consultation between citizen and government. If governments perceive citizens as consumers of services then arguably such democratic intent elide when municipalities use VGI. Our empirical research shows how assumptions embedded in VGI drive the interaction between citizens and government. We created a typology that operationalises VGI as a potential act of citizenship and an instance of consumption. We then selected civic apps from Canadian cities that appeared to invoke these VGI types. We conducted interviews with developers of the apps; they were from government, private sector, and civil society. Results from qualitative semi-structured interviews indicate a blurring of consumer and citizen-centric orientations among respondents, which depended on motivations for data use, engagement and communication objectives, and sector of the respondent. Citizen engagement, an analogue for citizenship, was interpreted multiple ways. Overall, we found that government and developers may increase choice by creating consumer-friendly apps but this does not ensure VGI offers an act of civic participation. The burden is placed on the contributor to make it so. Apps and VGI could potentially further a data-driven and neoliberal government. Planners should be mindful of the dominance of a consumer-centric view even as they assume VGI invariably improves democratic participation.

Keywords
Canada; citizen engagement; consumer; democracy; governance; government; municipal; open data; participation; volunteer

Issue
This article is part of the issue "Volunteered Geographic Information and the City", edited by Andrew Hudson-Smith (University College London, UK), Choon-Piew Pow (National University of Singapore, Singapore), Jin-Kyu Jung (University of Washington, USA) and Wen Lin (Newcastle University, UK).

1. Introduction

Cities across North America and Europe are collecting Volunteered Geographic Information (VGI) via mobile and browser-based apps. Their hope is that VGI can lead to better decision-making, improve service delivery, and empower municipal residents to become more involved in governance (Mooney, Sun, & Yan, 2011). Goodchild describes VGI as the "widespread engagement of large numbers of private citizens, often with little formal qualifications in the creation of geographic information" (Goodchild, 2007a, p. 212). Goodchild and others (e.g., Ganapati, 2011) perceive VGI's potential to engage a large body of the public at low costs to entry for capital and expertise, for example offering a mechanism for government to complete existing spatial data infrastructures. Authors argue that VGI in governance fundamentally shifts the relationship between the citizen and the state, in part because VGI challenges the notion of authoritative data (Coleman, 2013). In this formulation, the contributor becomes an essential component of new incarnations of the city, like the smart city, because their VGI is crucial to a dynamic location awareness of the urban environment (Roche & Rajabifard, 2012).

Review of VGI literature points to a dearth of the government perspective, particularly local government, on VGI. Extant discourse related to government emphasises spatial data accuracy, completeness of coverage, contributor motivations, and to a lesser extent, digital inequities revealed in the contributions (Coleman et al., 2009; Haklay 2010; Minkoff 2016). Because of this focus, governments may resist adopting VGI if it cannot be adapted to existing data structures and workflows or if the data is viewed as untrustworthy (Haklay, Antoniou, Basiouka, Soden, & Mooney 2014). Three areas are needed for VGI incorporation into government decision making: formalisation of VGI collection, collaboration within and between governments, and a reframing of citizens as partners in the planning process (Johnson & Sieber, 2011, 2013). As the focus is frequently more on the 'V' in the acronym than the 'GI', we are interested in how citizens are being formulated in governance.

Our empirical research shows that a specific set of assumptions about the V in VGI drives the interaction between individuals and their government. We are explicitly interested in the tensions between volunteer as citizen actively engaged in a participatory democracy and volunteer as market-based consumer of government services. VGI is frequently promoted by extolling its democratic potential, with words like empowerment, although empowerment can describe a collective redistributive form of political power or an individual emancipation from inefficiency. To examine this tension, we look at expressions of the V in VGI through the lens of civic applications or "apps". Unlike other research that repurposes VGI for uses other than the original intent of the contributor (e.g., in OpenStreetMap or Twitter), we look at active contributions, where contributors and app developers possess an explicit sense of how the data will be used.

This paper explores the citizen-consumer dichotomy and its expression in government and developer perceptions of VGI contributors. We first review the literature of VGI and related fields, highlighting invocations of the volunteer. We present a typology that operationalises VGI in city governance as an act of citizenship and as an instance of consumption. We then select civic apps that best represent these VGI types. We also chose to investigate a hybrid app, an app that ostensibly expresses volunteer as both citizen and consumer in case the dichotomy fails to neatly divide. We present the results of qualitative semi-structured interviews conducted with developers of these apps, who come from government, private sector, and civil society organisations. Findings from interviews indicate a level of citizen-centric perception in all apps, which sometimes conflicted with a consumer-centric orientation. Our hope in this research is that planners and civic app developers are mindful of the dominance of certain frames. Government may assume VGI invariably improves democratic participation even as its app casts the individual as a neoliberal consumer.

2. Literature Review

Numerous themes, like spatial data accuracy and volunteer motivations, connect VGI to governance because of VGI's potential to shift the roles and responsibilities of government relative to its inhabitants and VGI's opportunities to broaden public participation. We review the ways in which the VGI and related literatures have characterized the volunteer and the way this characterization propels thinking about governance in the Web 2.0 era.

Arguably, the largest discursive element of the volunteer in VGI invokes the volunteer as a democratic actor. Adams (2013, p. 465), for example, believes that "VGI might facilitate new forms of activism, participatory democracy and neighbourhood empowerment". Elwood (2008) suggests that the heterogeneity of VGI platforms may enable new narratives that circumvent existing data and power structures. Seeger (2008) describes VGI's potential to address low rates of public participation. VGI is argued to have a democratising effect over data production and use, offering a "social transformation in the way data can be collected and shared" (Fast & Rinner, 2014, p. 1287). Whereas information technologies can be used to promote participation, VGI contributors also have the power to undermine participatory processes (intentionally or unintentionally), for example overloading the process with information targeted towards a specific agenda (Tulloch, 2008). Some VGI, such as that passively harvested from social networks, may not even be intended as part of a political process. Similar to Public Participation GIS (PPGIS), VGI's predecessor, participants may be simultaneously marginalised and empowered in VGI (Harris & Weiner, 1998). A user interface may dissuade a broader public from participating, while being quite accessible to the technologically-comfortable.

