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The rise of AI urbanism in post-smart cities: A critical commentary on urban artificial intelligence

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Abstract

Artificial intelligence (AI) is emerging as an impactful feature of the life, planning and governance of 21st-century cities. Once confined to the realm of science fiction and small-scale technological experiments, AI is now all around us, in the shape of urban artificial intelligences including autonomous cars, robots, city brains and urban software agents. The aim of this article is to critically examine the nature of urbanism in the emergent age of AI. More specifically, we shed light on how urban AI is impacting the development of cities, and argue that an urbanism influenced by AI, which we term *AI urbanism*, differs in theory and practice from smart urbanism. In the future, the

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rise of a post-smart urbanism driven by AI has the potential to form autonomous cities that transcend, theoretically and empirically, traditional smart cities. The article compares common practices and understandings of smart urbanism with emerging forms of urban living, urban governance and urban planning influenced by AI. It critically discusses the limitations and potential pitfalls of AI urbanism and offers conceptual tools and a vocabulary to understand the urbanity of AI and its impact on present and future cities.

Keywords
AI urbanism, artificial intelligence, autonomous city, post-smart cities, smart urbanism, urban AI

摘要
人工智能 (AI) 正日益成为二十一世纪城市生活、规划和治理的一个重要特征。人工智能曾经仅限于科幻小说和小规模技术实验，现在却以城市人工智能的形式出现在我们身边，包括自动驾驶汽车、机器人、城市大脑和城市软件代理等。本文的目的是批判性地审视在人工智能新兴时代城市化的本质。更具体地说，我们阐明了城市人工智能如何影响城市的发展，并认为受人工智能影响的城市化（我们称之为人工智能城市化）在理论和实践上不同于智慧城市化。未来，人工智能驱动的后智慧城市化的兴起有可能形成理论上和实践上超越传统智慧城市的自治城市。本文将智慧城市化的常见做法和观点与受人工智能影响的新兴城市生活形式、城市治理和城市规划进行了比较。本文批判性地讨论了人工智能城市化的局限性和潜在危险，并提供了概念工具和词汇来理解基于人工智能的城市化及其对当前和未来城市的影响。

关键词
AI 城市化、人工智能、自治城市、后智慧城市、智慧城市化、城市人工智能

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Introduction: The urbanity of AI

Artificial intelligence (AI) is emerging as an impactful feature of the life, planning and governance of 21st-century cities. Once confined to the realm of science fiction and small-scale technological experiments, AI has now entered the *age of implementation* characterised by mass distribution and a wide range of real-world applications (Lee, 2018). Urbanists have noted that many of these applications can be found in cities, which are particularly attractive targets for AI implementation, due to their concentration of technologically advanced infrastructure (necessary to run complex AI systems) and high population densities that produce demand for new AI technologies as well as a sufficient return on investment (Barns, 2021; Cugurullo, 2020; Macrorie et al., 2021; Son et al., 2023).

During its evolution, AI has taken several urban forms. Some of these are visible, tangible and observable in many cities. Cars and trucks driven by AI are being mass-produced by companies such as Tesla and Volvo. They are no longer restricted to remote testing facilities, but are increasingly sold and deployed on public roads in ordinary urban settlements (Acheampong et al., 2021). Autonomous vehicles (AVs) represent an AI technology that has already been 'set free' and is now reshaping urban mobility as well as the logistics of the supply chains that sustain urban economies (Dowling and McGuirk, 2022; Hopkins, 2023; Tennant and Stilgoe, 2021: 848). Robots, ranging from androids to drones, operate across a variety of urban sectors, 'appearing and performing specific functions in public spaces'

(Mintrom et al., 2021: 123; While et al., 2021). Nowadays, service robots deal with human customers in shops, restaurants and airports (Lin, 2022; Lynch, 2021). Meanwhile, a growing number of drones are delivering goods in cities and keeping the built environment under continuous surveillance (Jackman and Brickell, 2021). The more-than-human fauna of the city has expanded, and urban robotics is its latest addition.

