Introducing AI into Urban Studies

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Abstract

Innovation in artificial intelligence (AI) is transforming cities in unprecedented ways. In this chapter, we unpack the connections between AI and the urban by introducing the concept of *urban AI* and reflecting on its most prominent incarnations: autonomous vehicles, urban robots, city brains and urban software agents. We then illustrate how the emergence of urban AI is producing a new urbanism that we term *AI urbanism*. AI urbanism originates from smart urbanism but also departs from it along three main axes, namely function, presence and agency. We discuss the similarities and differences underpinning *AI* and *smart* urbanism, highlight the problematic implications of human-machine interactions in the making and governance of cities and, finally, call on urbanists and urban stakeholders to scrutinize the critical intersections between urban development and the development of artificial intelligences.

Introduction: the dawn of AI urbanism

Innovation in artificial intelligence (AI) is transforming cities in unprecedented ways. Robots are increasingly managing key urban services, performing jobs that were once the exclusive domain of humans, and maintaining the infrastructure of cities (Lynch et al., 2022; Macrorie et al., 2021). Self-driving cars are reshaping urban transport systems, thereby triggering new mobilities that impact the design of the built environment (Cugurullo et al. 2021; Dowling and McGuirk, 2022). City brains and digital platforms are gradually reengineering the practice of urban governance by operating entire urban systems that range from health to transport and from security to ecosystems (Caprotti and Liu, 2020; Curran and Smart, 2021; Marvin et al., 2022). Meanwhile, through mobile apps and personal computers, invisible software agents are sifting and sorting urban lives, for instance, deciding which residents to quarantine and which residents qualify for a mortgage (Kitchin, 2020; Lee and Floridi, 2021). In essence, the advent of AI introduces multiple non-biological intelligences that act upon and within cities. For the first time in history, the control of the city is not determined exclusively by humans. It is also influenced by AIs whose logics and actions sometimes might diverge significantly from ours (Cugurullo, 2021; Russell, 2019). We are witnessing the beginning of a new and uncertain urban era, replete with risks and opportunities.

In different spaces and through diverse modalities, AIs and urban systems are converging at a rapid pace (Amoore, 2023; Son et al., 2023; While et al., 2021; Yigitcanlar et al., 2022). The urban changes associated with AI are challenging to describe and analyze in theoretical and empirical terms. There are many different types of AI being applied in heterogeneous urban spaces, unleashing a transformative force of rare impetus. These AIs are *urban* in the sense that they operate primarily in urban environments and, in order to function, they need resources and infrastructures, such as Big Data, electrical grids and server farms, that are urban in nature. We refer to this polymorphous agglomeration of AIs, comprising robots, autonomous vehicles, city brains and software agents, as *urban artificial intelligences* or simply *urban AI* (see also Cugurullo, 2020; Luusua et al., 2022). Moreover, we note that the diffusion of urban AI in the life, governance and planning of cities is generating a distinct kind of urbanism which we term *AI urbanism.* Here, the configuration of urban systems, the form of the built environment and, more broadly, the experiences of urban residents are morphing into something markedly distinct from past iterations and in ways that are only partially understood.

The emergence of AI urbanism is neither a linear nor an atemporal process, but rather a multiform and geographically sensitive phenomenon influenced by previous urbanisms that is destabilizing the material and immaterial fabric of cities. In this book, while we argue that the use of AI technologies in the management of urban services and infrastructures is connected to well-known practices of smart urbanism (see Coletta et al., 2019; Karvonen et al., 2019; Willis and Aurigi, 2020), we also claim that the emergence of AI in cities is a turning point at which *smart* is theoretically and empirically insufficient to explain the urban transformations generated by AI. Urban AI would not be able to function without common smart technologies, such as sensors and the repositories of Big Data that they generate. At the same time, however, urban AI embodies technologies, capabilities and operations which go well beyond traditional smart-city initiatives. For example, the ability to extract concepts and to reason, and the power to decide and act autonomously in real-life environments without human supervision, situates AI and its numerous urban incarnations in theoretical and empirical grounds which diverge from smart urbanism and, thus, require close scrutiny and debate (Cugurullo, 2020).