The word 'citizen' is regularly invoked in VGI, alongside collective agency, empowerment, democracy and public participation, although citizen is usually undefined or used synonymously with individual or volunteer. Goodchild (2007a, 2007b) describes the V in VGI as intelligent citizens sensors who can outperform credentialled experts in identifying subtle changes in their environment. A related concept from government is citizen-sourcing, defined as the intersection of engagement, crowdsourcing, and open government to leverage the knowledge of individuals (Nam, 2012). Nam links empowerment to citizen sourcing, which "may change the government's perspective on the public from an understanding of citizens as 'users and choosers' of government programs and services to 'makers and shapers' of policies and decisions" (Nam, 2012, p. 13). What complicates the V as citizen is that VGI is envisaged as an individual activity (Sieber & Haklay, 2015), where individuation serves as a precondition for a neoliberal view of the urban resident (Harvey, 2005; Massey, 2013). Here the V in VGI trades collective participatory engagement found in PPGIS for individuated consumptive behaviour in a market-based relationship with the state. Needing a working definition, we stipulate the citizen, albeit individuated, as one who engages with government on political issues for a collective good.

Citizen sensing and sourcing shift citizenship towards third wave styles of governance like New Public Management (NPM), where VGI is viewed as a process of coproduction. NPM presents government no longer as a provider of public services but as a manager of service providers, that also promotes outsourcing and market-based decision-making (Denhardt & Denhardt, 2000; Hood, 1995). In this model, volunteers "play an active role in producing public goods and services of consequence to them" (Ostrom, 1996, p. 1073). Coproduction "extend(s) across the full value chain of service planning...delivering, monitoring, and evaluation activities" (Bovaird, 2007, p. 847).

Coproduction preceded Web 2.0 but is reinvigorated by VGI, through the fusion of users and contributors of content. Termed produsage (Bruns, 2008), this describes a structural shift in economic production, a "collapse of older, production and product-based models" (Bruns, 2007, p. 7). Bruns identifies characteristics of produsage such as community-based production, fluidity in roles, continual development and common property. Bruns thus grounds his characteristics in an economic framing. Budhathoki, Bruce and Nedovic-Budic (2008) applies the concept of the produser to geographic information, differentiating contributors according to their motivations to contribute and level of expertise. Coleman et al. (2009) apply Bruns's produser to describe contributor motivations from civic and economic perspectives as well as the overlap in these two perspectives. For the purposes of this paper, we define consumers as market-based individuals who view the state as the provider of services and may be coproducers to ensure that efficient targeting of services serve their self-interests.

Forms of governance like NPM act as a paradigm shift that stresses efficiency, customer satisfaction, and profit-seeking behaviour as opposed to democratic empowerment, collective interest, and equity (Aberbach & Christensen, 2005). In this neoliberal shift VGI allows government responsibilities to be outsourced to volunteers who become part of a service provision ecosystem. Thus a citizen moves toward the market of self-interest, emphasising:

> "The liberal definition of the citizen, one that focuses on individual preferences and rights…it deemphasizes…the republican or collective tradition that emphasizes common goods and collective action through political parties, neighbourhood groups and participation in community activities." (Aberbach & Christensen, 2005, p. 241)

Leszczynski (2012) describes VGI as an enabler of that shift, part of a wave in geospatial web technologies leading to reduced and outsourced government mapping. Outsourcing data collection (and responsibility) transforms the state's role, allowing "corporations, non-state actors, and private citizens…fulfilling functions that were long the exclusive preserve of state mapping organizations" (Leszczynski, 2012, p. 78). Arguments for increasing efficiency or constraining government spending play key roles. The US government now relies on citizens to maintain certain datasets, from location of invasive species, to crisis information, to the underlying road infrastructure (Coleman, 2013; Goodchild, 2007b; Goodchild & Glennon, 2010). Ghose (2005, pp. 63-64) notes that neoliberalism via technocratically-enabled practices, which include VGI, leads to a multiscalar rescripting of citizenship practices where citizens bear the burden "to be entrepreneurial and to develop the capacity to be an active agent in claiming their urban space".

Why is it problematic to label a volunteer a consumer? When people are liberated from regulations (a goal of neoliberalism), certain people become freer than others and the state dismantles distributive and more equitable policies, focusing instead on decisions that favour specific sectors and individuals (Harvey, 2005; Massey, 2013). The potential is manifest in VGI: if one is not positioned (e.g., in terms of skills or structural bias) to be entrepreneurial, service is not given. Social inequalities such as gender biases and rural-urban divides have been identified in VGI production (Hecht & Stephens, 2014; Stephens, 2013). A census tract-based analysis of New York City's Open 311 system finds that higher home ownership is correlated with higher reporting; at the same time these areas are likely less subject to graffiti/noise (Minkoff, 2016).

It is easy to dichotomise the roles of the volunteer as either democratic (citizen) or market-based (consumer/producer). While critical of NPM, Aberbach and Christensen (2005) maintain that empowerment exists in both citizen and consumer orientations. A consumer orientation is not automatically disempowering if the democratic context follows the liberal definition of the citizen and is viewed as a more direct form of democracy (Aberbach & Christensen, 2005). Market based approaches like citizen-sourcing can lead to civic learning by increasing citizens' knowledge of political issues, reducing alienation from decision-making, and minimizing conflicts with government (Nam, 2012). Citizen-sourcing may "tap into the unique skills…and knowledge among the public" where citizens provide information, feedback and intelligence (Nam, 2012, p. 449). We speculate that context, such as a liberal tradition of governance, is important in setting how volunteers are perceived and VGI is valued.