Other urban incarnations of AI, such as *city brains*, are less visible and tangible, but their impact on cities can be substantial nonetheless. City brains are large-scale AIs residing in vast digital urban platforms and capable of managing multiple urban domains including transport, safety, health, environmental monitoring and planning, in real time (Caprotti and Liu, 2020; Curran and Smart, 2021). This urban AI is emerging particularly in China, Malaysia and Saudi Arabia. CCTV cameras, often equipped with facial recognition technology, serve as the eyes of city brains to observe urban spaces and develop a situational awareness. Predictive analytics are coupled with city brains to predict future urban conditions and govern collective services in an anticipatory manner (Cugurullo, 2021). Last but not least, a myriad of AIs have entered our cities and everyday life via apps and computer programs. Although we cannot touch them, their effects are tangible: contact-tracing apps that decide who must isolate at home to meet quarantine requirements (Kitchin, 2020); algorithms that calculate who will qualify for a home mortgage (O'Neil, 2016). These urban software agents are ubiquitous and deeply agentic despite their seeming immateriality (Cugurullo, 2020).

Autonomous vehicles, robots, city brains and urban software agents are currently the most prominent categories of urban artificial intelligence. The concept of urban AI refers to artificial intelligences that operate and take material form in urban spaces, urban technologies and urban infrastructures (Cugurullo, 2021; Luusua et al., 2023). On the one hand, urban AI reflects the core capabilities that are generally found in AI technology: acquiring data by sensing the surrounding environment (Russell and Norvig, 2016); making sense of data by extracting concepts from what is being sensed (ranging from *stop* when an autonomous car sees the color red on a traffic light, to *intruder* when a home surveillance drone senses the presence of a stranger), and thus showing a rudimentary form of thinking (Bostrom, 2017); handling uncertainty (Pearl, 2014); and acting rationally in an autonomous manner without human guidance (Cugurullo, 2020). On the other hand, the notion of urban AI stresses the urbanity of artificial intelligence or, in other words, the quality of AI of being urban. This quality is manifested in a threefold manner.

First, AI needs the city in order to increase and improve its intelligence. Artificial intelligence can only develop through the acquisition of data. As Lee (2018: 14) succinctly notes, 'there's no data like more data.' In terms of quantity, cities are enormous generators of data, because they are the primary locus of human societies, where intense and manifold human activities occur. In terms of quality, cities offer the best possible data for AI to learn from: real-life data, as opposed to carefully curated and cleaned datasets that are modelled on a computer. Urban AI learns in the wild by observing the messy dynamics of real-world urban environments. The life of urban AI intersects with the life of cities, because these are AI technologies designed and programmed to interact with humans and to mediate socio-economic activities that occur primarily in urban spaces, and thus deviate from the many AIs employed, for instance, to automate agriculture in rural areas or that are located under the sea and in outer space. Second, most AIs need a material base to operate and all AIs

need spaces to act upon because their activities always take place somewhere, whether it is a road where an autonomous car is driving or an apartment whose market value has been calculated by an algorithm (Fields, 2022; Safransky, 2020). The city gives AI a material iteration, situating it in the physical landscape. Third, AI is being infused into the governance of cities, and it has the potential to create the autonomous city where human agency might be overshadowed by the agency of urban AI (Cugurullo, 2021). This trajectory points towards a distinctly different type of city than exists today and raises questions about the opportunities and drawbacks presented by the contemporary rollout of urban artificial intelligences and their potential impact on urban futures.

The aim of this article is to critically examine the nature of urbanism in the age of urban AI. More specifically, we seek to shed light on how urban AI is influencing the life, governance and planning of cities. The focus is on emerging AI technologies that can already be found in the contemporary city, albeit on a limited scale, in an attempt to capture the likely urban transformations that will define the city of the future. We suggest that an urbanism influenced by artificial intelligences, which we term *AI urbanism*, differs in theory and practice from smart urbanism. We develop our argument in three steps. First, we compare the core characteristics of smart urbanism with those of AI urbanism. Second, we employ this comparison as a stepping stone to articulate the main issues associated with AI urbanism, by connecting each issue with a critical question, to generate debate and stimulate future research in urban studies. Third, we pose as key questions the extent to which AI urbanism is leading to the formation of autonomous cities and how these might differ from smart cities, expressing doubt about the need to integrate AI into the lifeblood of the contemporary city.

