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From Vision to Reality: The Use of Artificial Intelligence in Different Urban Planning Phases

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Abstract

In an urban context, the use of artificial intelligence (AI) can help to categorise and analyse large amounts of data quickly and efficiently. The AI approach can make municipal administration and planning processes more efficient, improve environmental and living conditions (e.g., air quality, inventory of road damages, etc.), or strengthen the participation of residents in decision-making processes. The key to this is "machine learning" that has the ability to recognise patterns, capture models, and learn on the basis of big data via the application of automated statistical methods. However, what does this mean for urban planning and the future development of cities? Will AI take over the planning and design of our cities and actively intervene in and influence planning activities? This article applies a systematic literature review supplemented by case study analyses and expert interviews to categorise various types of AI and relate their potential applications to the different phases of the planning process. The findings emphasize that AI systems are highly specialised applications for solving and processing specific challenges and tasks within a planning process. This can improve planning processes and results, but ultimately AI only suggests alternatives and possible solutions. Thus, AI has to be regarded as a planning tool rather than the planning solution. Ultimately, it is the planners who have to make decisions about the future development of cities, taking into account the possibilities and limitations of the AI applications that have been used in the planning process.

Keywords

artificial intelligence; decision-making; digital participation; planning phases; smart city; urban planning

1. Introduction: Artificial Intelligence and Its Utilisation for Urban Planning Practice

Artificial intelligence (AI) is changing cities and urban development processes comprehensively and at breakneck speed (Cugurullo et al., 2024a; Pellegrin et al., 2021; Wu et al., 2024). The fundamental potential of AI as a methodological tool for urban planning was already considered 15–20 years ago, but the implication of AI tools could only have been observed in recent years with the increasing availability of ever more powerful information and communication technology systems and more complex data volumes (Lazaroiu & Harrison, 2021; Sanchez et al., 2022).

Even if there is no standardised definition of AI (Cugurullo, 2021; Son et al., 2023), there is consensus that AI systems can perform tasks that typically require human intelligence (Pellegrin et al., 2021, p. 7). AI systems can learn and develop knowledge directly by capturing and analysing a specific environment with sensors such as cameras and microphones, or indirectly by evaluating large data sets in real-time (Cugurullo et al., 2024b, p. 2; see also Batty, 2023, p. 1046). AI systems then make sense of the information that they acquire by extracting concepts from it or by developing new content in the form of texts, images, or videos. In this context, the systems can automate, repeat, learn, discover, and adapt large amounts of data. These capacities are characteristics of their intelligence as they show the ability of the systems to act autonomously in real-life environments without human supervision, finding meaning, recognising ideas, or generating predictions about what is being observed (Cugurullo et al., 2024b, p. 4).

The possibility of AI systems to collect and analyse large data sets, the capacity to solve problems logically, the ability to learn from historical data, and the intelligent search for better solutions are also triggering urban planning practices (Popelka et al., 2023; Son et al., 2023). Digital platforms such as machines and robots are increasingly used to offer and control urban services or infrastructure systems, monitor public spaces, or draw spatial renderings and master plans (Caprotti et al., 2022; Marvin et al., 2022; Park et al., 2023; Zheng et al., 2023). The key to this is "machine learning," which is able to recognise patterns, capture models and learn on the basis of big data, and synthesize data with automated statistical methods. However, there is little research to date regarding the potential benefits and possible effects of AI on urban development. Does the use of AI mean, for example, that our cities will be planned by machines in the future and that everyday planning activities will be replaced? Will AI take over the planning and design of our cities? Or is AI only used in certain cases and planning phases to supplement existing planning tools? Up to now, AI systems in urban planning are mainly used in more technologically oriented fields, offering a wide range of possible applications (see Table 1):

- *Mobility and Transport Optimisation*: AI, for example, can help to observe traffic volumes and monitor traffic flows and reroute them if necessary (Cugurullo et al., 2024a, p. 366). The condition of road surfaces, such as potholes or manhole covers, can also be analysed using image capture with AI (Matouq et al., 2024).
- *Energy and Infrastructure*: AI can contribute to the development of smart grids that increase the security of supply (Kreutzer, 2023, pp. 375–376). Furthermore, AI tools can analyse aerial photographs to determine the potential for solar panels on roof surfaces (Assouline et al., 2017).
- *Public Management, Public Health, and Safety*: AI, for example, can measure, map, and make predictions about air quality (Barcelona Supercomputing Center, 2023). Additionally, AI can analyse aerial images to mitigate the impact of extreme heat waves and to indicate where trees and vegetation should be planted (Ghisleni, 2024).
- *Real Estate, Urban Planning, and Land Use Policies*: AI can be used to develop renderings of buildings, streets, and public spaces on the basis of large datasets and neural models. AI can furthermore be used to develop land use plans (Park et al., 2023; Zheng et al., 2023) or to monitor the rental of residential space to detect illegal rentals (Pellegrin et al., 2021, p. 20).

Table 1. Fields of AI application, examples, and functions in urban development.

Fields of AI-Application	Examples	References
Mobility and Transport Optimisation	Implementation of intelligent traffic light control (depending on traffic volume)	Alkhatib et al. (2022) Fraunhofer IOSB (2022) Sepehr (2024)
	Monitoring and forecasting traffic flows (on the basis of sensors)	Cugurullo et al. (2024a)
	Monitoring of road conditions (identification and classification of road damage and subsequent reporting to the municipal building department or the civil engineering department)	Jagatheesaperumal et al. (2023) Matouq et al. (2024)
	Implementing the infrastructure conditions for autonomous vehicles and autonomous driving	Dowling et al. (2024) Hopkins (2023)
Energy and Infrastructure	Development of smart grids that increase the security of supply and help to reduce costs for the end consumer	Alsaigh et al. (2022) Kreutzer (2023)
	Identifying and analysing the potential of solar panels on roof surfaces (via aerial image analysis)	Assouline et al. (2017) Ortiz et al. (2022)
Public Management, Public Health, and Safety	Surveillance of public spaces (use of neural networks for real-time threat detection)	Bissarinova et al. (2024) Narayanan et al. (2021)
	Identification of deficiencies in public spaces by analysing camera recordings	Amsterdam Intelligence (2024)
	Monitoring air quality in city centres	Barcelona Supercomputing Center (2023)
	Mitigating the impact of extreme heat waves via aerial image analysis (indication suggestions for the planning of trees and vegetation) and predicting the potential of green roofs to improve the thermal performance of buildings and reduce urban heat islands	Ghisleni (2024) Mazzeo et al. (2023)
	Calculating the water requirements of individual trees depending on the weather (by using sensors) and determining water requirements up to 14 days in advance	Rigal (2022)
Real Estate, Urban Planning, and Land Use Policies	Classifying land use patterns with neural networks that can process satellite and aerial imagery	Kumar et al. (2022) Wu et al. (2024)
	Identification of potential building areas by analysing aerial photographs	Rahnemoonfar et al. (2021)
	Automated detection and mapping of informal settlements in various locations	Moreno González et al. (2022)
	Generating spatial plans (on the basis of graph neural networks)	Park et al. (2023) Zheng et al. (2023)
	Rendering buildings, streets, and public spaces on the basis of large datasets and neural models	Lin et al. (2023) Pisu and Carta (2024) Sanchez et al. (2022)
	Control of illegal letting of housing by scanning the real estate platforms	Pellegrin et al. (2021)
	Predicting neighbourhood change and gentrification (or racial discrimination on the housing market) through machine learning	Naik et al. (2017) Reages et al. (2018) Rosen and Garboden (2024)

