frontiers | Frontiers in Sustainable Cities

TYPE Original Research
PUBLISHED 11 October 2022
DOI 10.3389/frsc.2022.1030318

OPEN ACCESS

EDITED BY
Federico Cugurullo,
Trinity College Dublin, Ireland

REVIEWED BY
Cian McCarroll,
Trinity College Dublin, Ireland
Miguel Valdez,
The Open University, United Kingdom

*CORRESPONDENCE
Simon Marvin
s.marvin@sheffield.ac.uk

SPECIALTY SECTION
This article was submitted to Innovation and Governance, a section of the journal Frontiers in Sustainable Cities

RECEIVED 28 August 2022
ACCEPTED 21 September 2022
PUBLISHED 11 October 2022

CITATION
Marvin S, While A, Chen B and Kovacic M (2022) Urban AI in China: Social control or hyper-capitalist development in the post-smart city? *Front. Sustain. Cities* 4:1030318. doi: 10.3389/frsc.2022.1030318

Urban AI in China: Social control or hyper-capitalist development in the post-smart city?

Simon Marvin[1]*, Aidan While[1], Bei Chen[1] and Mateja Kovacic[2]

[1]Urban Institute, University of Sheffield, Sheffield, United Kingdom, [2]Department of Interactive Media, School of Communication, Hong Kong Baptist University, Kowloon, Hong Kong SAR, China

Research and wider societal debates has explored the potentially transformative role of AI in extended social control and hyper-capitalist development in China. In this paper, we use those debates to reflect on experiments with Urban AI in China. The key issue is whether AI offers something distinctive or different compared with the logics and imaginaries of ideas of the smart city. Analysis of emblematic sites of urban AI management in the cities of Shanghai and Hangzhou demonstrates: the resonances and dissonances between urban AI and smart. But they also demonstrate distinctive and complex landscape of urban AI experiments that is not neatly captured in social control and free market applications perspectives on AI. Moreover, the urban experimental contexts in which AI is being rolled, reveal aspirations for creating new "digital empires," exploring new limits on data power and potential social resistance. The paper makes a distinctive contribution by providing a new framework for comparing logics of computational urban management in the context of emerging AI applications. As such the paper provides a distinctive framework for situating future applications of urban AI management in China and identifies the future urban research priorities.

KEYWORDS

artificial intelligence, cities, post-smart, social control, computational power

Introduction

Over the last decade, the urban has been a central focus for the application of computational systems most graphically captured in the growth of the smart cities discourse (Hollands, 2008; Vanolo, 2014; Luque-Ayalaand Marvin, 2015; Luque-Ayala and Marvin, 2020; Taylor Buck and While, 2017). A critical literature has traced the various ways in which robotic and computational technology is being used to extend surveillance and control in the city, through new technologies of surveillance, predictive policing and software sorting (Graham, 1998, 2005; Graham and Wood, 2003; Kitchin and Dodge, 2011; Eubanks, 2017). But automation is also being deployed to ease the stresses and strains of urban life, for example through weather forecasting, congestion management and automated environmental control (Luque-Ayala and Marvin, 2016).

Our interest in this paper is to take forward growing interest in the potential of Artificial Intelligence (AI) to vastly extend and perhaps transcend the existing landscapes and possibilities of computational urban management. AI can be defined as the extended capacity for replacing and supplementing human decision making with automated data

processing and prediction (Cugurullo, 2020). The possibilities for AI are being extended significantly through advances in AI applications and technologies that rely on AI or generate data that can be used for extended AI applications - drones, facial recognition software, automated traffic management - in the urban context (see Macrorie et al., 2021).

Urban contexts are emerging as key sites for AI experimentation, demonstration and application related to automated management of people, energy and mobility and surveillance (Vander Ark, 2018; Tomer, 2019; Cugurullo, 2020, 2021). However, there has been little critical assessment of the socio-spatial geography of experimentation, the urban challenges being addressed, and the potential consequences for urban life and infrastructures. This paper therefore attempts to understand the emergence of the new urban technological imaginary of Urban AI. Located in a number of different national contexts multiple claims are being made about the potential of AI as a more desirable and effective form of urban decision making – most notably in China and US where national AI priorities are being compared to a new arms race for global economic dominance (Ding, 2018).

The aim of the paper is to examine whether, and if so how, AI represents a distinctive mode of automated urban decision-making. Is AI a distinct - post-smart city - socio-technical logic and is it characterized by an extension of social control or intense hyper-capitalist development? The paper has three objectives. First, to provide an overview of the wider landscape of urban AI experiments, seeking to understand their resonances and dissonances with smart cities discourse in order to better understand their specificity and potential distinctiveness as an urban socio-technical capacity. Second, to understand how AI is becoming urbanized through a case study of the spatial dimensions of China's national AI strategy focuses on two sites with different styles of urban AI development – a commercial logic in Hangzhou and a strategic state exemplar in Shanghai. Third, we compare the cases by highlighting the way in which the cases exemplify a diverse and highly experimental landscape that simultaneously extends social control through AI enabled surveillance and also develops new contexts for urban AI products and services.

The research design for the project was three-fold. First, the paper is informed by a systematic review of key social sciences and urban studies literature related to AI and cities on the internet and *via* Scopus. The review of urban AI was based on web searching key words and put into a database of urban AI initiatives to identify exemplary and emblematic contexts of which China emerged as a key national context for urban AI experimentation. Second, the paper draws on empirical research on the development of urban AI projects in Shanghai - the Shanghai AI urban development zone and Hangzhou - the Alibaba city Brain project through a study visit in 2019 and following up interviews and discussions. These case studies were researched through study visits in Shanghai and Hangzhou, five interviews and a review of primary policy documents. The empirical research also included discussion and dialogue with six experts on smart cities and AI in China, including academics, entrepreneurs and government officials in Chengdu, Nanjing and Beijing. Third, following the study visit interviews were transcribed, key documents translated and empirical material reviewed and analyzed.

The structure of the paper is as follows. Section "China: National AI leadership produces urban experiments" provides a conceptual framework for situating urban AI within the longer history of computational urban management. Section "Experimental urban spaces of AI application in China" interrogates national AI priorities in China and the way in which these are shaping urban AI responses orchestrated through strategic intermediaries. Section "Urban AI: Social control and hyper-capitalist development" compares the two emblematic cases studies of urban AI in Shanghai and Hangzhou assessing the extent to which these constitute a complex landscape of both intensified modes of social control and hyper capitalist development. Finally, section "Conclusions" concludes by summarizing the key findings and identifies the future research priorities for urban AI.

Urban AI: Post-smart city?

