URBAN AI

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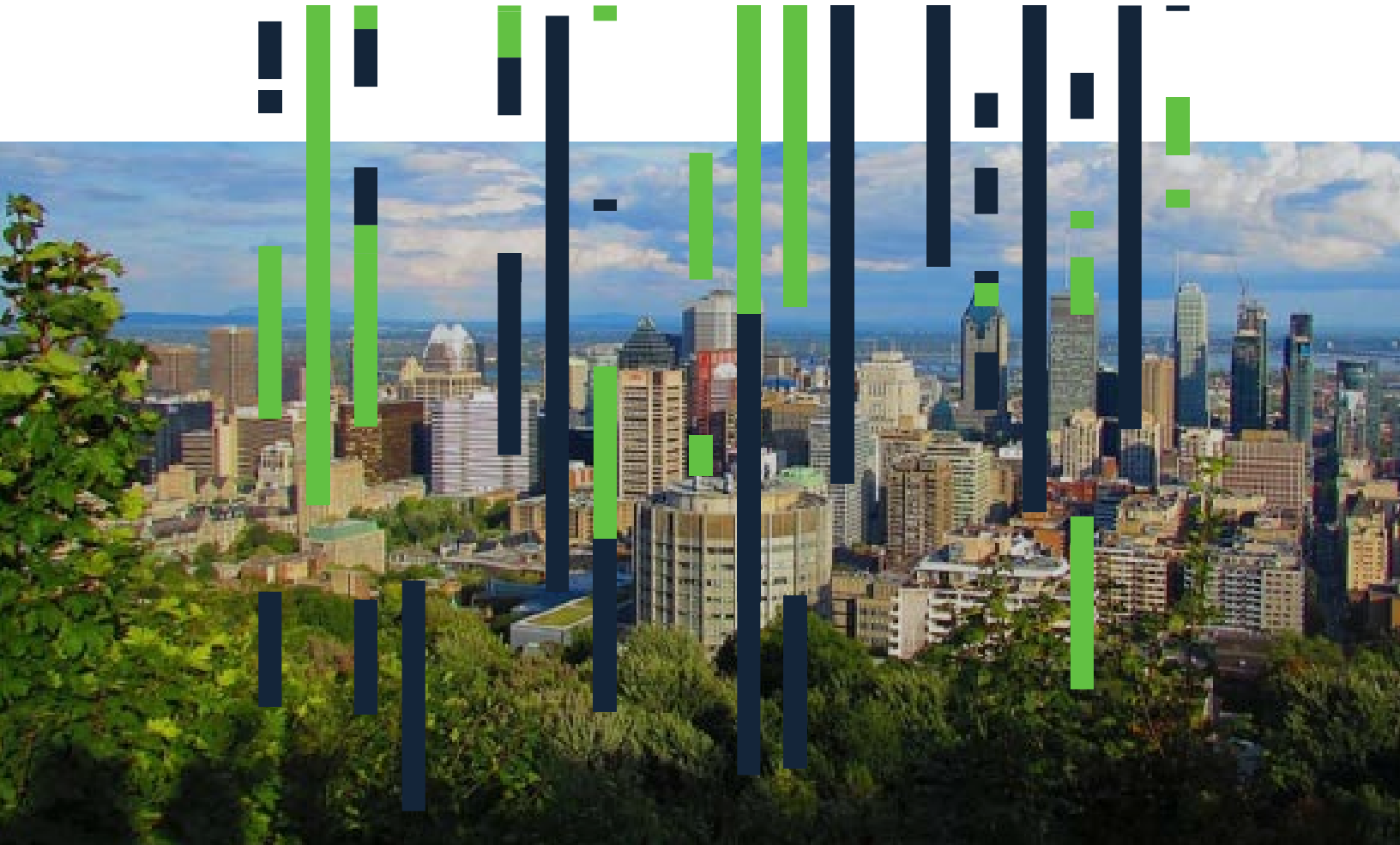

LET'S OPEN THE DOOR TO ARCHITECTURAL POSSIBILITIES

Mathieu Descout, Managing Director Novaxia Investissement

Today we are experiencing the scissors effect. Ecological practicality has pushed us to arrange things differently by taking advantage of what exists already, thanks to urban transformation and rationalizing each square meter. However, common sense tells us we should stop building new buildings, yet demographic pressure and migration trends are leading us to produce more housing in order for us to co-exist with more and more people and uses.

In addition, the health crisis the world is going through is having an impact on urban planning and people's lifestyles. Thousands of square metres of office space were left vacant for several months after the Government announced the containment, and the French people's living rooms took on the appearance of open space. Many local authorities, associations and companies organized themselves to requisition buildings deserted from their usual users in order to make them available to those who needed them. These models, much better adapted to contemporary lifestyles, can be imagined to last. And what if tomorrow, living rooms were imagined to be transformed into a meeting room? And what if tomorrow, every vacant square metre, whether for a few hours or for several years, could be reallocated and thus meet a use or need that had previously been non-existent or ignored?

We, the city's shareholders, are responsible for getting involved in the future by implementing new ways of building things. We need to imagine buildings that are reversible and increase their capacity to meet the big challenges that the cities of tomorrow are facing. A building should be as resilient as possible, and be built so that it can have several different lives, throughout time. Artificial intelligence is a precious tool for us to help create this urban regeneration, by absorbing an important amount of data linked to building materials, costs, uses, and fabrication systems that fit users' profiles and a territory's inhabitants...

AI has a supporting role for engineers, it helps set guidelines while taking buildings' shapes into account. Modeling it with certain parameters, for instance, allows for us to create modular and modifiable buildings that are adaptable and that optimize the space and the materials used. Far from making construction a uniform practice, using these digital tools opens up the field of architectural possibilities.

Using algorithms to create buildings re-defines the architect's profession. The die has been cast: the architect of tomorrow will be an "augmented" architect. Artificial intelligence will participate in structuring cities and buildings, in other

words “intra-muros”, the role of the architect will be like that of an artist. Guided by the quest for beauty and aesthetics of the buildings, they will be able to convey the emotion that an object is capable of producing. These “sensitive” parameters, which machines cannot calculate or quantify, protect us from the risk of an over-optimized city that no longer responds to its inhabitants’ needs. AI has already proved how useful it can be regarding the city’s carbon-reduction: optimizing resources and energy consumption and optimizing space to create green spaces… If it doesn’t make the city more “beautiful”, it at least has to help us make the city more useful, identify territorial deficiencies and explore hidden resources. Because this concerns more than just cities, innovation should be at heart when we imagine the countryside, and small towns. Obsolescence of these abandoned territories has been calculated. We have an obligation to re-mobilize them. Urban innovation must be used to promote better organization and enable citizens to express themselves.

Moreover, this reorganization 2.0 can only happen in collaboration with people that live in these areas and wish to participate in their renovations. Data can allow us to have a better conception of the city. It can allow us to better understand each person’s needs according to their profile and their territory. Let’s use it! Together, let’s give ourselves the possibility to make our cities, our dream cities!

Partnering Organizations

Report Presentation

Can AI help us build sustainable cities? In other words, dynamic cities, inclusive and respectful of the environment. Many questions revolve around this issue: What are AI ecosystems according to cities? Is this technology dissolving urban identities? Are we living in surveillance cities? Will the cities of tomorrow still be *inhabitable*? **In order to respond to these questions I went on a 6 month tour around the world.**

During 6 months, I explored 13 cities (Paris, Montreal, Boston, New York, San Francisco, Seol, Tokyo, Kashiwa-no-ha, Dubai, Amsterdam, London and Copenhagen) and exchanged with 128 players in AI and "Smart Cities" domains. I met 118 of them and 10 were interviewed virtually (the complete list of participants can be found at the end of the report).

To do this world tour, I was sponsored by 6 businesses and 2 partnering universities: Nova Veolia, Leonard, Novaxia, Total, IBM, GFI and The Sorbonne as well as emlyon Business School. In addition, 2 mentors helped, advised and accompanied me for this project: Carlos Moreno (recipient of the "Médaille de la prospective 2019" of l'Académie d'Architecture and Scientific Director of the **Chaire ETI** at The Université Panthéon Sorbonne) and Cedric Villani (2010 Fields Medal recipient and coordinator for the **Villani Report**).

The "Urban AI" report is the result of this world tour. It contains conversations, debates and discoveries. The goal of his study is to create and develop the notion of "Urban AI". Overall, the goal is to discuss the different aspects of this technology and reflect on its impact on future cities.

This report was co-written with 20 contributors. I was lucky enough to meet and interview these 20 women and men during this world tour that accepted to share their analysis, their experience and their thoughts. These contributions are woven into and enrich chapters that share similar themes. They are all answers to the same question: how will Urban AI transform our cities?

What is Urban AI?

"Urban AI" is the crossroads between AI and the notion of "Smart Cities." It is a set of algorithms that learn from **urban data** sets and are used for solutions that are, or could be, deployed in a city. The concept of Urban AI is directly linked to the "**Big Urban Data**" concept.

Two main branches of urbain AI were identified during this world tour:

Ontology: Transforming urban data into knowledge of the territory, infrastructures and uses. For example:

- In Tokyo, Yutaka Mastsuo used Web Mining to help Japanese cities fight against earthquakes and typhoons[1].

1 For more information on this project, see the section on "Resilience" in the "Biodiversity and Resilience" chapter.

- In Montreal, the startup CANN Forecast used Machine Learning to determine the risks of pipeline breaks[2].
- In Amsterdam, the AMS Institute collaborated with The University of Technology of Delft for Social Glass a behavioral analysis project based on data collected from social media networks[3].

Robotics: Creating robots that are capable of movement in an urban context and that can carry out one or several predefined tasks. In particular, in the case of autonomous vehicles, delivery drones and cleaning robots. Here, Urban AI is included in the software component of robots (environmental recognition, decision making, human-machine interactions, …).

In this context, the first element of this report is to illustrate a range of possibilities for Urban AI : what can we do with this technology? The first six chapters are designed to respond to this question. In order to do this, these chapters have been divided into urban sub-sections: Mobility, Buildings and Infrastructures, Resources, Urbanism and Architecture, Biodiversity and Resilience, Health and Safety.

The second goal of this report is to understand how a city can take advantage of Urban AI (and not the other way around). To illustrate this, the chapters "Data Governance", "Cities" (which is a testimony of 5 cities that use this technology) and "Recommendations" are the elements we will use to cover this topic

Moreover, reflexions and analysis on Urban AI are woven into the report: Can we predict the future of cities?[4] Will we live in invisible cities?[5] Is there an alternative to Big (Urban) Data?[6] How can we urbanize the technology?[7] And many other reflexions on the various aspects of this technology.

This report is not exhaustive. Far from concluding the debate on this subject, it aims to broaden the horizons. Urban AI represents an excellent resource for our cities. It can contribute to the creation of vibrant, peaceful and inclusive neighborhoods. It can help us to preserve urban biodiversity, build low-carbon buildings, reinforce local democracy, better inform urban planning and empower citizens. Furthermore, this will only happen if we study it's properties, explore its possibilities and integrate it into a sustainable political practice.

2 Referenced in Naysan Saran's contribution, co-founder of CAAN Forecast, in the "Resources" chapter

3 See the "Augmented Urbanism" section in the "Urbanism and Architecture" chapter

4 Referenced in Michael Batty's contribution in the "Urbanism and Architecture" chapter

5 Referenced in the "Invisible Cities" section in the "Urbanism and Architecture" chapter

6 Referenced in Luc Julia's contribution in the "Data Management" chapter

7 Referenced in Saskia Sassen's contribution in the "Recommendations" chapter

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CONTRIBUTIONS

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Cities of the Future will Rely on AI to Manage Vast Systems
of Interconnected, Interdependent and Interoperable Systems,
Mike Barlow and Cornelia Lévy-Bencheton, Co-authors of
Smart Cities, Smart Future: Showcasing Tomorrow

The Autonomous Vehicle

The autonomous vehicle is, by far, the technology that was the most highly-referenced during our world tour. And as a result, it seems quite promising. We estimate that it could lower the CO2 emissions that cars produce by 80%, reduce their numbers by 60% in urban areas and make car accidents almost irrelevant.[8] These results would only be achieved if autonomous vehicles are **shared, connected** and **electric**.

Shared and Autonomous Mobility

The autonomous car will be much more efficient than a car driven by a human being. One third of vehicles in Singapore will suffice for transporting the entire population with an on-demand autonomous vehicle service (AMoD: Automated Mobility Service on Demand)[9]. Although they are impressive, the results are relative and depend on the geography and the urbanism of the cities being analysed. Moreover, in Manhattan (New York), the entirety of the demand for taxis would be satisfied by a fleet of 8 000 autonomous vehicles (only 70% of the current New York city taxi fleet)[10]. On the other hand, if the taxi fleet were to be shared, this number **could be reduced to only 3 000**. A large majority of public institutions that we met were conscious of this phenomenon and showed interest in the development of autonomous *and* shared vehicles.

Though shared mobility services are growing throughout the world, solo driving is still the norm. Furthermore, the average occupancy rate per vehicle of OECD member countries is less than 1.5 and can be as low as 1.1 during peak hours[11]. In addition, in 2016, **only 20% of Uber transits were ordered using the "UberPool" option** (a shared mobility service). One of the obstacles to massive adoption of shared mobility is the intrinsic efficiency loss in its operating processes (detours for picking up or dropping off passengers). What's more is that Urban AI can be (and is already) used to optimize the itinerary for shared vehicles[12].

Though certain studies seem to show that users are ready to apply and use driverless vehicles[13], shared and autonomous mobility continues to raise a few questions. A driver doesn't just drive, he represents a form of safety. By delivering information, looking at passengers or talking to them, he *humanizes*

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8 Nikolaus Lang, Michael Rußmann, Antonella Mei-Pochtler, **Thomas Dauner, Satoshi Komiya, Xavier Mosquet and Xanthi Doubara**, *Self-Driving Vehicles, Robo-Taxis, and the Urban Mobility Revolution*

9 Marco Pavone, *Autonomous Mobility-on-Demand Systems for Future Urban Mobility,*

10 *Ibid*

11 Stephen Jia Wang and Patric Moriarty, *Big Data for Urban Sustainability,*

12 Abubakr Alabbasi, Arnob Gnosh and Vaneet Aggarwal, *DeepPool: Distributed Model-free Algorithm for Ride-Sharing using Deep Reinforcement Learning*

13 This is one of the results from the Transdev autonomous bus experiments in the old olympic park in Montreal.
Moreover, other studies have demonstrated similar results: Sina Nordhoff, Natasha Merat, B van Arem and Ruth Madigan, *User Acceptance of Driverless Shuttles Running in an Open and Mixed Traffic Environment,*

the vehicle. Without drivers/chauffeurs, would we be ready to share a vehicle with strangers? The shared autonomous vehicle (whether it's a car or a bus) involves a certain amount of interaction that takes place in an open area between its users. These factors might lead to feeling afraid or unsafe (oftentimes for a reason). It is unlikely that a single security camera is enough to maintain order in the vehicles, and even less so to reassure its users. Maybe we would need to create a new profession and/or new security systems. Thus, the deployment of this technology must be accompanied by a reflection on the uses and outcomes that this technology may have.

Likewise, cities have turned to businesses to **reinforce** or even **replace** their public transportation systems. Autonomous and shared mobility will accentuate the porous relationship between public and private sectors. Similarly, the **New York City's Department of Education decided to turn to the startup Via** to optimize its schoolbus network. Likewise, companies will probably collaborate with the Department of Transportation (DoT) to optimize their autonomous vehicle fleet and/or to integrate private autonomous vehicles into their (multimodal) transport networks. Moreover, digital sovereignty issues will emerge that will vary according to the resources and the political system at hand.

Autonomous and Connected Mobility

The primary goal of autonomous vehicle connectivity is to increase its abilities as well as those of the surrounding infrastructures all while maintaining occupant safety, and the security of other vehicles and pedestrians[14].

V2I (Vehicle-to-Infrastructures).Connection between the autonomous vehicles and the:

- Roads: Roadside communication to avoid dangerous zones (potholes, accident-induced traffic, …) and simultaneously, **transmit information about traffic status**, or accidents. The connected autonomous vehicle could even be used to do conduct preventative maintenance on certain infrastructures that need it (like bridges for example[15])
- Traffic lights: **Respond to instructions from stoplights** (without needing to use an image-recognition software) and vice versa, adapting traffic signals to the number of vehicles to improve traffic circulation (smart traffic signals)
- Health and Safety infrastructures: automatically notify health and safety infrastructures in case of accidents or abnormal/dangerous situations

V2V (Vehicle-to-vehicle). Connectivity between autonomous vehicles: Communication between autonomous vehicles would enable safer and better traffic flow. It would be safer because the vehicle would be capable of measuring and anticipating the movements of the surrounding cars and detect

14 David Elliott, Walter Keen and Lei Miao, *Recent advances in connected and automated vehicles*

15 Thomas K. Matarazzo, Paolo Sanit, Shamnim N Pakzad, Kristopher Carter, Carlo Ratti, Babak Moaveni, Chris Osgood and Nigel Jacon, *Crowdsensing Framework for Monitoring Bridge Vibrations Using Moving Smartphones*

their presence in addition to its sensors' abilities (for example the case of the intersection). It would improve traffic flow because the vehicle would be able to recalculate an itinerary according to the distribution of the other vehicles on the roads.

V2P (Vehicle-to-People). Connection between autonomous vehicles and people: Data exchanges between autonomous vehicles and smartphones would take place in order to provide traffic update notifications.