Drawing upon a range of urban disciplines and over 20 international case studies, the aim of this book is to explore in theory and practice how AI intersects with and alters the city. The chapters reveal a multitude of repercussions that AI is having on urban society, urban infrastructure, urban governance, urban planning and urban sustainability. At the same time, this collection aims to examine how the city, far from being a passive recipient of new technologies, is influencing and reframing AI through subtle processes of co-constitution and co-determination. The focus on AI is specific in the sense that we seek to explicitly look beyond the literature on smart urbanism, by synthesizing new empirical data on AI and its hitherto overlooked urban dimensions and presenting novel concepts and theories about AI urbanism. Our focus is also broad since we take into account multiple types of AI and urban scales from the individual citizen to the single building and from entire cities to regional and international urban networks.

Overall, we advance three main contributions and arguments in the book. First, we discuss the emergence of a post-smart trajectory for cities in which new material and decision-making capabilities are being assembled through multiple AIs. In so doing, we inquire into the distinctiveness and implications of novel AI logics in the urban context. Second, we stress the importance of understanding the mutually constitutive relations between the new experiences enabled by AI technology and the urban context. We question how AI shapes urban life and places and how the urban condition shapes AI in turn. Third, we engage with the concepts required to clarify the often opaque relations that exist between AI and the city, as well as how to make sense of these relations from a theoretical perspective. In essence, this collection provides a state-of-the-art review of AI urbanism, from its historical roots to its contemporary global emergence, in an attempt to develop the empirical and theoretical foundations for the next generation of urban socio-technical studies.

In the following sections, we unpack the connections between AI and the urban by clarifying the concept of *urban AI* and illustrating its most prominent incarnations, namely autonomous vehicles, urban robots, city brains and urban software agents. We then explain how the emergence of urban AI is contributing to the formation of a new type of urbanism which we call *AI urbanism*. We note how AI urbanism derives from but also extends well beyond smart urbanism, along three main axes: function, presence and agency. We discuss the similarities and differences underpinning *AI* and *smart* urbanism and, after stressing the problematic implications of human-machine interactions in the making and governance of cities, we call on urban researchers and stakeholders to scrutinize the critical intersections between urban development and the development of artificial intelligences.

Making sense of AI from an urbanistic perspective

Ai is now one of the dominant forces that is transforming our planet and lives, and yet its meaning and manifestations are elusive (Crawford, 2021). As Greenfield (2018) notes, AI is an obscure and esoteric set of technologies in the sense that the intricate mechanics and thought processes of artificial intelligences are usually understood only by a small group of experts with specialized knowledge in computer science and engineering. This epistemological complexity is exacerbated by the fact that neither a single type of AI, nor a universal blueprint to build one exists (Bostrom, 2017; Cave et al., 2020). The field of AI is thus difficult to navigate, especially from the perspective of the social sciences and humanities. To address this issue, we propose a threefold approach to make sense of AI. In this section, we begin by acknowledging the wide range of AI technologies that are present in the world. We then summarise the core characteristics of AI across its multiple incarnations and, finally, provide examples to makes them visible (and therefore easier to understand) by focusing on how they manifest themselves in real-life urban spaces.

The first step in making sense of AI is to talk about artificial *intelligences* and avoid the conceptual trap of singular nouns. A singular noun refers to (and thus makes us think about) a clearly delineated person, place or thing. Specifically in relation to the subject of our inquiry, the term *AI*, as a singular noun, is misleading since it implies the existence of a singular technology possessing a singular type of intelligence. In reality, this is far from being the case. There are many different artificial intelligences manifesting diverse types and degrees of intelligence (Russell and Norvig, 2016; Samoili et al., 2020). A useful analogy here is offered by a widely recognized form of intelligence: *biological intelligence*. We know that there is an extraordinary variety of intelligent life forms on Earth, ranging from mammals to insects, and human intelligence represents only a fraction of this variety. In science, we do not generalize biological intelligence and instead acknowledge the cognitive and behavioral differences as well as the similarities that exist among species. This same logic applies to AI. We understand AI as a complex cosmos comprising a myriad of diverse non-biological intelligences whose cognition and behavior varies significantly from case to case.