There is now a significant and growing literature on "Smart Cities," which explores various aspects of the theory, practice and claims about the potential for improved urban management through the application of digital and computational technologies (Hollands, 2008; Vanolo, 2014; Luque-Ayalaand Marvin, 2015; Taylor Buck and While, 2017; Barns, 2020). Although its lineage reflects a much longer history of computationally assisted urbanism and cybernetics, the smart city imaginary is grounded in advances in computational and digital power, including the increased automation of key aspects of urban management to transcend the limitations of human management. Much of the recent work on smart cities has been critical of the promissory claims for smart cities made by firms and governments. However, a wider body of work on the computational reworking of cities has raised concerns about issues of power and control *via* predictive techniques, "software sorting," the city as a site for mass surveillance and the selective enhancement of urban infrastructure (Graham, 1998, 2005; Graham and Wood, 2003; Kitchin and Dodge, 2011; Eubanks, 2017; Caprotti et al., 2017; Barns, 2021).

Research and policy interest in the computational restructuring of urban management has now also focused on the technological possibilities and potential of AI. While AI can be defined in many ways in our paper AI represents the increased potential for automated and robotic applications that can undertake functions and/or solve problems commonly associated with human intelligence, such as learning, problem

solving and pattern recognition (Marr, 2018; Bratton, 2021). A distinction might be made between the application of AI in different contexts of application, for example, the AI that enables robotic autonomy is different from the application of AI to sift through different types of data, or AI that is used to monitor and highlight "unusual" human movement, or AI that is used to predict behavior. From an urban management perspective, what is important is the potential of AI (i) to sift and process a larger amount of data much faster and more efficiently than any human system; and/or (ii) for AI to make complex decisions autonomously or semi-autonomously of human control. In short, AI allows for a vastly extended reach of computational power and automated control in urban management that cuts across infrastructure management (energy grids, traffic and pedestrian management) and policing (surveillance and tracking, traffic and pedestrian control, monitoring of social media use) (Vander Ark, 2018).

Much of the popular preoccupation of AI is with the idea of totally automated decision-making and autonomous systems outside of human control. Yet the interesting political questions about the use of AI are instead focused on the appropriate boundaries between "blended" forms of AI and human decision-making. Rather than total autonomy or total human decision-making the questions are instead at what point and in what circumstances should humans be brought into the decision-making process. It becomes critical to understand the variables and priorities that are used to inform AI applications and decisions and those the aspects of human activity and decision making that are controlled, triggered, augmented or displaced by AI. As with all forms of technology, the enhanced computational power of AI can be mobilized for social benefit or to enhance power and control. There are certainly major concerns about the potential for vastly enhanced forms of social control and the development of more nuanced automated mechanisms for controlling access to infrastructure and services and rewarding and disciplining aspects of human behavior *via* AI enabled techniques.

Urban AI technologies make significant demands on data provision, monitoring technology and application contexts. In its initial phase, AI will largely make use of existing data sources and infrastructures of data collection provided by the smart city. But the extended computational potential of AI is capable of managing enhanced data collection and monitoring. This is likely to be facilitated by the development of data gathering, monitoring, tracking and policing technology that relies on AI for extended functionality - sensors, cameras, tracking *via* mobile phones and cashless payment systems, the use of drones. Yet the technology has to be tested and developed in real world contexts to understand its feasibilities, limits and opportunities. Effective AI applications will co-evolve with infrastructures of data collection, tracking and monitoring these are often expensive to implement and operate, relying for example on significant energy inputs. AI technologies also raise significant concerns about privacy and safety that will need to be negotiated in urban contexts and with national governments and regulators.

In summary, urban AI may offer a way of automating urban decision making either by displacing humans from routine monitoring tasks or more rapidly and accurately substituting for human decision making. The critical questions then are what is distinctive about the functionalities and capabilities of AI that separates it from the smart city, why might AI be applied in the urban domain, and what happens to AI as it becomes embedded in existing social and technological arrangements within the urban context.

China: National AI leadership produces urban experiments

AI extends the smart cities logic that computational applications can solve a range of urban problems through enhanced decision making and monitoring/control. However new urban AI applications are likely to require substantial upfront investment in data processing capacity and monitoring infrastructure and also significant investment of time and resource in the recalibration of urban services - policing, traffic management - around urban AI management. In China three factors are converging to generate a particular interest in the possibilities for investment in urban AI.

First, the development of AI is now major part of national state strategy in China reflecting the economic potential of AI and China's advantages in AI research and application.

> "By 2030, China seeks to become the world's ***primary*** AI innovation centre, with a core AI industry gross output exceeding RMB 1 trillion (USD 150.8 billion) and AI-related gross output exceeding RMB 10 trillion (USD 1.5 trillion)." (State Council of the People's Republic of China, 2017)

Governments and leading tech firms in China are developing and extending the country's role as a leader in AI (Fischer, 2018; Dempsey, 2019; Roberts et al., 2021). Chinese firms such as Alibaba, Tencent, Baidu and Alibaba's fintech affiliate Ant Financial are now well represented in lists of the world's leading internet firms (Ding, 2018). *Urban* AI is not necessarily a major element of national R&D in AI technology and applications, but cities (and the things that happen in cities) are important for AI application and the market for specific urban AI applications is significant in its own right.

Second, the speed, complexity and challenges of urban growth in China might be expected to generate considerable interest from governments and cities in urban AI applications. The story of China's fast urban expansion is well-known. Rapid urbanization has given way to an emphasis on growth management as cities seek to maintain economic

competitiveness whilst addressing pressing problems of congestion and pollution (Mee Kam Ng, 2019). Simply moving large numbers of people around and supporting ways of living at high density are significant challenges in many Chinese cities. There is intense competition between Chinese cities for skilled workers and inward investment. For many of those cities, the second wave of growth is about reconciling high density living with quality of life, environmental quality and reduced journey times. Chinese governments have become increasingly interested in the potential of smart city technologies to address urban challenges (Caprotti et al., 2017).

Third, the extended monitoring and control functions of urban AI resonate with the broader and distinctive digitalization of Chinese society through the development of the platform economy (Chen, 2020). China is now one of the leading cashless countries through two main mobile and online payment platforms, Alibaba's Alipay and Tencent's WeChat Pay (Lee, 2018, pp. 57–61). Moreover, as part of wider strategies of social management there is widespread monitoring of population movement across China, which is being further extended through the ubiquitous use of the integrated WeChat and Alibaba platforms and extensive use of CCTV and facial recognition software in cities. As Ding (2018) suggests, the hardware and software for data harvesting gives China a potential 'data advantage' for AI, generating large volumes of data that can underpin AI applications (and can only be utilized fully through AI applications). In turn, AI technology opens up new possibilities for citizen monitoring and management, stimulating investment in technologies for generating new urban data (notably extended and higher resolution facial and movement recognition). China is recognized as the global leader in facial recognition algorithms (Liu, 2018) with a large pool of talent and expertise (Ding, 2018). However, as Ding (2018) points out, the potential data advantage is not necessarily reflected in reality because of organizational fragmentation within the large firms. Ding argues that 'economic benefits' are the primary driving force behind both the major public and private Chinese actors in AI, but social and political priorities are also significant in driving the application of AI in China.