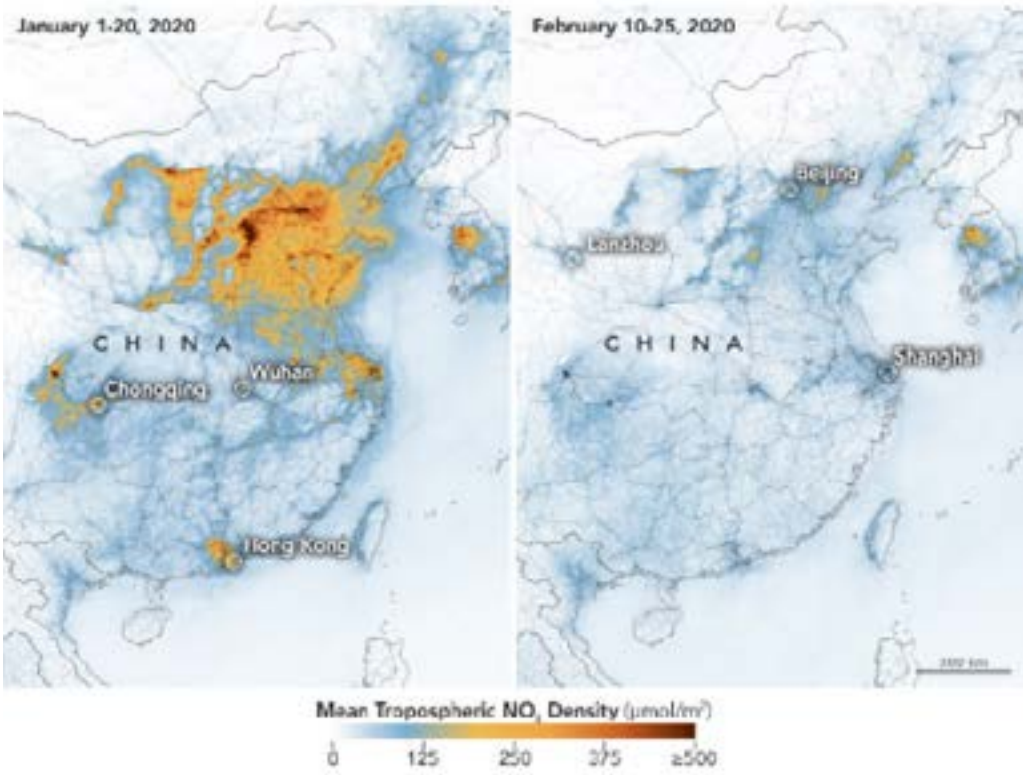
An autonomous vehicle that has re-routed around a dangerous area will also be able to communicate this information to security infrastructures and to nearby vehicles. In case of an accident, emergency response vehicles could be mobilized sooner (because they would be notified quicker) and traffic lights can automatically redirect traffic away from the accident site. The combination of these inter-connections allows us to get a sense of the multitude of possibilities we have to reduce risks and ensure road safety.

This interconnectivity has also brought to light a great deal of questions and uncertainties, more particularly in the cybersecurity arena. In 2016, **the journalist Reeves Wiedeman published a fictional article** about a cyber attack that hit New York. He imagined that, although the terrorists conducted the attack remotely, the autonomous cars were running into walls and hitting pedestrians. Paralyzed by a computer virus, the New York hospitals are incapable of responding to the urgent situation while the rest of the city has no access to electricity. Though fictional, this article emphasizes some risks of increasing connectivity between autonomous vehicles and their environment.

Autonomous and Electric Mobility

The goal of autonomous and electric mobility is to promote the transition towards a low-carbon society and to create breathable cities. Each year, 4.2 million people die in the world due to the air pollution according to WHO. In addition, according to the EPA (Environmental Protection Agency), cars are responsible for more than half of the emissions of carbon monoxide and nitrogen dioxide in the United States. Seeing as electric vehicles don't produce any *direct* emissions, their implementation could significantly reduce air pollution in cities[16]. To this effect, air pollution maps of China and Italy during the quarantine period of the COVID-19 crisis (2020) produce a realistic image of what a city could look like if electric vehicles were used exclusively.

16 Sandra Rafael, Luis P. Correia, Diogo Lopes, Jorge Bandeira, Margaria C.Coehlo, Mario Andrade, Carlos Borrego and Ana I.Miranda: lowering air pollution by 30% in the case of 30% penetration of this technology, *Autonomous vehicles opportunities for cities air quality*



Air pollution survey of Chinese air before and after the quarantine period, Source: NASA Earth Observatory

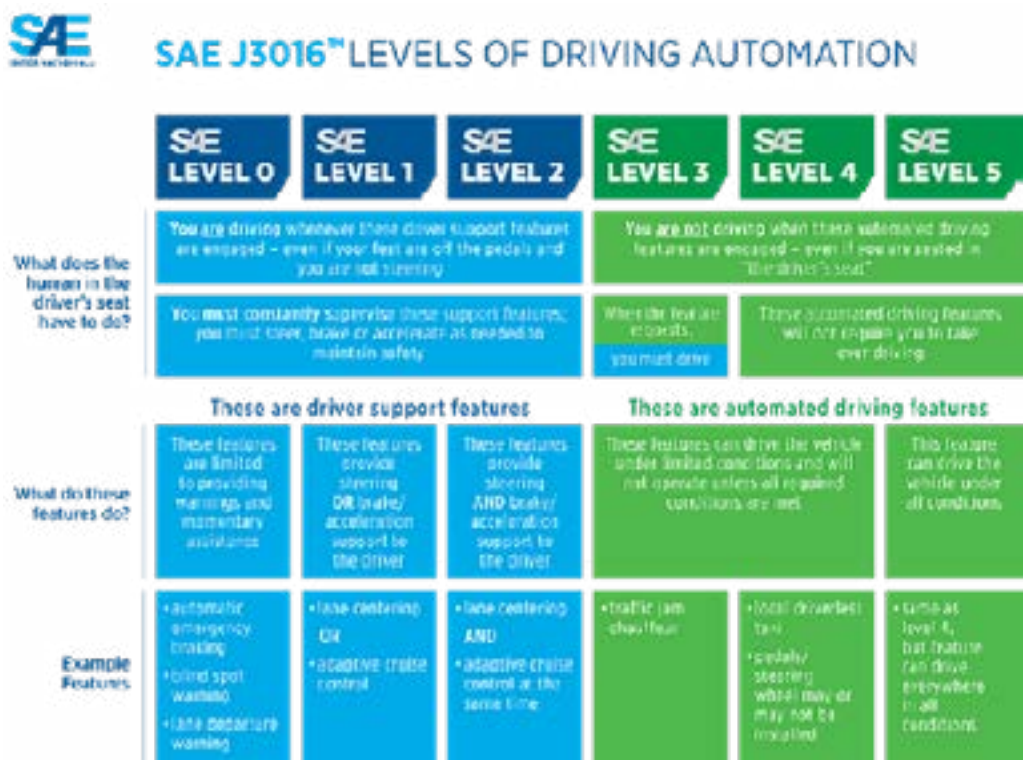
Regarding the low-carbon characteristics of this technology, it will depend directly on our capacity to recharge the vehicles' batteries using renewable energies. For this task, as we will see later on, Urban AI can be incredibly useful[17]. AI can also be used to help create more **high-performance batteries**, safer and **using materials that are more respectful of the environment**.

The autonomous car itself could also **lead to more traffic congestion** and increase air pollution[18]. They will only be truly beneficial for society if these vehicles are also shared, connected and electric. Each of these opportunities also represents urban, environmental and security hazards. Moreover this requires a systemic reflection on how to align these technical factors. Certain *leaders* will probably emerge: China and the Silicon Valley for autonomous and electric vehicles, South Korea for autonomous and connected vehicles and Europe as well as the North American west coast for autonomous and shared mobility. In order to learn from and better understand this technology, it is crucial that we observe the development trajectories of these regions. The autonomous vehicle is also bringing to light certain fears and suspicions, first and foremost about the technology. Many scientists have been reserved about the possibility of creating these autonomous cars on level 5. This is the highest level of autonomy that a car can achieve in the Society of Automotive Engineers (SAE) classification. In this case, the occupants of the vehicle are considered "passengers". Level 5 autonomy indicates that the vehicle **is autonomous in all**

17 Referenced in the section "Energy" in the "Resources" chapter.

18 *Ibid*

circumstances. This is a condition that is even more difficult to achieve since an autonomous vehicle evolving in an urban area risks being confronted with data with which it has never been trained, or has been poorly trained for (a child dressed up as a tree for halloween, **a particularly snowy road,**...). To respond to this difficulty, certain companies offer to outfit the autonomous vehicles with an HD map of the territory[19]. The other technological obstacle is the difficulty for AI to recognize and interpret the body language of an individual. An insistent look from a pedestrian that is getting ready to cross the street or a cyclist that raises their hand to indicate their intention to turn are still unreadable signals, sometimes non-existent for AI. These however, are important signals for a driver in their environment. Many researchers[20] and companies are trying to address this issue.In particular, in the case of **Perceptive Automata**, in Boston, that is training its algorithms to recognize and interpret behavioral data.



Source : SAE International

The second critique of the autonomous vehicle is related to urban areas. Several of the specialists I met were afraid that we would make the same "mistakes of the 20th century" by building car-centered cities. In this case, autonomous mobility would risk increasing air pollution problems and congestion instead of resolving them. This phenomenon could potentially be caused by 3 cumulative factors:

- Technological: Empty autonomous cars ("**zombie cars**") looking for parking spots or new passengers would add to road congestion. If

19 For more on this point we invite you to read Pierluigi Casale's contribution, at the end of this section

20 Agrim Gupta, Justin Johnson, Li Fei-Fei, Silvio Savarese and Alexandre Alahi, *Social GAN: Socially Acceptable Trajectories with Generative Adversarial Networks*

certain actors in the mobility field estimate that it's cheaper to let the autonomous vehicles circulate rather than retire them, congestion could maybe get worse.

- Economic: If we were to drastically reduce the price for shared autonomous vehicles (robo-taxi, ride-sharing,...), people may be more prone to take longer rides and more frequently.
- Behavioral: In 1960, the economist Anthony Downs formulated the Law of Peak-Hour Expressway Congestion[21] which states "on urban commuter expressways, peak-hour traffic congestion rises to meet maximum capacity". In other words, the space that we've freed up due to autonomous vehicle efficiency could end up replaced by other autonomous vehicles[22].

Overall, some experts I met shared their worries about using autonomous vehicles to create cities that are **over-optimized and by extension, uninhabitable**. The example of the intersection with autonomous vehicles perfectly illustrates this point: the intersection is uncongested, without any accidents, but people are unable to cross it[23].

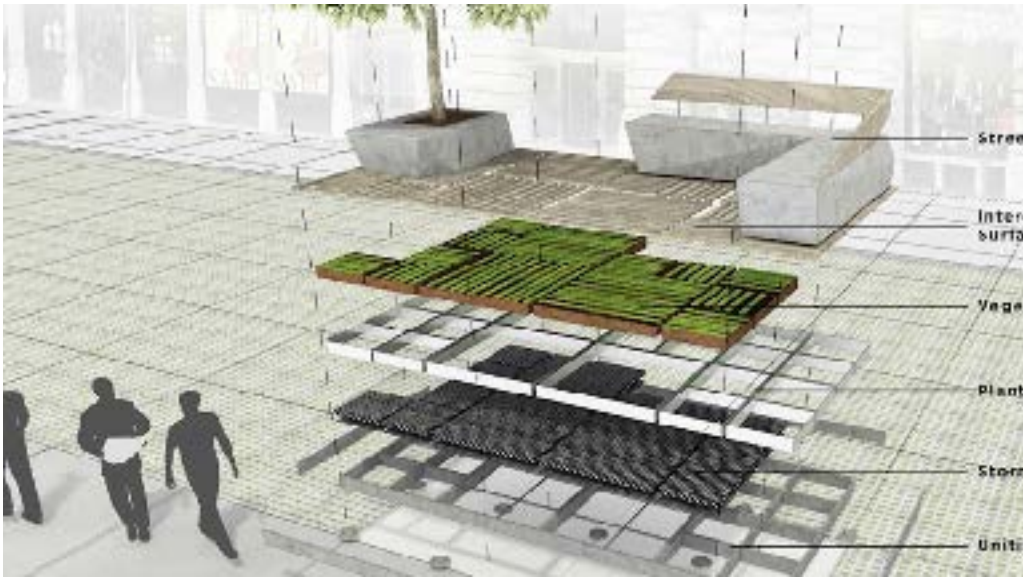
In order for autonomous mobility not to become "the right answer for the wrong problem" (Jeff Speck), it must work for the cities and the citizens (and not the contrary). Similarly, BlankSpace organized with the City of New York the "**Driverless Future Challenge**" in 2017. The goal of this contest was to understand how autonomous mobility can positively impact the city. The architectural firm FXFOWLE Architects and the company Sam Schwartz won the contest for their joint-project "Public Square". Assuming that autonomous mobility will decongest road traffic and reduce the number of parking spaces in the city, Public Square invested in a free space with a plug-and-play system of interlocking unitized squares. There were pre-designated squares (green spaces, bike storage areas, benches, trees,...) that can easily be interlocked and implemented in appropriate areas of the city. In addition, each of the square spaces were created in order to preserve the urban environment (biofiltration of rainwater, reducing the heat-island effect). During normal times, the space that has been freed up due to the efficiency of autonomous vehicles would be replaced by new traffic flow (aligned with the Law of Peak Hour Congestion). Public Square offers an alternative to this phenomenon using an agile solution that encourages sustainable urban planning on a human scale.

21 *The Law of Peak-Hour Expressway Congestion,* Anthony Downs 1960

22 "By increasing travel speeds and the density of vehicles on the road, introducing autonomous vehicles to city streets is largely equivalent to expanding the physical capacity of those streets" (*The Smart Enough City,* Ben Green)

23 *Ibid*

Public Square development project on an intersection in Manhattan (New York)



Several other similar initiatives are popping up around the world. In Boston, The New Urban Mechanics launched **Go Boston 2030**. A collaborative project between BCG, The World Economic Forum, the MIT Media Lab and several startups (NuTomonomy, Optimus Ride, Aptiv). This project has led to research on autonomous mobility, experiments and collaborative workshops with citizens in order to identify their expectations and ideas regarding this technology. The city of Boston has since been able to refine its strategy and propose a long-term mobility plan with several specific goals (safer streets, inclusive mobility, reducing car usage,). Amsterdam, Toronto and even Singapore have set up similar initiatives in order to prepare themselves for the arrival of autonomous vehicles.

It's difficult to accurately predict how autonomous mobility will transform our cities. For centuries, Marchetti's constant[24] **shaped our territorial development**. But will this still be applicable once autonomous vehicles are here? In such a vehicle, **passengers could enjoy themselves**, relax or work. Unlike previous evolutions in the transport sector which were primarily quantitative (increasing the average speed of transport), autonomous mobility is a qualitative revolution. The vehicle becomes a gameroom, a bedroom, or an office. In this sense, the autonomous vehicle resembles a moveable space, a "nomadic space". Moreover, individuals could be more willing to spend more time in a vehicle and travel for longer. Such a phenomenon would launch an urban revolution. Cities were built and developed around the principle of centrality which in and of itself gave way to labor division[25]. Eliminating Marchetti's Constant could open the door to urban diffusion and the creation of expanded and well-dispersed cities.

24 According to the Marchetti constant, an individual seems to travel no more than 30 minutes to get to their workplace.

25 Lewis Mumford (1961), *La cité à travers l'histoire,*

How does AI power the next generation of maps for autonomous driving?

By Pierluigi Casale, Group Data Scientist, TomTom

The way we move in and around our cities will change dramatically over the coming decades. And this is a good thing.

Our cities today are noisy, polluted and congested, taking a toll on the people who inhabit them. We are stressed by sitting in traffic on our commutes, breathing dirty air that is deteriorating the environment, and losing over 3,000 lives on the road each day.

We need a new mobility paradigm that allows us to keep moving in a safer, more efficient and healthier way. One that would shape cities where traffic flows freely and accidents don't happen. Where emissions are replaced by fresh air and combustion engines by electric vehicles.

A future where our cities are safer, greener and quieter, and we are happier.

Building the cities of tomorrow

Autonomous driving (AD) promises to bring about such positive change. By moving the task of driving from the person to the vehicle, AD will reduce the number of road accidents by eliminating human error and ease traffic congestion by making optimal use of the road network.

There are already many cars on the road today that offer some degree of automation. This ranges from adaptive cruise control for driver assistance to more advanced systems that can take conditional control of the vehicle when certain conditions are met. TomTom's maps for automated driving are used in over one million of these vehicles already, and the number is set to rise in the future.

Before reaching the end goal of fully automated driving, self-driving cars will not be a reality until we map the world in every season and every driving and lighting condition. Driving is not an easy task for a vehicle. To be able to do so in a way that is safe and comfortable for its passengers, an autonomous car must know where it is on the road at all times – down to the centimeter. It also needs to spot the difference between a tail light, a traffic light or a street light, to stop and start driving again at the right moment. Lastly, it must be able to safely plan a path in complex conditions, so that it can change lanes or take exits without endangering other traffic participants.

For autonomous vehicles to be safe, they need HD maps to help them know where they are, where they are going, and what will happen along the way.

A next generation of maps for safer driving

Highly accurate and up to date, HD maps give self-driving cars the most reliable eyes on the road.

Offering centimeter-level accuracy and providing a high degree of attribution, TomTom HD Maps use detailed information such as lane models, localization

objects, lane-level speed restrictions, traffic signs or road furniture to help a car drive itself.

The choice of top automakers around the world, our HD Maps make the roads safer and are powering the mobility revolution.

Artificial intelligence (AI) is key to this shift.

AI is driving the autonomous driving revolution

Making hi-tech maps that sit on the cutting edge of technology requires the smart use of AI.

Approximately 15% of roads change every year. From construction, new roads, a change in signage or road markings, roads do not stay the same for long. To reflect this, TomTom makes over two million map changes every single hour and our HD Maps currently cover over 400,000 kilometers of roads worldwide. We need artificial intelligence to make sense of petabytes of data, coming from multiple sources, at an accelerated pace. The sheer amount of information and the complexity of the mapmaking and updating process means that production needs to employ machine learning algorithms in order to scale.

How to use AI to create HD maps

TomTom uses deep learning algorithms to process masses of images no human cartographer could ever manage. But building those models is not even the difficult part: it is data that makes the difference. Adding 61 billion anonymous data points to our database each day, TomTom has an incredible amount of data to draw from.

AI is helping us achieve the impossible. For example, nobody could hope to photograph every street in every weather condition or at any time of day. But we have been training AI to take one image and apply different conditions to it – for example, in the rain or at night – which is crucial for autonomous vehicles to be able to recognize roads.

To do this, we use a technique called Generative Adversarial Network, where AI creates fake images and then sets to distinguish between the fake and the real ones. Once it does this for long enough, AI can create all-weather imagery of 400,000 kilometers of road.

AI also allows us to label data in a consistent, robust and scalable way, by extracting detailed geometry and semantics from our rich camera and lidar data sources. While two cartographers might interpret a road element in an image in a slightly different way, leading to different labels for the same element, AI will label it in the same way each time. The result is a higher quality TomTom HD Map, free of human errors.

While increased map quality is one of the benefits of using AI, reduced cost and speed of delivery are two additional ones. What would take humans hours

to complete only takes the system seconds. This ensures that the map is not only delivered much quicker, but at less cost. Since a continuously up-to-date HD map is critical to safe autonomous driving, this is an incredibly important aspect of using AI.

Preparing for the future, today

What future city do you envision living in? With more than 70% of us expected to live in cities by 2050, HD maps have the potential to improve our quality of life by making safe autonomous driving possible. At TomTom, we are employing the latest technologies in order to make this a reality, so that our cities are cleaner, safer, and free from congestion.