The second step is to identify and characterize the most common traits that are shared among different AIs. These traits include (a) the quality of being artificial, (b) the capacity for learning, (c) the ability to extract concepts, (d) the power to manage uncertainty and (e) the capability to act rationally and (f) autonomously. All AIs are considered to be artificial, in the sense that their development is not the outcome of a natural process such as the formation of the human brain, whose current morphology is the byproduct of thousands of years of evolution (Bruner, 2021; Galway-Witham and Stringer, 2018). In contrast, AI is either human-made or, as Bostrom (2017) notes, created by machines through technological processes that are relatively fast. The assembly of a simple robot, for instance, takes less than five minutes, while algorithms can be created in a matter of hours (Rubenstein et al., 2014; Sherry and Thompson, 2021).

In terms of key capabilities, AIs can learn and develop knowledge *directly* by sensing a given environment using sensors such as cameras and microphones, and *indirectly* by being fed large data sets (Russell and Norvig, 2016). AIs can then make sense of the information that they acquire by extracting concepts from it (Bostrom, 2017). This capacity is a mark of their intelligence, since it shows the ability to find meanings and recognize ideas in what is being observed. Examples include AI-driven cars that are capable of understanding that the color red in a traffic light means that they must stop, and service robots operating in a restaurant that can distinguish customers from inanimate objects and then comprehend that it is a good idea to attend to the customers. It is also important to note that AIs can, as a result of learning, devise new rule sets that take us beyond previously existing human-centred logics. As Bostrom (2017) remarks, it would be dangerous to always assume an affinity between the logics developed by biological and non-biological intelligences.

Ultimately concepts lead to actions and most AIs are designed to act in chaotic and uncertain situations in which some information might be missing or unclear (Kanal and Lemmer, 2014). Their actions are considered to be rational inasmuch as they are 'based on reasons' which determine what is right or wrong and inform their behavior (Lupia et al., 2000: 7; Russell and Norvig, 2016). This assumes the presence of a moral order underpinning the actions of AIs. However, the field of AI ethics remains underdeveloped, especially in practical terms. AI moral guidelines are often incoherent and ignored by the private sector actors that are supposed to implement them (Munn, 2022). As a result, there is a problematic lack of clarity regarding the moral compass behind AIs' actions, particularly in contexts in which AI systems operate with humans out of the loop. When humans do not steer the actions of an AI or supervise its behavior, that AI can be said to be *autonomous* because it is exercising intelligence in an independent manner (Cugurullo, 2020; Levesque, 2017).

The urban is the space where AIs become most prominently visible and materially situated in the physical landscape. It is the locus where their actions occur and where their behaviors are materialized. AI is intrinsically linked to urbanity, for three interconnected reasons. First, AI requires physical environments to act upon, and these are frequently urban. Autonomous cars, for example, operate on public roads in urban settlements. Similarly, service robots function in shops and restaurants located in urban environments. Even the actions of the most ethereal AIs have an inevitable material dimension, like in the case of algorithms that calculate the market value of a property or predict the location of a crime. Second, AI is an *agent* (Russell and Norvig, 2016). As such, it acts and, by nature, it engages in a plethora of activities. Urban settlements encapsulate an increasing proportion and range of activities on our planet (Balland et al., 2020; Elmqvist et al., 2021; Kaddar et al., 2022). Therefore, whether an AI is poised to participate in a social activity, engage in an economic transaction, influence a political process or contribute to global environmental changes, it is compelled to interact with urban systems. Third, the development of AI depends on urban development. Most AIs currently develop their intelligence through processes of *machine learning* whereby they are 'set loose on vast fields of data' to learn from them (Greenfield, 2018: 220). As Lee (2018: 14) points out, 'there's no data like more data'. The more data an AI is exposed to, the more and faster its intelligence grows. As the primary location of manifold human activity, urban spaces are massive generators of data, and it is thus in the urban realm that AI has the greatest opportunity to learn and evolve.

In terms of quality, the urban generates the fine-grain data most useful for machine learning. It is *real-life data* which differs substantially from datasets that are carefully curated and cleaned by computer scientists and then stored digitally. In urban spaces, instead, AI learns *in the wild* and has the possibility to contemplate actually existing social, political, economic, cultural and environmental phenomena as they unfold in real time in the real world. In terms of quantity, cities in particular offer the largest sources of data. Cities, as urban spaces with high population densities, host an unparalleled concentration of human activities that fuel intense processes of consumption, social interaction, mobility and intellectual exchange (Balland et al., 2020; Moran et al., 2018). There are few limits to what can happen in a large city, which is an ideal condition for machine learning and its limitless thirst for knowledge. In China, for example, AI companies are building a competitive advantage by using dense cities as a playground for machine learning (Lee, 2018). In essence, the contemporary city is the microcosm through which AI observes and learns about the entire world.