Apps and platforms structure data collection and consequently shape volunteer engagement with government. All VGI is structured in some way. In the private sector, Twitter limits each contribution to 140 characters. In the public sector, service requests are increasingly standardised via platforms like FixMyStreet and application program interfaces like Open311. The design and interoperability of software exert significant impacts on how we communicate with cities (Sieber, Robinson, Johnson, & Corbett, 2016). Governments arguably are shaped by the apps they use to interface with citizens.

Aberbach and Christensen's (2005) concerns are evinced in service request apps. King and Brown (2007) describe FixMyStreet as empowerment, "raising the volume of the citizen's voice", and part of "a growing movement towards encouraging customers/citizens/patients etc. to take greater control and responsibility for their own well-being" (King & Brown, 2007, p. 78). Baykurt (2012, p. 11) counters King and Brown's optimism; she contends apps like FixMyStreet may improve efficiency, transparency and accountability of service requests but "simultaneously produces an individualized, momentary, issue-focused government-citizen relationship while neglecting collective action and community power". The conflation of terms like citizen and consumer, or coproduction and empowerment, demonstrates that conflicting views within existing VGI projects need to be closely examined.

3. Methods

To assess the citizen-consumer dichotomy in VGI-driven civic apps, we surveyed government and developer perceptions of VGI contributors. A scan for cases in Canada was conducted using criteria from a model we created of the citizen and consumer. Respondents were identified using a two-staged snowball sample. After selection, we solicited government and developer perceptions using qualitative semi-structured interviewing. We then conducted descriptive coding to reveal themes in responses. Questions covered the use of VGI and perceptions about the user and volunteer engagement.

4. Modelling and Operationalizing the Citizen and the Consumer

As suggested above, concepts of citizen and consumer overlap and are diluted in ways that complicate operationalisation. We developed a basic model of the citizen and the consumer, which we used to operationalise the two concepts and assist in the selection of cases. We inferred the orientation of the volunteer from developer characterizations of the app as citizen-centric or consumer-centric, based on the assumption that developers' characterizations shape app construction and structure the ways that volunteers can contribute. Table 1 shows the four characteristics by which we operationalise citizen and consumer: content, purpose, users, and directionality of communication. Content and purpose serve as the main differentiators between types. For example, an app collecting feedback on public policy to inform said policy would appear to be citizen-centric; an app collecting data that would enhance a public service would appear as consumer-centric. The directionality of communication and users of data further resolve unclear cases.

If government views volunteers as citizens then government presumes its residents have expectations of government duties beyond service delivery, such as equitable service coverage. We presume that citizens require demonstrable forms of engagement and aspire to collective needs. Conversely, consumers present government with individual self-interests. With sufficient contributions, VGI represents the aggregation of individual preferences, akin to market demand. In this view, government responds to market forces to deliver public services with efficiency, effectiveness, and customer satisfaction.

Table 1. Volunteers operationalised in apps.

Criteria	Consumer-centric	Citizen-centric
Content	Service delivery, crowdsourcing	Politics, elections, policy, citizen opinions
Type of Volunteers	Individuated	Collective
Purpose	Improve services, input into analysis/decision-making	Collect feedback on policy. Promote transparency, openness. Advance rights
End User	Unelected officials	Elected officials
Communication	No dialogue. Solely a data-collector	Dialogue possible

4.1. Scan of Apps

We scanned existing civic apps in five of Canada's major cities: Ottawa, Toronto, Vancouver, Edmonton and Montreal. The first four cities are originators of Canada's open data consortium (Carl, 2012, May 7) so are likely to have mature apps built on their open data platforms. Montreal was added to provide a pool of Francophone apps. Examples of ideal citizen-centric or consumer-centric types were selected according to the criteria in Table 1. Our result set, particularly for citizen-centric apps, was small. A recent study found very few examples of apps that promote citizen engagement as opposed to apps that handle service requests (Sandoval-Almazan, Gil-Garcia, Luna-Reyes, Luna, & Rojas-Romero, 2012).

We were interested the suitability of the citizen-consumer dichotomy for each app and respondent perceptions aligning with the apps' pre-selected category. Not all criteria were required to determine category assignment. Preselection criteria included the content and the end user of the VGI. If according to the app's description and preliminary usage, the content elicited opinion on how government was run then this was deemed citizen-centric. VGI that appeared to be used as simple inputs to government decision-making was viewed as coproductive and thus consumer-centric. Requests for services (e.g., 311) were deemed consumer-centric, although we found citizen and consumer categorisation was not easily distinguishable without interviewing respondents. The communication and individual/collective criteria were less important, as we felt it would be difficult to identify apps as citizen engagement and customer feedback prior to interviewing respondents. All app development was outsourced. Outsourcing arrangements reflect the trend in government appification (Sandoval-Almazan et. al., 2012).

A case study—a brief description of its functions and applicable end users—was created for each of the final three apps (Table 2). Citizen Budget, a government budget feedback app, was chosen as the citizen-centric app because it elicits feedback on public policy. Toronto Cycling App, a cycling route app, was chosen as the consumer-centric app due to its crowdsourcing-like functionality, where data is used as input to improve service delivery. VanConnect, a 311 service request app, was chosen because it appeared simultaneously consumer-centric, due to service requests as the VGI content, and citizen-centric, because its feedback mechanism suggested a more engaged form of participation beyond customer feedback. Gordon and Baldwin-Philippi (2013) differentiate types of engagement afforded by Customer (or Citizen) Relationship Management (CRM) systems, ranging from simple one-way transactions (weak engagement), to community-wide interaction that builds community networks (strong engagement). This suggests a hybrid; for example, there may be more to service request apps than just one-way interaction or customer feedback.