Pierluigi Casale *is TomTom's Group Data Scientist. He holds a B.Sc. and M.Sc. in Electronic Engineering, a M.Sc. in Artificial Intelligence and a Ph.D. in Applied Mathematics. Having worked in both academia and business to develop machine learning algorithms and data analysis pipelines for IoT applications, he is now driving all data and AI initiatives across TomTom. Pierluigi is passionate about extracting actionable insights from unstructured data to improve human lives - a cause to which he has dedicated his entire professional life.*

Augmented Mobility

Urban AI can potentially be used to increase and optimize the networks and facilitate existing traffic circulation.

Facilitating Traffic Circulation

Since 2018, Singapore has been using a smart circulation traffic light system. Created by the Land Transport Authority (LTA) and the Institute for Infocomm Research, this technology aims to increase road traffic circulation of the city-state. In London, **the Turing Institute is also working with the Toyota Mobility Foundation (TMF)** to deploy smart traffic lights at intersections. Their technology uses neural networks that analyze the characteristics of each intersection (the surrounding signals, the number of cars as well as their speed and behavior) in order to optimize it in real-time. In this case AI could cut vehicles wait time in half.

On average, we estimate that "smart mobility" solutions could reduce 15-20% of road traffic and reduce the circulation time by 20-30 minutes per day, per automobilist[26].

Making Road Traffic Safer

Each year 1.25 million people die from car accidents in the world. To combat this, The **City of New York collaborated with DataKind and Microsoft**. One of the goals of this collaboration was to identify elements that cause accidents on the road. To do this, Datakind aggregated and analyzed several datasets (number of accidents, street design, demographics, infrastructures,) and used *machine learning*. Not only did this project allow the City of New York to better understand certain accident-prone elements, but it also demonstrated the missing data that would be needed for a better understanding of these phenomenons. Due to a lack of statistics, the number of cars, bikes and pedestrians had to be estimated by the teams at Datakind. This initiative is a part of an international movement called **Vision Zero** that aims to eliminate road accidents. The algorithms developed by DataKind for this project are also open-source.

Also in New York, the startup **OMETRY** uses *machine learning* to calculate the risk of road accidents per street and per intersection. In addition to their collaborations with the cities of Chicago and Washington D.C. OMETRY also works with insurance companies. They are also able to give advice and recommendations to their clients to help them drive better. By establishing a bonus malus system and *nudges* (emails, notifications,), insurance companies can encourage their clients to be more aware when they are driving in accident-prone areas.

26 *Smart Cities: Digital Solutions For a More Liveable Future*, McKinsey Global Institute

Smart Parking

Many IoT solutions exist for indicating the amount of free spaces in parking garages in real-time, however they are often very expensive. Therefore, the City of Copenhagen developed its own "Smart Parking" solution. The algorithm predicts, according to data history produced by the city's infrastructures, the percentage of free parking spaces in real-time without needing to use sensors or cameras. Interestingly enough, this technology can have an evolutionary pricing complement. Here, the idea is to slightly reduce the cost of parking places in unoccupied areas, and inversely increase the price for the particularly coveted parking spaces. Several other parameters can be taken into account when calculating the price such as the weather, the air pollution rate or even the time of day. Using this technology (with sensors), the City of San Francisco was able to increase parking space availability by 45% , reduce the average wait time for finding a spot by 6.5 minutes (or reduced wait time by 43%) and lowering traffic jams by 8% in certain areas[27].

We estimate that **30% of cars circulating in the city are looking for a parking place**. By helping people park their cars, the "Smart Parking" solutions aim to reduce this phenomenon that leads to traffic jams, pollution and frustration.

DoT

Urban AI could be very helpful for Departments of Transportation (DoT). Their job is just as important as the economic health of a city, which is directly correlated to its ability to have an efficient and sustainable traffic flow[28].

Analyzing use cases can help the DoT's to know if their city's services are adapted to the needs of its citizens. In order to do this, the City of Montreal developed the application **Montreal Trajet**. During 1 month (from mid-September to mid-October), they anonymously recorded the journeys of the citizens that downloaded it (pending upon user consent). The City is now able to analyse how people in Montreal use different spaces in order to best map out it's urban transport network. In London, the City Mapper data that was analyzed by the TFL (Transport for London) has already led to extending certain bus routes. Moreover, the company Optibus offers a Saas platform that uses AI to help public transit providers optimize their bus routes using a multi-scenario simulation.

We can also calculate the efficiency of a transit network by its ability to adapt to unexpected events. In Singapore, IBM collaborated with the LTA for the project FASTER. The goal of this project was to help the Singaporian mobility operator to roll out an optimal solution for incidents (breakdowns, delays, accidents,). In order to do this, IBM built a digital duplicate of the metro network and used it to run simulations. These simulations were then used to test several possibilities (adding a new bus route, making an alternative transport option available, …) and identify the most relevant solution according to the incident and/or pre-

27 *Pilot Project Evaluation, The SFMTA's evaluation of the benefits of the SFpark pilot project*

28 Mike Barlow and Cornelia Lévy-Bencheton, *Smart Cities, Smart Future: Showcasing Tomorrow (2019)*

defined emergency situations. It is important to note that this technology can also be used to estimate a transit network's ability to endure extreme climates[29]. Later on in the paper, we will further explore this subject[30].

MaaS

This is most likely one of the most promising innovations in the transport sector. Maas (Mobility as a service) indicates a collection of multimodal mobility platforms and the integration of several different suppliers. This means that one would no longer pay for a type of transportation but rather for a trip (which could include using several types of transportation). MaaS opens up the possibility for ultra-personalized mobility. It would moreover be possible to choose the fastest, least-polluting, and least expensive itinerary. In addition, one of the advantages of MaaS is that it automatically favors transit network optimization: "A broader mix of mobility options can also increase efficiency, as a variety of options allow the system to naturally balance itself out. When information is delivered in real-time, individuals can make informed decisions with a net positive effect"[31].

MaaS would also be a precious tool for cities. It would allow them to implement their programs (limiting Co2 emissions per trip), to react more efficiently in case of emergency (offering instantaneous detour itineraries) and ease traffic congestion. Furthermore, this technology helps to implement urban and pop-up "mini toll booths": areas in the city that would be more expensive to go through because of a high air pollution rate or recurring traffic.

MaaS has already inspired certain architects. Assuming that multimodal mobility will reduce the use of individual's cars in urban areas, Ben Van Berkel, UNStudio Founder, designed an infrastructure built to receive and recharge autonomous and electric vehicles. Set up at the city's periphery, these infrastructures are mobility HUBs from which a network of public transportation are accessible (metros, busses, electric scooters,). A person that comes to the city using an autonomous vehicle could leave the vehicle in this infrastructure (where it would be recharged and/or redeployed as a shared vehicle, according to the owner's preference) and be able to use each and every possible means of transportation available. Interestingly enough, if this infrastructure has access to the electricity in the batteries of the vehicles, it could also become an energy producer at every moment of the day[32].

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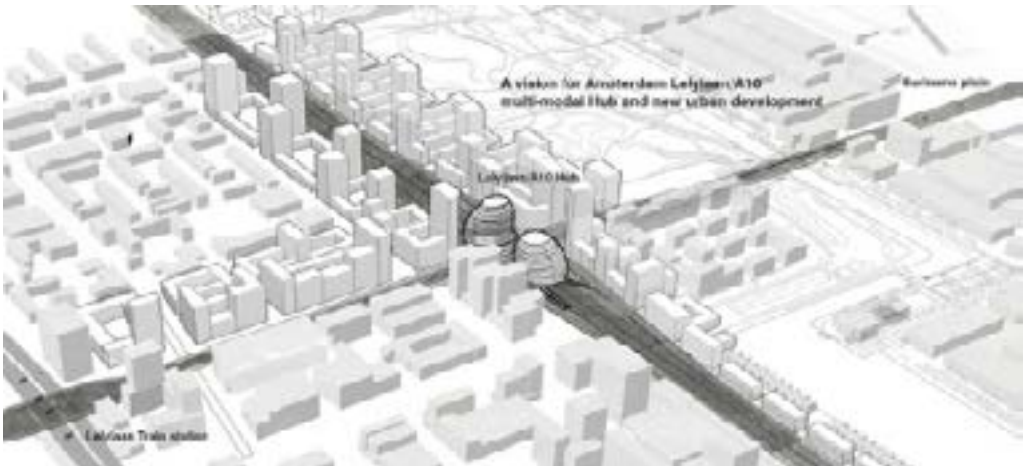
29 *Transport Risk Analysis for the United Republics of Tanzania*, Final Report. L'ITRC (a British consortium of universities and businesses) collaborated with the World Bank to simulate the impact of floods on the transit systems in Tanzania.

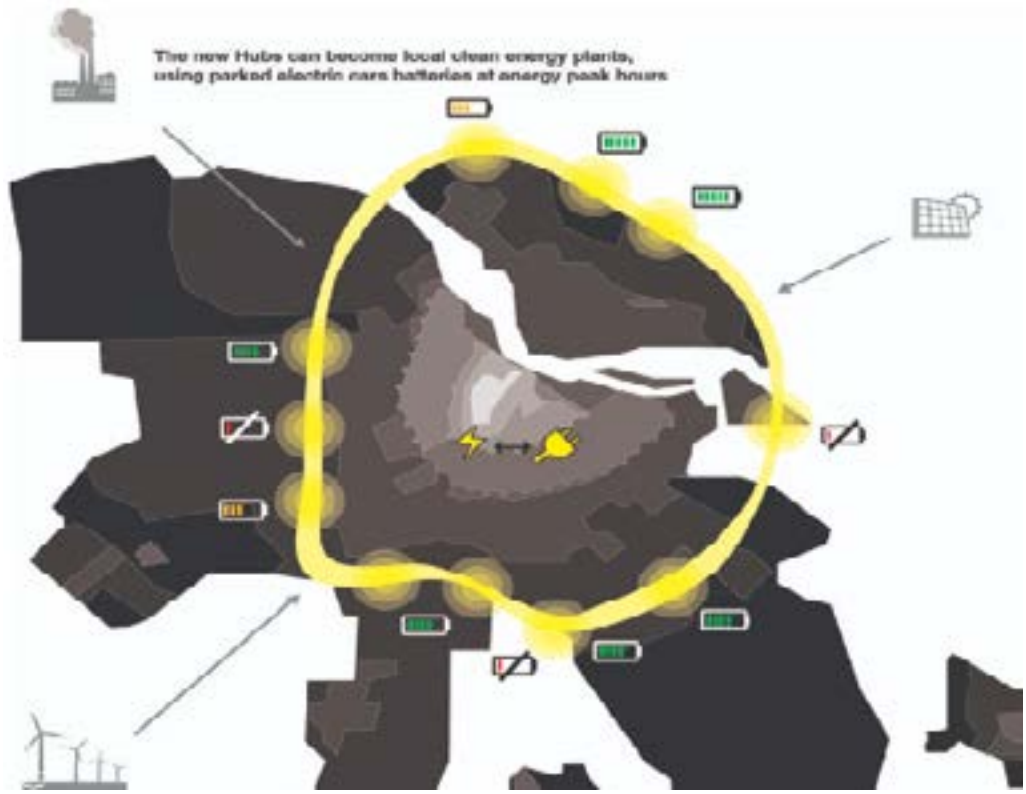
30 Referenced in the section "Resilience" in the "Resilience and Biodiversity" chapter

31 Carlo Ratti and Matthew Claudel, *The City of Tomorrow: Sensors, Networks, Hackers and the Future of Urban Life*

32 We will come back to this opportunity in the "Resources" chapter, in the "Energy" section

The Mobility HUB project by Ben Van Berkel, Source: UN Studio





MaaS also presents sovereignty issues. Many companies are trying to become the leader in integrative mobility, and logically so. This technology could contribute to the creation of sustainable cities and open up a whole world of possibilities. However, this could only be done if it works for general and civil interests.

A Pedestrian City

Urban AI can be used to help create "walkable cities". In Boston, Andres Sevtsuk and Michael Mekonnen developed the Urban Network Analysis (UNA)[33]. UNA is an open-source algorithm that allows users to simulate pedestrian activity for a space. To do this, UNA aggregated several data sets. Among others: building accessibility (how many individuals want to enter a building), their proximity (closeness) or even their size. Each of these parameters provides information about the pedestrian flow generated. By combining this information with the structure of a city (the size of it's sidewalks, crosswalks, etc.), it is possible to predict its "walkability". In other words, to see how much of the city is walkable. For example, a neighborhood with high walkability but small sidewalks may end up with "pedestrian congestion". Thus, UNA enables us to evaluate the "walkability" of an urban development project and contribute to the creation of "human-centric" cities.

If AI can be used to study the flow of pedestrians, it can also help to calculate the *legibility* of a city. This means "the ease with which parts of the urban landscape can be recognised and organised in a coherent pattern"[34]. The legibility of a city depends partly on our evaluation of it. A city that is "welcoming", and "friendly" is a city that is easy to read and easy to walk around in. The legibility of a city is linked to its uniqueness (it's ability to be recognizable) as well as it's "punctuation"[35] (reference points that enable us to get around the space). If a city is too unique it will be seen as indecipherable and too much punctuation risks making the space unreadable. It's interesting to note that each of these parameters can be measured by AI. The teams at the MIT Senseable City Lab used AI to calculate the uniqueness of cities[36] as well as quantifying the legibility of a space[37].

Other technologies could also be used to contribute to the creation of walkable cities. In London, the startup **Pavegen** proposes intelligent urban re-outfitting that analyzes pedestrian flow and, in small doses, creates electricity using kinetic energy from people walking by.

But why is it so important to create walkable cities ?

First of all, for economic and sanitary reasons[38] [39]. In addition, because walking is at the heart of our cities: "The first situated object of the human landscape

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33 Andres Sevtsuk and Michael Mekonnen, *Urban Network Analysis: A New Toolbox for ArcGis*

34 Kevin Lync (1960), *The Image of the City,*

35 Richard Sennett, *Building and Dwelling: Ethics for the City (2018)*

36 Fan Zhang Bolei Zhou, Carlo Ratti and Yu Liu, *Discovering place-informative scenes and objects using social media photos*

37 Zhoutongs Wang, Qianhui Liang, Fabio Duarte, Fan Zhang, Louis Charron, Lenna Johnsen, Bill Cai and Carlo Ratti, *Quantifying legibility of Indoor Spaces Using Deep Convolutional Neural Networks: Case studies in Train Stations*

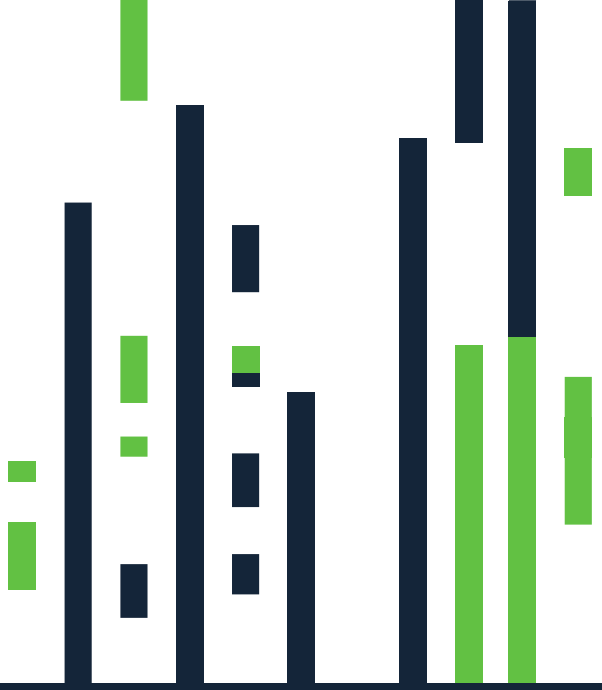
38 Joe Cortright, *Walking the Walk: How Walkability Raises Home Values in US Cities*

39 Jeff Speck, *Walkability City Rules: 101 Steps to Making Better Places, (2018)*

(the menhir) is born directly from wandering and nomadism "[40]. This is precisely because humans walked around the world and they then decided to erect stone monuments (the first architectural jest that exists). The stone monuments were the anchors for these first humans. A landmark, a constant that, due to its vertical nature, structured the evanescent horizon. When we walk, we explore, mapping out and designating territories. In this aspect, walking is not only a physical effort but also a cognitive process. Walking allows us to dive into the "unconsciousness of a city"[41], to encounter the unexpected ("hacking technology" as Saskia Sassen will say) and to read the space. Walkable cities are moreover, and more simply, *human* cities. And vice-versa.

40 Francesco Careri, Walkscapes: Walking as an Aesthetic (2002)

41 *Ibid*



Cities of the Future Will Rely on AI to Manage Vast Systems of Interconnected, Interdependent and Interoperable Systems

By Mike Barlow and Cornelia Lévy-Bencheton, co-authors of **Smart Cities, Smart Future: Showcasing Tomorrow** (Wiley, 2018).

In smart cities, AI will help people make better decisions based on better information.

Cities are complex systems of overlaying and interdependent systems, making them ideal testbeds for artificial intelligence (AI) research and project development. Indeed, smart cities will likely become "power users" of AI, since their continuing growth and success will depend largely on managing ever-growing mountains of data, from structured, unstructured, legacy and social media data sources.

In addition to growing in scale and complexity, city systems will become increasingly standardized and interoperable, which are prerequisites for agility, adaptation and continuous improvement. In a very real sense, AI will become absolutely indispensable as cities grapple with the need to "micromanage" thousands of interlocking and interoperable systems that are essential for modern urban environments.

AI will help cities do a better job of managing data and understanding how well – or how poorly – its systems are operating. That understanding, in turn, will enable cities to optimize the delivery of vital public services and to improve the lives of residents, visitors and workers.

Cities are enormous engines of continuous activity. Each passing moment in a city generates mountains of data. Until recently, there were few practical techniques available for spinning that data into gold. AI provides cities with a powerful tool for releasing the potential of data and turning it into usable information.

With their size, complexity and diversity, cities offer unique opportunities for collaboration between private firms, public agencies, academic institutions and local grassroots organizations. Cities are fertile ground for experimentation with AI and other techniques for understanding data.

It is reasonable to assume that smart cities of the near future will emerge as leaders in the creative use of AI and its various subfields, such as machine learning, natural language processing, computer vision, reinforcement learning and conversational AI.

Based on research we've conducted for our next book, we believe that cities with advanced AI capabilities will gain significant economic and cultural advantages, and become magnets for attracting the best companies and the most talented workers.

Some U.S. cities have already incorporated AI into programs related to public health, education, housing, water conservation, energy efficiency, traffic management and infrastructure modernization.

"Traffic management is definitely one of the areas where AI will benefit cities," **says Jonathan Reichental**, a globally respected technology expert and former chief information officer of Palo Alto, California. "In Palo Alto, for example, we

experimented with using smart sensors to dynamically change the sequence of traffic signals to optimize the flow of automobiles. Those kinds of AI applications will become increasingly common in cities."