The connection between the urban and AI makes the latter visible in four distinct forms which, in turn, can be understood as four main types of urban AI. The first one is represented by *autonomous vehicles* (AVs). These are terrestrial devices built for transporting persons or things, which are driven by an AI. They are characterized by different vehicle types including autonomous cars, trucks and buses, as well as by diverse public and private ownership models and service types, such as car-sharing, mass transport, and mobility-as-a-service (Acheampong et al., 2021; Nikitas et al., 2021). The urbanity of AVs is evident from a spatial perspective, since this type of urban AI necessitates urban spaces to fulfil its main function: transportation. Most pointedly, autonomous cars operate on public roads predominantly in urban environments where the quality of road infrastructure tends to be higher (and thus easier to sense and navigate for an AI) than in rural areas, and where it is more common to find fast and reliable communication networks. Cities, in particular, are at the centre of AV innovation and related disruptions (see Figure 1.1). It is in cities that companies like Waymo and Tesla are testing their autonomous cars (Dowling and McGuirk, 2022). It is in cities that car-sharing services and mobility-as-a-service initiatives abound and drive the deployment of fully autonomous fleets à la Uber (Schaller, 2021). It is across cities that autonomous trucks are employed to sustain the logistics of urban economies. And it is in the city that human road users (ranging from drivers to pedestrians and from cyclists to people with disabilities) and AVs are struggling to share the same spaces and ultimately competing to preserve their own mobility (Gaio and Cugurullo, 2022; Talebian and Mishra, 2022).

<Figure 1.1 here>

Figure 1.1: an autonomous car operating in Hong Kong

Source: Yu Chun Christopher Wong

Urban robots represent a second type of urban AI. Similar to AVs, robots have an evident physical presence, but unlike vehicles they do not have an empty interior to accommodate passengers or cargo and do not operate exclusively within the field of transportation. Instead, urban robots come in many different shapes and their influence cuts across a plethora of urban domains. There are robots whose design mimics the general features of the human body including limbs, eyes and an erect posture, with *androids* being almost indistinguishable from humans (Mara and Appel, 2015; Müller et al., 2021). Other robots, such as *drones*, do not have an anthropomorphic appearance, while *nanobots* are so small that they are almost undetectable (Jackman, 2022; Toumey, 2013). Overall, urban robots are infiltrating core sectors of cities, including security, education, retail and hospitality, and their role in the maintenance of urban infrastructure is increasing (Macrorie et al., 2021; Tiddi et al., 2020; Valdez and Cook, 2023; While et al., 2021). In so doing, robots are in continuous interaction with the principal inhabitants of the built environment: humans. *Service robots*, for instance, populate everyday urban spaces and are designed to assist humans *in the frontline* (Pozharliev et al., 2021; Wirtz et al., 2018). This position involves direct and often face-to-face interactions, as in the case of robot waiters that are deployed to understand and accommodate a client's needs (see Figure 1.2). The proliferation of service robots, however, does not necessarily imply cooperation. De facto urban robots are a 'new class' of intelligent machines whose labour frequently comes at the expense of a human's job, and it is important to remember that 'few employment fields are immune' (Bissell and Del Casino, 2017: 436; Del Casino, 2016: 847). From this perspective, urban robots are replacing rather than supporting their human counterparts.