AI is also already being used in participatory planning processes, e.g., to provide up-to-date information in chatbots (Senadheera et al., 2024), to analyse comments in urban land-use planning procedures, or to create visualisations in participatory processes (Sanchez et al., 2022), often using digital twins, AR and VR applications, climate models, and other digital applications (Batty & Yang, 2022; Brüggemann et al., 2023; Pisu & Carta, 2024). However, the focus of most of the AI studies or research articles is often on specific AI systems or technologies and the functionality of these systems for solving concrete problems in an urban context. In contrast, the effects of AI systems on planning processes have been less considered or researched to date. This particularly applies to the consideration of different AI systems and applications in the course of a planning process and the extent to which AI influences decision-making processes, opportunities for participation, and the results of planning across the various planning phases and specific technical AI applications (Du et al., 2024; Liang & Kang, 2021). This is the starting point for this article, which considers the following research questions: How can AI systems and applications in the field of urban planning and development be classified? What tasks can AI solve in planning processes and projects? Which AI systems and applications are used in which planning phases? How does AI change our understanding of planning?

2. Research Design and Methodology

In a first step, we classify AI systems and applications in the field of urban planning and development following the knowledge map of Corea (2019), which was further developed by Son et al. (2023). As shown above, "AI-enabled technologies are employed to address specific problem-solving activities" (Son et al., 2023, p. 3). Utilising large data collections, either obtained directly via IoT-enabled infrastructures or indirectly via access to data sets (Batty, 2023; Cugurullo et al., 2024b), various AI paradigms can be formulated for different problems and solution capabilities (Corea, 2019, p. 26):

- *Logic-based tools*: Tools that are used for knowledge representation and problem-solving;
- *Knowledge-based tools*: Tools that are based on ontologies and huge databases of notions, information, and rules;
- *Probabilistic methods*: Tools that allow agents to act with incomplete information and data;
- *Machine learning*: Tools allowing agents and systems to learn from historical data and to use the gained knowledge to interpret new data;
- *Embodied intelligence*: An engineering toolbox having the ability to affect the physical environment;
- *Search and optimisation*: Tools that allow intelligent search with many possible solutions.

It is from these approaches that different AI-enabled "technologies" are developed and utilised (Corea, 2019; Sarker, 2022; Son et al., 2023), leading to the categorization of different types of AI, including analytical, functional, textual, visual, and interactive systems (see Figure 1). *Analytical AI* embraces practices of identifying, interpreting, and communicating meaningful patterns of data (Sarker, 2022, p. 157). In this regard, analytical AI aims to discover new insights, patterns, and relationships or dependencies in data and to assist data-driven decision-making. Subsequently, logic-based and knowledge-based tools as well as analytical processing capabilities are of central importance here. The same applies to reasoning, i.e., the capability to solve problems, as underlying the problem-solving classification of AI systems (Corea, 2019). *Functional AI* is similar to analytical AI but executes actions rather than making recommendations (Sarker, 2022, pp. 157–158). Here, perception as underlying the problem-solving classification of AI systems plays a

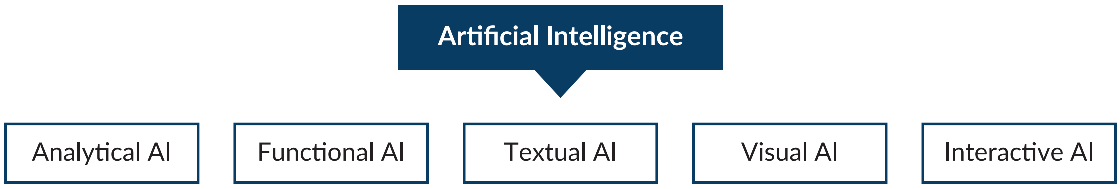

Figure 1. Various types of AI.

key role, referring to the ability of AI to transform raw sensorial inputs (e.g., images, sounds, etc.) into usable information and action (Corea, 2019). At the same time, the embodied intelligence of AI systems is addressed here.

Textual AI covers textual analytics or natural language processing for text recognition, speech-to-text conversion, machine translation, as well as content generation (Sarker, 2022, p. 158). Subsequently, logic-based and knowledge-based tools as well as analytical processing capabilities are of central importance here. The same applies to the ability of the AI system to act with incomplete information. *Visual AI* is able to recognize, classify, and sort items, as well as convert images and videos into insights. This sort of AI is often used in fields such as computer vision and augmented reality (Sarker, 2022, p. 158). Here, the ability to transform raw sensory inputs into usable information and the ability to understand, interpret, and communicate the images and videos accordingly are key conditions for practical use. *Interactive AI* enables efficient and interactive communication models, for example in chatbots and smart personal assistants (Sarker, 2022, p. 158). Here, a variety of techniques such as machine learning, frequent pattern mining, or reasoning are relevant. This also includes the use of various AI problem-solving domains (Corea, 2019), such as the ability to understand language and communicate or the capability to solve problems.

However, our research questions focus not only on the classification of AI, but on different AI systems and applications in the course of a planning process, i.e., the extent to which AI influences decision-making processes, opportunities for participation, and the results of planning. This is of central importance insofar as decision-making processes in urban planning can be defined as a transformation of information that takes place in phases, which are characterised by the search for and selection of information to reduce the degree of uncertainty regarding the decisions to be made. At the same time, different actors are involved during the various planning phases where divergent approaches to information procurement, processing, communication, and knowledge transfer can be observed. This raises key questions particularly with regard to the use of AI in planning decision-making processes, including the availability of data (training data); the accuracy of a problem representation; data protection (protection of personal data); and the acceptance and transparency of planning processes.