Within that context, a key dimension of the Chinese urban AI nexus is the potential for different urban trajectories in urban AI application and development. Although there is strong central government management of urban development and R&D priorities, leading cities now have significant autonomy in urban management and development strategies. Indeed, there is growing inter-urban competition in China for higher value firms and workers and urban government officials have strong incentives to find innovative solutions. Moreover, as Ding (2018) points out, "China is not a monolithic actor" in high tech and that "matters when it comes to AI." National and municipal governments are important actors alongside private companies, state owner companies, mixed ownership companies and the People's Liberation Army. Leading high tech cities such as Shenzhen, Hangzhou, Shanghai, Guangzhou and Beijing have distinctive AI R&D milieus which could provide the basis for place-specific interests approaches in using cities as demonstrators and test beds for new technology - and also spatial variations in technology specialisms and expertise. Companies have particular attachments with their cities, with national AI aspirations underpinned by geographical variation and intense competition between cities to attract and retain high-tech firms and skilled graduates.

Experimental urban spaces of AI application in China

Research on the application of AI in urban contexts has been largely speculative because it has been difficult to find explicit "urban" AI projects. Variants of machine learning, automation and AI are increasingly used in computational work and data analysis that impact on cities, but experiments in the automation of urban infrastructure have been limited. In the following sections, we examine two notable urban AI experimental initiatives from China—the Hangzhou City Brain project and the AI development zone initiative in Shanghai—through which government and/or private interests are scoping out the potential for urban AI. Each case is structured through: a review of the specific origins of urban experimentation; an assessment of the role of urban authorities and the use of the context as an experimental site; and, the wider consequences and implications of the experiment both within and outside the urban context.

Shanghai – The infrastructure for an urban AI test bed

Shanghai is positioned as one of China's most emblematic urban test-beds for the development, production and utilization of AI technologies. In May 2019, Shanghai was approved by China's Ministry of Science and Technology (MST) as a National Pilot Zone for Innovative Development of New-generation AI - Shanghai AI Development Zone - the second of its kind in the country after Beijing (Wang, 2019; Xinhua, 2019). The Shanghai AI (SAI) initiative has a distinctive urban dimension designed to transform the city's economy, public services and develop new modes of management (Municipal Commission of Economy Informatization, Shanghai, 2019). Shanghai's status as national urban AI test bed was a result of interplay between multiple socio-political and spatial priorities.

First, as a national priority, the formation of the AI pilot zones needs to be placed within China's all-of-nation strategy of being the global leader in AI fundamental theories, technologies

and applications by 2030. State Council of the People's Republic of China (2017) suggested that selected pilot zones should be set up as models for others to follow. MST stated:

> Shanghai AI Development Pilot Zone will focus on in-depth integration of AI technology and socioeconomic development, exploring new mechanism and approaches to development of new-generation AI. Shanghai should gain experience from AI experimentation, shaping an AI growth model that can be spread and replicated nationwide. Shanghai's AI initiative will play a significant role in shaping a global influential sci-tech innovation hub, and advancing the integrated development of Yangtze River Delta (MST, 2019).

The Shanghai AI Development Zone also had a strong urban dimension in compliance with China's "new-type urbanization plan" (State Council of the People's Republic of China, 2014), which placed a high priority on technologically upgrading the economies of three mega-city clusters, namely, Yangtze River Delta (YRD), Pearl River Delta, and Beijing-Tianjin-Hebei region. Located geographically at the heart of the Yangtze River, Shanghai was widely viewed as a strong economic engine of growth in the YRD urban agglomeration (China Development Research Foundation, 2019). In this sense, the Shanghai AI initiative was becoming strategically significant as part of China's new urbanization strategy. Shanghai was becoming a national global center for AI entrepreneurs, skilled workers and venture capital investment. By the end of 2018, the city hosted more than one third of China's AI scientists and engineers, and thousands of tech companies specializing in, or partially engaging with, AI hardware and software service, ranging from chip makers to computer vision technology and venture capital firms actively involved in deals related to financing AI industries (AI Era, 2019; International Talent, 2019). Shanghai demonstrated its potential by attracting new AI labs affiliated to Baidu, Microsoft, IBM, Alibaba and other major IT tech companies, and further turning AI innovations into commercial products for wide use in domains such as autonomous vehicles, facial recognition cameras, and smart speakers.

Second, the municipal government was one of the early adopters of AI for its internal operations, which was arguably a key factor driving urban AI development. In its *Shanghai Master Plan (2017–2035)*, the Shanghai city government set out the vision of transforming Shanghai into a sci-tech innovation hub (Urban Planning Land Resource Administration Bureau, Shanghai, 2018). In 2017, Shanghai issued an *Opinion on Facilitating Implementation of New-generation AI Development*, the city's first AI policy document, that marked the municipality's effort to launch large scale urban AI experimentation. The *Opinion* set out the 2020 targets of 'forming 60 real-life contexts with AI applications, building five leading AI industrial clusters, and expanding the city's scale of AI industry to more than 100 billion yuan (Shanghai City Government, 2017). The *Opinion* prioritized the adoption of AI in the "optimization of the urban operating system," in order:

> "to improve intelligent sensing and data collection mechanisms, thus upgrading the urban management capabilities in security, environment, and infrastructure; to enhance the application of image and biometric recognition technology to society management and the mass surveillance system, thus boosting the city's intelligent capabilities in security control". (2017 no page)

In 2018, in a more detailed delivery document *Implementation Measures for Accelerating High-Quality Development of AI* (Municipal Commission of Economy Informatization, Shanghai, 2018), the municipality put forward 22 specific policies designed to import high-end international AI talent, set up the Shanghai Municipal Big Data Center to integrate data across the city's different government departments for utilization by AI companies, and provide financial support for core AI technologies and AI companies (Municipal Commission of Economy Informatization, Shanghai, 2018). Additionally, in 2019, the municipal authorities set up an AI development fund worth 100 billion yuan ($14.78 billion).