AI urbanism versus smart urbanism

The news media often promotes a false impression of AI as a cutting-edge technology intertwined with narratives of innovation. In reality, artificial intelligence both as a technology and as a field of research has existed for many years and its inception can be traced back to the 1950s. What is novel these days is the large-scale implementation of AI technology and its filtering into urban spaces and infrastructures, through urban artificial intelligences (such as autonomous vehicles, robots, city brains and urban software agents) whose application in the life, governance and planning of cities is generating a new urbanism: AI urbanism.

AI has a complex past and an even more complicated present. We are facing a decades-long strand of technological innovation that has only recently gone mainstream, and in the study of AI urbanism it is therefore key to acknowledge the lineage of AI, and to identify what is new as well as what has had a longer gestation. AI urbanism is history and future at the same time and its most evident ancestor is smart urbanism which forms the starting point of this section. Our intention here is to compare traditional practices and understandings of smart urbanism with emerging forms of urban living, urban governance and urban planning influenced by AI. Our use of the term 'versus' is aimed to draw out a comparison, rather than contrast. Smart and AI are different, but they are not oppositional.

Table 1 compares smart urbanism and AI urbanism through nine categories: technology, action, space, agency, culture, personality, governance, time and materiality. First, we focus on the core technology that has been driving smart urbanism for more than two decades and now underpins AI urbanism. Within this category, we identify the Internet of Things (IoT) as a key technological

Table 1. Smart urbanism versus AI urbanism.

	Smart Urbanism	AI Urbanism
Technology	IoT	AIoT
Action	Count	Account
Space	Confined spaces	Open spaces
Agency	Automation	Autonomy
Culture	Niche	Pop
Personality	Impersonal	Characterful
Governance	Tool	Stakeholder
Time	Present	Future
Materiality	Soft	Concrete

Source: Authors' original.

component of smart-city initiatives. IoT is an umbrella term encapsulating several smart technologies: sensors integrated into everyday objects and the built environment, producing large amounts of data, so-called *big data*, which is instantly shared over digital networks by the object itself (Kitchin and McArdle, 2016; Kummitha and Crutzen, 2019). AI urbanism takes IoT to the next level with the newly formed Artificial Intelligence of Things (AIoT). The concept of AIoT builds on that of IoT to describe emerging technologies capable of acting as well as sensing. Sensors, big data and digital networks continue to be fundamental components, since urban AIs, such as autonomous cars, robots and city brains, need sensors (cameras, for instance) to perceive the surrounding environment and they produce big data that is digitally shared and then mediated by digital platforms (Caprotti et al., 2022). What is different is that AIoT brings artificial intelligence and its key capabilities into ordinary things and spaces (Zhang and Tao, 2020). This means that the capacity to extract concepts and act autonomously (which IoT does not possess) is being infused into previously inanimate objects present in our homes, offices and urban infrastructures.