In a second step, we thus divide the planning process into distinctive planning phases (see Figure 2). In the *Preparatory or Exploration Phase*, the initial planning situation is analysed. During this phase, informal participation processes and preliminary political consultations take place, resulting in visions and scenarios as well as a joint definition of planning objectives (Diller et al., 2017; Schönwandt, 2008; Yigitcanlar & Teriman, 2015). In the *Feasibility and Master Planning Phase*, feasibility studies are conducted and a (strategic) master plan is developed, which is discussed with relevant stakeholders and builds the basis for the next steps. The *Formal Planning Phase* refers to the development and approval of the formal planning documents (e.g., land use plans, zoning plans, building regulation plans) in accordance with the master plan and the

Figure 2. Principal phases of a simplified urban planning process. Source: Own illustration based on Diller et al. (2017) and Urban Learning (2024).

relevant national regulations. This phase includes the participation of stakeholders in public presentations and the balancing of conflicting interests. After the formal plan is approved, the plan will be realized. In the *Design and Implementation Phase*, the final design of buildings and public spaces will be discussed and determined in accordance with the provisions of the formal plan (Baltic Urban Lab, n.d.-b; Urban Learning, 2024). Then the building permit is issued and the planned project can be implemented or constructed. Continuous and transparent communication is important here to inform the public at regular intervals about milestones in the realisation and progress of a project. Feedback in the *Operational or Monitoring Phase* can also optimise subsequent planning processes and contribute to more efficient planning. The illustration depicts the phases of a planning process in an idealised and simplified manner. In line with Diller et al. (2017, p. 8), we have chosen a linear model with circular feedback between individual phases, which is often found in practice (see also Baltic Urban Lab, n.d.-a; Urban Learning, 2024).

In a third and final step, we merge the two classifications or models into a conceptual framework (see Figure 3). The planning phases can be found on the horizontal axis and the various types of AI systems including the AI problem-solving domains on the vertical axis. The framework then allows us to analyse and evaluate different AI systems and applications in terms of their functions, the fit accuracy of the problem-solving approaches, and their impact on decision-making processes in different planning phases considering the role of urban planners (see Section 3).

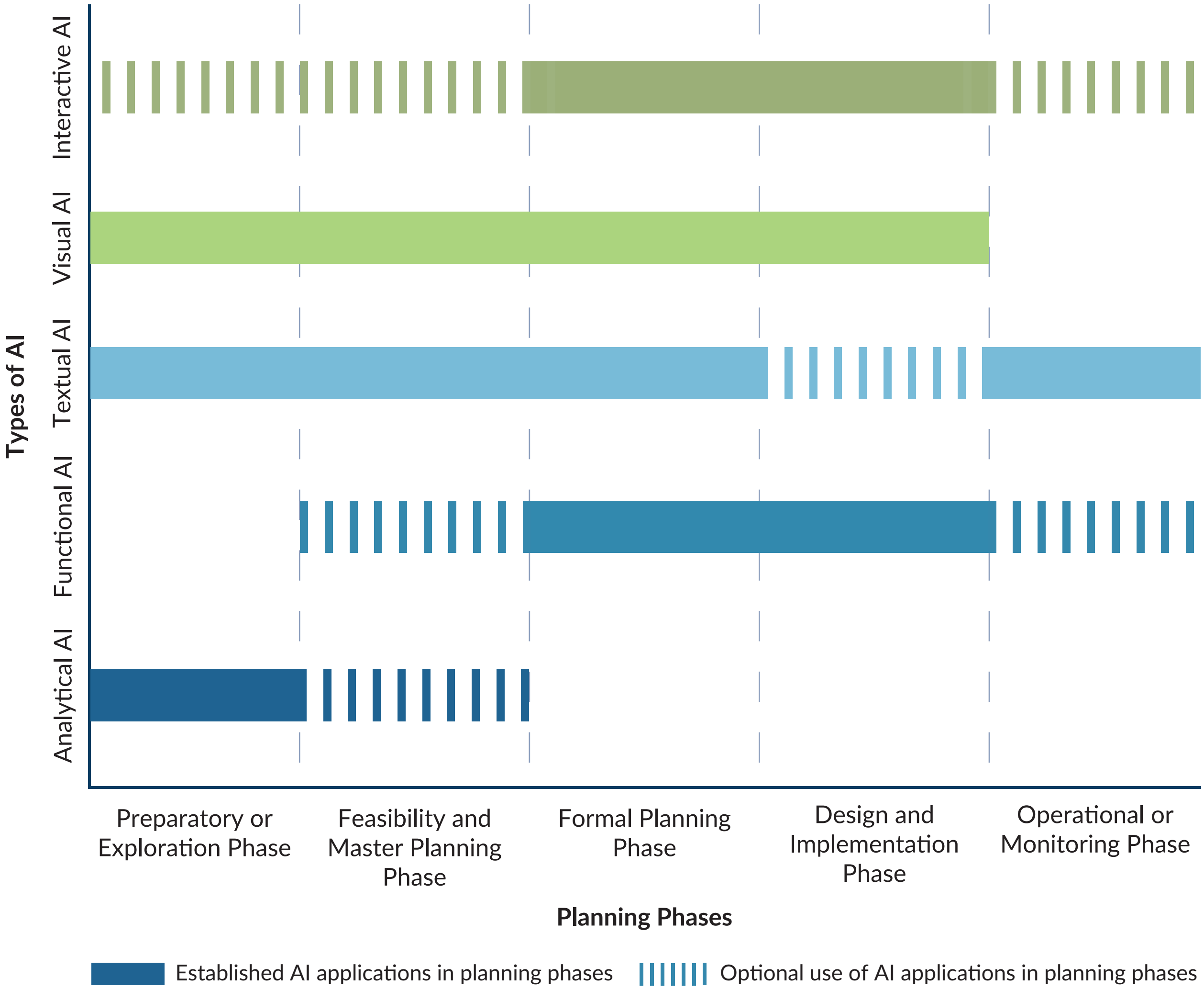

Figure 3. Use of AI tools in different planning phases. A proposal for the use of AI tools related to urban planning in different planning phases.

To analyse the impact of AI on planning practices, particularly with regard to the design of planning processes and decision-making, we conducted a systematic literature review based on published articles in the Web of Science, ScienceDirect, and Scopus databases. First, relevant articles were identified using the specific keywords "artificial intelligence," "machine learning," "artificial intelligence and planning processes," "artificial intelligence and urban planning," and "artificial intelligence and decision-making." Second, we read the abstracts of articles from step one to narrow the selection of papers to those in which the terms and concepts in the abstract strongly overlap with the subject of our study. Finally, we identified and analysed 32 articles with the aim of deriving criteria for classifying AI applications and assessing the potentials and weaknesses of AI in urban development processes.