5. Interviews

Empirical research consisted of qualitative semi-structured interviews, where respondents were identified via a two-staged snowball sample. After identifying apps, officials and developers responsible for app development and use were identified. Except for Citizen Budget, municipal officials were contacted and interviewed first. Those interviewed in the first stage referred us to the next respondents in the developer or government side. Questions differed slightly whether we interviewed individuals within government or outside government (outsourced developers). Developers were asked how they hoped the data (VGI) would be used by their client; government respondents were asked to describe its actual use. All were asked to describe the app and its development, their organisation and role within, the use of VGI, the characteristics of the volunteer, and the nature of volunteer engagement.

Respondents were selected based on their experience with the app and their leadership or managerial

Table 2. Overview of cases.

	Citizen Budget	Toronto Cycling App	VanConnect
Best Practice Example of	Citizen-centric	Consumer-centric	Hybrid
Government	Borough of City of Montreal, Le Plateau-Mont-Royal	City of Toronto, Cycling Infrastructure and Programs—Transportation Services division	City of Vancouver, 311 Call Centre
Developer	Open North Non-profit, data host, analytics	Brisk Synergies Private sector, data host, analytics	PublicStuff Private sector, data host
Data Content	Residents' simulated budgets with postal code identification, feedback	Cyclist demographics, feedback, and GPS points	Geolocated 311 service requests. feedback

Table 3. List of respondents.

	Respondent #	Sectoral Type	Organisation	Position
Citizen Budget	1	Government	City of Montreal, Le Plateau-Mont-Royal	Political Aide (attaché politique)
	2	Non-profit developer	Open North	Director of Product and Service Development
Toronto Cycling App	3 4	Government	City of Toronto - Cycling Infrastructure and Programs	Manager Project Lead
	5	Private sector developer	Brisk Synergies	CEO
VanConnect	6 7	Government	City of Vancouver	Director of Digital & Contact Centre Services Open Data Coordinator
	8 9	Private sector developer	PublicStuff	Founder, CTO of PublicStuff Cloud Delivery Manager

position. We looked for respondents with sufficient knowledge to describe the app and the broader objectives of the project. Table 3 shows the respondent by identifying number, sectoral type, organisation, and position within the organisation. Citizen Budget interviews were conducted in person, the rest by telephone. In-person interviewing allows for more nuance in responses on complex issues (Shuy, 2003); telephone interviews are less nuanced but are found not to sacrifice data quality or responsiveness (Siemiatycki, 1979).

We presumed that respondents might be tempted to present themselves as 'pro citizen engagement'. Respondents were not directly asked to categorise users but instead were asked multiple, semi-structured questions to triangulate responses and capture the widest possible range of perceptions of the volunteer. These included questions on motivations to develop the app, uses of the VGI, and interactions with app users. Questions on volunteer engagement were purposely open ended: "How does the app help engage citizens?" and "Are you satisfied with the level of engagement provided through the app?". This allowed respondents to express their own perceptions and, hopefully, minimise bias. We realised that use of the term 'citizen' was a potential bias, although we saw no broadly used alternative to describe a resident of the city. Respondents generally used 'citizen' without prompting.

6. Coding

Descriptive coding, using a mixture of a priori and in-vivo techniques (Saldana, 2009), was performed on the interview data. A priori codes, such as 'efficiency', and 'market' were created beforehand to classify responses as citizen- or consumer-centric. In-vivo, descriptive codes (e.g., 'dialogue', 'service coverage') were derived from the interview data and categorised with the help of a priori codes. We then grouped codes under either citizen or consumer. Assuming not all respondents would similarly interpret 'engagement', we focus on the context to which the code was applied.

7. Results

Results are presented in three sections. First we describe the apps, respondents, and VGI, to provide context for interview responses. Then we assess the reasons for VGI and apps. Finally, we characterise interview results in terms of respondents' perceptions of users and engagement. Results show a citizen-centric perception in all apps with some respondents described a mixture of citizen and consumer sentiment towards the apps. Respondents had different positions and emphases when it came to interpreting engagement.

7.1. Descriptions of the App and the Role of the Respondent

This section describes the apps and their functionality, user interface, data collection, and objectives based on interaction with the app and respondent descriptions.

Citizen Budget is our best practice example of the citizen-centric type. It is a browser-based web app that allows individuals to create their own annual budgets for Le Plateau-Mont-Royal, a borough of the City of Montreal. Users respond to questions on tax rates, levels of service (e.g., frequency of snowploughing, which is very expensive but highly important in this Northern city), and investment projects (e.g., construction of a new library). The user interface is composed of slider bars, multiple choice boxes, and binary (yes/no) switches. The budget is automatically calculated and users can be forced to balance their simulated budget. Users can implement a new tax or raise existing taxes. Citizen Budget had two main objectives: obtain citizen feedback to inform decision-making and promote civic learning by educating citizens on the cost of public services and the challenges of funding diverse urban priorities.

Figure 1 is a screenshot of the user interface. Users contribute their simulated budget, feedback, and a postal code, which acts as a location identifier and as a way to filter out those living outside the borough. Political aides analyse collected budget simulations and results are presented by the Mayor during annual budget consultation. App development was outsourced to Open North, a non-profit organisation promoting government transparency and public participation in Canada through online and digital tools. (Note: in the year of interviewing (2015), the app was not used due to major restructuring of the City of Montreal's budget allocation to its boroughs.)

Toronto Cycling App represents the best practice of the consumer-centric type. This smartphone-based app has two main components: a user survey and a trip collector. Users contribute demographic information and they can choose to report their satisfaction with their overall cycling experience (e.g., comfort level in traffic). Comments about satisfaction are geolocated with partial postal codes for their home and work places. Cycling trips are recorded by collecting GPS points from user phones. Users classify trips according to eight predefined categories like commute, exercise, and work. The app displays cycling-related information on a map such as road closures and bike shops. The primary objective is to collect patterns on actual cycling behaviour; route-finding specific functionality like road closures is not the primary objective of the app. A secondary objective is to assist in Toronto's cycling infrastructure planning, including their 10-year Cycling Network Plan. Figure 2 shows the cycling route data traced on a map before being uploaded, and an optional demographic survey. Brisk Synergies was the private sector developer.