The second category, action, refers to what the technology in question actually does. To unpack this aspect of our comparison, we draw upon the philosophy of Byung-Chul Han who points out that IoT does not generate narratives, in the sense that it simply counts instead of telling a story (Han, 2017). Here in lies a major difference between smart urbanism and AI urbanism. The former, by means of IoT, counts. It calculates and determines the quantity of a given urban phenomenon, such as how much energy a building is consuming or how many people are using a subway. Its outcome appears in the form of numbers: mainly quantitative data provided for human consideration and intervention. In contrast, in AI urbanism we find multiple urban artificial intelligences that are capable of producing accounts. An account is a basic narrative that explains why and how certain things occur in the city. For example, Palantir is a predictive technology that analyses urban data to provide explanations about who will commit a crime, how and where (Brayne, 2020). Such narratives are not full stories, as urban AIs' accounts are interpreted, expanded and then acted upon by human stakeholders (police officers, in relation to Palantir's example). This is because, unlike humans, AIs are not conscious entities and, as the recent example of ChatGPT reveals, they can produce a detailed account in the shape of text, for instance, without grasping its meaning (see Floridi, 2023). However, even if they are unconscious and unable to reflect on the meaning and implications of what they do, urban AIs perform actions that are imbued with moral values. From an ethical point of view, recent studies stress that many AIs are now in the problematic and deeply contested position of determining what is right or wrong, fair or unfair, good or bad, such as in the case of predictive technologies that identify suspected criminals or AVs that have to distribute inevitable harm when accidents occur (Awad et al., 2018; Floridi et al., 2018). These emerging ethical dynamics were not present in traditional smart-city initiatives where complex moral questions remained exclusively in the hands of humans.

The third category of comparison refers to where smart and AI technologies operate, which is fundamentally a question of space. There is plenty of evidence of the implementation of smart technology in existing cities all around the world (Burns et al., 2021; Karvonen et al., 2019). Yet, there is an ambiguous aspect to this spatial diffusion. Smart technologies, although present in ordinary cities, are often installed in confined spaces or in infrastructures that are detached from human encounters. For example, the smart grid, a hallmark of smart urbanism, lies and operates below the surface of the city and within the infrastructures of buildings, conveniently out of sight of local residents. Similarly, automated transport systems tend to function underground in restricted spaces devoid of humans and traditional vehicles (Cugurullo, 2020). This is not the case in AI urbanism. Service robots operate on the front line, engaging face to face with human customers (Belanche et al., 2021). Drones and digital assistants interact with people within their domestic environments (Strengers and Kennedy, 2020). Autonomous cars traverse real-life open spaces where everyone is allowed and anything can happen (Cugurullo et al., 2021). In the city, the space of urban AI intersects with the space of human life without barriers.

Fourth, we focus on how technology operates in smart and AI urbanism with an emphasis on matters of agency. Here there is a crucial distinction between automation and autonomy. Automation, as Bourdieu (2018: 37) notes, is about 'repetitive processes' which are 'constant and automatic.' We observe this in smart urbanism where the machine always does what it has been

programmed for, continuously repeating the same actions. An automated train in a rapid transit system always follows the same route and cannot leave its circuit. A motion-sensitive smart light that automatically switches on when someone walks by, cannot diverge from this programmed course of action. It is bound to follow strict rules determined by human engineers and computer scientists. Autonomous urban AIs are different. When AI comes into play, 'we willingly cede some of our decision-making power to machines' (Floridi et al., 2018: 698). On these terms, autonomy is the capacity to make decisions independently and this is what we observe in AI urbanism. For instance, an autonomous car makes decisions of a geographical nature deciding which route to take, and a service robot in a shop recommends different products to different customers after listening to their individual preferences. In these cases, prescription gives way to performance and this is where AI urbanism begins to exhibit agency that was never present in smart cities. However, it is important to stress that urban AIs' quality of being autonomous does not imply a complete detachment from humans. In fact, from a conceptual perspective, it is quite the opposite. An urban AI can indeed make a certain decision independently, but that decision would be inevitably influenced (and thus biased) by previous human-made decisions, since these are machines trained on large datasets reflecting past human experiences (Crawford, 2021). In this sense, the machine's act of making a decision might be innovative, while its decision could 'echo existing ideologies and regimes' and therefore be conservative (Cugurullo, 2020: 10).