We then transferred and applied these criteria to an internet-based desktop research for practical examples. The identification of relevant examples of AI applications in urban planning for the in-depth analysis followed a rather pragmatic research approach. We combined (a) local practice examples where AI applications have been recently developed and tested, and (b) AI technologies and applications that are typical of current use in urban planning and that in turn represent the different types of AI. Our internet-based desktop research has shown that various metropolitan regions, such as Helsinki, Vienna, and Amsterdam, are among the pioneers in the application of AI systems in urban planning and development, and that different approaches are being pursued to integrate AI into planning processes. Here, we conducted interviews with representatives of the respective municipal planning authorities and with representatives who are responsible for the implementation of AI strategies. Additionally, we identified companies or research institutions that deal with the development and use of AI systems and applications—thus representing specific AI systems and tools without a specific local context—and conducted corresponding interviews with leading experts there. In total, we conducted eight interviews with regard to different AI technologies or AI problem-solving areas to identify the opportunities and challenges of AI in urban planning processes. The interviews were analysed using qualitative content analysis according to Mayring (2015). The results were then grouped and analysed using the conceptual framework (see Figure 3) and compared with the findings from the literature review.

3. The Use of AI in Various Planning Phases

The aim of our study is to classify the use of various current AI systems in the field of urban planning. At this point, relevant practical examples of AI in urban planning are considered on the basis of the literature analysis, the internet-based desktop research, and the expert interviews. These AI systems or tools are first assigned to the basic types of AI before discussing them in individual planning phases and specific fields of application. The results are interpreted qualitatively with regard to the formulated research questions.

3.1. Analytical AI in Urban Planning: AI for Generating Data-Based Analysis and Scenarios

Analytical AI applications are used for creating data-based scenarios and clustering ideas. Park et al. (2023), for example, describe a pilot project to map urban density scenarios for a neighbourhood area in Seoul, South Korea, using AI-based construction of image datasets coded with urban data (Park et al., 2023, p. 1). The aim was to develop an AI advisor that can support laypersons in urban planning participation processes by generating land use plans for selected locations and possible density scenarios (Park et al., 2023, p. 1). In a study on the development patterns of Delhi in India, Kumar et al. (2022) similarly describe the development of an AI model for pixel-based classification of land use data to map the land cover of developed and undeveloped areas with the Google Earth Engine and to describe the changes in urban sprawl with the help of machine learning and powerful computational platforms. Using crowdsourced data and generative adversarial networks, a generational model was trained to create coloured renderings of master plans within seconds that resemble those of experienced urban planners and can be used in participatory processes (Ye et al., 2021). Digital city twins can also use AI to simulate, for example, the microclimate in a neighbourhood. To do this, the AI generates climate models and wind flows and transforms them into the city model. Wind flows can be generated in real-time in every planning phase and analysed in the model in the design variants. The aim is to analyse the microclimatic conditions of a neighbourhood and thus discuss and make adjustments to the draft plans for possible extreme weather events ("AIT CoDeC-Symposium," 2023). For the simulation of wind in drafts, the first planning drafts must be available. According to some of the respondents, participation with the help of an AI-supported simulation takes place in the middle of the participation process. However, it should be noted that, due to the specific orientation of various AI applications, some Analytical AI applications also contain elements of Functional AI if certain knowledge is produced through their use in the planning process, which is why they could also be assigned to this type.

We can conclude here that Analytical AI tools in urban planning are particularly suitable for use at an early planning stage in order to carry out data-based analyses, explore possible scenarios, and prepare decision-making processes. Their use is therefore particularly conceivable in the Preparatory or Exploration Phase as well as the Feasibility and Master Planning Phase, in which specific spatial analysis studies are carried out, for example to prepare design concepts for planning (see Figure 3). The use of AI enables the automated analysis and evaluation of data. This primarily relates to standardised data and evaluation processes, which enable planners to make a comprehensive assessment of development opportunities at an early stage of the planning process and thus support and accelerate the decision-making process.

3.2. Functional AI in Urban Planning: AI-Based Planning Processes

For the use of Functional AI in urban planning, digital tools can be identified that are used for the digital participation of citizens in spatial planning procedures (Geertman, 2002). Such applications are already being used in some municipalities, for example in Hamburg and Rostock in Germany. Here, AI-supported tools are used to organise the entire urban planning process, including the formal participation of authorities, organisations, and citizens online (Lührs, 2017, p. 45). Planning documents can be imported digitally here, plan drawings integrated into maps, users of the application authorised, and relevant organisations and authorities informed of the participation by email. According to one of our interviewees, this makes it possible in the formal participation process to carry out balancing processes in planning and approval procedures in an efficient and transparent way and to facilitate cooperation with sectoral planning authorities (e.g., transport, water, etc.) by supporting the evaluation of the received comments by using AI information models. The AI tool identifies certain topics in the planning process, carries out AI-based keywording, groups similar comments, anonymises personal data, and sends an evaluation result to the groups involved by email at the end of the process.

Accordingly, functional approaches often have elements of a Textual AI, although these can also be integrated into Functional AI. In addition to the example of AI tools in formal urban land-use planning procedures, the use of AI in the granting of planning permission can also be categorised as Functional AI. AI is used here when applying for and granting approval for building permits, meaning that AI is used late in the planning process. During a research project in Vienna, building owners were able to submit their documents for their building project online. Once the documents were submitted, an AI analysed the documents and checked whether everything was complete and whether the client filled out the application correctly. The AI scanned text elements, put them into their basic linguistic form, connotated them, set them in relation to each other, and balanced them. In the final step, the AI then analysed the intention of the content (Urban et al., 2021, p. 7). As one of our respondents confirmed, the AI also checked whether the information in the application complies with the specifications of the city's applicable planning documents and legal texts. In addition, a model of the construction project was created as BIM (Building Information Modelling). These generated models were intended to make the construction projects clearer and more transparent for citizens (Stadt Wien, 2024). After extracting the relevant data, the AI summarised it into meaningful categories.

Analysing different Functional AI applications in the context of urban planning, we can conclude that these tools are mainly used in the Formal Planning Phase. As the examples indicate, the intention is to structure the planning and approval process and to carry out steps that convert information into concrete actions to improve the planning processes as a whole. However, the AI applications could also be used in the directly subsequent phases of formal processes, e.g., to organise participation processes at an early stage or to structure the Design and Implementation Phase in order to speed things up.

3.3. Textual AI in Urban Planning: AI-Based Evaluation of Text Elements

From a technical perspective, Pellegrin et al. (2021) describe the use of AI in the urban context of urban planning and administration as collecting, interpreting, and analysing data for political decision-making and improving public services. Various forms of data analysis can be carried out and evaluated, having close links to the possible applications of Textual AI that can be used, for example, to analyse documents and thus improve participation opportunities or implement dynamic policies. For example: historical analyses of documents are conceivable to predict future developments and trends on this basis; near real-time analytics enable analyses of indexed data to increase the transparency and monitoring of certain processes; real-time analytics enable the analysis of data directly in an ongoing process to enable immediate evaluation; and predictive analytics encompass statistical models that classify data for the near future and predict events (Pellegrin et al., 2021, p. 19). In this context, Textual AI can be used to analyse the opinions of parts of the urban population by using AI in conjunction with social media. Here, public tweets can be collected and analysed to gain an overview of current issues and needs that affect a large proportion of the population and fall within the remit of local government (Pellegrin et al., 2021, p. 20).