<Figure 1.2 here>

Figure 1.2: a robot waiter serving food at a restaurant in Chennai (India)

Source: Arun Sankar

A third type of urban AI is the *city brain*. City brains are *large-scale* urban AIs inasmuch as their agency extends to large portions of urban territory, infrastructure and the public sector (Cugurullo, 2021; Zhang et al., 2019). While in the case of AVs and urban robots, AI is animating a car or a drone, in the case of city brains what is being controlled by AI are buildings, telecommunication networks, and even entire cities. This type of urban AI is materially and geographically more extensive but also elusive when compared to the previous types. It does not reside in a single material artefact. Instead, it is located within a digital platform, infused through the urban fabric, where AI acts like a brain and controls different parts of the city in a way that resembles a human brain in control of the different parts of a human body. Due to their existence inside digital platforms, city brains can be understood as an extension of *platform urbanism* (Barns, 2019; Caprotti et al., 2022; Caprotti and Liu, 2020; Hodson et al., 2020). Because of its hybrid physical and digital nature, platform urbanism is challenging to map and so are city brains (Fields et al., 2020; van der Graaf and Ballon, 2019). To further complicate matters geographically, city brains have *actuators* which bridge digital and physical spaces. These are material components through which city brains penetrate the real world, such as CCTV cameras that a city brain uses as eyes to observe what is happening in the city (Curran and Smart, 2021). However, more than just a neutral observer, a city brain acts on the city and influences its governance by attempting to predict the future and enacts adaptations to respond to future conditions including, for example, anticipated traffic congestions or concentration of demand for emergency services (Cugurullo, 2021; Zhang et al., 2019). This is essentially what Brayne (2017) defines as the shift from *reactive* to *proactive* approaches to urban governance, whereby the unprecedented computational power of AI is exploited to calculate large amounts of future possibilities, and then enable certain urban futures while suppressing others (Luque-Ayala and Marvin, 2020).

Urban software agents are a fourth type of urban AI which captures a seemingly invisible yet highly impactful dimension of AI in urban contexts. While the other types of urban AI are physically embodied and possess material actuators allowing them to act tangibly on cities, urban software agents are immaterial. Examples include computer programs that use algorithms to determine which individuals or families qualify for a home mortgage or insurance policy, contact-tracing apps that identify individuals to be quarantined, AI chatbots that create social bonds with humans, and digital assistants such as Alexa and Siri that respond to voice commands and execute domestic tasks (Kitchin, 2020; Lee and Floridi, 2021; O'Neil, 2016; Strengers and Kennedy, 2021). Using Waze, a popular navigation map app, as an example, Fisher (2022: 75) notes that these aethereal AIs have a *spatiality* since they change 'how space is known, experienced, and acted upon.' Urban software agents are more prolific than one might imagine, and their immateriality belies their profound influence on the daily lives of urban residents. From a geographical perspective, the location of many urban software agents shows how AI is entering our private spaces, including our homes, and becoming part of our everyday life. In the shape of software agents AI is always with us, whether talking through a speech synthesizer sitting on the kitchen counter, or simply operating our smartphones silently. The intimacy of this AI tech implies that, willingly or not, we are constantly sharing personal information with AI systems (Zuboff, 2019). These are systems that, XAI (Explainable Artificial Intelligence) scholars warn us, only few experts in computer science and engineers comprehend. Yet, as Zuboff (2019: v) remarks, these AIs are growing in popularity, assimilating unprecedented quantities of behavioral data and contributing to the formation of a system of surveillance 'that asserts dominance over society' (Baum et al., 2022; Langer et al., 2021).

From smart to AI urbanism

The four types of urban AI described above serve as the organizational scaffolding for this book and provide a means to classify the current evolution of urbanism from *smart* to *AI*. In the first section of the book on *Autonomous Vehicles and Mobility,* the authors examine the impact that vehicles driven by AI are having on cities, and the social, political and economic dynamics through which such vehicles are accommodated and integrated into the city. In the second section, *Urban Robots and Robotic Spaces,* the contributors illuminate the presence and role of robots in a variety of urban domains, as well as the diversity of urban spaces altered by robotics. The authors in the third section of the book explore *City Brains and Urban Platforms* and highlight the operation and influence of large-scale AI control systems intended to manage vast portions, aspects and domains of the city, which underpin everyday life. In the final section on *Urban Software Agents and Algorithms*, the authors focus on immaterial AIs and consider the implications of digital assistants, computer programs and seemingly neutral machinic procedures for urban living, design and governance.

Overall, the book draws on over 20 case studies based on empirical research. We use these case studies to illustrate the emergence of *urban AI* defined as a class of material and immaterial artificial intelligences that operate most intensely in urban spaces and that depend on urban resources, as they mediate urban services and influence urban sectors, by means of their capacity to understand manifold spheres of urban life and act on them in an autonomous manner (see Figure 1.3). In addition, we emphasise how the proliferation of urban AI across urban spaces and sectors is generating what we term *AI urbanism*: a novel urbanism that derives from smart urbanism but also departs both empirically and theoretically from traditional smart-city projects and trajectories. More specifically, we identify a series of points of connection and departure along three axes, namely *function*, *presence* and *agency*, captured in Figure 1.4.