Finally, the city's recent initiative has focused on providing both the funding and 'real-world' contexts for AI companies in China and from abroad to live-test their technologies and products in the urban context. A total of 40 social and business settings – involving schools, hospitals, government services, living communities, foreign exchange centers, parking lots, metros, trash sorting, farming – were made available for AI applications (Sun, 2019). The city government would fund and provide access to the context for firms to develop and demonstrate live applications. There is a notable absence of key governmental priorities in this strategy in relation to the purpose of AI applications. Instead the logic is simply to experiment – and presumably to learn about the potential of these systems to automate services and substitute AI for human decision making of both routine and specialist functions.

A notable example of this will to experiment with AI applications is in the waste sector. Increasing solid waste flows and an increasing emphasis on resource recovery have stimulated AI applications to develop more sustainable forms of waste management (Abdallah et al., 2020). A new mandatory trash-sorting rule was introduced in Shanghai with the aim of increasing levels of recycling to 35%. The challenge of sorting waste into 4 categories initially prompted multiple complaints from citizens about the challenges involved in complying. In response dozens of AI bins capable of automatically distinguishing 95% of waste items from "recyclable" to "compostable" were put to the test on AIsland of the Pudong AI Application Zone (Lin, 2019). Waste bins automatically classified deposited trash into four categories and then collection

FIGURE 1
A real-time image captured by AI chip-embedded surveillance cameras.

vehicles automatically identified the appropriate bins and processed them accordingly. The waste was then transported to temporary transfer stations by driverless vehicles, and robots then sorted out recycled or hazardous items before sending them to different end points for processing. The experiment, jointly enabled by national and city government and AI companies, explored a possible trajectory for an AI-enabled operating waste system. This produced an experimental mode of automated waste management used driverless vehicles, image recognition cameras and robotics to autonomously monitor, collect, transport, recycle, dispose of waste without – apparently - the intervention of humans. However, this pilot system needs to be viewed as part of a much wider experimental landscape of technical and social measures designed to promote waste sorting (see Li and Wang, 2021). Yet the urban AI can also be used to control humans (see Figure 1). Shanghai uses AI to autonomously identify lawbreakers, jaywalkers, and other criminal suspects. This is reflected in trial installments of facial recognition cameras in the Shanghai Bund and some of the city's metro stations for the aim of ensuring urban security.

Hangzhou City Brain: A commercial urban AI operating system

Hangzhou is headquarters to Alibaba, China's most valuable technology company and a leading provider of cloud computing power (Brandz, 2019), and three of China's largest providers of AI enabled video surveillance equipment (Hikvision, Dahua and Uniview) (Dai, 2019). The city is ranked along with Beijing, Shenzhen, and Shanghai in 'the top tier with the combination of AI and urban development' (Deloitte China, 2019, p. 15), but has had far less state support than other leading Chinese cities. Hangzhou's configuration as an urban test bed for AI applications, notably in its urban traffic management and public security, hinges largely on the technological affordances of Alibaba Cloud's ET (meaning "extreme technology") City Brain and the city's booming surveillance technology market (Curran and Smart, 2021; Caprotti and Liu, 2022).

First, initially applied to Hangzhou's Xiaoshan district in 2016, the ET City Brain project was carried out by Alibaba Cloud (AliCloud) – a subsidiary of Alibaba Group – in collaboration with the Hangzhou government with the initial the aim of easing road congestion. City Brain aggregated data from multiple sources, such as video cameras installed at road intersections, real-time GPS locations of cars sent from mobile mapping apps, and traffic police's social media feeds (Alibaba Cloud, 2018a). Powered by AI technologies and its large-scale cloud platform Apsara, City Brain is said to have the capacity for analyzing a huge amount of heterogeneous data and come up with real-time solutions for road transportation, like automatically adjusting traffic signals to allow emergency vehicles to travel through the city without interruption, or identifying vehicle breakdowns through image recognition technologies.

The critical factor contributing to Hangzhou's urban AI trials was the ready availability of sufficient AI-powered surveillance equipment, driven by the overlapped interests of local companies and the central government's priority in managing public security. Hangzhou is also known as a center for surveillance technology firms for instance the Binjiang district in Hangzhou is famed for its AI-assisted surveillance camera industry, as it is home to Hikvision, Dahua and Uniview. The three companies' combined revenues accounted for 30% of the global video surveillance sales, while more than half of China's video camera market shares is supplied by Hikvision and Dahua (IHS Markit, 2017). These local companies laid a technological foundation for Hangzhou to be extensively equipped with AI cameras, which can automatically track a vehicle, recognize a person or spot a criminal suspect through gait or face recognition techniques (see Figure 2). After a two-year pilot run Hangzhou saw its ranking on the list of China's most congested cities drop from 5th place in 2016 to 57th in 2018 according to data provided by Alibaba-owned digital map AutoNavi (Hsu, 2018, n.p.). Alibaba Cloud said its ET City Brain has increased people's traveling speed by 15% in Xiaoshan district, and halved the amount of time it took ambulances and fire trucks to get to the scene of emergencies [Alibaba Cloud, (n.d.)].

Second, in 2018, an updated version of "ET City Brain 2.0" was jointly launched by AliCloud and the Hangzhou government, demonstrating the effort of multiple-party interests to create a new metropolitan wide control infrastructure for the city. The new version was designed to monitor and control the city's traffic at a larger scale (see Figure 3). In addition, the cloud platform extended its actionable data insights beyond the traffic management to the city's fire rescue system, by identifying fire emergencies, flashing green lights for fire trucks, and providing

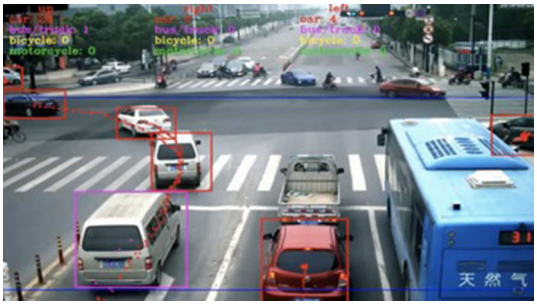

FIGURE 2
Screen shot of AI enabled CCTV camera screen.

FIGURE 3
City Brain control room Hangzhou.

real-time information for fire fighters through IoT sensors, trans-department data integration, and video footage (Alibaba Cloud, 2018b). In Hangzhou, the City Brain has extended its intervention from the initial scope of transportation to city management and government service areas, such as public security, fire control, health care, and tourism, as evidenced by its continuously updated versions (Xu, 2018). Hangzhou's City Brain pilot project has supported AliCloud's position in rolling out AI-embedded smart cities in other contexts.