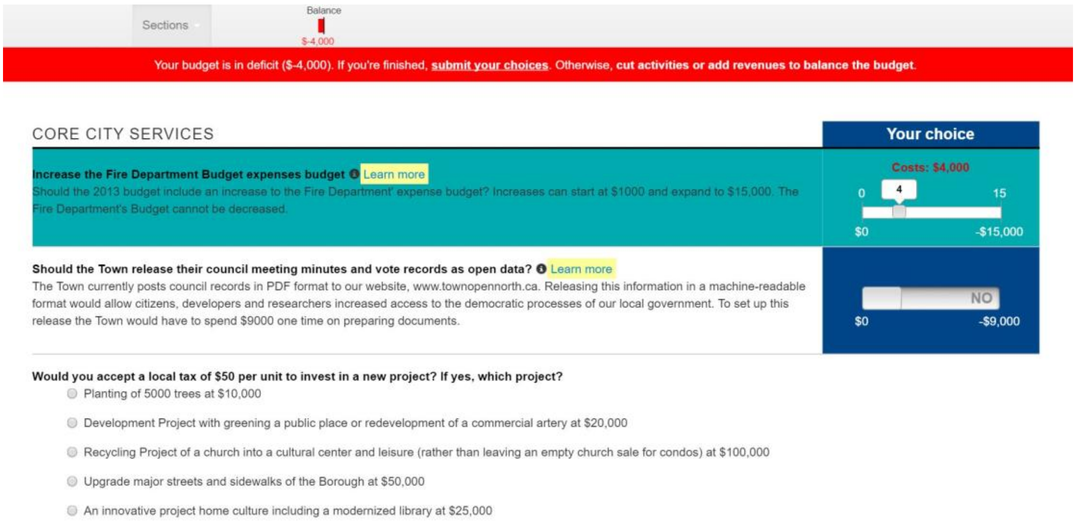

Figure 1. Citizen budget interface.

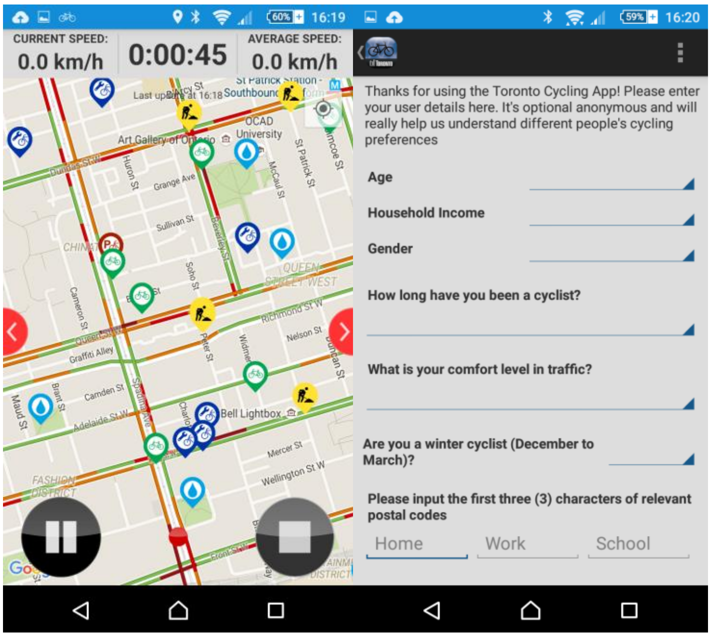

Figure 2. Toronto Cycling App interface.

The third app, VanConnect has multiple features, but its main objective is to collect service requests for the City of Vancouver's 311 Call Centre. Major cities throughout North America and Western Europe have some form of 311-style citizen-reporting service (Gordon & Baldwin-Philippi, 2013; Minkoff, 2016). VanConnect collects geolocated service requests that include location (coordinates and address), type (selected from a predefined list of service categories like graffiti, potholes, broken streetlights), user-generated answers to issue-specific questions (e.g. name of the object) and optional unstructured feedback. Reports are forwarded to the specific departments responsible for the identified infrastructure, or to an external organisation if outside the city's jurisdiction (e.g., Canada Post boxes). Users may receive automated updates on the status of their service request via an optional Facebook login or email registration. VanConnect displays other information, including maps and city announcements, as a separate component of the app. Figure 3 shows the predetermined list of service categories, location selection via a map interface, and options available when submitting a pothole repair request. PublicStuff was the private sector developer.

7.2. Reason for Volunteered Data Via an App

In this section we present respondents' reasoning for VGI as a method of engagement as well as VGI's potential to transform engagement. Reasons focused on reach, accessibility, and quality. Apps, particularly on smartphones, were seen as reaching a wider audience, particularly younger generations otherwise estranged from civic participation. Smartphones also allowed collection of broader types of content (e.g., images, coordinates) and at higher positional accuracy. Respondents spoke of a need or benefit to government collecting additional data. Respondent 5 reported that VGI supplied essential input to decision making and planning, providing the four main data elements needed for cycling planning, "Where are they from in the city…from and to which part city they're cycling to. And at what time". Cycling route collection via an app provides actual routes ridden by cyclists; the same exercise in public consultation might collect route preferences (Respondents 3, 4). Cycling planners needed data on both routes taken *and* demanded routes so an app was the ideal choice to map traffic separately from demand.