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Figure 1.3: urban AI

Source: authors' original

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Figure 1.4: comparing smart and AI urbanism

Source: authors' original

First, there is a notable difference between the function of technologies employed in smart cities versus the function of artificial intelligences in AI urbanism. The technologies in smart cities are used to count and calculate urban metabolic processes. This involves quantifying specific phenomena, such as household energy consumption and neighborhood crime rates by collating and analysing *Big Data* (Bhati et al., 2017; Catlett et al., 2019; Kitchin and McArdle, 2016). In contrast, urban AI produces an account of urban phenomena by collecting and analyzing data to explain why and how certain things occur in cities. Urban AIs extract patterns and concepts from large datasets, and follow seemingly objective and unbiased logics to produce predictions of urban futures yet to come. This is particularly evident in the case of urban software agents like *Palantir*, a predictive policing system whose function is to explain why some urban residents are more likely to commit a crime and to foresee where unlawful activities will cluster within a given city (McDaniel and Pease, 2021; Richardson et al., 2019). In essence, along the *function* axis we observe an evolution in the role and purpose of technology from performing calculations on enormous sets of quantitative data to providing an account of the urban condition. AI uses Big Data to produce explanatory and interpretative models akin to narratives. These models are not comprehensive stories analogous to human storytelling, but they denote AI's novel capacity to interpret urban phenomena, rather than simply quantifying them. An interpretation is, in turn, a sign of thinking. Although rudimentary and different from human thought processes, such manifestation of thinking is absent in traditional smart city technologies.

The second axis concerns the space where urban artificial intelligences function. While smart-city technologies are usually installed in confined spaces or infrastructures that are detached and hidden from humans, urban AIs are more visible sociotechnical phenomena. A smart grid, for example, is located below the surface of the city in areas that are inaccessible to urban residents (Quitzow and Rohde, 2022), where it manages the distribution of energy services. Citizens are aware of the existence of this technology but cannot see it because it is buried in the bowels of the city, away from human perception. Other smart technologies provide limited accessibility and visibility. In urban transport, for instance, automated track-bound metro systems and personal rapid transport networks can be accessed by passengers, but only in specially built guideways that are often underground and devoid of other vehicles and, above all, of pedestrians (Cugurullo, 2021). This is not the case in AI urbanism. Autonomous vehicles traverse public roads, operating next to pedestrians and sharing the same space with traditional vehicles and cyclists (Brovarone et al., 2021; Martens et al., 2022). Many robots work on the frontline in environments such as shops, restaurants and airports, where they are constantly encountering and interfacing with humans (Lin et al., 2022; Sumartojo et al., 2022). Even software agents can make their presence visible by animating the apps in our omnipresent smartphones. Overall, this describes an evolution of the *presence* of technology from being covert in smart urbanism to becoming overt in AI urbanism.

Third, we observe notable differences with respect to *agency*. In smart urbanism, technologies are programmed to repeat the same actions over and over. They are *automated* technologies in the sense that they follow ‘repetitive processes’ which are ‘constant and automatic’ (Bourdieu, 2018: 17). These processes are programmed by human engineers and computer scientists, and the machine is compelled to abide by them. A smart sensor, for example, automatically switches on the light every time a movement is detected. Similarly, an automated tram follows a prescribed route and is bound to fixed tracks from which it cannot escape. In essence, when it comes to automation, ‘there is no room for variations or improvisation’ (Cugurullo, 2021: 161). In contrast, urban AIs are becoming more and more autonomous. Our observation resonates with the notion of *autonomous technology* developed by Langdon Winner (1978: 16), whereby ‘technology governs its own course.’ At the end of the third axis, machines decide the course of their actions. They make important decisions de facto engaging with ethical conundrums about what is right or wrong on a logical course of action derived from machine-learning and then act accordingly, with little or no human supervision. An autonomous vehicle, for instance, determines its own route which is constantly changing *on the run* as unexpected factors, such as traffic jams and accidents, come into play. In this context rich in uncertainty, autonomous technologies introduce new ethical dilemmas, especially in situations where harms to humans are unavoidable (Awad, 2018; Hagendorff, 2020; Kaker et al., 2020). Autonomy is not a concern in smart cities where decision-making and ethical decisions remain firmly in the hands of humans.