Textual AI is also used in other systems and tools, for example in AI-supported digital participatory platforms that can be used by municipalities to organise participation processes. Here, citizens can find out about planning concepts in their city and contribute with their ideas and opinions. Here, the AI first analyses the citizens' comments and then clusters the comments, for example, according to specific subject areas, demographic data, or the mood conveyed by the comments. According to one of our interviewees, a comparative evaluation of ideas and comments received from planners and a Textual AI shows that the AI analysis process is very similar to the human analysis process and produces similar results. However, the AI only needs a fraction of the time of the planners involved, so that planners gain capacity for the conceptual development and planning realisation of the ideas.

To conclude, we see the use of text-based AI applications particularly in those planning phases in which text-based analyses, for example of participation processes, appear to make sense. Accordingly, this type of AI application is particularly suitable at the beginning of a planning process, e.g., in the Preparatory or Exploration Phase, in order to obtain a basic assessment of the planning proposals from citizens and to systematically analyse the assessments. Using text-based AI applications in the Formal Planning Phase can also accelerate the planning process and support decision-making if citizens' comments are analysed more quickly. Textual AI could also be used in the Monitoring Phase to evaluate the implementation of the plan concept, ensure ongoing citizen participation, and obtain relevant information.

3.4. Visual AI in Urban Planning: AI for Image-Based Generation of Spatial Scenarios

The use of AI tools further enables the image-based generation of various spatial scenarios and alternatives; this is often based on web applications using self-made photographs or images stored in Google Streetview. This makes it possible to present and discuss, for example, different variants for the design of street spaces or public squares, the reutilisation of an old industrial hall, or the design of new residential buildings in participatory planning and co-design processes. The aim is to actively involve citizens and stakeholders in the design of planning processes by allowing their ideas to be directly mapped by the AI. The tools are therefore particularly suitable as a basis for discussion in planning workshops to interactively discuss ideas for urban projects and give users the opportunity to visualise them without specialist and technical expertise.

In addition, AI is already being used to create urban planning designs and concepts (As et al., 2022; Pisu & Carta, 2024). Here, generative design engines built on rule-based systems, parametric design, and neural networks enable the development and visualisation of development structures, building blocks, open spaces, building heights, etc. (Landes, 2022; Sari et al., 2022). As a rule, the Visual AI first determines latent patterns, i.e., identifying building blocks and building hierarchy, before designing and composing new city layouts (3D representations of the corresponding area and buildings). According to various studies (Landes, 2022; Pisu & Carta, 2024; Sari et al., 2022), generative Visual AI allows planners and designers to develop a large number of possible design variants in the shortest possible time and to produce accurate urban models with greater precision than ever before.

According to our research, we can summarise that image-based AI tools are mainly used in informal processes at earlier stages of a planning process. It is therefore conceivable that they could be used in the Preparatory and Exploration Phase as well as in the Feasibility and Master Planning Phase (see Figure 3). The aim of planners in such phases is to have an innovative planning tool in a co-design process to make participation interesting for different target groups and to collect ideas from citizens for the planned area. The AI-generated images and variants contribute here to provide the same level of information for all participants; at the same time, AI can ensure that participants can visualise their comments and suggestions on a project in an ongoing planning process. Image-generative AI approaches also offer the possibility of being used in later planning phases, e.g., in the Formal Planning Phase, although it should be critically noted that planning processes are often already well advanced at a later stage and generated images and ideas may no longer be taken into account in the planning process and the development of design concepts. However, Visual AI offers the opportunity to visualise and discuss specific changes in local land use plans (e.g., changes in building height) and regulations on the ratio of developed and undeveloped areas, meaning that Visual AI can improve the information base of all stakeholders involved in the planning process, as well as the transparency of planning decisions in the Design Phase.

3.5. Interactive AI in Urban Planning: AI-Based Chatbots for Communication and Information

AI language models as chatbots offer an efficient approach to relieve the burden on municipal administrations, which can simultaneously break down access barriers to the administration (Hein & Volkenandt, 2020, pp. 28, 44). The aim of using chatbots is to provide precise answers to citizens' questions in a timely manner and to offer the opportunity to address concerns to the city administration at any time (Senadheera et al., 2024, p. 2). Bots can be embedded in natural language processing and work as a large language model. The applications are trained in such a way that the AI captures the texts as part of a semantic analysis, recognises keywords, and reacts to them. The AI system analyses which questions are asked most frequently and whether its own answers were helpful and can thus continuously improve itself. Chatbots can facilitate the allocation of appointments for registration and vehicle matters for the population, for example, by being set up as a defect reporting and information system or be used as part of the dialogue process in planning procedures to collect and evaluate opinions (Hein & Volkenandt, 2020, pp. 44–45). This means that defects can be reported, the current status of planning procedures can be requested, or information on specific measures can be obtained. In the city of Berlin, for example, an AI-based assistant can be asked questions on administrative matters (e.g., "What measures are planned in Burgfrauenstraße in 13467 Berlin to change the traffic?"). The tool then searches, for example, documents from the main committee meetings of the administration as well as written enquiries and generates short answers—based on the content (as far as possible)—that match the question. Some cities, for example Vienna or Heidelberg, now use AI-based chatbots as citizen service that address urban planning processes. However, it is obvious here that chatbots only have a supporting function for the administration and urban planning. They can provide information on current planning procedures, administrative processes, etc.; however, they cannot develop new plans or make further-reaching decisions.

In the projects we are aware of, Interactive AI systems and particularly chatbots are currently being used for rather limited procedures and phases. This includes tasks that are well suited to the programming of AI systems due to their frequency, delimitation, and structure. Against this background, Interactive AI systems are primarily found in the Formal Planning Phase, the Design Phase, and the Operational Phase. At the same time, it is also conceivable that chatbots and other interactive applications will also be used in earlier planning phases in the future (e.g., to support participatory processes) as there are no limits on the use of chatbots in these phases.

4. Conclusion

AI has found its way into urban planning in recent years. The literature analysis and the analysis of various practical examples show that the areas of AI applications in urban planning processes are as diverse as the timing of its use in the individual planning phases. Wherever AI is currently used in the planning process, innovative applications support the work of planners. For example, complex data-based planning analyses can be carried out with the help of AI in early planning phases to support decision-making (Analytical AI) or formal procedures of the planning process can be simplified and structured (Functional AI). AI can also be used to effectively support the complex evaluation of comments in the participation process, making time-consuming activities easier (Textual AI). AI can take on routine tasks (for example, summarising and evaluating statements, formulating pre-draft documents or designs, creating textual justifications of formal plans, etc.) and provide planners with scope for more strategic and conceptual considerations or participation processes. Additionally, Analytical, Functional, and Textual AI in particular can support internal administrative procedures and planning processes, e.g., checking procedural steps or checking whether the documents required for the planning application are complete. This could—at least based on views expressed by several of our interviewees—possibly lead to a kind of roadmap for administrations on how administrative processes and therefore planning procedures could be systematically supported with AI.