Finally, in 2017, Alibaba was named alongside Baidu, Tencent – collectively known as BAT – and voice recognition specialist iFlytek as the first tranche of China's national technological leaders in boosting AI development (Meng and Dai, 2017). In the case of Alibaba, the Chinese government suggested its AliCloud subsidiary leverage its "City Brain" cloud computing capabilities to build an open innovation platform, thereby providing AI solutions for urban development. ET City Brain then became a core part of its ambition to create an all-encompassing "ultra-intelligent" agent for the city, because in addition the company also started working on Medical Brain, Environmental Brain, Industrial Brain, Aviation Brain, Sport Brain, and Financial Brain (Alibaba Cloud, 2018c). According to Min Wanli, then Chief Scientist of Machine Intelligence at Alibaba Cloud, the ET brain is "an ultra-intelligent platform capable of multi-dimensional perception, real-time analytic insights, optimization of overall performance, and continuous evolution" (Min, 2018). The premise of Min's argument was Alibaba Cloud's ultra-strong machine-learning and real-time visual computing capabilities, which can help connect, extract meaningful values from a huge amount of heterogeneous data (Zhang et al., 2019) could be applied in other domains.

Subsequently, the City Brain project was soon introduced to more than 10 other cities in a company-government collaborative model, including Xiongan – a brand new city of national significance for performing Beijing's non-capital functions, Macau – Alibaba's first smart city market outside mainland China, and Kuala Lumpur – the capital of Malaysia. The City Brain had wider resonance with the Chinese market for surveillance equipment – in particular, the deep learning-enabled video surveillance while "city surveillance is the largest end-user industry" in China (IHS Markit, 2018, p. 9). This huge investment in video-controlled cities needs to be understood from a broader socio-political context, wherein the government's Xueliang Project became a booster. With its name deriving from a Mao-era idiom that "the masses have sharp eyes," the Xueliang Project was launched in 2016 as part of the country's Skynet national security network. By installing surveillance cameras in cities, towns and villages, the project was designed to establish a comprehensive video data-sharing network to guard against potential terrorists and criminals. Given the rise in China's AI innovations and cloud computing, the public surveillance cameras enabled with AI were in widespread use.

Urban AI: Social control and hyper-capitalist development

Chinese aspirations for global leadership in AI provide an active context for urban responses. State and private sector prioritization in AI technologies has created a context in which significant resources and capacity can be mobilized at the urban level to undertake AI experimentation. There are, however, important differences in the urban landscape of experimentation within China and potentially different trajectories for the AI in the future focused on combinations of social control and market competition. This evidenced through three areas of tension:

First, there are tensions in Chinese urban AI policy between state security and corporate priorities. While historically Chinese state sponsored digital megaprojects have been primarily focused on ensuring internal control and external military security this is not solely the case with the AI programme (Ho, 2018; Horowitz et al., 2018; Keane and Hu, 2019). Chinese state owned and private corporate interests are strongly represented in initiatives that target the development of building internal leadership in key AI technologies. Research

needs to recognize that urban AI is likely to represent both these agendas with the cases illustrating logics of social control through security, surveillance and AI enabled facial recognition which co-exist with strategies designed to develop new products and services and establish these as internationally competitive platforms to complete with US dominance in urban platform technologies. These dual priorities are closely reflected in the case studies we have considered above where find logics of enhanced social control and market development. Shanghai provides evidence of a state sponsored test-bed that involves the development of AI initiatives designed to enhanced social control and develop new commercial priorities. Recognizing the significant business opportunity for AI control systems, Alibaba has since sought to market City Brain as platform for its wider urban functionality in different contexts with cities able to pick and mix from different functions depending on their priorities and budget. Further iterations of the system have been developed and more than 10 urban municipalities have purchased the programme in China. These products also contain the potential for intensified commercial control. Consequently, there is a need to recognize the dual processes involved in urban AI development and its inherent overlaps and tensions between commercial and military domains. The movement across these domains and their translation into urban applications has been central to the development of smart cities in the West (Marvin and Luque-Ayala, 2017). Further work needs to be undertaken on the dynamics of these processes of transmutation in the Chinese context (see Luque-Ayala and Marvin, 2020).

Second, there are tensions between central direction and fragmented implementation. There is a tendency to overstate the degree of state direction and control in the social organization of Chinese megaprojects (Ding, 2018). While the national priorities and funding are set centrally our cases demonstrate that there is considerable diversity in how urban municipalities and their wider city-regions respond to these opportunities (Horowitz et al., 2018). National AI priorities are reworked through particular forms of place based partnership and through contextual urban priorities to produce specific experimental configurations and applications. In the case of Hangzhou, a coalition was developed between local government and the locally embedded digital corporate Alibaba *via* an application created to address issues with heavily congested highway networks. In contrast Shanghai was positioned as a national exemplar, alongside Beijing, and with its much more significantly well-resourced programme was able to use the programme to position the city-region as national test-bed for Chinese companies, attract local talent and also incentivise west tech companies to established AI research centers in Shanghai. This is designed to be part of a wider strategy to diverse the Greater Shanghai area economic structure. In both contexts, there is a much more varied and diverse programme of AI experimentation in which urban authorities have differing degrees of autonomy to set priorities and form partnerships.

Finally, it is therefore by no means inevitable that the national strategies priorities will be realized in practice. The aspirations to build a "digital empire" utilizing Chinese AI platforms outside China (Keane and Hu, 2019) that can compete with incumbent platforms is challenging. To date only the City Brain product has only found one other context for application outside China in Kuala Lumpa the capital of Malaysia. Within China the 996 movement has campaigned against long hours and exploitative working conditions in the technology sector. Online digital resistance to the priorities and activities of urban and regional government – but rarely the central party – is used to gauge levels of dissent and used by the state to modify central messaging. In the Chinese context extended AI applications are so far justified that they are needed to help manage the difficulties created by the movement of large numbers of people in dense urban contexts, but the national embracing of AI may raise unintended consequences and contradictions that are difficult to anticipate and control. AI roll out is subject to multiple contingencies that go beyond the potential for citizen resistance, including: the energy costs and capacity needed to process data, the staff costs required to act on information provided, and the on-going task of defining what sorts of data and AI might be useful and for what purposes.