Respondents were asked whether VGI via apps could potentially replace traditional data collection or consultation. Respondent 1 stated that their administration had considered online-only consultation but had yet to move further. The hesitation was due to a lack of online responses. The app's population of VGI contributors (averaging 500 annually) and number of website hits (people who viewed the survey questions without contributing) outstripped the level of participation at traditional public consultations. Respondent 1 was hopeful that apps and online consultations could remedy this discrepancy. All other respondents described VGI via apps as an enhancement to, not a replacement for, traditional public consultation or feedback. Respondent 6 of VanConnect hoped the app could replace existing methods such as the 311 telephone service because of the latter's high operating costs. They believed that providing equitable service coverage was critical; therefore media such as telephone and email were still necessary to bridge any digital divides.

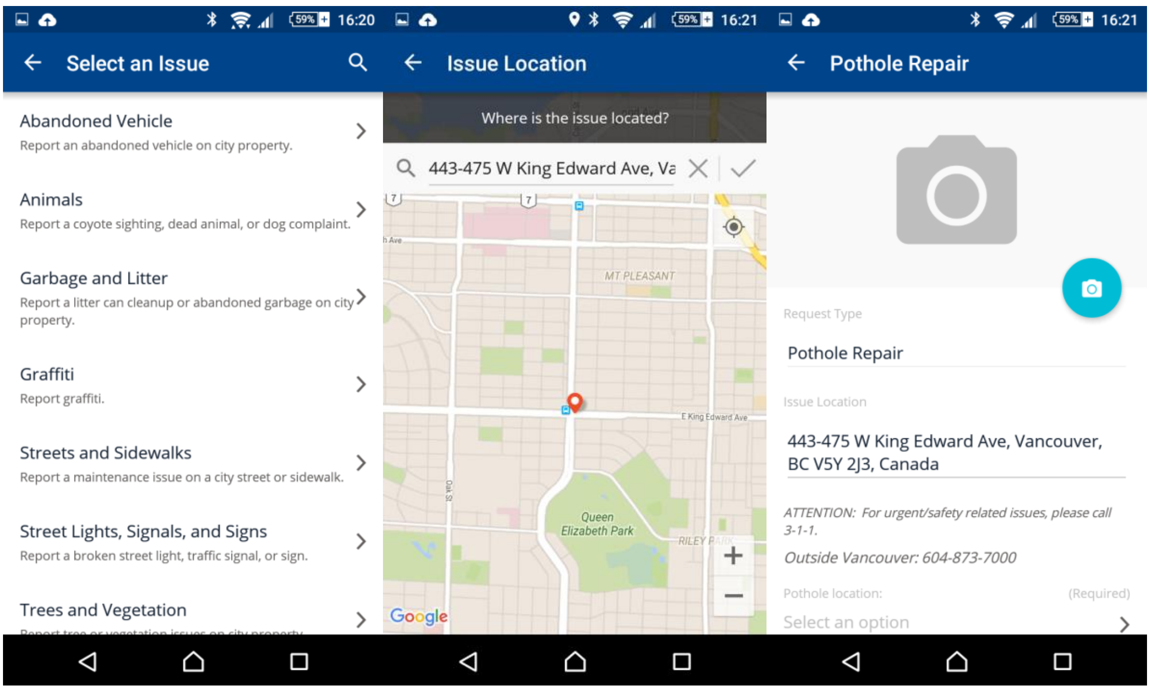

Figure 3. VanConnect interface.

7.3. Respondent Perceptions of App Users and Interpretations of Engagement

This section covers respondent descriptions of and satisfaction with volunteer engagement through the app. We also asked respondents to contextualise the app within larger engagement objectives. We synthesise the results in Table 4 below.

As seen in Table 4, Citizen Budget's respondents exclusively referred to volunteers as "citizens" or "users" and contextualised them as constituents for whom government has responsibilities. Respondent 1, the political aide, spoke of engagement as a key responsibility of "the elected", "to explain and to make it simpler for the citizen, and to be honest also". Responsibilities, they felt were invoked in the app, included citizen consultation and civic education. Respondent 2 was outspoken on citizen engagement, likely due to Open North's mission to promote citizen engagement through online tools. They differentiated between strong and weak engagement, defining engagement as ideally "to have people to have their voice heard and have a clear impact on how the budget is spent" and their non-profit being part of a "virtuous cycle" of interaction where, citizens understand that the next time "I send something, it's being heard and it's being useful".

There was disagreement on satisfaction with engagement via the app due to concern with engagement overall. Respondent 2 (Open North) was satisfied with Plateau-Mont-Royal's implementation because the surveying was run concurrently with the budget planning process. They believed VGI directly affected decision-making, which was crucial because "it's only working if people feel that what they do has an impact". Respondent 1 was somewhat dissatisfied with the level of engagement through the app. As mentioned above, the app generated a user population of 500, which far exceeded public consultations. However, this was considered insufficient in a jurisdiction of 120,000. Nonetheless, Respondent 1 was heartened by the quality of engagement, reporting that "we are having today better discussions with the citizens than five years ago". They also attributed apps with generating higher quality political discussions at public consultations.

Toronto Cycling App respondents were generally satisfied with the quality of engagement in the app. VGI allowed users to influence the planning process instead of reacting to a completed plan. When asked about satisfaction with the level of citizen engagement via the app, they felt that "it would have been great to see engagement that was distributed around the city at a higher level. We had a lot of users that are from the downtown core, and it would have been great to see more engagement beyond that area" (Respondent 3).

Respondent 3 blurred the distinction between consumption/coproduction and certain attributes of citizenship (e.g., concerns over equity). They were "satisfied with the way that the app can engage residents", but believed added functionality, such as service requests, would further enhance engagement into the app. At the same time, Respondent 3 reported that "we can't rely on engagement occurring in the app, at least the democratic kind." Respondent 4 expressed frustration with traditional public consultations, finding them "limiting". The app's goal was to make users "feel like they're contributing in a very useful sort of fashion. And they actually see what…what has been done…cause and effect".

