Out of the loop? On the radical and the routine in urban big data

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Abstract
This commentary interrogates what it means for routine urban behaviours to now be replicating themselves computationally. The emergence of autonomous or artificial intelligence points to the powerful role of big data in the city, as increasingly powerful computational models are now capable of replicating and reproducing existing spatial patterns and activities. I discuss these emergent urban systems of learned or trained intelligence as being at once radical and routine. Just as the material and behavioural conditions that give rise to urban big data demand attention, so do the generative design principles of data-driven models of urban behaviour, as they are increasingly put to use in the production of replicable, autonomous urban futures.

Keywords
artificial intelligence, big data, cybernetics, machine learning, urban futures

Introduction
Cities are full of routine behaviours. There are certain hours of the day when traffic becomes more congested; there are payment systems that enact financial transactions...
between merchants and customers. There are signals sent between mobile devices and global satellites, according to established spatial co-ordinates. Traffic lights operate within a regular, defined colour spectrum, generating requisite actions from mobile subjects. These routine behaviours, operating according to agreed conventions, occur within the established elements or ‘images’ of the city: the grid; the path; the node; the intersection; the open space; the landmark. Where Lynch (1960) posited that each standard ‘image of the city’ allows a city to become legible to its inhabitants, today it is also the case that routine behaviours allow a city to become legible computationally.

With billions of sensors and devices now distributed throughout urban environments, the routine is now being computed daily. Indeed, it must be acknowledged that this very process of translating any activity, content or meaning into common, abstracted ‘divisible parts’ is now itself a routine urban behaviour. Routine computational behaviours are, in fact, increasingly integral to the functioning of all the other routine behaviours that make up urban systems (Batty, 2018), from the timing of the traffic lights to the financial transactions that constitute urban economies worldwide.

Much big data in the city is now derived not just from the computation of daily, routine behaviours, but also from the work of ‘training’ rules or algorithms to replicate routines computationally (Allam and Dhunny, 2019; Cugurullo, 2020; Yigitcanlar and Cugurullo, 2020). This training or modelling of routine behavioural dynamics can be undertaken, now with sufficient volume and regularity of data inputs, to the point that such behaviours can be replicated independently. In this way, the production of big data by instrumented urban selves, services and infrastructures generates new urban actors; actors that routinely intervene, autonomously, to shape behavioural outcomes.

There is much attention today towards the many radical implications of big data in cities (Allam and Dhunny, 2019; Bettencourt, 2013; Kitchin, 2014; Thakuriah et al., 2017), but less is said about what is more quotidian, and the role of the routine in the production of big data. The need to replicate routines and behaviours computationally is a problem for mathematicians and computer scientists, which are fields accelerating at a rapid pace. But what of the urban research agenda, and how does it respond? Through the adoption of computational methods of analysis? Certainly this is important. But so, too, is the work of intervening into how relationalities between discrete, constituent parts are enacted and spatially reproduced computationally. Indeed, questions about how data is able to be ‘put to use’ in computational design models can be anticipated to become more central to achieving certain design outcomes in urban precincts and places. Such questions and reflections are the focus of this article.

**Routine questions**

Urban studies researchers are well equipped to interrogate how relationships between complex, interacting subjects reproduce themselves relatively autonomously. Such interrogations are also critical to the ongoing work of automation. Rules-based systems, known alternatively as ‘machine-learning’ systems, ‘neural networks’, ‘natural language processing’, ‘predictive analytics’, ‘digital twins’ and of course the umbrella term ‘artificial intelligence’, each operate in ways that replicate routine behaviours computationally. The volume of data now generated by instrumented infrastructures, services and selves now means such models are being trained to the degree that they are becoming equipped to act ‘autonomously’, that is, without human supervision (Cugurullo, 2020; Levesque, 2017). Big data, generated largely through the routine and the
repetitive, ‘trains’ or teaches such programmes to essentially reproduce output data in ways that replicate the patterns of data inputs. The patterns that denote the routine and repetitive must be identified and trained to recreate the routine and repetitive, through iterative procedures that run until there is a convergence (Batty, 2018: 4).