Cutting across these three main axes, we begin to notice the emergence of a fourth axis which encapsulates the dominant *discourse* underpinning smart urbanism and AI urbanism. The grand narrative that fueled the genesis of smart cities was based upon a modernist ideal of control (Cugurullo, 2018; Datta, 2015) whereby technology was understood as an instrument in the hands of humans, designed and employed to fulfil human dreams and visions in an anthropocentric manner (Berman, 1983; Boyer, 1986; Cugurullo, 2021). Nowadays, in the practice of AI urbanism some of the core principles of modernity no longer hold. In particular, AI urbanism pushes beyond the modernist ideal of control by ceding agency to autonomous technologies that take initiative instead of following human instructions. Urban artificial intelligences cannot be conceptualized as tools completely in the hands of humans and in the service of human visions, given that they have the capacity to develop their own narratives and to act autonomously in the pursuit of emergent futures. The modernist logic of control applied in the case of smart cities where technology was confined and contained in specific spaces, but it is not pertinent in an urban context in which multiple AIs increasingly roam free as autonomous agents. Modernist ideals of control are gradually falling apart, along a trajectory towards *post-modernity* which we understand as the faltering of the tenets, assumptions and promises of modernity (Harvey, 1989). More specifically, we see in the advent of an emergent urbanism shaped by co-constitutive human/AI relations a condition in which modernist promises of centralized and anthropocentric control are broken by dispersed forms of control that are more-than-human in nature. This post-modern age of AI upends the central role of humans as the sole builders and governors of cities, spreads power and control across uncharted digital platforms and opens up urban development to new post-human conditions.

Conclusions: transcending smart urbanism in the age of AI

The urban trends that we have discussed in this chapter indicate that, with the advent of AI in cities, practices and theories of urban development, governance and design are transcending what for decades has been known as *smart urbanism*. The transition to AI urbanism has begun, but its empirical and theoretical implications remain to be seen. The future that lies ahead is unknown, though it is unlikely to be spatially homogeneous, as different cities are experimenting with AI technologies in ways that reflect their specific geography, history and political economy. We already see the emergence of new master-planned urban settlements like The Line in Saudi Arabia, where AI is being rolled out to have complete control over urban governance, and a single AI system is intended to monitor the life of every urban resident (Batty, 2022). In other places, AI is being implemented through small-scale urban experiments to manage buildings and districts autonomously, which suggests that AI's impacts will be felt differentially *within* as well as across urban geographies (Aguilar et al., 2021; Marvin et al., 2022). Overall, the comprehensive and piecemeal applications of AI serve as two ends on a broad spectrum of trajectories of AI urbanism. However, one common denominator in AI urbanism is clear: a more-than-human component that is redefining the urban experience, as artificial and biological intelligences collide and collude in the making and governance of cities.

These collisions and collusions of humans and urban AIs will be significant regardless of the scale. Some urbanists, for example, ponder the genesis of *autonomous cities* where 'diverse artificial intelligences, from service robots to digital platforms, perform urban activities that have traditionally been human activities' (Allam, 2021; Cugurullo, 2021: 17). Even if such fully autonomous cities do not become a reality around the world, there will still be a myriad of small-scale human-AI interactions whose impact on the everyday life of cities and urban residents will be largely invisible but profound. For example, one can imagine the devastating consequences of a declined mortgage application assessed by an AI on a family struggling to find shelter during a housing crisis. Such an example is not the work of science fiction. As this book shows, similar episodes are rapidly emerging as the new normal for everyday life in many cities. The enormous and multifaceted impact of AI urbanism, and its problematic and progressive possibilities, requires sustained scrutiny, research and critique. AI technologies have been introduced into the city and they are here to stay. Their form, function and impacts will be variable and co-constituted by existing urban contexts. Now is the time to introduce

AI into urban studies, to understand empirically and theoretically the intersection between the development of artificial intelligences and the development of cities in the decades to come.

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