Relatedly, our fifth point stresses the cultural aspects of AI urbanism compared to smart urbanism. The term 'smart city' began to circulate in the late 1990s and back then its meaning was obscure, as it was a niche that only few urban policymakers and citizens had heard about (Vanolo, 2014). Ten years later, even in a cutting-edge urban settlement like Masdar City in Abu Dhabi, packed with smart technology in every single building, people could barely make sense of smart (Cugurullo, 2013). Today, AI strikes a different chord. From a cultural point of view, artificial intelligence is popular. People might not know how artificially intelligent entities are created, but they are aware that AI is in our phones and is being evoked when someone says *Hello Alexa!* or *OK Google* and *Hey Siri!* Similarly, it is no mystery that AI is behind the making of blockbuster movies and that many kids grow up playing against AIs or cooperating with them in videogames. In essence, unlike smart, AI has become part of the cultural landscape of the 21st century. However, the roots of its imaginary go back to at least the previous century with popular books and movies such as Asimov's *Foundation* series and Kubrick's *2001: A Space Odyssey*. Nowadays, many AI-centred narratives, like the bestselling novels by Cixin Liu and Kazuo Ishiguro, are projecting fictional images of autonomous and conscious artificial intelligences that are capturing the imaginations of people around the world. It is arguably because of this pop aspect of artificial intelligence that a number of urban AIs are being accepted, thereby rapidly becoming part of everyday life in cities.

Sixth, is an interrelated aspect: personality. Returning to Bourdieu (2018: 37), the process of automation tends to 'reduce the role of personality . . . in order to have regularity, repetition.' Bourdieu's reflections fit the nature of automated smart technologies. What personality does a sensor have? Or a smart grid? None. By design, these technologies have no specific behavioural or mental traits, since they are not built to have a mind. The growing trend that we observe in AI urbanism is different and it is best exemplified by robots and urban software agents. It

is common practice in the robotics industry to name robots and for urban stakeholders to later nickname them, so to convey a sense of personality (Lin and Yeo, 2023). In Milton Keynes (UK), for instance, delivery robots are patted like pet dogs (Valdez and Cook, 2023). Common software agents that populate our homes today, like Alexa, not only have a name, but also a way of talking and a tone of voice purposefully meant to express character (Strengers and Kennedy, 2020). On the one hand, this trend shows the intention of AI developers to create characterful technologies. For example, robotics engineer Boris Sofman was inspired by Pixar characters when he invented Cozmo, a small domestic robot, in 2016 to stimulate a sense of empathy in human–machine relationships. On the other hand, however, we need to remember that these technologies do not have a personality beyond what is projected on them by human users who, as Marenko and van Allen (2016: 54) remark, often tend to attribute personality to complex high-tech devices 'because it is the easiest route to explain their behavior' (see also Turkle, 2020). Overall, while we are still a long way from facing empathic AIs that behave and feel like humans, we are already far from the cold and impersonal machines of the era of smart urbanism.

Seventh, the cultural diffusion of AI extends to the political sphere. Both smart and AI are part of the governance of cities, but in different ways. In traditional smart-city initiatives, technology is a tool in the hands of policymakers and planners. For instance, sensors are used to produce data on the metabolism of the city in terms of energy consumption, and human decision-makers manage energy production in light of the insights that smart technology has generated. In a similar way, the urban dashboard, a much-debated article of faith in smart urbanism, brings together a variety of information about a given city, to inform city managers and policymakers (Mattern, 2021). The dashboard's influence is indirect. It informs human decisions but does not make decisions by itself. In AI urbanism instead we observe a different status quo. Urban AIs like city brains and urban software agents, in particular, are directly influencing the governance of cities, by making decisions. City brains manage urban traffic and determine apparently optimised mobility strategies independent of humans (Caprotti and Liu, 2020). Predictive policing programmes identify for themselves individuals and potential criminals that they classify as suspicious (Brayne, 2020). In this sense, urban AI is not merely a passive tool to inform human decision-makers, but rather an active stakeholder which makes decisions and shapes urban governance. This situation is not accidental. Political decisions made by humans place urban AIs in the position to make decisions about the governance of cities. This is particularly evident in technophilic political contexts where governments embrace innovation in AI and foster its integration into multiple levels of governance (Roberts et al., 2021).