Conclusions

The paper highlights considerable political and financial investment in the hardware and software of urban AI in China. There are a range of interests and priorities in the 'national' AI initiative, including the potential to use AI for internal social control, the potential for external military and political control, the search for profit by firms and entrepreneurs, and intense competition to establish the technology for future tech platforms that can be applied outside China. While commentators and critics have the rise of AI as part of an authoritarian state project (Feldstein, 2019) others have linked it to a distinctive logic of hyper-capitalist development in China (Keane and Hu, 2019). Both perspectives have perhaps overstated the coherence of the national AI project in China. There is not necessarily any singular logic to the "national" AI development push, and that becomes particularly the case for AI applications in urban contexts (see Horowitz et al., 2018). In effect, AI is being taken forward through a trial and error process of experimentation around particular sites of intervention – which involves the urban context – to address both security and economic priorities. The national innovation system for AI in China is multiple, dispersed and fragmented, consisting of a large number of actors and stakeholders whose interests might conflict, coincide and coalesce. The key dimension of that complexity is the relationship between different central

agencies (the Army, government) and cities as sites of distinctive clusters of semi-autonomous AI technology and also as sites of application and experimentation.

Further research needs to unpack the dynamics of this landscape of urban AI experimentation. We suggest three research priorities that are of critical importance in understanding the distinctiveness of urban AI as a mode of urban governance. The first is the need to understand the ***specific genealogies of AI*** before they are transmuted into urban context. AI has more diverse origins beyond the computational sector, including in advanced manufacturing, automated logistics, automation of aviation, military and defense robotics. It is necessary for urbanists to unpack the ways in which operational logics, rationalities and modes of organization from existing contexts where AI and robotics are already applied might shape their transmutation into urban contexts (Luque-Ayala and Marvin, 2020). These histories are critically important for revealing the controversies, glitches and tensions associated with the prior use of AI systems. Fundamentally this raises wider questions about who owns AI technologies, whether this then creates new opportunities for private involvement in urban development and crucially how can urban authorities govern the roll pout of AI systems. The second research priority is to focus on teasing out the techno-spatial ***distinctiveness of urban AI systems*** and the ways in which they are inserted into an already highly technicised urban context (Macrorie et al., 2021). While urban AI applications build on the data structures, computational and digital systems they also seek to extend these in novel ways through new enhanced functional capacities. Key to this is the ability not solely to generate new ways of knowing the urban but also to provide the capacity for enabling novel forms of machine-mediated action in urban life. This requires engagement with the ways in which AI enables modes of automated decision-making that exceed the cognitive capacity of humans and how AI enables material and physical action(s), whether this is in the form of AVs, drones, delivery robots, the repair of infrastructure, or other actions. Research will need to focus on the different spaces AI occupy whether constituted as metropolitan wide platforms or selectively incorporated into highly specific products or services in a highly distributed manner. The third research priority is to interrogate the ***ambivalent logic*** of urban AI. On the one hand the promise of AI is that it provides more accurate, efficient, error free and rapid decision making but on the other there are clearly risks of social control and deepening inequalities. While at their inception new technologies are often associated with utopian imaginaries these progressive social and environmental potential are often marginalized when constituted as private liberalized services. The question then is whether and how urban authorities can develop the knowledge and capacity to shape the trajectory of urban AI application in order to capture and promote wider social and environmental benefits that support strategic urban priorities. National state sponsored programmes of urban AI experimentation provide an important context in which learning about the potential and limits of AI can take place. Critically it is important that urban research capacity is developed and deployed comparatively to understand the ways in which urban life is being reshaped.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

Author contributions

SM and AW applied for funding, structured the paper and led writing of conceptual, analytical sections, and conclusion. BC and MK led writing of the case studies. BC led in setting up of site visits. All authors undertook relevant see visits and agree to be accountable for the content of the work.

Funding

Royal Society/NSFC International Exchange – Beyond Smart Cities: A comparative analysis of China and UK IEC/NSFC/170606.

Acknowledgments

We acknowledge the support of the Royal Society and NSFC for enabling site visits and dialogue with Chinese smart city scholars, urban policy makers and commercial smart technology vendors.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

References

Abdallah, M., Talib, M., Feroz, S., Nasir, Q., Abdalla, H., and Mahfood, B. (2020). Artificial intelligence applications in solid waste management: a systematic research review. *Waste Manag.* 109, 231–246. doi: 10.1016/j.wasman.2020.04.057

AI Era (2019). *2019 中国人工智能独角兽白皮书[2019 White Paper on China's AI Unicorn]*. Available online at: https://www.dx2025.com/newsinfo/1044223.html

Alibaba Cloud (2018a). *Introducing Alibaba Cloud*. Available online at: https://video-intl.alicdn.com/Campaign%20038%20Introducing%20AC%20Whitepaper%20v5e.pdf

Alibaba Cloud (2018b). *Alibaba Cloud ET City Brain helps the firefighters in Hangzhou*. YouTube. Available online at: https://www.youtube.com/watch?v=SxNb-mvPs5A

Alibaba Cloud (2018c). *ET Brain: Exploring New Uses for Data and AI*. Available online at: https://resource.alibabacloud.com/whitepaper/et-brain-exploring-new-uses-for-data-and-ai_192?spm=a2c41.11486547.0.0

Alibaba Cloud. (n.d.). *ET City Brain*. Available online at: https://www.alibabacloud.com/et/city (accessed August 19, 2022).

Barns, S. (2020). "Joining the dots: platform intermediation and the recombinatory governance of Uber's ecosystem," in Urban Platforms and the Future City: Transformations in Infrastructure, Governance, Knowledge, and Everyday Life, eds J. Stehlin, K. Ward, A. McMeekin, J. Kasmire, and M. Hodson (London; New York, NY: Routledge). doi: 10.1007/978-981-32-9725-8_7

Barns, S. (2021). Out of the loop? On the radical and the routine in urban big data. *Urban Stud.* 58, 3203–3210. doi: 10.1177/00420980211014026

Brandz (2019). *Top 100 Most Valuable Global Brands 2019*. Brandz.com. Available online at: https://brandz.com/admin/uploads/files/BZ_Global_2019_WPP.pdf

Bratton, B. (2021). AI urbanism: a design framework for governance, program, and platform cognition. *AI Soc.* 36, 1307–1312. doi: 10.1007/s00146-020-01121-9

Caprotti, F., Cowley, R., Bailey, I., Joss, S., Sengers, F., Raven, R., Spaeth, P., Jolivet, E., Tan-Mullins, M., Cheshmehzangi, A. and Xie, L. (2017). *Smart Eco-City Development in Europe and China: Policy Directions*. Exeter: University of Exeter (SMART-ECO Project). Available online at: https://ore.exeter.ac.uk/repository/bitstream/handle/10871/29876/Smart%20Eco%20Cities%2012pp%20A4%20Europe%20%26%20China%20Brochure.pdf?sequence=1&isAllowed=y (accessed 19th august 2022).