If this can now be achieved, what does this replication of the routine and repetitive actually achieve, and what insights are gained? To grapple with the ramifications not just of the creation of big data, but of real-time algorithmic replications of routine city behaviours – that is, algorithmically-generated big data – is to move into uncharted territory. The speed and volume of data now training what we can call algorithms of ‘urban artificial intelligence’ (Cugurullo, 2020) are unprecedented. If everyday routine behaviours, and the complex patterns and constellations of aggregated routine behaviours, can be replicated or ‘twinned’ algorithmically, then trained models or ‘city brains’ will act in ways that can further replicate, or predict, or coordinate, in ways that are autonomous.

Through methods such as predictive analytics, it is not just that the routine is replicated: the routine is established as the guarantor or ‘governor’ of all future routine behaviours. In this sense, the ‘radical’ nature of such technologies is their capacity to accurately replicate those actually existing patterns (of walking, of inequality, of corruption, of traffic flows, of resource depletion, of air pollution) as an agent of the future. The architect Manfredo Tafuri once decried utopian formalism as an ‘actuarial colonisation of the unknown’ (in Jameson, 2005: 228) and the same could be said of big data and autonomous agents, which are trained to reproduce the future through recourse to historically-routine patterns.

In one sense, the emergence of today’s ‘digital twins’, which sees the digital replication of urban morphologies and systems, marks the return to that moment, fore-shadowed by architect and futurist William Mitchell in 1996, when the ‘city of bits’ constellates according to what Mitchell called the ‘logical linkages of software’ rather than the ‘physical materials’ of stone and timber, doors and streets (Mitchell, 1996: 24.). However, on reflection, the ‘logical links of software’ are in some senses not so different from the known, physical world of streets and doors. Today’s autonomous, rules-based ways of computationally processing routine urban activities are not always divergent, but rather seek to replicate their flows in mathematical form.

When charting this territory, the need to reflect on basic principles and imagistic perceptions is important, but often obscured under the opaque rubrics of ‘AI’. Leibnitz, a patron saint of cybernetics, believed all knowledge and action should be capable of expression as discrete, binary parts, through a universal, symbolic language that was infinitely ‘computable’, known as the ‘calculus’ (Boyer, 1996: 141; Rescher, 1979; Weiner, 1948). On his ‘stepped reckoner’, an unsuccessful precursor to the calculator, Leibnitz observed in 1685:

I saw for the first time an instrument which, when carried, automatically records the numbers of steps by a pedestrian [and] it occurred to me at once that the entire arithmetic could be subjected to a similar kind of machinery so that not only counting but also addition and subtraction, multiplication and division could be accomplished by a suitably arranged machine easily, promptly, and with sure results. (Cited in Morar, 2015: 126)

Counting the number of steps taken by a proto-pedometer is rather mundane and routine, but by its routine nature it can generate sufficiently replicable data so as to equip a counting machine with a certain agency. The ‘stepping reckoner’ was an original attempt
to not only numerically replicate mundane urban activity in motion, but to also extrapolate other possible numerical outcomes. It might thus be considered a prototype ‘digital twin’.

The opportunity to interpret a routine urban activity mathematically, which James Clark Maxwell did when he sought to decode the operations of a steam engine, created the imagistic potential for a new ‘systems-oriented’ view of urban life operating at infinitesimal and very large scales of operation. Immersed within a rapidly industrialising urban environment, Maxwell observed how the self-adjusting ‘valve mechanism’ of the modern steam engine was able to autonomously keep the engine at a constant speed, despite varying loads. Translating this process mathematically, Maxwell’s ‘centrifugal speed controller’ was later recognised by Norbert Weiner as a novel way to conceptualise the way relations between inputs and outputs, and systems and parts, required regulatory mechanisms or ‘feedback loops’ (Weiner, 1948) in order to maintain a steady state.