In Chattanooga, Tennessee, researchers at the University of Tennessee are using a combination of sensors and machine learning techniques to analyze traffic patterns that result in higher levels of toxic emissions at some of the city's downtown intersections.

Ideally, the research will lead to a more precise understanding of the relationship between traffic flow and air pollution, enabling the city to mitigate the effects of an airborne pollutant called PM2.5 at specific intersections during the busiest times of day.

"PM2.5 poses a real danger to children. When we looked at the data, we saw higher levels of PM2.5 in the air at different points in the day that nobody was aware of," explains **Josh Patterson**, an experienced data scientist who serves as a consultant to the university's **Center of Urban Informatics and Progress (CUIP)**. "We hypothesized that we could forecast PM2.5 levels just by using cameras to count objects in the intersections. Then it becomes a linear regression problem, which is relatively easy to solve from a data science perspective."

The researchers at CUIP hope to use that type of highly granular data analysis to optimize traffic flow during the times of day in which the intersections are heavily used by pedestrians, which would reduce the chances of children inhaling the toxic pollutants while on their way to school.

In its 2019 Smart City Data Challenge, CUIP invited researchers to use its collection of sensor data to build models for predicting PM2.5 levels in the air. In addition to generating valuable insight the city could potentially use to reduce pollution and improve the health of residents, the competition demonstrated how cities are rapidly becoming essential testbeds for innovative applications of AI and machine learning.

At the **New York City Mayor's Office of Data Analytics (MODA)**, data scientists deploy a variety of techniques such as matching, comparing, targeting, anomaly detection and scenario analysis to improve the quality of public services and make life better for residents. The enormous scale and administrative complexity of a large city like New York, where all segments of a multigenerational population require attention, make data science and analytics particularly challenging but critically important.

Amen Ra Mashariki, NYC's former chief analytics officer, says the city agency shapes policy and delivers results in a way that has a profound influence on residents' lives. For instance, MODA used data science to protect affordable apartments and crack down on landlords who violated fair housing laws. The agency also launched a successful pre-K program in 2014 that placed more than 53,000 four-year-old children in over 1,700 newly formed full-day programs by

the first day of school, using data science techniques to combine and analyze a wide range of disparate information from multiple databases.

In 2015, MODA reduced outbreaks of Legionnaires' disease by helping city officials identify and register approximately 5,000 cooling towers suspected of harboring the bacteria that causes the dangerous flu-like illness.

"Cities need data science to make sense of the data they collect," Mashariki says. By combining good data and proper analytic techniques, cities can build "digital twins" of themselves, opening new avenues of research, exploration, experimentation and innovation.

AI will empower cities to go even further with data, allowing them to create highly accurate models and realistic simulations that will dramatically improve decision making and enable citizens to choose between different possible versions of the future.

Our research supports the idea that smart cities will rely on AI and other forms of advanced data analytics to strengthen, streamline and improve key decision-making procedures. In other words, AI will become a normal part of the city's decision-support processes – an important tool, but not a replacement for human wisdom and experience.

"We are not saying that AI should become a substitute for people," says **Mina Sartipi**, director of **CUIP** and a professor at the University of Tennessee. "Cities use AI because it can process, analyze and integrate data from many sources, much faster than people can. That's the point of AI."

Mike Barlow *is an award-winning journalist and prolific writer. He is the author of* ***Learning to Love Data Science*** *(O'Reilly 2015), and coauthor of* ***Smart Cities, Smart Future*** *(Wiley 2019),* ***The Executive's Guide to Enterprise Social Media Strategy*** *(Wiley 2011), and* ***Partnering with the CIO*** *(Wiley 2007). He authored articles, reports, and white papers on technology subjects including AI, machine learning, advanced data analytics and digital transformation.*

His feature stories appeared regularly in The Los Angeles Times, Chicago Tribune, Miami Herald, Newsday, and other major US dailies. He has written extensively on data science for O'Reilly Media and other publishers.

Cornelia Lévy-Bencheton, *Principal of CLB Strategic Consulting, LLC, is a career professional services executive and consultant who has worked in the United States, France and Switzerland. She is a published author and marketing communications strategy consultant whose data-driven marketing and decision-support work helps companies optimize their performance and grow their business. She focuses on the impact of disruptive technologies and associated cultural challenges that open up new opportunities and necessitate refreshed strategies.*

Her technology reports are ranked consistently among the top downloaded eBooks offered by O'Reilly. She is the coauthor of ***Smart Cities, Smart Future*** *(Wiley 2019).*

BUILDINGS AND INFRASTRUCTURES

CONTRIBUTIONS

The Story of a Construction Company that doesn't Build,
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The Story of a Construction Company That doesn't Build

By Ludivine Serriere, Catalyst Lead in North America at Leonard

Custom prescribes that I write an article that boasts about the technologies and innovative projects that were initiated by businesses in the construction industry. The importance of counter-balancing lagging productivity, particularly nowadays, is so great that the environmental impact of the sector has become a vital issue.In the field of Sustainable Development, entire companies are working on the subject, and there is no shortage of sollicitations for initiatives in this area. And it's actually pretty good news that there is so much activity: the number of bid solicitations is increasing each and every year, to the point where they don't know how to handle all of the bids in a certain sector, like low-income housing for example.

The business model of construction, however, hasn't changed for centuries.

The more bids we win, the more the revenue increases and if we do our job well, margins will follow.

The primary goal is to win bids and to build. It's simple and it works. Private-sector clients, local/regional governments and everyday people have needs, and we are here to answer those needs.

In France, according to IDDRI (Institut du Développement Durable et des Relations Internationales) this land artificialization process is increasing by about one regional department every eight to nine years. The initiatives and projects that are oriented towards sustainable development are not enough to make up for the impact that land artificialization and over-use of natural resources has.

We could compensate in every possible way if we were practical, but the only way to truly reduce our impact would be to avoid building in the first place. Our business model is in direct conflict with the idea of sustainable development, it's hard to face that fact, but that's the reality of it.

And where are all of the new disruptive businesses in the construction industry ?

There is no doubt about the existence of incremental innovations in our companies, those that optimise and improve what already exists: digitizing processes, robotics, eco-friendly building materials, etc. But what about disruption? Real disruption?

According to Clayton M. Christensen's definition "a disruptive technology or innovation is a product/service that helps to create a new market, or a new value chain, it disrupts an existing market by destabilizing companies, products and partnering businesses of this market. These innovations will help improve a product or a service in a way in which the market wasn't expecting".

So, where are the examples in the construction industry? What businesses or technologies have created a new market and disrupted our value chain? Who destabilized the leading firms?

A good example of this is Katerra. This business made a groundbreaking entrance on the market with its unique fundraising methods. The goal for this business was to digitize and industrialize the global cycle by optimizing the design and construction process, from logistics to land surveying.

So, was it disruptive or incremental innovation? Did they optimize the construction process or create a new market by destabilizing the more traditional companies already in place? Some would say disruption because of the digital DNA of the company and the fact that they built up the company from ground zero. We could also consider another angle. They sped-up the path that has long since been mapped out for the construction industry, a path that other industries like the automotive, aviation or shipbuilding industries before us cleared the way for.

The more traditional construction businesses have been working for more than 10 years on the topic of industrialization and digital aspects, especially through BIM (Building Information Modeling). The number of elements to take into account, the unique characteristics of our buildings and the cost for these changes make it so that a massive integration of this technology is delayed, but the appropriate technologies do exist. We can't change 100 years of logic in 2 minutes.

Katerra's genius lies in their ability to start from scratch, ignoring pre-established practices and bringing together profiles that are otherwise uncommon in the construction industry. They were able to digitize their processes quicker than the other businesses on the market, by detaching themselves from the way construction was traditionally done and inventing their own universal barcodes to get to the checkout lane quicker.

Despite their desire to establish themselves as a disruptive actor that can change our payment methods, the basis of their businesses still stays the same: **The more bids we win, the higher our total revenue and if we do a good job, the results and margins will follow.**

The conclusion is still the same, the impact on the environment is still significant, because the actual action of building something has an impact. By definition, a sustainable and disruptive construction company would moreover be a construction company that would seek all possible solutions not to build.

Once we've established that, we've made progress.

The idea is to reduce activity in order to promote a new kind of sustainable growth, limiting our consumption and aiming for more frugal technologies. However, this reasoning can become absurd once we start talking about housing. Is society ready to reduce low-income housing for climate-related issues? No one is ready to talk about abandoning their construction projects by saying the following: "the low-income housing buildings will not be built due to sustainable development issues, our sincerest apologies". It is just inconceivable, cities and local governments need to take care of their citizens.

Therefore we are stuck with a business model that we know isn't sustainable, and an increasing demand due to demographic trends. Metropolitan areas, a growing source of employment, are getting crowded and have to respond to a demand that is increasing each year: Build faster, cheaper but still eco-friendly (at least a little bit). If we take a look at the commercial real estate market we see the same trends: increased demographics, more employees, more office spaces needed, an increase in the number of cars and number of people using public transportation, traffic, pollution problems.

Despite these elements, our answers to our clients stay the same.

Revive rather than re-build

What if we had the choice? Because the business model of the construction companies doesn't depend exclusively on building new buildings? What if there was an alternative?

Let's take a look at the services sector.

When we asked our clients why they launched construction bids for their new headquarters, we received the following answers:

- The company is naturally increasing in size which means more workspaces are needed
- Combining resources for economic and strategic reasons
- Relocating activities
- Projecting a new image of the company
- Modernizing the way they work via more innovative spaces
- Attracting Talents

Today, responding to these needs means launching a construction project. The expectations of these clients are enormous, as if simply investing in a new building would transform the business and change management for its employees. The etymology in and of itself of the term real estate in French "immobilier" seems to be incompatible with the notion of transformation: Im-mobilis literally meaning non-mobile.

Why invest in new walls when we could invest in the most valuable part of a business: employees.

Rather than a construction project, the goal would be to propose a new initiative for the company. Companies would have to work on the WHY of their client's needs in order to have a wider spectrum on HOW to solve it. The priority is no longer just about construction but moreover about organizational and environmental performance. The first aspect would be investing in understanding how to use it's employees before investing in a concrete building. The new offer would be an alternative to a more traditional construction project, with a counter-analysis of the initial investment that would otherwise

be dedicated to the construction project. The initial investment would be re-distributed to the three primary aspects of the project:

1. Managing employee mobility and their workspaces in real-time
2. Digitizing ways of working via employee counseling
3. Renovating a premium space within the metropolitan area, dedicated to collaboration and facilitating company culture

1.Managing employee mobility and their workspaces in real-time

The company's "mobility" system is the central point of the approach; it is intended to be intelligent, learning, but above all trustworthy, the collection of employee data allows to better understand their needs and to adapt the framework to their individual constraints in order to better identify their needs and offer a more neural and flexible network.

This platform would be connected to a network of workspaces spread out throughout the region, depending on the geographic position of the employees. An online interface for organizing meetings in real-time and reserving workspaces according to geographic data on individuals would optimize the travel time for each employee, depending on their transport preferences and their personal constraints (school, sports, fun, next meetings).

Partners: Software companies, SAAS solutions, MAAS.

2.Digitizing ways of working via employee counseling

Each department and each position would be audited to decipher the required work environment for optimal performance (physical and service-oriented). The employees' work could be done by working remotely or in a workspace that corresponds to their needs. Investments that would otherwise be used for building a new office site would be re-invested in training employees on how to use new digital tools and management strategies. Imagine if only 10% of the initial project budget was re-distributed in order to help improve employees' skills.

Partnership: A company that specializes in employee training programs and digital transformation.

3.Renovating a premium space within the metropolitan area, dedicated to collaboration and facilitating company culture

This space would be more financially affordable for the company because it would be more structured. In fact, this space would not be dedicated to individual work but for teams that want to work together, collaborative projects and client presentations.

Partnership: A business specialized in office renovation and environmental performance audits.

Technology that can be used for company projects:

- Artificial intelligence and interoperability of different systems (transportation, workspaces, professional calendars and personal obligations)
- Tools for communicating, training courses and knowledge management. Integrating these necessary technologies into making a workspace digital (Hardware & Software)
- Technologies linked to renovations and the environmental performance of newly renovated buildings, the goal is to concentrate on the development and deployment of new analytical technologies in structural, energy-related and interior design techniques before construction takes place.

The Secret Sauce

The true catalyst for this kind of project is employee-engagement and client-engagement. It is essential for the company to integrate sustainable growth as a strategic pillar in its culture and for its employees to take part in it. The company should offer employees the opportunity to participate in a company project that would lower its environmental impact by avoiding construction, while digitally transforming the company and the unspoken rules of the workplace. This transformation would be beneficial to them because they would be able to better understand employee needs: by authorizing them to work in workspaces closer to them, and also allowing them to improve their abilities.

A Profitable hybrid model for the average contractor

The average company doesn't only look at the construction aspects like they would anyways when renovating their office space, but they also could develop new partnerships with their service suppliers using a co-created "mobility" system that they would develop with their software editor and adapt to their clients.

The business model is changing: **The more we win more bids the more we avoid building new buildings and maximize existing infrastructures by rehabilitating them. Moreover, the more we ensure a long-term profitability in the long-run, using our new system and integrated mobility.**

We can see that the new generation is experiencing cognitive dissonance between their careers in construction that have a high carbon impact, and their hopes for the environment. The changing economic model will allow for better alignment as well as attracting new Talents to the company.

Ludivine *supporte d the development of open-innovation in the construction sector at its very beginning. To start, a first experience at Bouygues Construction in the implementation of new methods of collective intelligence and the intrapreneurship program. Followed by the setup of a new department at VINCI Construction France dedicated to foresight and start-up relationships, using Open-innovation, Creativity, and Innovation management as tools thus helping individuals to unleash their hidden potential and acculturate the company.*

Since May 2019 she is the Leonard antenna in North America. Analyzing market trends, new technologies, and innovative thinking in Silicon Valley. Aimed at bringing a new vision from the other side of the planet to Leonard's teams and to the VINCI Group's Innovation Departments.

She graduated from ENSGSI, an engineering school specializing in innovation management, and HEC Paris Business School in management of complex projects.

Optimizing Energy

Energy consumption from buildings is responsible for roughly **30%** of our CO2 emissions. **In New York this figure is as much as 70%**, moreover making skyscrapers the primary source of pollution in the city. In this context, Urban AI can help us optimize building energy consumption.

In Montreal, the startup MAXEN Technology uses deep learning to optimize the heating, ventilation and air conditioning (HVAC) systems of buildings. The startup uses its algorithms on a complex data set (building insulation, weather, occupancy rate…) in order to transition from a reactive model (changing the temperature when it gets too high or too low) to a more proactive one. The AI developed by MAXEN Technology is also able to anticipate and adapt to climate variations as well as user preferences. Therefore, it is possible to reduce rapid and unpredictable temperature changes and integrate several other settings (thermal inertia that a platform can use, areas that are more exposed to sun rays, …) to the operating conditions of HVAC systems. We estimate that these techniques could, on average, lower a building's energy consumption by 15%. In certain cases, optimizing HVAC systems using AI can even reduce the building's energy consumption by 44%.[42] Other practices (reducing necessary energy for heating water, intelligent lighting,...)[43] can also contribute to creating buildings that are less energy-hungry.

Interestingly enough, good data governance can also lead to lowering a building's energy consumption. This is what happened in New York after Local Law 84 and 87 were implemented that required certain buildings to make their energy consumption data public. Two behavioral phenomenons appeared as a result. On one hand, the possibility to track one's own energy consumption resulted in self-regulation. In addition, the ability to access the data of the other buildings resulted in a free market effect.This policy change led to a 13% reduction in EUI (Energy Use Intensity[44]) of buildings that these regulations applied to over the course of 4 years[45].

Furthermore, Urban AI can contribute to the increase in renewable energies used by buildings. In this case, AI is primarily used to create a model of a building's energy consumption behavior. Once completed, it is then possible to shift the building's energy consumption peaks (using nudges, economic incentives or smart charging stations) towards peaks in producing renewable energy and stocking renewable energy (using batteries) in order to use it later during energy consumption peaks.

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42 Chin-Chi Cheng and Dasheng Lee, *Artificial Intelligence-Assisted Heating Ventilation and Air Conditioning Control and the Unmet Demand for Sensors: Part 1. Problem Formulation and Hypothesis.*

43 D. Rolnick, *Tackling Climate Change with Machine Learning*

44 EUI is a building's energy consumption with regards to its size

45 Ting Meng, David Hsu and Albert Han, *Estimating Energy Savings from Benchmarking policies in New York City*

The combination of these initiatives can, in a certain way, push the development of green building (almost exclusively building using renewable energies). This is the case of the Asian headquarters of Schneider Electric (Singapore) and the RHW.2 tower (Vienna).

Photos taken during the Schneider Electric HQ visit in Singapore

As we've seen with the infrastructure designed by Ben Van Berkel[46], buildings can also be a resource for energy production. Based on this idea, the startup Blueprint Power proposed a SaaS platform to help property owners and those renting the spaces to sell excess electricity that their buildings produced. In addition to the economic interests, it can also contribute to increasing the amount of renewable energy used in the city. A green building could also contribute renewable energy in the city's electricity grid rather than storing it and not using it at all.

Augmented maintenance

Urban AI can also be used to do preventative maintenance on buildings and infrastructures. This technique is equally as interesting since the malfunctions or the deterioration of an infrastructure could put people's lives in danger and cost millions of dollars. The cost for repairing aqueducts alone was roughly 3 billion dollars in North America in 2018.

In Angers (France), the water treatment plant in la Baumette used AI to do preventative maintenance on its equipment. A provider for Veolia, the station uses connected sensors to anticipate mechanical failures. Developed by Cartesiam, this technology in particular uses embedded AI. Before being

46 Refer to the "MaaS"section of the "Mobility" chapter

operational, the solution must undergo a 7-day test period (unsupervised) during which it records equipment vibrations that it will eventually be monitoring. At the end of this learning phase, the connected sensors are able to signal any deviance that may lead to machine failure or equipment malfunction. Another way to use machine learning to do preventative maintenance is to analyse the data history and to draw patterns from it. This is what CANN Forecast does in Montreal, with their pipe-breaks analysis. These methods allow for preventative maintenance to be done on a number of elements like elevators[47], roads or even bridges.

Photos taken during a visit of Veolia's water treatment plant in Amiens. The yellow boxes are the NanoEdge solutions that monitor the equipement

AI can also be used to make building and infrastructure inspections easier and safer. In Singapore, the startup H3 Dynamics used drones (augmented by computer vision) to automate building inspections (cracks, paint problems, etc,). The anomalies detected by the drone were then sent to a technician that used this information to write a maintenance report. The H3 Dynamics solution is particularly useful in cities with seismic activity in which the buildings need to be verified regularly. In time, these similar solutions could be used for indoor building maintenance (using robots to inspect such spaces[48]).