Caprotti, F., and Liu, D. (2022). Platform urbanism and the Chinese smart city: the co-production and territorialisation of Hangzhou City Brain. *Geo Journal.* 87, 1559–1573. doi: 10.1007/s10708-020-10320-2

Chen, J. Y. (2020). The mirage and politics of participation in China's platform economy. *Javnost.* 27, 154–170. doi: 10.1080/13183222.2020.1727271

China Development Research Foundation (2019). 中国城市群一体化报告*[China Urban Cluster Integration Report]*. Available online at: https://cdrf.org.cn/jjh/pdf/yitihua.pdf

Cugurullo, F. (2020). Urban artificial intelligence: from automation to autonomy in the smart city. *Front. Sustain. Cities* 2, 38. doi: 10.3389/frsc.2020.00038

Cugurullo, F. (2021). *Frankenstein Urbanism: Eco, Smart and Autonomous Cities, Artificial Intelligence and the End of the City*. London: Routledge. doi: 10.4324/9781315652627

Curran, D., and Smart, A. (2021). Data-driven governance, smart urbanism and risk-class inequalities: security and social credit in China. *Urban Stud.* 58 487–506. doi: 10.1177/00420980209 27855

Dai, S. (2019). *How 9/11 and China's plan for blanket surveillance created a wave that CCTV camera makers Hikvision and Dahua rode to huge success*. South China Morning Post. Available online at: https://www.scmp.com/tech/gear/article/3010312/how-9/11-and-chinas-plan-blanket-surveillance-helped-hikvision-and-dahua

Deloitte China (2019). *Scenarios and potentials of AI's commercial application in China. Deloitte*. Available online at: https://www2.deloitte.com/cn/en/pages/innovation/articles/china-ai-industry-whitepaper-intelligence-driven-by-innovation.html (accessed August 19, 2022).

Dempsey, P. (2019). AI *passes Go: where next for China's artificial intelligence ambitions?* Engineering and Technology. Available online at: https://eandt.theiet.org/content/articles/2019/09/ai-passes-go-where-next-for-chinas-artificial-intelligence-ambitions/

Ding, J. (2018). *Deciphering China's AI Dream: The Context, Components, Capabilities, and Consequences of China's Strategy to Lead the World in AI*. Oxford: Future of Humanity Institute, University of Oxford.

Eubanks, V. (2017). Automating Inequality: How High-Tech Tools Profile, Police, and Punish the Poor. New York, NY: St. Martin's Press.

Feldstein, S. (2019). The road to digital unfreedom: how artificial intelligence is reshaping repression. *J. Democr.* 30, 40–52. doi: 10.1353/jod.2019.0003

Fischer, S. (2018). *Artificial Intelligence: China's High-Tech Ambitions. CSS Analyses in Security Policy*. Centre for Security Studies. (CSS), ETH Zurich. Available online at: https://ethz.ch/content/dam/ethz/special-interest/gess/cis/center-for-securities-studies/pdfs/CSSAnalyse220-EN.pdf

Graham, S. (1998). Spaces of surveillant simulation: new technologies, digital representations, and material geographies. *Environ. Plan. D.* 16, 483–504. doi: 10.1068/d160483

Graham, S. (2005). Software-sorted geographies. *Prog. Hum. Geogr.* 29, 562–580. doi: 10.1191/0309132505ph568oa

Graham, S., and Wood, D. (2003). Digitizing surveillance: categorization, space, inequality. *Crit. Soc. Policy* 23, 227–248. doi: 10.1177/0261018303023002006

Ho, E. (2018). Algorithmic authoritarianism: China's ideological export for the digital age. *J. Int. Public Aff.* 1. Available online at: https://www.jipasg.org/posts/2018/9/11/algorithmic-authoritarianism-chinas-ideological-export-for-the-digital-age (accessed July 16, 2020).

Hollands, R. G. (2008). Will the real smart city please stand up? Intelligent, progressive or entrepreneurial? *City* 12, 303–320. doi: 10.1080/13604810802479126

Horowitz, M. C., Allen, G. C., Saravalle, E., Cho, A., Fredirick., and Scharre, P. (2018). *Strategic Competition in an Era of Artificial Intelligence July 2018, Centre for a New American Security's series on Artificial Intelligence and International Security*. Washington, DC. Available online at: https://css.ethz.ch/content/dam/ethz/special-interest/gess/cis/center-for-securities-studies/resources/docs/CNAS_AI%20and%20International%20Security.pdf

Hsu, J. W. (2018). *Alibaba Cloud Launched 'ET City Brain 2, 0.' in Hangzhou*. Available online at: https://www.alizila.com/alibaba-cloud-launched-city-brain-2-0-hangzhou/

IHS Markit (2017). *Top video surveillance trends for 2017*. Available online at: https://cdn.ihs.com/www/pdf/TEC-Video-Surveillance-Trends.pdf

IHS Markit (2018). *Top video surveillance trends for 2018*. Available online at: https://cdn.ihs.com/www/pdf/Top-Video-Surveillance-Trends-2018.pdf

International Talent, Shanghai. (2019). *Shanghai gears up to be AI hub*. Available online at: http://subsites.chinadaily.com.cn/shanghaitalent/2019-08/01/c_392787.htm

Keane, M., and Hu, H. (2019). A digital empire in the making: china's outbound digital platforms. *Int. J. Commun.* 13, 4624–4641. Available online at: https://ijoc.org/index.php/ijoc/article/view/10995/2803

Kitchin, R., and Dodge, M. (2011). *Code/Space: Software and Everyday Life*. Cambridge, MA: MIT Press. doi: 10.7551/mitpress/9780262042482.001.0001

Lee, K. F. (2018). *AI Superpowers: China, Silicon Valley, and the New World Order*. Boston, MA: Houghton Mifflin Harcourt.