The previous aspect of AI urbanism leads us to the penultimate category of our comparison: time. In smart urbanism, the temporal dimension of cities is clearly conceptualised by Kitchin (2014) through the notion of the 'real-time city'. This is the city of sensors producing large volumes of data in real time, meaning the actual time in which what is being sensed by smart technology is occurring. For example, a smart building calculates how much energy is being consumed, while its occupants are using various appliances. The focus of smart technologies is on the present when diverse urban activities take place. In AI urbanism the focus of technology is mostly on the future: activities and situations that have not yet taken place, but that are likely to occur – autonomous cars anticipating and avoiding

busy junctions; service robots anticipating a customer's next request; city brains foreseeing how much energy a city will consume in the coming years and how much carbon dioxide will be emitted; algorithms predicting the future value of a property or who is about to commit a crime. These are all examples of how urban AI extends the timeframe of urbanism into the future. To some extent, the will to anticipate the future has been an important part of urban governance since the 17th century with the invention and application of statistics and probability theory to determine the likelihood of uncertain scenarios (Reith, 2004). What is different today is that the intelligence behind the prediction of possible urban futures is nonhuman.

Finally, we emphasise the materiality of AI urbanism and the material impact that all urban AIs have on urban spaces. To unpack the final category of our comparison, we draw upon Bauman's (2013) theory of light modernity. For Bauman (2013), light modernity characterises cities and societies after the age of the Industrial Revolution which saw the emergence of heavy technologies and building materials such as cars and reinforced concrete. Light modernity represents the era of soft technologies which are lightweight and diminutive, and these are the sensors, microchips and IoT devices that smart urbanism has made popular in urban development. Their small size and light materiality translate into a soft and barely visible material impact on the built environment (Cugurullo, 2021). Because of their often more substantive materiality, urban artificial intelligences are different from traditional smart technologies. Autonomous cars and trucks are heavy technologies whose transit require vast amounts of urban space. Delivery robots have a clear and unignorable material presence in public spaces that require urban policymakers to redefine the rights of way on sidewalks. Seemingly ethereal urban AIs like city brains do not have a body, but they have multiple physical actuators and appendices (CCTV cameras, for example), and their material impact is significant when their decisions affect urban planning, leading to the construction of new buildings and districts. AI urbanism transcends light modernity, thus opening up a new modernity whose urban impact is still largely unknown and poorly understood. It is with the double aim of identifying and discussing AI urbanism's most critical issues that we move to the next section.

Critical questions surrounding AI urbanism

We see AI urbanism more than in purely abstract terms. This is an emerging urbanism that is transcending smart urbanism, thus posing new challenges that require new questions and debates in urban studies. In the following paragraphs, we employ the nine categories examined in the previous section as stepping stones to critically discuss AI urbanism's main issues, connecting each issue with a critical question, in an attempt to generate debate and stimulate future research.

Issue #1: To what extent is AI urbanism sustainable?

Like smart urbanism, AI urbanism is an urbanism driven by technological development and innovation. As such, it is an expensive urbanism that is difficult and costly to sustain, financially and environmentally. AI technology is expensive and energy-intensive, and it consumes vast quantities of critical raw materials (Crawford, 2021; Dauvergne, 2020). AI urbanism also reinforces a compromising reliance on tech companies which come into play by producing, installing, maintaining and updating AI technology. In Western countries, this condition leaves cities and nations vulnerable to the same

neoliberal and socially unjust outcomes often associated with smart urbanism (Masucci et al., 2020). In a country like China instead, we expect heavy-handed and undemocratic government interventions that will further extend the power and influence of the state (Lee, 2018; Roberts et al., 2021). However, as philosophers in particular remind us, new pathways of resource consumption, environmental preservation and social organisation are possible in the age of AI (Cowls et al., 2023; Floridi et al., 2018). As urbanists we care to note that every opportunity presented by AI urbanism in terms of sustainability will have to confront the legacy of social, environmental and spatial inequality created by decades of smart urbanism.