Respondent 5 (Brisk Synergies) chose to interpret engagement in three ways. First, engagement represented the level of interest and participation in the cycling data initiative, which they acknowledged depended on continued marketing to sustain interest. Second, they viewed engagement as synonymous with enduser adoption. The developer believed that if users perceived the app had value then this would lead to more daily app usage, which would increase VGI contributions. Third, engagement was interpreted from a crowdsourcing perspective, where citizens provide useful information to the city to aid and, in particular, evidentially support decision-making. Matching other respondents of the consumer-centric app, coproduction was considered a form of engagement.

Our a priori-designated hybrid app, VanConnect, offered further confirmation that citizen-centric views can be framed in market-oriented language. Respondent 6 expressed three reasons for implementing the app. The first two were to enhance citizen-government interaction and to increase government efficiency. These were presented respectively as the citizen-side and business-side (i.e., front and back end) of the app. In all but two instances when "customer" was used, the respondent referred to users as "citizens". VanConnect was aimed to improve what Respondent 6 termed the "citizen experience". Citizen experience, while not explicitly defined, represented the entirety of a citizen's interaction with government and analogous to a customer experience.

The third reason for the app was to extend government efforts in collecting data and citizen requests. For Respondent 6, data collection and analysis enabled government to engage and listen to its residents. In turn, a responsive government would create an improved citizen experience. They were "pleasantly surprised" with the quality of engagement and generally satisfied with the level of engagement, but stated, "I don't know if we'll ever be 100 percent satisfied but we're certainly very happy". Respondent 6 revealed additional nuance when answering "Why did you use a mobile app?":

> "We have people that use our services from two years old to 100 years old and…can we get to whole new consumer group that needs to use our pools

Table 4. Aggregated responses on citizen engagement.

Themes around engagement	City of Montreal	Open North	City of Toronto	Brisk Synergies	City of Vancouver	PublicStuff
A priori app orientation	Citizen	Citizen	Consumer	Consumer	Both	Both
After analysis app orientation (by respondent)	Citizen	Citizen	Both	Consumer	Both	Consumer
Predominant terms used to refer to app users	Citizen	Citizen	User, Citizen, Resident	User	User, Customer, Citizen	User, Citizen
Characterizations of good engagement	Results in demonstrable impact on policy Allows for increased alignment with government policy Improves discussions in traditional consultations Increases citizen awareness of political issues	Results in demonstrable impact on policy Enables contributions to be embedded in government processes Creates a positive feedback loop	Improves communication via ease of use of app Broadening of geographic and demographic diversity User perceptions that their contributions are valued	Improves communication via ease of use of app Produces high user adoption Produces evidence-based decision-making	Improves communication via ease of use of app Reduces communication time between contributor and government Enables more direct interaction with government Generates more opportunity for feedback and dialogue	Produces evidence-based decision-making Automates the citizen to government interaction Enables more direct interaction with government

> and community centres and our golf courses, without closing channels off that are very traditional where, more senior citizens will still want to pay in cash, they still want to come to city hall, they may be using email as opposed to a smartphone. We're…trying to open up channels; we're trying to be more efficient and more transparent and hopefully more cost effective."

Apps offered a new consumer group; market demand (for apps) needed to be met, which increased consumer choice and efficiency (through cost reduction) via the app. Complicating this purely consumer orientation was the respondent's desire to ensure equity, a citizen orientation, in 311 service provision.

Turning to the private sector, PublicStuff's Respondents 8 and 9 were outwardly citizen-centric but invoked terms related to consumption. When speaking on communication between citizen and city, both respondents spoke of frictionless communication using terms like ease, directness and automation, where "Automating the interaction and allowing for the direct lines of communication really is the core of the product" (Respondent 8). Respondents 6, 8 and 9 argued that apps provided more choices for public engagement. That interaction *should* be automated and cater to individual needs suggests a consumer-centric view of users.

In addition to varied definitions of engagement, where engagement was occasionally equated with mere interaction with the user interface, we found that respondents' perceptions of engagement blurred data collection with citizen engagement. For example, Respondent 8 believed that data collection would "engage their citizens and get them involved (in) submitting information (that would) help them improve the City", making the city more efficient. Conversely, data collection might matter little compared to interaction. For Respondent 2, "what people in the end put in the tool doesn't matter that much; it's what they understood from using the tool that's important". Different forms of engagement, the soft-coded citizen education and the hard-coded data collection, can occur within the same interaction. Respondent 6 saw VanConnect as "a connection piece more than just a service request app". VGI allowed them to "figure out where are the tension points in the organization, what's bothering people, and what do we need to do differently or better". Data collection represented both coproduction and a way for the city to engage residents.

8. Discussion

Our a priori selections of apps as consumer or citizen-centric selections were not easily confirmed through interviewing. Consumer and citizen-centric characterisations overlapped and blurred distinctions. Blurring depended on the motivations for data use, the professional sector of the respondent, and the level of structuration of the contributions by endusers. We preliminarily classified Toronto Cycling App as a consumer-centric app. Its government respondents viewed data collection as a discrete part of the planning process that should not sacrifice responsibilities for citizen engagement. Empirical research nuanced the citizen-consumer dichotomy. VanConnect was assumed to be a hybrid model and, while attempting to balance citizen and consumer views, responses were grounded in a business management paradigm. Only Citizen Budget aligned with a citizen-centric orientation.

Classification challenges partially stem from numerous functionalities implemented in the same app, which in turn lead to diverse user roles and potential for produsage. Respondent 6 labelled their app an "omni channel approach to how we deliver customer service to citizens". This multi-faceted app obscures the distinctions between types of users, rendering it difficult to pinpoint whether engagement or participation serves citizens or consumers. Just as multiple functions converge into a single app, we argue that usage will move beyond simple data production or consumption, to produsage (and conceivably its citizen analogue of rights and responsibilities). VanConnect's combination of VGI collection and tailored data output such as maps and announcements means a user can contribute and receive content. Engagement prospects of VGI apps will depend on the context in which data is processed and objectives are articulated.