AI can also help to generate planning and design variants quickly and easily (Visual AI), either to increase the visualisation of planning content and planning intentions or to develop planning variants together with citizens as an interactive tool in co-design processes. Here, AI applications as digital tools can help planners make decision-making and planning processes more effective. By involving different stakeholders and using visualization tools, AI applications can help to reduce power asymmetries, discrimination, and social inequalities (Wilson et al., 2019, p. 287). AI-based systems, for example, can carry out automated text analyses in participation processes by using algorithms to analyse and visually process citizens' objections and comments on plan concepts. In addition, AI can reduce the (unconscious) subjectivity and bias of planners towards certain people or planning topics, for example, by automating anonymised evaluation of comments in the participation process to increase the objectivity of planning decisions. However, this does not mean that discrimination can be completely eliminated by AI, but the likelihood of discriminatory decision-making processes could be reduced by training which is a central prerequisite for AI in public planning and participation processes (Pellegrin et al., 2021).

The growth of AI systems might also trigger further innovations and changes for planning (see Figure 3). By linking, for example, Textual AI, Functional AI, and Visual AI it would be possible for planners to analyse comments and documents and to create urban land use plans or concepts on this basis. This future is seen by some interviewees as very realistic, especially with regard to the development of local land use plans. In this vision, the AI first translates the written or verbatim objectives and (legal) framework conditions for a plan into corresponding graphic specifications. The AI then uses the drawings to generate initial proposals for formulating the textual explanations of the plan. Another possibility for the further and increased use of AI could be digital twins that display temperature and wind systems (Analytical AI), communicate interactively with users (Interactive AI), and record and analyse their discussions and comments (Textual AI) into urban designs (Visual AI), considering all the relevant information and data from the other phases.

But what does this mean for the future of urban planners? Will they become redundant, similar to the drivers that become redundant by the introduction of self-driving cars? Does this not mean that urban planners, designers, or architects will disappear eventually, just as the human driver will disappear (Leach, 2022, p. 175)? In our understanding, this question does not really arise. We are convinced that planning processes will not be fully automated by AI. Planning is still dependent on the decisions and valuations of planners, which is confirmed by all of our interviewees. AI-based applications are used here as supplementary tools for the work process: They can contribute to the collection and analysis of relevant information and data, they can support decision-making processes, and they can do this very efficiently, freeing up planners for other tasks or decisions. However, results of AI systems have to be embedded or interpreted against the background of political decision-making processes, the way a society wants to organize coexistence, participatory procedures, or questions of planning and building culture. This is where purely technical systems reach their limits, despite their ability to think. This is one reason why planners can use AI for the future development of cities in different phases, but AI will not replace planners. At the same time, this also raises the question of how ethical concerns of AI, especially as urban planning activities involve human-centred approaches, could be mitigated (Son et al., 2023, p. 9). AI systems are set to act with increasing autonomy and will probably be widely used in the future; consequently, responsible practices are needed to ensure that the technological progress is in line with social values and norms (Pellegrin et al., 2021; Wu et al., 2024). This requires planners to consider the ethical implications of using AI in participatory planning carefully. Ensuring transparency, accountability, and inclusivity in AI decision-making processes is critical to achieving more equitable outcomes (Du et al., 2024, p. 193).

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Conflict of Interests

The authors declare no conflict of interests.

References

AIT CoDeC-Symposium: KI-gestützte Planung von Städten bringt vielfältige Planungsszenarien und neue Lösungswege. (2023, March 31). *APA-Science*. https://science.apa.at/power-search/9273802767319885462

Alkhatib, A. A. A., Abu Maria, K., Akzu'bi, S., & Abu Maria, E. (2022). Novel system for road traffic optimisation in large cities. *IET Smart Cities*, *4*(2), 143–155. https://doi.org/10.1049/smc2.12032

Alsaigh, R., Mehmood, R., & Katib, I. (2022). *AI explainability and governance in smart energy systems: A review*. arXiv. https://doi.org/10.48550/arXiv.2211.00069

Amsterdam Intelligence. (2024). *AI for public space*. https://www.amsterdamintelligence.com/projects/public-space

As, I., Basu, P., & Talwar, P. (Eds.). (2022). *Artificial intelligence in urban planning and design: Technologies, implementation, and impacts*. Elsevier. https://doi.org/10.1016/C2019-0-05206-5

Assouline, D., Mohajeri, N., & Scartezzini, J.-L. (2017). Quantifying rooftop photovoltaic solar energy potential: A machine learning approach. *Solar Energy*, *141*, 278–296. https://doi.org/10.1016/j.solener.2016.11.045

Baltic Urban Lab. (n.d.-a). *Baltic Urban Lab*. https://www.balticurbanlab.eu

Baltic Urban Lab. (n.d.-b). *Integrated planning and partnerships*. https://www.balticurbanlab.eu/content/integrated-planning-and-partnerships

Barcelona Supercomputing Center. (2023, April 25). *BSC develops pioneering artificial intelligence method to fight urban air pollution*. https://www.bsc.es/news/bsc-news/bsc-develops-pioneering-artificial-intelligence-method-fight-urban-air-pollution

Batty, M. (2023). The emergence and evolution of urban AI. *AI & Society*, *38*, 1045–1048. https://doi.org/10.1007/s00146-022-01528-6

Batty, M., & Yang, W. (2022). *A digital future for planning: Spatial planning reimagined*. Digital Task Force for Planning. https://digital4planning.com/wp-content/uploads/2022/02/A-Digital-Future-for-Planning-Full-Report-Web.pdf

Bissarinova, U., Tleuken, A., Alimukhambetova, S., Varol, H. A., & Karaca, F. (2024). DL-SLICER: Deep learning for satellite-based identification of cities with enhanced resemblance. *Buildings*, *14*(2), Article 551. https://doi.org/10.3390/buildings14020551

Brüggemann, J., Köckler, H., Walter-Klose, C., Vittinghoff, M., Flacke, J., & Pfefferc, K. (2023). Enabling people with diverse abilities to participate in the design of digital mapping tools for inclusive community planning in Germany. *Proceedings of Science*, *442*, Article 020. https://doi.org/10.22323/1.442.0020

Caprotti, F., Chang, I.-C. C., & Joss, S. (2022). Beyond the smart city: A typology of platform urbanism. *Urban Transformation*, *4*, Article 4. https://doi.org/10.1186/s42854-022-00033-9

Corea, F. (2019). *An introduction to data: Everything you need to know about AI, big data and data science*. Springer Nature.