Li, W., and Wang, J. (2021). Household waste management in Shanghai and its implications for the second-tier cities in China. *J. Clean. Produ.* 321. doi: 10.1016/j.jclepro.2021.128980

Lin, S. J. (2019). *AI provides virtual hand in sorting trash. China Daily*. Available online at: http://www.chinadaily.com.cn/a/201908/17/WS5d573823a310cf3e35566467.html

Liu, X. (2018). China a world leader in facial recognition algorithms. *Global Times. AI provides virtual hand in sorting trash. China Daily*. Available online at: http://www.globaltimes.cn/content/1128177.shtml

Luque-Ayala, A., and Marvin, S. (2015). Developing a critical understanding of smart urbanism? *Urban Stud.* 52, 2105–2116. doi: 10.1177/0042098015577319

Luque-Ayala, A., and Marvin, S. (2016). The maintenance of urban circulation. *Environ. Plan. D. Soc. Space* 34, 191–208. doi: 10.1177/0263775815611422

Luque-Ayala, A., and Marvin, S. (2020). *Urban Operating Systems: Producing the Computational City*. Cambridge, MA: MIT Press. doi: 10.7551/mitpress/10869.001.0001

Macrorie, R., Marvin, S., and While, A. (2021). Robotics and automation in the city: a research agenda, *Urban Geograph*. 42, 197–217. doi: 10.1080/02723638.2019.1698868

Marr, B. (2018). *The key definitions of artificial intelligence (AI) that explain its importance Forbes*. Available online at: https://www.forbes.com/sites/bernardmarr/2018/02/14/the-key-definitions-of-artificial-intelligence-ai-that-explain-its-importance/#76bba204f5d8

Marvin, S., and Luque-Ayala, A. (2017). Urban operating systems: diagramming the city. *Int. J. Urban Reg. Res.* 41, 84–103. doi: 10.1111/1468-2427.12479

Mee Kam Ng (2019). Governing green urbanism: the case of Shenzhen, China. *J. Urban Aff.* 41, 64–82. doi: 10.1080/07352166.2016.1271623

Meng, J., and Dai, S. (2017). China recruits Baidu, Alibaba and Tencent to AI 'national team'. *South China Morning Post*. Avaialble online at: https://www.scmp.com/tech/china-tech/article/2120913/china-recruits-baidu-alibaba-and-tencent-ai-national-team

Min, W. L. (2018). <<万物智联ET大脑>>·2018云栖大会(演讲) [Connected Things, Intelligently Conducted (Speech) The Computing Conference]. Youku. Available online at: https://v.youku.com/v_show/id_XMzQ5NjYzODU0MA$==$.html

MST (2019). *Ministry of Science and Technology's endorsement letter to formally support Shanghai's proposal to establish China's National Pilot Zone for Innovative Development of New-generation AI [*科技部关于支持上海建设国家新一代人工智能创新发展试验区的函*]*. Ministry of Science and Technology of the People's Republic of China. Available online at: http://www.most.gov.cn/mostinfo/xinxifenlei/fgzc/gfxwj/gfxwj2019/201906/t20190611_147034.htm

Municipal Commission of Economy and Informatization, Shanghai. (2018). 加快推进上海人工智能高质量发展的实施办法*[Implementation Measures for Accelerating High-Quality Development of AI]*. Available online at: http://www.sheitc.sh.gov.cn/sswgh/679122.htm

Municipal Commission of Economy and Informatization, Shanghai. (2019). 上海国家新一代人工智能创新发展试验区启动建设 市民'医'住'行'未来五年更智能*[Shanghai launches National Experimental Zone for Innovative Development of New-generation AI; Citizens will enjoy more intelligent service of health care, housing, and transportation]*. Available online at: http://www.sheitc.sh.gov.cn/gydt/682588.htm

Roberts, H., Cowls, J., Morley, J., Taddeo, M., Wang, V., Floridi, L., et al. (2021). The Chinese approach to artificial intelligence: an analysis of policy, ethics, and regulation. *AI Soc.* 36, 59–77. doi: 10.1007/s00146-020-00992-2

Shanghai City Government (2017). 关于本市推动新一代人工智能发展的实施意见*[Opinion on Facilitating Implementation of New-generation AI Development]*. Available online at: http://www.shanghai.gov.cn/nw2/nw2314/nw2319/nw12344/u26aw54186.html

State Council of the People's Republic of China (2014). 国家新型城镇化规划*(2014-2020*年*)[National New-type Urbanisation Plan (2014-2020)]*. Available online at: http://www.gov.cn/zhengce/2014-03/16/content_2640075.htm

State Council of the People's Republic of China (2017). 新一代人工智能发展规划*[New-generation of Artificial Intelligence Development Plan]*. Available online at: http://www.gov.cn/zhengce/content/2017-07/20/content_5211996.htm

Sun, Y. (2019). 上海已发布40个AI应用场景 人工智能发展联盟正式成立[Shanghai opens 40 real-life contexts for AI applications; AI industrial alliance takes shape]. *IT Times*. Available online at: http://www.it-times.com.cn/a/hulianwang/2019/0704/28523.html

Taylor Buck, N., and While, A. (2017). Competitive urbanism and the limits to smart city innovation: The UK future cities initiative. *Urban Stud.* 54, 501–519. doi: 10.1177/0042098015597162

Tomer, A. (2019). *Artificial intelligence in America's digital city Brookings*. Available online at: https://www.brookings.edu/research/artificial-intelligence-in-americas-digital-city/

Urban Planning and Land Resource Administration Bureau, Shanghai. (2018). 上海市城市总体规划*(2017-2035) [Shanghai Master Plan. (2017-2035)]*. Available online at: http://www.shanghai.gov.cn/newshanghai/xxgkfj/2035004.pdf

Vander Ark, T. (2018). How cities are getting smart using artificial intelligence. *Forbes*. Available online at: https://www.forbes.com/sites/tomvanderark/2018/06/26/how-cities-are-getting-smart-using-artificial-intelligence/#6c447ff33803

Vanolo, A. (2014). Smartmentality: The Smart City as Disciplinary Strategy. *Urban Stud.* 51, 883–898. doi: 10.1177/0042098013494427

Wang, Y. (2019). Pudong to get major role in opening-up. *China Daily*. Available online at: http://www.chinadaily.com.cn/a/201906/26/WS5d12c4cea3103dbf1432a3f8.html

Xinhua (2019). *Shanghai launches nation's 2nd pilot zone for AI*. Available online at: http://www.xinhuanet.com/english/2019-05/25/c_138088573.htm

Xu, K. (2018). *Hangzhou updates ET City Brain: A comprehensive version [*杭州城市大脑*(*综合版*)*来啦*]*. Hangzhou.com. Available online at: http://ori.hangzhou.com.cn/ornews/content/2018-12/29/content_7124639_0.htm

Zhang, J. F., Hua, X. S., Huang, J. Q., Shen, X., Chen, J. Y., Zhou, Q., et al. (2019). The City Brain: Practices of large-scale artificial intelligence in the real world. *IET Res. J.* Available online at: https://www.researchgate.net/profile/Zhihang_Fu/publication/333456538_The_City_Brain_Practice_of_Large-Scale_Artificial_Intelligence_in_the_Real_World/links/5cf5d8f0a6fdcc847502dd92/The-City-Brain-Practice-of-Large-Scale-Artificial-Intelligence-in-the-Real-World.pdf doi: 10.1049/iet-smc.2019.0034