This, in addition to the preventative maintenance, augmented building and infrastructure inspections open up many new possibilities. Routine testing

47 Kesheng Wang, Guohong Dai and Lanzhong Guo, *Intelligence Predictive Maintenance (IPdM) for Elevator Service- Through CPS, IoT and Data Mining*

48 The robots used by the startups Telexistence (Tokyo) and Boston Dynamics (Boston) could perform such tasks

would be completed then replaced by targeted and optimized inspections. This means that only the areas that have been predicted to be at risk or having detected risks would need to be analyzed, as opposed to inspecting the entire structure. The same drone or interior robot would be able to inspect several buildings and infrastructures in a matter of hours. Besides saving money, this practice would contribute to urban relief. Elevators would be repaired before they even break down, potholes would be filled in before they cause accidents and bridges would be renovated before they fall apart.

Usage analysis

Usage analysis is one of the major elements of building management and operations (both tertiary and residential). This would allow for a better understanding of how individuals use a space and move around in a building. This information would contribute to optimizing the occupancy rate of a building and increasing occupant well-being and productivity[49].

WeWork was one of the first startups to use IoT (Wifi sensors, Beacons, thermal sensors) and Machine Learning in a more in-depth way to optimize its workspaces and co-living spaces. Using the data collected in these buildings, the algorithms developed by the company are capable of predicting the average hourly usage rate for their meeting rooms[50], workplace conditions that are best for concentration, or even to determine day-to-day coworker preferences for self-service products consumed during the week. By combining this data, it is possible to better understand how the building lives: tracking occupant flow, identifying the most highly solicited areas and how those areas are used. This information allows us to maximize the occupancy rate of a building (which is 50% on average for the tertiary sector) all the while maintaining the well-being of its occupants. WeWork was moreover able to reduce the marginal cost of a desk by 33% in 2017[51].

In the retail sector, usage analysis **enables us to identify the layout that optimizes how attractive the store is**, and detect zones that have a high concentration of activity and determine an individual's average journey. Using computer vision, the French startup XXII is even able to calculate the conversion rate of a product, meaning the relationship between the number of times that the product was picked up and purchased. These resources can therefore be used by a retailer to refine their strategy (product placement, store layout, luminosity,...).

Inversely, Urban AI also allows us to understand how much the architecture of a space impacts the use of that space. In her dissertation The Shape of Segregation: The Role of Urban Form In Immigrant Assimilation, Arianna Salazar Miranda tried to determine if certain buildings, due to their configuration,

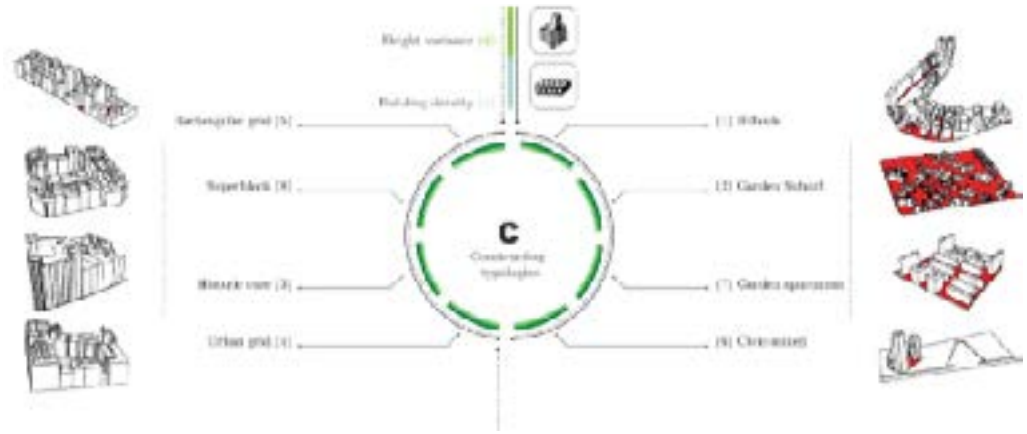
49 Albert Saiz and Arianna Salazar Miranda, *Real Trends: The Future of Real Estate in the United States*

50 *The WeWork Report,* CB Insights

51 *Ibid*

promoted immigrant assimilation in the city of Barcelona between 1998 and 2008. In order to do this, she used machine learning to analyze and group buildings in Barcelona according to their architecture. She then calculated the cultural integration index per building typology and noticed significant differences between the indexes. In other words, some architecture actually promoted and encouraged cultural mixing.

Below are the types of buildings identified by Arianna Salazar Miranda using Machine Learning.
Source: The Shape of Segregation: The Role of Urban Form in Immigrant Assimilation, Arianna Salazar Miranda



What makes Arianna Salazar Miranda's work so original is that she doesn't focus on the functionality of a building (study, sleep, healing[52]...) but rather on a value (cultural openness). Twentieth century cities were built around the idea that "form follows function". This principle led to the creation of fragmented cities. Urban spaces became a sort of a mosaic, a place of separation. On one side the work areas, and on the other side the place where people lived and even more "cultural" infrastructures. This model is, in its essence, not urban[53]. A functionalist city is set and programmed for obsolescence despite the fact that it should be subversive and polymorphous. A city should welcome and facilitate existing uses as well as those that haven't come to light yet. This is the only way to have a lasting effect.

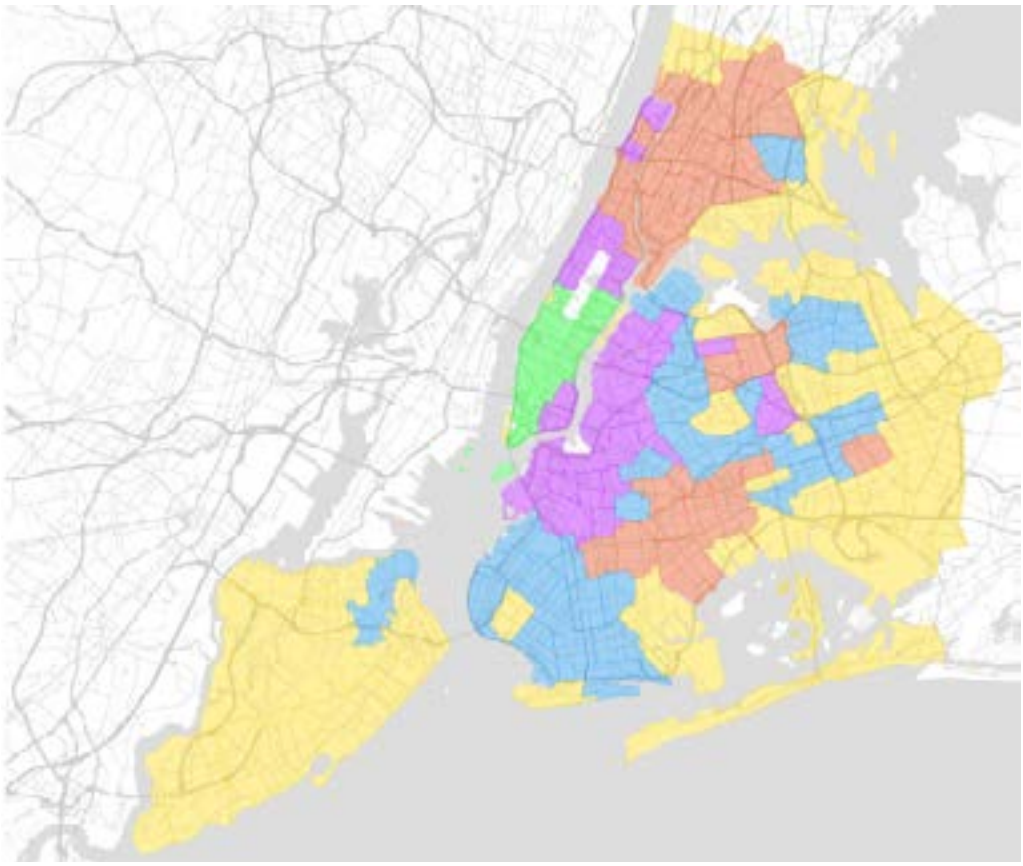
Augmented Planning

In New York, the startup Topos used *computer vision*, a Natural Language Processing (NLP) and Network Science to re-partition New York and remap the city. Unlike traditional maps that illustrate the geographic layout of a space, the partitioning created by Topos uses ontology. In other words, it illustrates interconnectivity between neighborhoods based on what makes up the neighborhood (its visual identity, its infrastructures, the kind of people that live there, etc.). In order to do this, Topos aggregated and analyzed hundreds of

52 Roger Ulrich, Xiaobo Quan, Craig Zimrig, Anjali Joseph, Ruchy Chouhary, *The Role of the Physical Environment in the Hospital of the 21st Century: A Once-in-a-Lifetime Opportunity*

53 This subject is addressed in: Christopher Alexander, *A City is not a Tree (1965)*

data sets (economic, visual, demographic, etc.) using several different sources. The startup was able to generate a new map of New York:



Source : https://topos.com/

This map, divided into 5 "boroughs" (each represented by a different color), makes you look at the city differently. The yellow borough (named "The Meadows"), is peri-urban, spread out and characterized by the presence of abundant vegetation. On the other hand "Minhattan" (the green borough) is particularly dense, and contains a number of buildings and businesses/ companies and is the most expensive in New York.

By "matching" the characteristics of a company (branding, products,...) with those of a neighborhood (using this new map), Topos was able to identify optimal implementation zones. To refine their model, this startup also used collaborative filtering[54].This technology is used by several other businesses like: WeWork, Starbucks, Unilever and even Shell.

54 This is a method that Spotify uses to generate recommendations. The idea is simple: Spotify groups individuals by the songs that they listen to. Its AI then offers recommendations to the individual according to the music that the person likes in their group. Then, the model tailors it's recommendations according to what the individual liked, or didn't like, of the recommendations. For client recommendations, Topos uses a similar AI technology. The startup puts the companies in different categories (shared values, similar clientele,...) and looks at which ecosystem their target market lives in.

Urban AI can also help to optimize infrastructure planning. In the United Kingdom, 7 universities collaborated with 55 private-sector partnerships to create the ITRC (Infrastructure Transitions Research Consortium). They developed the NISMOD (National Infrastructure Systems MODel), an algorithm that calculates a territory's infrastructure needs in terms of energy, digital, transportation and water management. The NISMOD aggregates several complex data sets (demographic, economic, environmental,) to model a city's growth patterns and better understand the demand evolution for infrastructures over time. What's unique about NISMOD is that it takes the interdependence of its infrastructure network[55] into account to have a more systemic approach. Once the needs are identified, NISMOD is able to optimize infrastructure planning using digital copies or digital twins[56]. In the United Kingdom, this algorithm was used by the National Infrastructure Commission (NIC), the Institution of Civil Engineers and the National Grid.

Organic Architecture

Several actors that I met shared their enthusiasm regarding organic architecture. Meaning, creating buildings that use their materials or their operating processes to interact with their environments and individuals.

One of the goals of organic architecture is to contribute to creating a better urban environment. We no longer consider the facade of a building as an epidermis, but moreover an active component of the urban climate. That being said, **Google R&D announced a collaboration with the architect Doris Sung** to create a coating that can sanitize the air in a city. In France, the startup Cool Roof developed a reflective paint that deflects 90% of the sun's rays and also fights against the heat island effect. In addition, in Los Angeles, DOSU Studio Architecture created a structure capable of self-ventilating. In each of these cases, AI can intervene on two distinct levels. First and foremost, in the way these solutions are applied. Heat islands[57] or air pollution are both phenomenons that can be modeled and located by these learning algorithms. This information could then help optimize the locations where these organic architectures could be placed in order to maximize their efficiency. Moreover, Urban AI can help a building "feel" it's environment and react accordingly. An adjustable structure[58], using reflective paint or anti-pollution coatings could be deployed as soon as the AI predicts a heat island formation or a high concentration of carbon monoxide.

Organic architecture can also be applied to infrastructures. In Amsterdam the AMS joined the MIT Senseable City Lab for Roboat, an autonomous boat project. What is unique about these autonomous boats is that they are multi-

55 This interdependence was more specifically measured in ITRC's *Infrastructure criticality hotspot analysis,* ITRC

56 *Data for the public good*, National Infrastructure Commission.

57 Steven Jige Quand, Florina Dut, Erik Woodworth, Yoshiki Yamagata, Perry Pei-Ju Yang, *Local Climate Zone Mapping for Energy Resilience: A Fine-grained and 3D Approach*

58 Like the Building Raincoat in Toronto and the Shed in New York

directional and that they can "plug into" each other. They can be assembled to create bridges or mobile structures on the water. Though it's only in the prototype phase, these autonomous boats open up a world of possibilities. A bridge or a platform could be spontaneously created according to inhabitants' needs. This makes it possible to modify the urban landscape by adding ephemeral structures.

Below, autonomous boats link to form structures. Source: Roboat.org

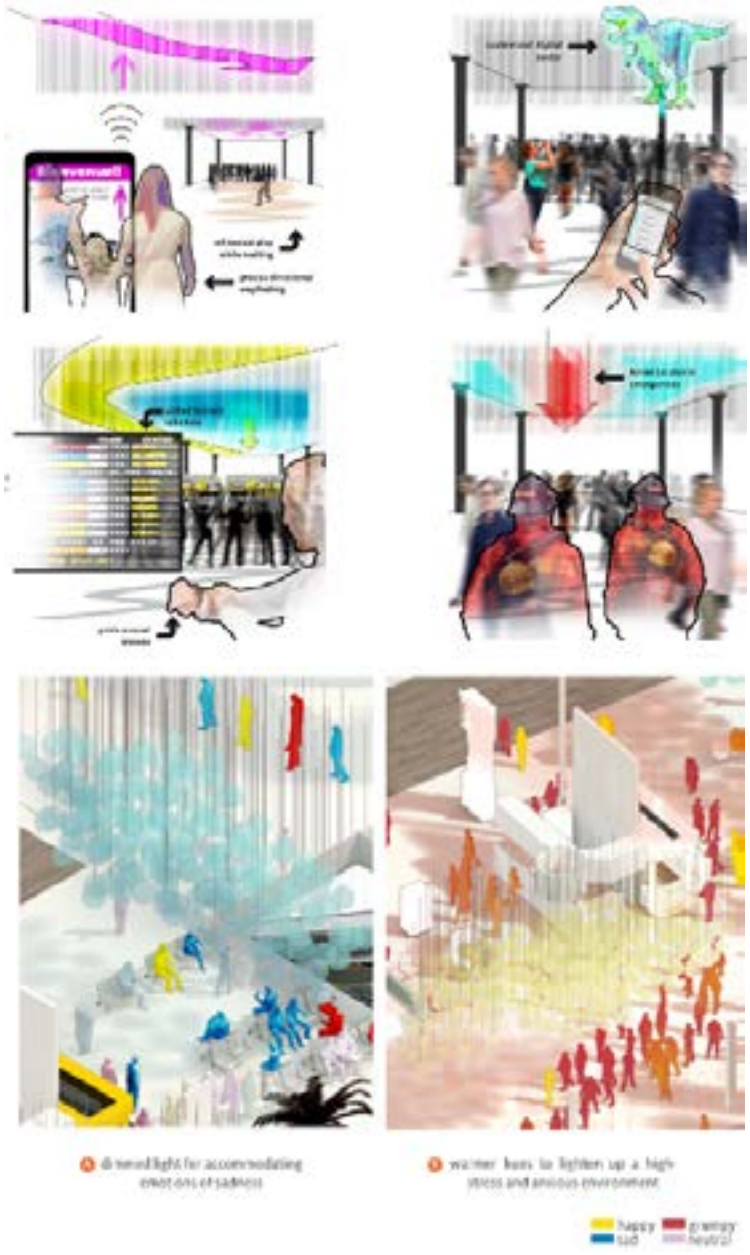
The other fundamental principle of organic architecture is the interaction between individuals to, *in fine*, enhance them:

"The most important implication of radically integrating digital systems into architecture will be to refocus technology and the built environment on humans. A living, cybernetic program in spaces of dynamic interactions will make architecture more like an extension of the body-and its cyborg "tools" that enable the environment to respond. Augmented or "living" architecture is the large-scale hardware that digital-physical cyborgs create, plug into, and interact with."[59]

59 Carlo Ratti and Matthew Claudel, *The City of Tomorrow: Sensors, Networks, Hackers and the Future of Urban Life*

Organic architecture is therefore a “hybrid” reality. The notion of an “interface” is at the heart of this man-machine-building hybrid. The interface gives a digital body and materializes the data. This is where “the atom and the bit” meet[60].

In Copenhagen, Marius Hartmann,Chief Advisor for the Danish Business Authority, brought up the possibility of using urban interfaces to guide us through a building (or in the street), to be alerted in case of an emergency or to get us interested, and even to receive a notification (call, message,...)[61]. In the case of **Senseable Guide Paris**, students from MIT created interfaces for the Gare de Lyon (Paris). Several of them continued the reflections of Marius Hartmann:



Exemples d’interfaces imaginés par des étudiants du MIT. Source : Senseable Guide Paris

60 *Ibid*

61 Marius Hartmann, *Interfacing Ambient Intelligence,*

The urban interface also opens up a world of possibilities. In addition to generating information, a building[62], a tree[63], or even a statue could "tell us their stories". In doing this, the entire city becomes an interface. It is therefore no longer a question of combining intelligence and knowledge in the palm of our hand but rather spreading it around us, and going out and discovering it.

The last few decades have pushed us to be disconnected from our environment in order to "connect us with the world". Caught up in the world of smartphones, we have become "smombies"[64]. **Some cities have even installed light signals to protect pedestrians and warn them of approaching vehicles.** In this case, organic architecture doesn't just help us enhance, it transforms our relationship with cities and with ourselves. It gives us the possibility to see the world and to know and appreciate its beauty before doing anything else.

Multi-use Spaces

3Urban AI can also contribute to facilitating shared spaces, and link infrastructures as well as optimize the occupancy rate of buildings. In other words, "**explore the hidden ressources of a city**" (Carlos Moreno). On this subject, I recommend that you see Rafael Luna's contribution.

62 In Singapore, the "**City Hall: If Walls Could Talk**" exhibit offers an immersive experience inside City Hall to see what happened in the city-state.

63 Andy Hudson-Smith, Martin de Jode, Leah Lovett, Duncan Hay, Richard Milton, Lucy Fraser, *Internet of Things of trees-Controversial objects via SMS protocols,* opens up a practical discussion.