We found apps being deployed to increase accessibility of government and reach out to the previously unengaged. However, accessibility may be interpreted as an instrument to capture (free) untapped labour, reflecting concerns over market framings that sway governance in a participatory democracy (Aberbach & Christensen, 2005). Apps ostensibly increase choice but developers leave the responsibility to participate with the user. Presumably, increased availability of communication channels will spur engagement with those, for example, with a preference for mobile technology. Just because anyone can use the app then it might be concluded that everyone is using it (Elwood & Lesczynski, 2013). Citizen Budget's insufficient user population suggests that apps alone cannot generate that connection. This supply-side—"build the app and they will engage"—approach addresses demands for digitally-enabled efficiency but may fail to inculcate civic duty or overcome digital divides in participation.

Considerations of engagement vary among and within apps, including user adoption, levels of interaction with the user interface, data collection, and degrees of empowerment. A single interaction can simultaneously represent several levels of engagement (e.g., direct conversation, participation within a planning process). An interaction can be perceived hierarchical-ly, as a gateway to more meaningful forms, although respondents may not agree on the order. Brisk Synergies' response contrasts with the virtuous cycle of engagement described by OpenNorth. Instead of increased contributions being driven by demonstrable impacts from engagement, the Brisk Synergies respondent suggested an app's utility to volunteers will drive contributions. We note that a virtuous cycle of engagement does not dictate users of Citizen Budget also be contributors. Users may first gain knowledge of the budget, for example by visiting the website; they may or may not submit contributions at subsequent rounds of consultation. Using an app does not necessitate contribution and engagement can be website visits. We argue that planners should reach agreements on definitions and goals of forms of engagement. Moreover, there may be a design-reality gap (Paré, 2015) from intended to actual engagement. Government may expect strong engagement to occur simply by providing consumer-friendly interfaces, but the outcome may be much weaker than anticipated.

Lastly, our research points toward a data-driven government, in which more data is considered better and VGI is sought to confirm existing policy. Politics-as-usual represents a chronic governance problem but may be exacerbated with the use of VGI. Toronto Cycling App respondents asserted that more data always would improve decisions, without clear ideas of how the big data would be managed. Politicians may seek to use data and statistics to support pre-existing policy outcomes. VGI from Citizen Budget allowed the Mayor to justify budgeting decisions and demonstrate the administration's alignment with their constituency. Respondent 1 admitted that the VGI had yet to contradict government plans. VGI may as easily be co-opted by political agendas as used to inform policies. Moreover, we note potential issues in the aggregation of VGI. If citizens are presented with aggregated results after the budget is complete, they must trust that the VGI was appropriately analysed and their contributions influences the final decisions. Respondent 1 also revealed a lack of analytical sophistication. Simple percentage calculations, with no tests for significance, appeared sufficient even though there was ample opportunity to conduct deeper descriptive statistics. By not taking advantage of explorations afforded by the data, governments may fail in their integration of VGI into decision-making and instead create another layer of opacity.

9. Conclusion

Our research was prompted by Massey's (2013) concern over creeping vocabulary of neoliberalism. Market-based terms, like individual self-interest, normalise what she saw as an inevitability of social inequality through capitalism and ignore non-monetary transactions and social responsibilities that are necessary in the social life of the city. Forcing a citizen into a customer role can transactionalise their relationship with government, eventually producing a hegemony of the market that displaces politics and democracy. This potential erosion did not begin with apps, but might be nurtured by the appification of contributions from inhabitants of the city, who are increasingly easy to characterise as producers contributing to more efficient service delivery than as citizens engaged in a messy democracy.

VGI as used within government may inevitably trend towards a consumer-orientation. The appification of VGI allows government to control whether VGI offers a form of citizen engagement or a platform for the coproduction of public services. If the latter, citizens must turn back towards traditional methods of consultation to have their voices heard. Appification of government services, in these cases, does not appear to be leading to a redistribution of power. Government does not appear to bend to what the literature argues is VGI's empowerment potential, namely the unstructured, heterogeneous characteristics of the data (Zook, Graham, Shelton, & Gorman, 2010). Instead of embracing the crowd and realising the empowerment promised by data heterogeneity, government may fit VGI to its own processes and infrastructure without seeking radical modifications, allowing control over data to remain in squarely within the government domain. Our findings suggest that the empowerment opportunities of VGI might be high in theory (Elwood, 2008; Elwood & Leszczynski, 2013), but low in practice.

A limitation of our study was that it did not extend to perspective of endusers—the city residents. Capturing the perspective of contributors would allow us to assess whether they think of themselves as citizens or clients and allow for a comparison between government, developer, and citizen perspectives. A mismatch in perspectives could indicate that government VGI endeavours are creating false expectations and therefore a failure in their app-enabled citizen engagement strategies.

Should VGI apps replace traditional modes of civic participation, as hinted by respondents, and app outsourcing continue through consumer-oriented developers, we may see a flowering of NPM-like governance that will fundamentally alter roles and expectations. Use of market terminology is only likely to increase with government's appification of VGI. We look forward to research that attempts to reconcile market terminology with citizen participation *vis-a-vis* the state.

Acknowledgments

This research was funded in part by the Canadian Social Science and Humanities Council Partnership Grant 895-2012-1023. We would like to thank the grant's research partners in helping coordinate research interviews.

Conflict of Interests

Respondents 2 and 7 are partners in the grant but were not obligated to participate.

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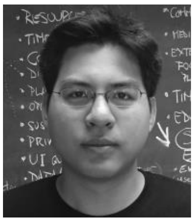

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Urban Planning (ISSN: 2183-7635)

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