This presence of a ‘steering mechanism’ was fundamental to the maintenance of equilibrium and routine, constantly working on behalf of a system to maintain a constancy of communicative flow (Dechert, 1965). Its primacy in the autonomous governance of complex systems inspired Weiner, and others, to retrieve Ampere’s notion of the ‘kybernete’, meaning governor, guide or steersman, as the basis for a ‘cybernetics’ or new science of ‘communication and control’ (Kline, 2009; Weiner, 1948). In these early years of cybernetics, which emerged out of the ravages of the Second World War, equilibrium was an important desired state to attain. Disparate relations between discrete and separate outputs were reconceptualised as part of wider ‘systems’ governed by control mechanisms and ‘feedback loops’ which are trained with sufficient volumes of data input as to be able to operate autonomously in ways that replicate existing conditions. Weiner conceived such systems as either ‘open’ or ‘closed’: the steam engine represents an open loop, capable of ‘sensing’ external environmental changes as it moves through different terrain, in order to transmit appropriate ‘effector’ responses that keep it moving at a constant speed.

What is important here for our purposes is not so much the volume of ‘data’ or information being generated by the complex system, but the imagistic foregrounding of autonomous governance to the continued successful operation of the system in equilibrium – a process computed mathematically by Maxwell centuries ago. Today’s autonomous agents or ‘steering mechanisms’ remain central to the ongoing production of big data in the cities, seeking out the steady state patterns and routines in order to replicate the complexity of the real world mathematically (Batty, 2018: 5). But as we have seen, this notion of the autonomous governor is not itself a product of big data but is in fact a predecessor. In mathematical terms, it was established as being essential to the maintenance of the complex system in a steady state or equilibrium.

**Routine spaces**

Cities remain ideal sites for instrumentation in this way, because they are already governed according to agreed conventions around land uses, transportation protocols, waste management, energy flows and more. The groundwork for autonomous agents has been achieved through urban planning, a field that has successfully championed, often on public health grounds, the need for more systematic rationalisations of space, in order to clear out conditions of pestilence and disease (Acuto, 2018: 165; Geddes, 1915; Hall,
2014; Kent and Thompson, 2014). Straight
and wide passageways, replicable subdivi-
sions and consistent building typologies
have themselves acted as their own ‘steering
mechanisms’ for the management of urban
activities and flows, ensuring that the rou-
tine continues to be replicated as a major
biproduct of urban life. Standardised spatial
co-ordinates, patterns, intersections, grids
and so forth have already pre-programmed
the routine, now instrumented, as an auton-
ous urban subject.

In this sense, the spectre of autonomous
agents, trained continuously through repli-
cations of the routine, must be recognised as
consistent with the historical production of
urban space, and urban subjects, in ways
that have prioritised the systematic rationali-
sations and regulation of behaviours, human
and non-human, rather than representing an
aberration or an outside ‘twin’. While
‘glitches’ and epistemological weaknesses
remain ever present (Leszczynski, 2020;
Mattern, 2013) – accidents will always hap-
pen – computational forms of measurement
are also geared to replicate and automate
routine urban conditions towards appropri-
ate ‘steady state’ conditions.

Understanding the ‘pulse of the city’, as
many data scientists now seek to do in cities,
taking into account mobility, energy use,
communications and economics, proceeds
by defining the normal state against which
anomalies can be judged. When the urban is
viewed as an expression of systems and
parts, in a steady state of equilibrium, the
task becomes, to quote researchers from the
Centre for Urban Science and Progress
(CUSP), ‘to understand how macroscopic
city observables emerge from the aggregate
behaviour of many individuals’ (see Dobler
et al., 2015). Researchers at CUSP harvested
building energy data released through open
data channels and combined this with the
use of hyperspectral imaging and broadband
infrared to generate new ways of ‘seeing’ the
city, capturing information such as energy
usage through novel data science techniques
(see Dobler et al., 2015; Papadopoulos and
Kontokosta, 2019). The curation of energy
benchmarking data also provided the basis
for a predictive benchmarking tool used for
wider energy performance monitoring
(Kontokosta, 2019), with the objective of
reducing carbon emissions by 80% by 2050.
In this instance, the particular selection of
‘training data’ available through building
performance monitors could be used to set
appropriate ‘steady states’ of urban activity
(energy use) that, ideally, could operate
autonomously, replicating desired outcomes
or goals as routine behaviours.