64 A combination of the word smartphone and zombie to designate a pedestrian with their eyes fixed on their smartphones and not paying attention to their surroundings

The Value of a Distributed Collective

By Rafael Luna, Hanyang University

The megapolitan condition once envisioned as a unified world city by Constantinos Doxiadis in the 1960's has become more of a reality than a futuristic hypothesis. The planetary urbanization involving infrastructures that cross geopolitical boundaries have eroded the concept of a distinguishable city, leaving the problem of how to manage future urbanities. As one of these quintessential expansive megalopolises, Seoul has been able to rise from a war-torn state during the middle of the 1900s to an economic and technological power by the turn of the century becoming a test bed for managing equitable space for its 20 million citizens.

In the 21st century, Seoul has been able to stabilize its growth and take a step back to visualize not only what its future could be, but also future city models. It is no longer seeking a fast and expansive growth, but a controlled transition towards a qualitative growth. The early 2000s marked a transition for a new agenda of Seoul becoming a "Cultural Capital." After the long period of heavy industrialization, and city growth preoccupied with the quantity of building stock rather than the quality of urban space, now Seoul could focus on how to reestablish and promote its cultural heritage in the urban space. This fomented a series of projects that aimed at transforming infrastructural obstructions into public spaces. The most notable examples are the Cheongyecheon stream, Seoul Forest, and the Seoul City Hall Plaza. The emphasis on enhancing Seoul's urban space as well as promoting its heritage through a generation of new designers earned Seoul the label of World Design Capital in 2010, celebrated with the inauguration of the Dongdaemun Design Plaza. Yet, Seoul's most revolutionary agenda, which builds a new layer of complexity on the previously set goals, was proposed in September of 2012, when Mayor Park Won-Soon launched the "Sharing City Seoul Project" in order to explore the optimization of the city driven by the "4th Industrial Revolution."

The new agenda set by Mayor Park, seeks to answer how to optimize the use of the current infrastructure and urban fabric, and to understand what role the 4th industrial revolution plays in the quality of urban life. To answer these problems, it is necessary to understand the implication of the new industrial era. Each industrial revolution has been marked by a transformation of energy production and its effects on manufacturing production. The first industrial revolution is set by mechanization and the steam engine. The second revolution was powered by electricity, gas, and oil, and evolved singular labor into mass production. The third revolution is marked by nuclear power, which drastically advanced the field of electronics, robotics, and information technologies leading to automated production. Lastly, the fourth industrial revolution starts with the creation of the internet, which is often categorized as an era of digitalization through the internet of things (IoT). The process of digitization completely revolutionized the understanding of the physical context by providing the basis for a decentralized society that blurs the boundary between the physical and the digital world. Digital platforms allow for services to become decentralized and distributed. The term "Smart City" is born out of this context as big data is collected through sensors on legacy infrastructures for the purpose of city management. Mayor Park's agenda of a "Sharing City" in the 4th industrial revolution could move beyond the cliche model of "Smart City" as previously explained and explore how the actual urban space can react to its user in real time.

Digitalization brings the potential of optimizing the use of the city enhanced through artificial intelligence and machine learning in order to leapfrog the concept of Smart Cities as cities that are connected through data nodes, but more as cities that can give back to its citizens by understanding how and which spaces are utilized. After more than three decades since the invention of the modern internet in 1983, the industrial revolution we are entering has evolved from the Internet of Things (IoT) to the Internet of Value (IoV). The digitalization of context implies an inherent value that can be traded. Blockchain technology allows for a decentralized record of transactions, which will allow being able to trade any asset such as real estate. At the same time, it will allow for true decentralized ownership of the city and the appropriation of public space by private citizens as much as the shared private space by the collective. Choreographed through AI, a city could be analyzed by its use of public space, vacancies, and use of semi-public or semi-private spaces in order to optimize these spaces by finding transformative programs and different users depending on time.

Seoul already presents some initial examples in analog form, such as the appropriation of the infrastructural space as the commons. There is a social understanding of these spaces as spaces that can be used for private endeavors such as street vendors, micro shop booths, or outdoor restaurant seating for example since they enhance the public atmosphere. Another direct example of reusing the infrastructural space for a collective good is the use of the subway underground stations as homeless shelters. After the last train has run, the Seoul City Hall Station gets occupied by the homeless since the station provides public toilets and heat. This double use of public infrastructural space solves a social issue making the city more equitable. Infrastructural spaces are shared spaces that in a smart city could be categorized and scheduled for private use by means of smartphone applications more efficiently. A future city would make use of its infrastructure not just for its engineered purpose but for social use.

The distributed workplace is another example. Shared kitchens in Seoul allow restaurants to open without having to rent a commercial space, but share a kitchen. These are restaurants that only function online through delivery services. Similarly, the workplace could be distributed throughout a neighborhood in underutilized spaces in order to promote micro-industries. A digitized list of vacancies could be managed by the city to provide temporary learning rooms, reading rooms, study rooms, workshops and so on in these spaces. Communities in Jongo are already organizing to reuse underutilized rooftops for collective use, which are managed digitally.

Digitalization brought the misconception of a Smart City as one that collects data in order to better manage its infrastructure. Yet, the value of a decentralized network is that it can be organized and distributed by the citizens, and a smart city can optimize its use by facilitating the data. AI will allow for a city to transform and adapt its economy by further empowering the citizens to self organize. This will prove to be a more sustainable solution for maintaining a thriving urbanity.

Rafael Luna *is an assistant professor at Hanyang University and co-founder of the architecture firm PRAUD. He received a Master of Architecture from the Massachusetts Institute of Technology. Luna is the award winner of the Architectural League Prize 2013, and his work has been exhibited at the MoMA in New York, Venice Biennale, Seoul Biennale, as well as published internationally. He has international professional experiences in Japan (Toyo Ito), UK (KPF), France (Ateliers Jean Nouvel), and the US (Martha Schwartz Partners, dECOI, Sasaki Associates, and Machado and Silvetti). He is currently pursuing his Ph.D. research on Infra-architectural typologies as urban models at L' Accademia di architettura in Mendrisio, Switzerland. His writings have been published in international journals such as MONU, SPACE, IntAR Journal. He is the co-author of, "I Want to Be Metropolitan," and editor of the "North Korean Atlas."*

RESSOURCES : ENERGY, WATER, WASTE AND FOOD

CONTRIBUTIONS

Artificial Intelligence and blue gold,
Naysan Saran, Co-founder of CANN Forecast

A Foodie's Today and Tomorrow,
Haibei Peng, Project Architect chez Google R+D for the Built Environment

Energy

We have already seen how AI can optimize buildings and infrastructures' energy consumption patterns[65]. This section concentrates on the characteristics of Smart Grids.

Smart Grids are networks of electricity that "[A Smart Grid is one that] incorporates information and communications technology into every aspect of electricity generation, delivery and consumption in order to minimize environmental impact, enhance markets, improve reliability and service, reduce costs and improve efficiency"[66]. In order to do this, two types of technologies are used:

- Sensors (*IoT*): Used to collect data on production and consumption in real-time and to supervise the network.
- *Machine Learning*: To predict the energy demand, anticipate production capacity and perform preventative maintenance on the network.

The issues at stake regarding this innovation are primarily economical (metering and optimizing consumption), technical (coordinate and securing the grid) and environmental (increasing the amount of renewable energies used by the grid). This last point is particularly important since 25% of our CO2 emissions result from our electrical systems.

At Stanford, **Jacques de Chalendar** is using applied mathematics and statistical modeling to secure and optimize the campus' power grid according to different variables. This task is even more complicated since the campus functions on electrical heating and cooling mechanisms and that a part of the energy **comes from a photovoltaic plant** and thermal energy storage. Moreover, the region goes through heat wave periods. In some cases, this climate-related phenomenon can even lead to having to shut down some buildings due to a lack of energy to cool them down. In this context, AI is used to anticipate the heat waves and divide up energy consumption over an extended period of time. Stanford's case is interesting because it represents problems that the cities of tomorrow may be confronted with (extreme climate conditions, system electrification, combining different energies).

Also in California, the startup Autogrid uses AI to optimize global distributed energy resource production (*Global distributed energy resource*). This method, **which more and more cities are attracted to,** allows them to connect local energy resources and also sustainable resources (solar, wind,...) to a power grid. Because the majority of these resources are intermittent, anticipating their evolution before using them is an essential step. That being said, *Machine Learning* can predict the network's energy production periods as well as consumption peaks[67]. Using this technology, **Autogrid collaborated with the energy supplier MCE** to reduce their clients' electricity bills and increase the

65 "Buildings and Infrastructures" chapter in the "Energy Optimization" section

66 IEC *Smart Grids Standardization Roadmap*

67 D. Rolnick, *Tackling Climate Change with Machine Learning*

amount of renewable energies used. To do this, consumers received messages to incentivize them to lower their energy consumption during high-demand peaks[68]. Moreover, the startup examined how MCE could integrate the energy that their clients produce into their grid[69].

It is also important to mention that distributed production allows us to create resilient networks. Kashiwa-no-ha city, in Japan, uses this technology in particular for closed-circuit functioning in order to keep providing electricity to people during natural disasters (earthquakes, cyclones, etc.). The network is linked to solar panels, batteries and the national energy plant. However, It can disconnect from it at any moment. Using this method, Kashiwa-no-ha city can sustain 60% of its population's energy needs for 3 consecutive days.

Decentralized production shows excellent potential for cities[70]. Combined with Machine Learning, this gives us the opportunity to vary energy sources, produce low-carbon electricity and create a resilient network. In any case, several of the experts that I spoke with about "AI & Energy" mention that this technology **was not the miracle solution**. The majority of the renewable energy storage systems have a high carbon footprint. What's more, the optimization software requires powerful computations in energy-hungry datacenters[71]. Overall, the amount of renewable energy that we are able to produce is **relatively low compared to our actual needs**. To deal with the climate emergency, deploying this technology needs to be accompanied by a change in how we use it and a change in consumer behavior.

Water Management

A civilizations' fate seems intermittently linked to its ability to manage water. As such, Roman aqueducts, arabic gardens (like those of Alhambra, that use ingenious irrigation systems) or even parisian sewers (invented by the Hausmannian Baron) illustrate the grandeur of an era. Despite beign a source of pleasure, power or money, water is the source of all life. Despite all this, its management remains widely imperfect. Worse : each year, 2.2 millions of people die because of unsanitary water sources.

This commodity, as rare as it is plentiful, represents one of the major issues that cities face. For this, AI can help us optimize water management. In Montreal, the startup CANN Forecast developed "InfoBaignade". This solution is able to

68 This technique has more than just economical advantages, but is also used to shift electricity consumption towards periods when renewable energies are being produced

69 In Japan, in Hachinohe, Mitsubishi Electric also deployed smart grids that use solar panels, wind turbines and batteries. Not only does this limit the dependance on the grid according to climate conditions, but this technology also reduced the network's CO2 emissions by 50% without altering the quality: Operation Result of the Hachinohe Microgrid Demonstration Project, Yasuhiro Kojima

70 Shaun Howell, Yacine Rezgui, Jean-Laurent Hippolyte, Bejay Jayan, Haijang Li, *Towards the next generation of smart grids: Semantic and holonic multi-agent management of distributed energy resources*

71 Several companies and research institutes are trying to develop "low-carbon AI". This is one of the focal points for Federated Learning, a decentralized machine learning approach. For more information about this, refer to Luc Julia's contribution.

predict the concentration of E.coli (the intestinal bacteria) in a lake with 95% precision. Traditionally, this bacteria is withdrawn and analyzed in a laboratory. This method takes between 18-48 hours and since rivers are moving bodies of water, these results can quickly become irrelevant. By aggregating several data points (rainfall, overflow, and other variables) the startup is able to offer a more intelligent water management model due to its proactiveness and how it adapts to the dynamic aspect of lakes and rivers. For more on this topic, I suggest you read Nasyan Saran's article.

Similarly in Singapore, Suez partnered with the PUB (Singapore's National Water Agency) to implement 1200 water-level sensors. These solutions, that integrate the Wize network, use individuals' water consumption data. This data is then analyzed in order to identify patterns[72] and abnormal behavior (potential indicators of leaks) as well as network malfunctions. Suez also developed the application WaterGoWhere that updates citizens and encourages them to lower their water consumption using personalized quizzes and other games. PUB estimates that its solutions led to a 5% drop in water consumption. Overall, we estimate that each euro invested in these water-level sensor solutions can generate up to 3 euros of ROI[73]. The city-state emphasized the importance of water management in particular, since it represents a **major geopolitical** issue for them. 50% of the water that they consume is actually imported from Malaysia. From this moment on, Singapore has two possibilities for reducing their water dependency: optimizing water management and increasing the production of local drinking water (which is done using artificial reservoirs and seawater desalination factories).

As we saw beforehand, Urban AI can also contribute to optimizing infrastructure planning [74]. Optimatic, acquired by Suez, also developed Optimizer, an algorithm capable of simulating thousands of construction and/or water infrastructure management scenarios. The configurations proposed by Optimizer vary according to the territorial characteristics and client's needs. The startup, which has already optimized the water network in Casablanca (Morocco) and Coimbatore (India), can generate financial gains anywhere from 10-30%.

In conclusion, we will further examine how Urban AI can help cities fight against flooding.

72 We estimate that the water demand prediction on the short-term (24-48 hours) could reduce management costs by 18-55%. For more information:, A.Antunes, A.Andrade-Campos, A.Sardinha-Lourenço and S.Olivieira, *Short-term water demand forecasting using machine learning techniques*

73 *Data for the public good,* National Infrastructure Commission

74 This subject is partially addressed in the "Enhanced planning" section, in the "Buildings and infrastructures" chapter

Artificial Intelligence and Blue Gold

Naysan Saran, co-founder of CANN Forecast

Artificial intelligence has come a long way, and is now omnipresent in our day-to-day management. Surprisingly, AI is still used infrequently to optimize our most precious resource: water. Here are a few explanations.

A long road to intelligence

Vienna, 1770

To impress the Austrian empress Marie-Thérèse, Wolfgang von Kempelen created an automaton capable of playing chess. This was called "**The Mechanical Turk**" and because of its turban, the machine caused a lot of controversy.

"The idea that an AUTOMATON would be able to correctly move the chess pieces around [...] is COMPLETELY IMPOSSIBLE" Philip Thicknesse wrote in 1784. The "Mechanical Turk" was, in fact, a hoax: someone was operating the machine from inside.

New York, 1997

In 19 moves, the computer Deep Blue from IBM forced Garry Kasparov to forfeit the game. Outraged, the world champion in chess accused the machine of being manipulated by humans, but ended up retracting his statement: Deep Blue's computing power allowed it to anticipate up to **74 moves ahead**, compared to "only" **15-20 moves** by the best human players.

However, according to Joe Hoane, one of Deep Blue's programmers, this feat "**wasn't in any way artificial intelligence**" but *simply* a matter of computing speed. To be intelligent, the machine had to prove that it could be creative.

Seoul, 2016

The champion of the game Go, Lee Se-dol, lost 4-1 to Google's AlphaGo algorithm. With more combinations possible than atoms in the visible universe, the Go couldn't be won by pure calculating capacity, it required both intuition and creativity to win.

This time, it was truly about artificial intelligence: AlphaGo combined heuristic algorithms with **deep neural networks.** The world champion **announced that he would retire** in 2019. His explanation: "Even if I was number one, there was an entity that I could never beat".

Even though AlphaGo sparked public interest, experts knew that a revolution was already on the way. In 2012, the neural network *AlexNet* won the image recognition contest **ImageNet**, marking the beginning of a new era for artificial intelligence: **deep learning**. The irony of the story: to build the database for ImageNet, researchers used the *crowdsourcing platform...* **Amazon Mechanical Turk**.

Despite all of this, we still have a long way to go. Yoshua Bengio, one of the fathers of this new trend in artificial intelligence, admits that "computers of today, with deep learning, are still **pretty stupid**. They are capable of doing very sophisticated things [...] but will struggle doing certain tasks that a 2 year-old child could do."

Train it to do something specific, it can beat champions. Ask it for something *common sense related* and it's lost. Because of this dichotomy, algorithms of today are optimized for specific tasks, which are increasing every day.

Artificial Intelligence is everywhere

Do you take pictures with your phones? An algorithm is used to optimize the **settings**. Are you thinking about a career change? Your next **interview** will probably be conducted by AI. Each day, new models are being developed to optimize fields as varied as **health, finance** and the **arts**.

Moreover, the book "Deep Learning", one of the bibles of deep learning, was **translated** from English to French… mostly using a deep learning algorithm. There are certain areas where AI's progress is slower. Among these, is the management of our most precious resource: water.

When it comes to Water

According to the Financial Times, water will be the **petroleum of the 21st century**. However, invisible problems are rarely a priority: between 30-50% of this precious resource is **lost before even reaching our faucets**. Here's why: in big cities, the majority of water pipes that were installed more than 70 years ago, are reaching the end of their lifespan, causing more and more leaks and pipe breaks.

According to the EPA (Environmental Protection Agency) the required cost for replacing these pipes is up to **500 billion dollars**, which will primarily be financed by governments, and thus will come out of our taxes.

People need to get ready to pay this enormous bill over the course of the next few decades. To avoid increasing our taxes more than necessary, it is crucial that we use the available data to optimize the maintenance on these water networks. Keeping in mind that the majority of cities already collect data on their infrastructures, what would slow down adopting artificial intelligence in this field?

Case Study

Since 2017, **CANN Forecast has** used city data to help it best manage its water resources. Last year, our team created the **first pancanadian research project** which aims to apply artificial intelligence to optimize pipe replacement for the drinking water network.

In addition to McGill University and INRS, nine municipalities across Canada joined us in this challenge. Though the end of the project is planned for summer 2020, a few trends have already appeared. In fact, even some of the results are very promising, certain issues must be addressed in order to allow the algorithms to reach their full capacity, both in terms of data and *interpretability*.

What about the data?

According to current practice, *data scientists* spend about **80%** of their time formatting data. This is definitely the case when it comes to water management, due to a lack of standardized formatting, the data saved using a variety or resources (Esri database, proprietary software, PDF maps, free-hand surveys…).

While we're waiting for a universal template for all cities, we are developing, in collaboration with the **Centre d'Expertise en Infrastructures Urbaines** of Québec, an automatic data processing tool based on artificial intelligence.

The interpretability question

This question is applicable in two ways: the first is **model interpretability.** Often, with AI, new models are developed with the sole purpose of having better results than their predecessors. In this race for higher performance, few researchers take the time to understand what is happening inside of their blackbox.

However, with regards to water management where every bad decision can have crucial impacts on the health of citizens, few institutions are ready to trust opaque systems. **Interpretability of algorithms** is a domain that is relatively new to AI, and we must accelerate it's expansion.

The second factor is about the **interpretability of results**. Data scientists estimate the success of their algorithms in a jargon that only they speak: *accuracy, train/split, cross-validation, etc.* On the other hand, municipal institutions want to know *how many years it will take to make up for their infrastructure deficit*. In order for these two to communicate, performance metrics need to be translated into a measurable ROI for municipalities, which is not easy to do in terms of risk management.