Cugurullo, F. (2021). *Frankenstein urbanism: Eco, smart and autonomous cities, artificial intelligence and the end of the city*. Routledge.

Cugurullo, F., Caprotti, F., Cook, M., Karvonen, A., McGuirk, P., & Marvin, S. (2024a). Conclusions. The present of urban AI and the future of cities. In F. Cugurullo, F. Caprotti, M. Cook, A. Karvonen, P. McGuirk, & S. Marvin (Eds.), *Artificial intelligence and the city. Urbanistic perspectives on AI* (pp. 361–389). Routledge.

Cugurullo, F., Caprotti, F., Cook, M., Karvonen, A., McGuirk, P., & Marvin, S. (2024b). Introducing AI in urban studies. In F. Cugurullo, F. Caprotti, M. Cook, A. Karvonen, P. McGuirk, & S. Marvin (Eds.), *Artificial intelligence and the city. Urbanistic perspectives on AI* (pp. 1–19). Routledge.

Diller, C., Karic, S., & Oberding, S. (2017). Mehr als nur normative Heuristik? Zur empirischen Verifizierbarkeit von Planungsprozessmodellen. *pnd|online*, *2017*(1). https://www.planung-neu-denken.de/wp-content/uploads/pnd-online_2017-1.pdf

Dowling, R., McGuirk, P., & Sisson, A. (2024). Reinforcing and refracting automobility. Urban experimentation with autonomous vehicles. In F. Cugurullo, F. Caprotti, M. Cook, A. Karvonen, P. McGuirk, & S. Marvin (Eds.), *Artificial intelligence and the city. Urbanistic perspectives on AI* (pp. 23–37). Routledge.

Du, J., Ye, X., Jankowski, P., Sanchez, T. W., & Mai, G. (2024). Artificial intelligence enabled participatory planning: A review. *International Journal of Urban Sciences*, *28*(2), 183–210.

Fraunhofer IOSB. (2022, February 1). *Traffic lights controlled using artificial intelligence* [Press release]. https://www.fraunhofer.de/en/press/research-news/2022/february-2022/traffic-lights-controlled-using-artificial-intelligence.html

Geertman, S. (2002). Participatory planning and GIS: A PSS to bridge the gap. *Environment and Planning B: Planning and Design*, *29*(1), 21–35.

Ghisleni, C. (2024, February 8). Artificial intelligence and urban planning: Technology as a tool for city design. *ArchDaily*. https://www.archdaily.com/1012951/artificial-intelligence-and-urban-planning-technology-as-a-tool-for-city-design

Hein, T., & Volkenandt, G. (2020). *Künstliche Intelligenz für die Smart City. Handlungsimpulse für die kommunale Praxis*. K&T Knowledge & Trends.

Hopkins, D. (2023). Autonomous lorries, artificial intelligence and urban (freight) mobilities. In F. Cugurullo, F. Caprotti, M. Cook, A. Karvonen, P. McGuirk, & S. Marvin (Eds.), *Artificial intelligence and the city. Urbanistic perspectives on AI* (pp. 53–68). Routledge.

Jagatheesaperumal, S. K., Bibri, S. E., Ganesan, S., & Jeyaramane, P. (2023). Artificial Intelligence for road quality assessment in smart cities: A machine learning approach to acoustic data analysis. *Computational Urban Science*, *3*, Article 28. https://doi.org/10.1007/s43762-023-00104-y

Kreutzer, R. (2023). *Künstliche Intelligenz verstehen. Grundlagen—Use-Cases—unternehmenseigene KI-Journey*. Springer Gabler.

Kumar, A., Jain, A., Agarwal, B., Jain, M., Harjule, P., & Verma, R. A. (2022). Pixel based classification of land use: Land cover built-up and non-built-up areas using Google Earth Engine in an urban region (Delhi, India). In M. Lhaby, U. Kose, & A. K. Bhoi (Eds.), *Explainable artificial intelligence for smart cities* (pp. 245–268). Routledge.

Landes, J. (2022). Spacemaker.Ai: Using AI in developing urban block variations. In I. As, P. Basu, & P. Talwar (Eds.), *Artificial intelligence in urban planning and design: Technologies, implementation, and impacts* (pp. 263–291). Elsevier. https://doi.org/10.1016/C2019-0-05206-5

Lazaroiu, G., & Harrison, A. (2021). Internet of things sensing infrastructures and data-driven planning technologies in smart sustainable city governance and management. *Geopolitics, History, and International Relations*, *13*(2), 23–36.

Leach, N. (2022). *Architecture in the age of artificial intelligence: An introduction to AI for architects*. Bloomsbury Visual Arts.

Liang, X., & Kang, Y. (2021). A review of spatial network insights and methods in the context of planning: Applications, challenges, and opportunities. In S. C. M. Geertman, C. Pettit, R. Goodspeed, & A. Staffans (Eds.), *Urban informatics and future cities* (pp. 71–91). Springer Nature.

Lin, C. H., Lee, H.-Y., Menapace, W., Chai, M., Siarohin, A., Yang, M.-H., & Tulyakov, S. (2023). *InfiniCity: Infinite-scale city synthesis*. arXiv. https://doi.org/10.48550/arXiv.2301.09637

Lührs, R. (2017). demosplan: Behörden und Öffentlichkeit an Planungen beteiligen. In P. Patze-Diordiychuk, P. Renner, & T. Föhr (Eds.), *Methodenhandbuch Bürgerbeteiligung: Online Beteiligung zielgerichtet einsetzten* (Vol. 3, pp. 44–57). oekom Verlag.

Marvin, S., While, A., Chen, B., & Kovacic, M. (2022). Urban AI in China: Social control or hyper-capitalist development in the post-smart city? *Frontiers in Sustainable Cities*, *4*, Article 1030318. https://doi.org/10.3389/frsc.2022.1030318

Matouq, Y., Manasreh, D., & Nazzal, M. D. (2024). AI-driven approach for automated real-time pothole detection, localization, and area estimation. *Transportation Research Record*. Advance online publication. https://doi.org/10.1177/03611981241246993

Mayring, P. (2015). *Qualitative Inhaltsanalyse* (12th ed.). Beltz Verlag.