Issue #2: What visions of the city are urban AIs going to diffuse?

Storytelling has been a core human skill since the earliest forms of social organisation. It is a capacity that has also had a significant impact on urban development as, across time and space, different urban stakeholders have developed and promulgated different visions of the good city, leading to the genesis of new settlements while influencing the governance of existing cities (Cugurullo, 2021). Now that urban AIs are capable of producing narratives and accounts that define what is good or bad in and for the city, there is the risk that AI-generated idealisations of the city might not correspond to crucial human ideals such as justice and equity. In fact, there is already evidence of AI-generated narratives that, particularly in the fields of housing and real-estate, are penalising racial minorities (Fields, 2022; Safransky, 2020). Moreover, it would be dangerous to assume that artificial and human intelligences reason in the same way (Bostrom, 2017). Particularly around thorny ethical urban questions, such as trolley problems in urban transport, planning and predictive policing (see Cugurullo, 2022), the AI's side of the story must be carefully examined and debated in a collective manner.

Issue #3: What new human–machine relations are emerging in AI urbanism?

Urban AI is entering everyday urban spaces of life and work. It will not be confined to labs or remote infrastructures, and the trajectory of urban living is soon going to intersect with the life of robots, autonomous cars, city brains and software agents. Physical and digital ecosystems are colliding, producing complex new geographies characterised by tensions, outright clashes but also instances of cooperation. It is unlikely that AI urbanism will be evenly distributed. We expect a spatial distribution akin to that of smart urbanism, marked by fragmented spaces, hackable and glitchy technologies that are not compatible with one another and open the city to security vulnerabilities, and interventions that splinter urban societies (Cugurullo, 2021; Graham and Marvin, 2002; Leszczynski and Elwood, 2022; Maalsen, 2022). In some cases, urban AIs will compete against humans, but also against one another, to control urban spaces and services. In others, as computer science literature suggests, humans will learn to cooperate with AI (and vice versa), thereby forging novel human–machine relations (Crandall et al., 2018).

Issue #4: What levels of autonomy are human and artificial urban stakeholders going to have?

The autonomy of urban AIs means that, in AI urbanism, we will cede part of our decision-making power to machines (Cugurullo, 2021; Floridi et al., 2018). Most importantly, from an urbanistic perspective, autonomy means that the repetition and monotony of traditional smart technologies will be replaced by their

opposites: improvisation and sporadic actions that might differ substantially from existing patterns, norms and relations. The problem is that autonomy is a zero-sum game: somebody's (or something's) autonomy grows at the expense of someone else's autonomy. It is crucial that human stakeholders retain high levels of autonomy to act and make decisions, in situations and contexts where the actions of urban AI tend to deviate from the norm. In addition, it seems critical that human autonomy should be retained especially where AI logics can generate uneven outcomes that negatively affect particular social groups or places.

Issue #5: What characters will urban AI develop and how can we avoid racist and sexist characterisations in AI urbanism?

Having a character is an important trait for urban AI: one that can facilitate human–machine interactions and promote cooperation rather than antagonism. However, the characterisation of urban AI (e.g. robots and urban software agents, in particular) is often stereotypical, racist and sexist (Lin and Yeo, 2023; Strengers and Kennedy, 2020). In essence, the character of urban AI urgently needs a feminist reboot to avoid the reproduction of existing gender stereotypes (Strengers and Kennedy, 2020; Toupin, 2023). Furthermore, we see in postcolonial theory an essential perspective to promote the formation of AI personalities that go beyond Western images, to fully capture the ethnic, cultural, political and ideological diversity of contemporary cities around the world. This is about decentering the characterisation of urban AI and 'rejecting an imitation of the West' when the designers of robots and urban software agents craft the aesthetics and tone of these technologies to evoke a sense of personality (Mohamed et al., 2020: 664).

Issue #6: How can urban AI be made explainable?