It is widely recognised that the arts of
measurement are by no means well equipped
to capture the diversity of knowledge that
constitutes urban experience today (2017).
Likewise, it remains vital to continue to chal-
lenge the ways that big data systematically
replicates the ‘unwanted routines’ associated
with endemic inequality and injustice in cities
(Ford and Graham, 2016; Kitchin, 2017;
Taylor, 2017). But in addition to these con-
cerns, more attention is also needed towards
the uses of autonomous urban agents in
empowering constitutive relationships with
other urban selves, services and infrastruc-
tures over time – and how such agents might
be ‘trained’ to replicate alternative, more
socially-just or environmentally-responsive
routines and patterns. Seeing and sensing
data-driven urban agents operating both
autonomously and relationally in cities opens
up new spaces of encounter and engagement
with big data in cities.

Media and information scholars have, in
recent years, turned their attention to the
ways in which AI replicates existing forms
of injustice and prejudice, paying attention
to the ‘anatomies’ of AI spanning a range of
ethical, philosophical, computational and
political economy registers (Ananny and
Crawford, 2018; Crawford, 2021). This
research examines particular manifestations of AI and interrogates the range of data used as training inputs. The field of facial recognition, advanced through techniques of computer vision, has been accompanied by significant controversy over the methods and implications of using large volumes of personal data to train algorithms, which can in turn be used to target particular racially subjugated groups. In these fields, an understanding of the productive conditions through which personal data and media assets have been enlisted in the production and replication of autonomous agents has helped raise the bar for improved protocols of ‘informed consent’.

For urban studies researchers, there is likewise the need to interrogate how productive urban conditions and behaviours act as training data for autonomous urban agents. The emergent concerns of ‘platform urbanism’ are one such field that foregrounds how the design of application programming interfaces (APIs) and data-driven business models intervenes to govern diverse urban behaviours and experiences. Here, questions of software design intersect with questions of business model design, and their role in accelerating asymmetries of data access and use in ways that further extend and entrench conditions of labour exploitation (Barns, 2020; Fumagalli et al., 2018; Langley and Leyshon, 2017; Van der Graaf and Ballon, 2019; Van Doorn, 2017). This lens allows for closer interrogations of how urban big data can be coordinated through machine-learning tools to shape urban interactions in cities – such that ‘platform labour’ expresses both the particular urban experience of labour exploitation and the sophisticated operation of autonomous urban agents (van Doorn, 2017).

Radical asymmetries of access to big data can be expected to remain a source of urban inequality for decades to come; we are witnessing the replication of the gilded age of hyper inequality between data ‘haves’ and data ‘have nots’ (Sadowski, 2019; Zuboff, 2018). Conditions of access to the best and most powerful algorithmic agents or ‘guides’ now depend, to no small extent, on owning the means through which co-ordinating selves and services are digitally intermediated (i.e. most of them). Such autonomous agents, which might be experienced in the form of a navigation app or a signal process co-ordinating resource flow, are not ‘disruptive’ as we may have once imagined robots to be, because their ideal role is to replicate the routine autonomously. More disruptive is the extent to which the quality of agents’ routine replication depends upon globalised conditions of constant ‘intelligence amplification’ and agglomeration that exceed the capacities of many traditional knowledge institutions today.

Conclusion

The advent of big data in cities presents novel mathematical challenges and visualisation opportunities, to make the invisible visible, the routine replicable. However, such potentials are not autonomous from the many endemic challenges of urban life, including the many routine conditions that replicate or suppress social justice, the distribution and consumption of finite resources and the health of populations and diverse ecologies. Of course, as Mumford (1961) once put it, it will not be simply through technical means that alternative urban futures will be realised. But we must ask: if big data visualises, replicates and reproduces that which is routine about existing cities, and uses these existing patterns to create agents that act autonomously on behalf of humans, what prospects are there for change? A closer interrogation of the conditions, assumptions, training data and applications that allow autonomous urban intelligence to be created remains vital to the future of urban research.
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