Conclusion

Water management is a complicated challenge, and recent progress in artificial intelligence could clearly help with part of this. But even today, some reactions remind us of Philip Thicknesse's reaction when faced with the *Mechanical Turk.* However, realistically speaking, we are in the AlphaGo era.

In conclusion, even if AI has come a long way, there are still several challenges to address. This article presents some food for thought for us to be able to fully take advantage of the data revolution to optimize one of our most precious resources: blue gold.

Additional Reading

https://fortune.com/2019/11/12/in-ai-era-human-judgment-matters-eyeonai/

https://www.journaldequebec.com/2019/11/19/infrastructures-municipales-45-m-par-an-a-injecter-pour-rattraper-le-deficit-dentretien-a-quebec

https://hbswk.hbs.edu/archive/turning-on-the-tap-is-water-the-next-oil

Naysan Saran *is the co-founder and CEO of CANN Forecast (CANN), a startup based in Montreal, that helps municipalities transition towards a proactive approach to water management. The startup was founded by the winning team of the 2016 AquaHacking challenge. CANN is now collaborating with partners such as the Montreal Institute of Learning Algorithms McGill University, as well as municipalities such as of Montreal, Gatineau, Windsor and Halifax. Prior to founding CANN, Naysan worked as a scientific programmer at Environment Canada. Naysan holds a background in both Computer Engineering and Mathematics, and is passionate about using artificial intelligence to help solve environmental challenges.*

Waste Management

A city's sanitation is at the root of urbanism. And rightly so, it's the first problem that pre-urbanists thought about. We also find reflexions on the cleanliness of cities in the writings of Etienne Cabet[75], Benjamin Ward Richardson[76], and even Jules Vernes[77]. These written texts speak to the sanitary urgencies of their time. Overpopulation, the rampant spread of cholera and filthy streets went along hand in hand with the development of industrial cities. The Hausmannian renovations, during the Second French Empire, were specifically created to combat this phenomenon.

The reason that the streets in developed cities look nothing like they did in Paris in the 19th century is because sanitation became priority, and even became a controversial subject for municipal governments and citizens (especially in cities with a high level of tourism). To that extent, Urban AI can be used to map out street cleanliness. Scientists from Ecole Polytechnique of Lausanne have therefore refined an **algorithm that is capable of identifying and classifying waste**. This technology can be used to estimate the city's cleanliness in real time and analyze data records in order to identify recurring issues. An important aspect to mention is that collecting this data can be done in two different ways:

- Top-down: The city or the private company in charge of waste management on the street uses cameras equipped with a trash-recognition software on garbage trucks. This is what the startup Cortexia has built.
- Bottom-Up: Citizens have access to a mobile application and can take pictures of garbage in the street (that is automatically identified) and can therefore "crowdsource" street cleanliness. This is an example of the startup Literatti's services.

This data can then be used to create **a sanitation index per street or neighborhood**. In addition to optimizing urban sanitation, this practice allows us to rationalize it. Like Georges Vigarello showed us, the notion of "sanitary" differs among people and cultures[78]. In this context, the sanitation index is an objective indicator that contributes to de-escalating the debate about urban cleanliness.

Identification and classification of garbage contributes to other solutions, which include:

- Waste separation assistance: In Toronto, **Intuitive** developed a solution that helps users sort their garbage. A user can simply point their camera at the garbage they want to throw away and the application almost instantly indicates which trash can the garbage should be thrown away in. This technique can also be used at the other end of the recycling

75 E.Cabet, *Voyage en Icarie,* (1840)

76 B. Ward Richardson,Hygeia, (1876)

77 Jules Verne, *Les Cinq Cents Millions de la Bégum,* (1879)

78 Georges Vigarello, *Le propre et Le Sale; l'hygiène du corps depuis le Moyen-Age,* (1985),

chain. In Amiens, in France, Veolia uses the Max AI robot to improve recycling efficiency in its recycling center. Max AI was in fact able to recognize and automatically sort garbage.

- Automated cleaning robots: Automatic garbage identification can contribute to automating street cleaning vehicles. This innovation could open the door to other transformations. Because street cleaning vehicles need to transport people, their design was naturally inspired by cars. If this is no longer a requirement, autonomous cleaning vehicles could evolve and become the more adapted robots for an urban morphology.

On another note, Urban AI can contribute to the creation of "circular cities". In other words, cities that use the circular economy model (favoring recycling to linear creation, transforming waste into compost or into energy,...). In London, the Centre for Advanced Spatial Analysis (CASA) also developed a bio-inspired algorithm to optimize industrial symbioses[79]. An industrial symbiosis is an ecosystem of companies that exchange waste flow between each other and re-use it according to their industrial activity. Furthermore this is referred to as an eco-industrial park. The city of Kalundborg, in Denmark, uses this kind of area. Today there are roughly 30 different exchanges between members that save a total of 15 million dollars each year. **In China, in the eco-industrial park REDA, construction plants benefit from 66 000 tons of fly ash that are later used as construction materials.** The difficulty with industrial symbiosis is that it takes time to create them, classify them beforehand (to identify what waste is absorbable and what should be rejected) and implement a supply chain and logistics that are particularly efficient (to create a cost-effective waste flow). This is where CASA uses AI to simulate several configurations for eco-industrial parks (geographic location, industrial grouping factors, transportation costs,...) and identify those that maximize the profits for all participants. This model is even more interesting because the industrial symbiosis principle could be applied to an urban system. In this new paradigm, participants would not be industrial companies, but regular companies or individuals. The French application Too Good to Go opens up the possibility of this practice.

Organic waste is an equally precious energy source. It is possible to use it to create biogas using a methanation process[80] [anaerobic digestion] or promoting microalgae growth (which then produces biomass)[81]. In each of these cases, AI can be used to optimize these particularly complex processes. It allows us to predict daily waste flow, determine the best place to set up these production factories and facilitate the implementation of this kind of energy into the smart grids[82].

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79 Juste Raimbault, Joris Broere, Marius Someveille, Jesus Mario Serna, Evelyn Strobom, Christine Moore, Ben Zhu, Lorraine Sugar, *A spatial agent based model for eco-industrial systems*

80 This is one of the propositions of Sidewalk Labs in it's urban planning for the Quayside neighborhood in Toronto. For more information **click here**.

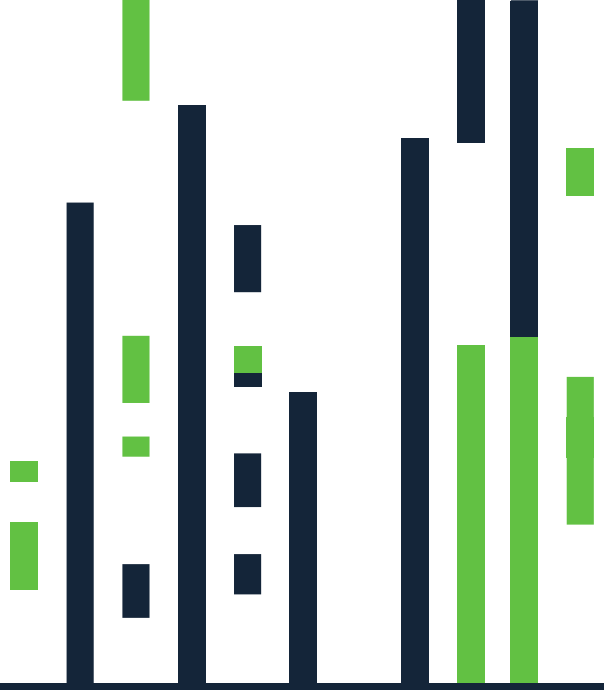
81 Daniel Castro-Lacouture, Steven Jige Quan, Perry Pei-JU Yang, GIS-BIM *framework for integrating urban systems waste stream and algal cultivation in residential construction*

82 *Ibid*

The “circular city” challenges us to look at society and our consumer behavior in a new way. Moreover, it is important to note that this concept applies to a large number of biomimicry innovations. Industrial symbiosis, methanation of waste as well as compost are all phenomenons that were inspired by organic processes. All this reminds us that our best hope for fighting the climate change urgencies is still nature.

Food

For this section, please see Haibei Peng’s contribution.



A Foodie’s Today and Tomorrow

Haibei Peng, Architect at Google R+D for the Built Environment

If given the choice, do you want a robot to make your food, serve your food, or both? This has become a real question for the restaurant industry in San Francisco with emerging startups working on robots that begin to revolutionize the food industry. As a foodie living in San Francisco, I've been surrounded by some of these restaurants and services, and the results have been a little surprising.

When I first heard about the idea of introducing technology into the food industry, my initial reaction was that machines would quickly take over operational jobs like cashiers or waitresses to reduce business labor cost. In fact, this was what the company "Eatsa" did starting in 2015. In their "restaurants", customers order customizable quinoa bowls from their phone or a kiosk in the store. Food appears behind glass in a cubbyhole with the customer's name. There's no cashiers and customers do not need to take off their headphones to talk to anyone from ordering to getting their food. While it allowed for efficiency, some customers became upset after they found out there were back-of-house human workers preparing their bowls, put the bowls into the cubbyhole but never see the customers or receive any tips. There's a sense of isolation when eliminating any form of communication and connection between the customer and the making of the food. By 2019, all Eatsa stores have closed as the business focuses solely on being a platform provider instead of being the cook as well.

So rather than hiding workers backstage and automating the front of the house, new automated restaurants flipped the system-- to have food be served entirely by humans, but cooked by robots. I first walked into Creator-- a burger-making robot restaurant in downtown San Francisco during Friday lunchtime and there was a line out of the door. The line moved quickly and customers were greeted by friendly cashiers taking orders on an ipad while explaining to all the first-timers the difference between burgers the robot can make and the serving process. After placing the order, I walked inside to find a crowd of audiences standing in front of an impressive "robot cook" efficiently warm the bun, slice, cook and put on all the ingredients one by one. The whole process took less than 5 minutes before I received my $6 burger, which is well done and cheaper than any other burger you can get in this city. The crowd of customers held their phones high to take pictures and videos of the robot cook while they chatted with each other and enjoyed their casual lunch in this excitement of watching food being made by a robot. This is the type of experience desired today-- a type of human interaction facilitated by robots.

All these forefront projects lead more public interests into the robot-food industry as more and more related projects happen behind the scenes. Take a step further than robots, can AI be used in the food industry? Can AI learn our taste? The company "Tastry" combines analytical chemistry, flavor preferences and machine learning to track consumer preferences and recommend what individuals would prefer. "Dodo Pizza AI" learns to find non-obvious connections between pizza ingredients to help pair and influence orders. Can AI help with food sourcing and nutrition tracking? The company "Whisk" connects food, recipes and products, and maps ingredients to store items while tracking food properties. Entrepreneurs continue to find new ways to use AI to help advance our food industry.

However, I truly hope the impact of AI with food is not just limited to majestic robot cooks and targeted advertising. Can it help us solve some more essential problems such as helping with poverty, food safety and access to food? Recently, with the spread of Coronavirus around the world impacting millions of people's access to food as cities and neighborhoods being under quarantine, an old research I saw years ago at the MIT Media Lab came to mind. How wonderful would it be if we can have all our food grown in a lab at home with AI teaching them what to grow and how to grow the most delicious food. The Media Lab research on "personal food computers" presented the idea on a device that uses robotic systems to control and monitor climate, energy and plant growth inside of a specialized growing chamber. It's supposed to be able to support anyone anywhere in the world and by being open source, supposed to collect data and learn from them to help grow the best plants under any environment. Unfortunately, the project seems to have gone on pause for various reasons, but the potential such projects present remains inspiring.

I grew up in a farmer's family. Since I was young, I learned the importance of storing seeds, and the danger of natural disasters and plant diseases. With the world's growing population and increasing demand for fresh healthy food, could AI help decrease some of these risks? Can we teach AIs to recognize and discover diseases in an earlier stage more efficiently and accurately than humans? With global warming and changing climate around the world, can we teach AIs to adapt farming techniques to new environments? With desire for healthier food and less use of chemicals, could AI help with pest control such as the locust swarms ravaging east Africa right now?

In the end, I'm no expert in AI, but just a foodie living in San Francisco with lots of questions and hopes. I am seeing different ways robots and AI are starting to help us taste more healthy, nutritious and delicious food today, and hope it can continue to help solve some of the world's most fundamental food problems tomorrow.

Haibei Peng *is an architect, fabricator and storyteller based in San Francisco. She has a background in economics and anthropology, and likes to explore design and place-making with an interdisciplinary approach through story-telling and creative representation. Her past and current research focuses on memory and the built environment in various cultural settings. She currently works as a project architect at Google R+D for the Built Environment.*

URBANISM AND ARCHITECTURE

CONTRIBUTIONS

From Smart Cities to Street Knowledge,
Ariel Noyman, MIT Media Lab

A Dilemma for Our Times,
Michael Batty, Chair of the Centre for Advanced Spatial Analysis (CASA)

A City's Biology Has Yet to be Invented,
Thierry Gruszka, Senior Technology Manager at Cisco

From Smart Cities to Street Knowledge

Ariel Noyman, MIT Media Lab

"You're about to witness the strength of street knowledge"
NWA, Straight Outta Compton, 1988

The current phase of the information revolution marrys bits and bricks, code and concrete. After taking over the *cloud* and the internet of all *things*, cities became the next target for nano-metric silicone and futuristic algorithms. As with their predecessors, the phone, the watch or the washing machine, cities added 'smartness' to their brand, distancing themselves from centuries of being, well, dumb. But beyond these trends and marketing stunts, can modern tech truly help us recenter cities around humans, one bit at a time?

Outsmarting

For urban decision-makers, the Smart City movement came at the right time. As the world urbanized population crossed the 50% threshold, and some cities grew tenfold their size in less than two decades[83], urban leaders had to consider unconventional solutions. The massive movement of population into cities turned high-valued land into notoriously expensive, and struggling urban systems to borderline useless. Countless new projects, from infrastructure to housing to amenities, were needed to support millions of urban migrantes. These developments often had to be planned, constructed and populated in heist, while skipping legacy urban processes and proper due-diligence[84]. Under pressure, health-driven zoning laws and community-centered building-codes were put aside in favor of optimizing space, productivity and yield.

Amidst these challenges, urban decision makers got captivated by the promise of smarter, more efficient and better controlled cities. Instant optimization of roads, buildings, grids or pipes through sensors, cameras, and of course - AI, became the go-to solution for hundreds of cities worldwide[85]. Billions of dollars changed hands, sci-fi command & control centers were erected in municipalities and the word 'smart' was etched next to the city's name. Perfumed with the scent of fresh gadgets, Smart City solutions offered elected officials a fast, cheap and easy escape route[86]. But at what cost?

Lost in the transition

As happened time and again during the 20th century, the attempt to tame the city was often deemed to failure. In the past, cities were restrained and molded using bricks-and-mortar, with which success or failure could only be measured after a long period of time. Smart Cities advocates for a 'softer' type of control, but growing concerns over the short-sighted nature of technological

83 Glaeser, Edward L., and Matthew E. Kahn. "Sprawl and urban growth." In Handbook of regional and urban economics, vol. 4, pp. 2481-2527. Elsevier, 2004.

84 Assembly, General. "sustainable Development goals." SDGs), Transforming our world: the 2030 (2015).

85 Silva, Bhagya Nathali, Murad Khan, and Kijun Han. "Towards sustainable smart cities: A review of trends, architectures, components, and open challenges in smart cities." *Sustainable Cities and Society 38* (2018): 697-713.

86 Anthopoulos, Leonidas G. "The Smart City Market." In *Understanding Smart Cities: A Tool for Smart Government or an Industrial Trick?,* pp. 187-213. Springer, Cham, 2017.

dependency might already hint to a grim density of urban-tech. Too often, Smart Cities solutions tend to lack a fundamental understanding of what drives change in the city, and instead focus on micro-optimizations of broken systems. Cities are in a constant mode of change, bringing them closer to living organism than to predictable machines. For that reason, attempts to 'solve' the city while favoring top-downed, monolithically conceived solutions, will most likely fail as soon as *humans* are added to the equation. The ever changing needs of groups and communities in cities are hard to predict, and impossible to fit into a function.

The general tendency towards Smart Cities is often binary: its advocates tend to observe technological solutions as the one silver bullet needed to futureproof the city. On the other hand, opposers often dismiss technology as a whole, while nostalgically embracing legacy processes. But what if instead of focusing on 'solving' the city, technology could be effectively harnessed to engage some of the more fundamental issues of citizens? What if we can marry technology and traditional, human centered processes in order to better shape our cities?

Towards Street Knowledge

In recent years, a global movement of urbanists, scientists and decision-makers was formed to explore new ways in which wider crowds than ever could have an active role in shaping their cities[87]. This approach utilizes technology not in order to 'fix' the city, but instead to augment traditional urban processes with the tools and data available today. This effort is focusing on two aspects: first, balancing the discourse around the built environment, so that both experts and the general public can have their voices heards. Second, constructing an evidence-based, data-driven urban decision-making processes, expedited through the usage of modern methods and tools. This attempt aims to harness the good in both worlds: From the world of Smart Cities and urban-tech, this effort inherits the systematic, scalable, evidence-based and data-driven approach; From traditional urban processes, this new model adopts the comprehensive, long-term, and community driven attitude.

In the past few years, my team at MIT joined this momentum through the design, development and deployment of the CityScope platform[88]. CityScope is an open-source[89], urban modelling and simulation tool which aims to marry traditional urbanism with modern tech. It is built by a growing number of urban-enthusiasts that share a mutual goal to construct human-centric, collaborative urban processes. CityScope is being deployed all around the world to tackle fundamental questions affecting residents, planners and decision makers: what is the right balance of development, services or amenities in our neighborhood?

87 Harrison, Colin, and Ian Abbott Donnelly. "A theory of smart cities." In Proceedings of the 55th Annual Meeting of the ISSS-2011, Hull, UK, vol. 55, no. 1. 2011.

88 Noyman, Ariel. "POWERSTRUCTURES: the urban form of regulations; Power structures; Urban form of regulations."thesis, MIT, 2015.

89 **https://cityscope.media.mit.edu**

How do people move, observe or use our city? How might a change affect our urban experience?[90]

To achieve these goals, CityScope is designed as a hub that aims to gather the best tools, models and methods available for tackling urban questions: from transportation and energy to innovation potential and behavioral patterns analysis. But where CityScope truly shines, is in the multi-party engagement and collaboration process it embodies. Since its inception in 2013, CityScope was fundamental in several urban processes ranging from finding refugee housing in Hamburg[91], to consensus building for transit planning in the US[92], to predicting tourism patterns in Andorra[93] or re-thinking urban design competitions in Europe[94]. What unifies these diverse deployments of CityScope, is the focus on the general public's understanding of change in the tactile and tangible realms of their cities, neighborhoods and streets.