There is a fundamental tension in the societal acceptance of urban AI. On the one hand, as noted in the previous section, AI is part of popular culture. On the other hand, literature in the field of Explainable Artificial Intelligence (XAI) indicates that AI technology, its mechanics and, especially, its impacts remain obscure even to the very AI scientists who are building the technology (Miller et al., 2022). Without an expanded public debate, education and disclosure, it is then likely that the diffusion of AI urbanism will be accelerated by the blind acceptance of a technology that we believe we understand, while in reality most of us are clueless.

Issue #7: How can urban AIs' goals be understood and aligned?

Approaching urban AI as a participant with an active role in the governance of cities, rather than an inanimate tool built to improve urban governance, has a twofold implication. First, there is the empirical and theoretical question of which specific urban AIs can be considered as stakeholders in urban governance, and how their stakes and logics can be identified and understood. Second, there is a potential issue of alignment which should make us question and then examine the extent to which urban AI's actions and goals are compatible with human interests and values. The alignment problem refers to the challenge of aligning the values and goals of artificial intelligences with those of human beings (Han et al., 2021). For centuries, urban governance has been the arena where human values and goals have been debated and discussed, and it is now time to bring the alignment problem into these debates and discussions.

Issue #8: What urban futures is AI urbanism producing and preempting?

The future is not simply the temporal focus of AI urbanism but also its target. Any policy based on predictive algorithms 'inevitably alters a future that is yet to come' (Luque-Ayala and Marvin, 2020: 134). Urban AIs, such as city brains and urban software agents, can produce certain futures while preventing others from happening. There is no guarantee that urban AIs' predictions are accurate, let alone the risk that anticipatory policies might feed on so-called 'dirty data' that is 'derived from or influenced by corrupt and unlawful practices' and can generate runaway feedback loops (Richardson et al., 2019: 18; see also Brayne, 2020). What is at stake here is the future of the city. The future cities that urban AIs are calculating and shaping are perhaps not the types of cities that humans want to inhabit.

Issue #9: How can urban planning respond to the rapid urban changes triggered by AI?

AI urbanism has a substantial materiality that cannot be ignored. It is a materiality that, in the worst-case scenario, can kill - as it has already happened in the field of autonomous transport when Elaine Herzberg was struck by a self-driving car in the city of Tempe, Arizona (Stilgoe, 2020). The issue here is that the production of urban AI and the discharge of its materiality in cities, proceeds at a pace that is not remotely comparable to that of urban planning. In 2020, for instance, the total global investment in AI increased by 40% (Zhang et al., 2021). This is a major boost in the implementation of all the different urban artificial intelligences discussed in this article. While capital is being pumped rapidly into the AI industry, the planning process remains slow and inefficient in many cities. There is an evident and chronic problem with urban planning's inability to catch up with processes of technological change that surpass urban change in speed and growth.

Conclusion: Post smart and towards autonomous cities?

Autonomous cars, robots, city brains and urban software agents are technologies that already exist and populate urban spaces, and their impact on urban planning, urban governance and urban living is transcending smart urbanism. This transition beyond or *post* smart is both theoretical and empirical in nature. Theoretically, we have shown in the second section that AI urbanism is not synonymous with smart urbanism. Empirically, we have stressed, in the third section, that an urbanism driven by urban artificial intelligences is already producing and will continue to give rise to new practical and conceptual challenges.

By transcending the smart city, the rise of AI urbanism might lead in the future to the formation of the autonomous city defined as a space where diverse urban AIs perform social and managerial functions that have traditionally been human activities, in an unsupervised manner. While we can already observe the seeds of the autonomous city in experimental urban projects like Neom in Saudi Arabia and Beiyang AI Town in China, the future emergence of this model of urban development remains an open question. This is an urgent question for urban scholars to consider because, 'a city run not by *human* but by *artificial* intelligences' would challenge the autonomy of human stakeholders and struggle to be environmentally sustainable due to energy-intensive supply chains (Cugurullo, 2021: 14). We began this article by explaining why AI needs the city, and we want to conclude it by pondering the question: does the city need AI?

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