Mazzeo, D., Matera, N., Peri, G., & Scaccianoce, G. (2023). Forecasting green roofs' potential in improving building thermal performance and mitigating urban heat island in the Mediterranean area: An artificial intelligence-based approach. *Applied Thermal Engineering*, *222*, Article 119879. https://doi.org/10.1016/j.applthermaleng.2022.119879

Moreno González, L. A., de Laet, V., Vazquez Brust, H. A., & Zambrano Barragán, P. (2022, February 22). Can artificial intelligence help reducing urban informality? Discover MAIIA, the new IDB software. *Ciudades Sostenibles*. https://blogs.iadb.org/ciudades-sostenibles/en/can-artificial-intelligence-help-reducing-urban-informality

Naik, N., Kominers, S. D., Raskar, R., Glaeser, E. L., & Hidalgo, C. A. (2017). Computer vision uncovers predictors of physical urban change. *PNAS*, *114*(29), 7571–7576. https://doi.org/10.1073/pnas.1619003114

Narayanan, M., Jaju, S., Nair, A., Mhatre, A., Mahalingam, A., & Khade, A. (2021). Real-time video surveillance system for detecting malicious actions and weapons in public spaces. In S. Smys, R. Palanisamy, A. Rocha, & G. N. Beligiannis (Eds.), *Computer networks and inventive communication technologies* (pp. 153–166). Springer Nature.

Ortiz, A., Negandhi, D., Mysorekar, S. R., Nagaraju, S. K., Kiesecker, J., Robinson, C., Bhatia, P., Khurana, A., Wang, J., Oviedo, F., & Lavista Ferres, J. (2022). An artificial intelligence dataset for solar energy locations in India. *Scientific Data*, *9*, Article 497. https://doi.org/10.1038/s41597-022-01499-9

Park, C., No, W., Choi, J., & Kim, Y. (2023). Development of an AI advisor for conceptual land use planning. *Cities*, *138*, Article 104371. https://doi.org/10.1016/j.cities.2023.104371

Pellegrin, J., Colnot, L., & Delponte, L. (2021). *Research for REGI Committee—Artificial intelligence and urban development*. European Parliament.

Pisu, D., & Carta, S. (2024). Architectural AI: Urban artificial intelligence in architecture and design. In F. Cugurullo, F. Caprotti, M. Cook, A. Karvonen, P. McGuirk, & S. Marvin (Eds.), *Artificial intelligence and the city. Urbanistic perspectives on AI* (pp. 339–359). Routledge. https://doi.org/10.4324/9781003365877

Popelka, S., Narvaez Zertuche, L., & Beroche, H. (2023). *Urban AI guide*. Urban AI. https://doi.org/10.5281/zenodo.7708833

Rahnemoonfar, M., Chowdhury, T., Sarkar, A., Varshney, D., Yari, M., & Murphy, R. R. (2021). FloodNet: A high resolution aerial imagery dataset for post flood scene understanding. *IEEE Access*, *9*, 89644–89654. https://doi.org/10.1109/ACCESS.2021.3090981

Reages, J., De Souza, J., & Hubbard, P. (2018). Understanding urban gentrification through machine learning: Predicting neighbourhood change in London. *Urban Studies*, *56*(5), 922–942. https://doi.org/10.1177/0042098018789054

Rigal, M. (2022, December 5). Ein Jahr QTrees: Learnings über Künstliche Intelligenz und Stadtbäume. *Technologie Stiftung Berlin*. https://www.technologiestiftung-berlin.de/profil/blog/ein-jahr-qtrees-learnings-ueber-kuenstliche-intelligenz-und-stadtbaeume

Rosen, E., & Garboden, P. (2024). Algorithms and racial discrimination in the US housing market. In F. Cugurullo, F. Caprotti, M. Cook, A. Karvonen, P. McGuirk, & S. Marvin (Eds.), *Artificial intelligence and the city. Urbanistic perspectives on AI* (pp. 322–338). Routledge. https://doi.org/10.4324/9781003365877

Sanchez, T. W., Shumway, H., Gordner, T., & Lim, T. (2022). The prospects of artificial intelligence in urban planning. *International Journal of Urban Sciences*, *27*(2), 179–194. https://doi.org/10.1080/12265934.2022.2102538

Sari, E., Erbas, C., & As, I. (2022). The image of the city through the eyes of machine reasoning. In I. As, P. Basu, & P. Talwar (Eds.), *Artificial intelligence in urban planning and design: Technologies, implementation, and impacts* (pp. 163–178). Elsevier. https://doi.org/10.1016/C2019-0-05206-5

Sarker, I. H. (2022). AI based modeling: Techniques, applications and research issues towards automation, intelligent and smart systems. *SN Computer Science*, *3*, Article 158. https://doi.org/10.1007/s42979-022-01043-x

Schönwandt, W. (2008). *Planning in crisis: Theoretical orientations for architecture and planning*. Aldershot.

Senadheera, S., Yigitcanlar, T., Desouza, K. C., Mossberger, K., Corchado, J., Mehmood, R., Yi Man Li, R., & Cheong, P. H. (2024). Understanding chatbot adoption in local governments: A review and framework. *Journal of Urban Technology*. Advance online publication. https://doi.org/10.1080/10630732.2023.2297665

Sepehr, P. (2024). Mundane urban governance and AI oversight: The case of Vienna's intelligent pedestrian traffic lights. *Journal of Urban Technology*. Advance online publication. https://doi.org/10.1080/10630732.2024.2302280

Son, T. H., Weedon, Z., Yigitcanlar, T., Sanchez, T., Corchado, J. M., & Mehmood, R. (2023). Algorithmic urban planning for smart and sustainable development: Systematic review of the literature. *Sustainable Cities and Society*, *94*, Article 104562. https://doi.org/10.1016/j.scs.2023.104562

Stadt Wien. (2024). *BRISE als Zukunft für die Verwaltung*. Smart City. https://smartcity.wien.gv.at/brise-als-zukunft-fuer-verwaltung

Urban, A., Hick, D., Noennig, J. R., & Kammer, D. (2021). With a little help from AI: Pros and cons of AI in urban planning and participation. *International Journal of Urban Planning and Smart Cities*, *2*(2), 19–33.

Urban Learning. (2024). *Planning process*. http://www.urbanlearning.eu/toolbox/planning-process

Wilson, A., Tewdwr-Jones, M., & Comer, R. (2019). Urban planning, public participation and digital technology: App development as a method of generating citizen involvement in local planning processes. *Environment and Planning B: Urban Analytics and City Science*, *46*(2), 286–302.

Wu, P., Zhang, Z., Peng, X., & Wang, R. (2024). Deep learning solutions for smart city challenges in urban development. *Scientific Reports*, *14*, Article 5176. https://doi.org/10.1038/s41598-024-55928-3

Ye, X., Du, J., & Ye, Y. (2021). MasterplanGAN: Facilitating the smart rendering of urban master plans via generative adversarial networks. *Environment and Planning B: Urban Analytics and City Science*, *49*(3), 794–814.

Yigitcanlar, T., & Teriman, S. (2015). Rethinking sustainable urban development: Towards an integrated planning and development process. *International Journal of Environmental Science and Technology*, *12*, 341–352.

Zheng, Y., Lin, Y., Zhao, L., Wu, T., Jin, D., & Li, Y. (2023). Spatial planning of urban communities via deep reinforcement learning. *Nature Computational Science*, *3*, 748–762. https://doi.org/10.1038/s43588-023-00503-5

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