As time passes, and the hype-cycle of many urban technologies begins to descend, it's clearer that the future of our cities is not to be found in any specific technology. Great cities flourish with or without technology while poorly-designed ones would not recover simply be naming themselves as 'smart'. It is however possible, that for the first time in the history of urbanism, modern technology could help leaders, planners and the general public to construct new processes and discourse through which they shape their cities. Whether they are AI, IOT, cloud or the yet-to-be invented technology, our goal as the research community is to provide the best tools possible, while framing them not as the 'elixir of cities', but as mediums for constructive urban processes.

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90 Alonso, Luis, Yan Ryan Zhang, Arnaud Grignard, Ariel Noyman, Yasushi Sakai, Markus ElKatsha, Ronan Doorley, and Kent Larson. "Cityscope: a data-driven interactive simulation tool for urban design. Use case volpe." In *International Conference on Complex Systems, pp. 253-261. Springer*, Cham, 2018.

91 Noyman, Ariel, Tobias Holtz, Johannes Kröger, Jörg Rainer Noennig, and Kent Larson. "Finding places: HCI platform for public participation in refugees' accommodation process." Procedia computer science 112 (2017): 2463-2472.

92 Doorley, Ronan, Ariel Noyman, Yasushi Sakai, and Kent Larson. "What's your MoCho? Real-time Mode Choice Prediction Using Discrete Choice Models and a HCI Platform." (2019).

93 Noyman, Ariel, Ronan Doorley, Zhekun Xiong, Luis Alonso, Arnaud Grignard, and Kent Larson. "Reversed urbanism: Inferring urban performance through behavioral patterns in temporal telecom data." Environment and Planning B: Urban Analytics and City Science 46, no. 8 (2019): 1480-1498.

94 **https://www.grasbrook.de/wp-content/uploads/2019/11/Upload__Grasbrook_Auslobungsbroschuere.pdf**

Ariel Noyman *is a PhD candidate at the* ***MIT Media Lab City Science Group,*** *a lecturer at Northeastern University, an architect and an urban designer working to fuse cities and technology. His research is on* ***novel methods*** *for urban modeling and simulation,* ***future mobility*** *and* ***decentralized participation****. In recent years, Noyman coordinated and deployed a worldwide network of City Science Living-Labs (in* ***Boston, Hamburg****, Shanghai,* ***Andorra*** *and Helsinki to name a few) in an effort to confront his lab's work with real-world challenges.*

Noyman's work received awards and recognitions from the ***European Commission, the OECD****, the Israeli Gov., was featured by* ***The Guardian, 60 Minutes, The New York Times*** *and was displayed in exhibitions, conferences and summits worldwide. Noyman received his Master's of Science in Architecture and Urban Design at MIT, where he was also a researcher at the* ***Center for Advanced Urbanism****. Prior to MIT, Noyman graduated from the School of Architecture at Bezalel Academy of Arts & Design, Jerusalem (cum laude), where he later held an Adjunct Professor position. Noyman is now an Adjunct Professor of architecture and urbanism at Northeastern University, where he teaches design workshops on architecture, micro-housing, and urban design. Since 2006, Noyman has practiced in leading architecture and design firms in the US, Europe, and Israel, while developing an independent body of work through projects, competitions, research and exhibitions.*

Augmented Urbanism

As Ariel Noyman mentioned in his article, AI make "augmented urbanism" possible. There are 2 characteristics:

1. Balancing the discourse around the built environment, so that both experts and the general public can have their voices heard.
2. Constructing an evidence-based, data-driven urban decision-making process, expedited through the usage of modern methods and tools (Ariel Noyman).

In addition to Cityscope, several other projects in the world used augmented urbanism.

In Singapore, the Future City Laboratory (ETH of Zurich) developed the software **Ideas for Tanjong Pagar**. This software is available online and uses the Tanjong Pagar Terminal (a part of the singaporian port) as a "game space" with which users can design their ideal neighborhood (like in *SimCity*). Moreover, players can add parks, housing or even sports complexes. The designed spaces are then analyzed to identify patterns (create models) and take into account the locals' ideas for urban development. This initiative is a part of the interdisciplinary project "Big Data Informed Design and Governance" which, via 5 workshops, participated in the creation of augmented urbanism[95].
One of the goals of the project "Big Data Informed Design and Governance" is to identify urban consistencies. In other words, to identify laws that dictate city development. To do this, the teams at the Future City Laboratory aggregated and analyzed behavioral data from several regions around the world (Portugal, Boston, Singapore,...). These researchers were able to establish a mathematical relationship between the attractiveness of a space and its accessibility[96].

Interestingly, Future City Laboratory's goals are similar to those of MIT Media Lab. Alex Pentland, Director of MIT Connection Science, illustrated how Data-mining and Reality-mining can enrich "social physics"[97]. This discipline, which was inspired by Montesquieu's work[98], seeks to predict **socio-economic phenomena:**

- **Social:** In Amsterdam, Delft University of Technology collaborated with the Amsterdam Institute for Advanced Metropolitan Solutions (AMS) to develop the platform **Socal Glass**. It uses Web Mining on social networks[99] (Twitter and Instagram) to better understand how individuals use the city. In order to do this, Social Glass collects different kinds of data:

95 Pieter Hertogs, Fabien Clavier, Katja Knecht and Gerhard Schmitt, *Big Data Informed Urban Design and Governance*

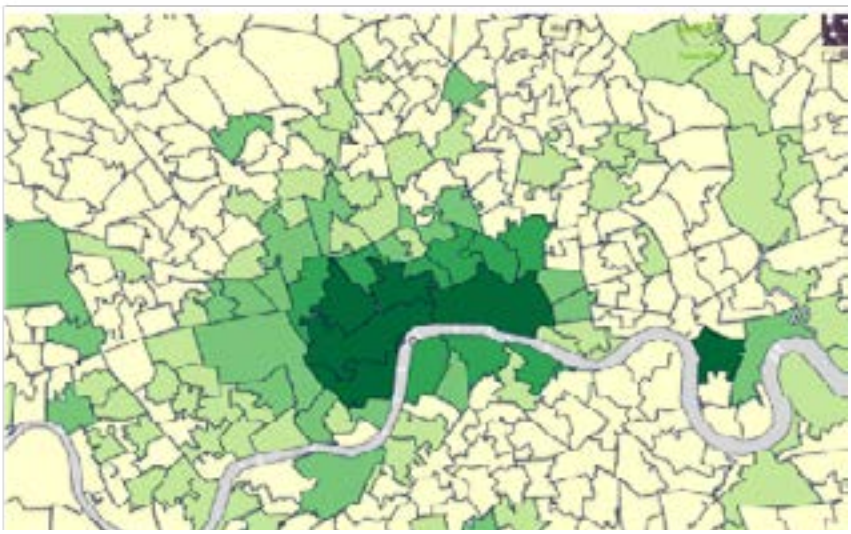
96 *Ibid:* "We derived a first principles argument stating that the number of visiting individuals should decrease as an inverse square of the product of travel distance and visitation frequency; or, equivalently, as a power law whose exponent is≈−2."

97 Alex Pentland, *Social Physics,* (2014)

98 Montesquieu, *The Spirit of Laws* (l'esprit des lois) (1748)

99 To learn more about how web-mining works on social media networks, please see the "Resilience" chapter (Resilience and Biodiversity)

images and unstructured texts, all of which are geolocalized. The platform can moreover calculate the popularity of an area, the demographic composition of a neighborhood as well as tourist flow (and their individual countries of origin)[100]. This data enables us to anticipate areas that may become crowded or congested and see how the city is perceived by its inhabitants. What's more, in London, CASA created **QUANT,** an algorithm capable of simulating the population distribution in an area after an economic event (job creation, company layoffs,). By analyzing the mobility network of a city and it's housing policies, QUANT is able to notify, among other things, gentrification trends.



Social Glass analysis of Amsterdam (source **https://social-glass.tudelft.nl/***)*
et QUANT analysis for London (source **http://quant.casa.ucl.ac.uk/***)*

- **Economic:** Alex Pentland showed how behavioral data analysis can be used to measure the economic state of an area and even predict the it's GDP growth[101]. Similarly, the startup Aretian uses AI to identify the

100 *Social Glass A Platform for Urban Analytics and Decision-making Through Heterogeneous Social Data,* Stefano Bocconi, Alessandro Bozzon, Achilleas Psyllidis, Christiaan Titos Bolivan and Geert-Jan Houben

101 Alex Pentland, *Human Interaction, Idea Flow and Wealth Generation,*

economic identity of a city. This is what Ricardo Hausmann called "know-how". In other words, a body of knowledge that can be used by a city to produce wealth. For instance, some areas are "industrial", "governmental", and others "academic" etc. Each kind of area has its own demographic, social and financial characteristics[102]. Equipped with this knowledge, a city can conduct urban development projects and investments to renew (like Pittsburgh did in it's industrial areas[103]) or re-orient the know-how of an area (like Boston did with Kendall Square[104]). This practice opens the door to an enlightened urbanism where the economic complexities of a city can become a source of fulfillment and prosperity.

Overall, AI can help an urban planner determine the optimal layout for an area or a city. Generative Design is the kind of AI used for this type of project. Using physical capacities and objectives (as *inputs*), this technology simulates thousands of scenarios that apply to certain situations. Generative Design can moreover create several urban configurations that reduce the heat island effect, **decrease density in an area** and/or improve its breathability. This technique in particular was used by Autodesk for designing a residential neighborhood in Alkmaar, in the Netherlands[105]. Here, Generative Design allowed them to determine different scenarios that maximized both profitability of the project and renewable energy production for the neighborhood (using solar panels). We will go over Generative Design more in detail in the "AI and Architecture" section.

Augmented Urbanism is creating a revolution. Traditionally, physics was distinguished from social sciences by its ability to *predict* a phenomenon. It owes this ability to an inalterable force: gravity. More precisely, the discovery of the laws of gravity. On the other hand, social sciences are not based on fundamental principles. They explain a world without a dropping point, a certain "weightlessness." But AI seems to change this epistemological condition. *Machine Learning* can more accurately predict an individual's personality[106] than it can predict climate-induced events. Are social sciences in the midst of their "newtonian revolution"[107] because of AI? If we don't have an answer to this question, let's remind ourselves that the first thing that man did when he discovered nature's secrets was to enslave it.

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102 Jeremy Burke and Ramon Gras, *The Atlas of Innovation Districts,*

103 *Ibid*

104 *Ibid*

105 Danil Nagy and Lorenzo Villaggi, *Generative Urban Design: Integrating Financial and Energy Goals for Automated Neighborhood Layout,*

106 Wu Youyou, Michal Kosinski and David Still well: *Computer-based personality judgements are more accurate than those made by humans:* An AI can identify an individual's psychological profile with 95% precision.

107 For more on this question, see M.Batty's contribution: *A Dilemma for Our Times*

A Dilemma for Our Times

Michael Batty, Chair of the Centre for Advanced Spatial Analysis (CASA)

We cannot predict the future of cities, all we can do is invent them. But we cannot predict what we will invent. Will AI Help Us?

The conventional wisdom of science is that the future is unpredictable. This perspective which was thrown into stark relief in the middle of the last century by the philosopher Karl Popper is based on the very obvious notion that at any point in time, individually we assume we are in control of our own destiny. We may not be for we may be subject to what we consider to be forces beyond our control but at least *en masse* we are not able to predict our individual actions. I may be able to predict my own but there is no way I can predict yours and this is the dilemma that has slowly changed our view of prediction over the last hundred or more years.

One may object to this blanket assumption of inherent unpredictability. We can surely make predictions if we isolate a system from its wider environment in such a way that we remove any extraneous events, thereby enabling every element of its form and structure to be determined, hence knowable. It is easy to see in social and some natural systems that this can never be the case because our very definitions of what constitutes the subject matter is subject to ambiguity. Such systems are ill-defined and will never be otherwise. In physical systems, the only way we can predict is to control every element in a laboratory setting, thus observing the laws of physics in an entirely controllable manner. Popper himself made this point many times, particularly in his seminal book *The Logic of Scientific Discovery* (Routledge, 1934 and 1957) where he argued that our initial success in constructing a science of mechanics was to develop and test it on a relatively isolated system; and it is no accident that Newton did so on sets of observations drawn from our own solar system. Even that is not completely isolated as subsequent better and more applicable theories, not least relativity theory, have made clear.

The dilemma that we face is that in human systems, particularly cities, we need to think about them in the future for these are the environments that we create and which dictate our quality of life across every dimension one might think of. In short we have the power to at least think about what the future city will be like, even if we do not have the ability to invent it. On the way to this future, it is somewhat obvious that we would like to predict what this future might be like for the time-honoured way in city planning is to see what the future looks like and to create a plan that does better than this. This is based on the notion that any prediction we make is not likely to solve all the problems that motivate us in the first place for if our predictions did not reveal any of these problems, we would hardly want to invent a better city. Indeed much of city planning in the last 150 years has been predicated on this basis for improving the quality of life in the industrial city.

There are varying views of course about the predictability of the future when it comes to social systems such as cities. Some argue that the further into the future we look, the more likely it is that our predictions will be wrong; in other words, that short term predictions are more likely to be correct because bigger changes take longer to play out. Of course there is much anecdotal evidence

to show that this conclusion is wrong. Unanticipated massive changes can happen at any time and there is nothing in the structure of the modern world, physical, natural and social, that suggests that changes in the long term are likely to be more different or bigger or smaller than those in the short term.

Moreover many have reflected on the stability of prediction where it is now widely assumed that when it comes to the future, we cannot predict, we can only invent it. But there is a twist in the tail. *Although we might be able to invent it or at least principle we can, we are not able to predict what we might invent.*

There is another feature of the cities that confounds our ability to predict and even invent. It is now very clear that as populations have grown inexorably over the last 10,000 years and as the world at least from the 16th century has become ever more complicated as we have invented more and more technologies, then our theories of how the city works always lag behind what is happening to their form and function. In short as cities are complex systems, they defy understanding largely because they are open to their wider environments and therefore our predictions are always of the 'what if' variety, our forecasting procedures being contingent on what we see which is always less than what there is.

We have come to these realisations after many years of thinking about what the city is and what its future should be like. 100 years ago, dreams about what future cities might be like were largely figments of rich imaginations mainly in terms of visual and geometric pictures of the future. Ideas about how complex systems like cities were organised and functioned in space and time have introduced a little humility into what we are now able to do with respect to inventing better cities. Yet into this scene have come new ideas that somewhat fly in the face of the limitations that we have obsessed about here. There are two major forces that have the potential to change the conventional wisdom pertaining to prediction we have just outlined. The first is the smart cities concept and the second is AI and we will elaborate these in turn in a most inconclusive way.

The smart cities movement is very much in the spirit of invention, masquerading under the banner of producing better predictions which reveal problems which can be solved by embedding computers into their fabric so that we can exercise better control. The irony of all this is that it is naïve. It does not recognise the increasing complexity of cities, nor does it grapple with how we generate a better future for cities. Our second theme locks with smart cities in a superficial way in particular with respect to developing models of cities which rely on the real time focus of the smart city, thus generating big data which in principle has the potential for unravelling the deep patterns that are assumed to underpin the way cities develop and evolve. This of course is AI. What is different and exciting is that these developments of massive data about what happens in the very short term city – the high frequency city – may hold the key to understanding new relationships which we wish to tease out when it comes to how cities work. We do not understand much of this at present, but there is the distinct possibility that there are no deep patterns to be discovered that we do not know about already. The problem with the kind of weak AI that has developed is that

If you do not go in there with some theoretical preconceptions, you are not likely to come out with any.

The big question then is will big data combined with AI enable us to break through the prediction barrier, and generate new and powerful theories that will guide us to invent better futures? This relates to another issue and this concerns the theories we have about the city which we have implied have become ever more irrelevant as the complexity of cities has increased. Will AI begin to reveal order in patterns of our own behaviour? These are patterns we ourselves are unable to understand without the kinds of deep learning that are needed to unravel structure in the great tranches of behavioural data that are now being generated in the smart city. Frankly we simply do not know but these are the questions we must ask ourselves and we urgently need some answers.

I have elaborated some of these ideas in my recent book Michael Batty**,** *Inventing Future Cities,* The MIT Press, 2018.

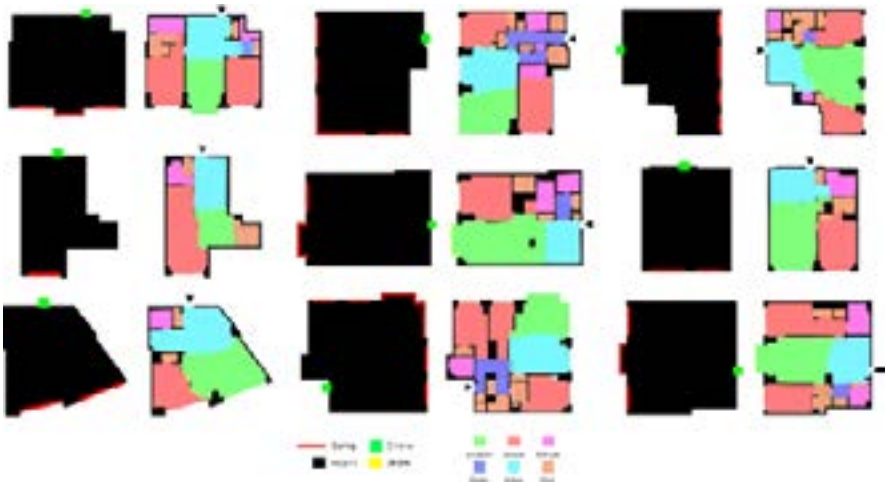
Michael Batty *FRS FBA is Bartlett Professor of Planning at UCL where he is Chair of the Centre for Advanced Spatial Analysis (CASA). His work is focussed on computer models of cities and their visualisation, and more recently how computation lies at the heart of the smart cities movement. His most recent books are* ***The New Science of Cities*** *(2013) and* ***Inventing Future Cities*** *(2018) published by MIT Press. Both have been translated into Chinese. You can follow his research is at* ***www.spatialcomplexity.info****.*

AI and Architecture

We illustrated earlier how Generative Design augmented urbanism. This technology can also be used to optimize the creation process for architectural forms[108]. In order to do this, AI starts by learning what architecture is.This learning is done in phases: the AI will first learn to draw a building, then a floor, the surface area of an apartment, its layout and finally the way furniture is placed in a room. In each of these steps the type of AI used is the GAN (*Generative Adversarial Network*). What makes this technology unique is that it is composed of 2 algorithms: a generator and a discriminator. The discriminator was programmed to recognize architectural forms. The generator, on the other hand, generates the forms. Depending on whether those forms look similar to the discriminator's projections, the generator will be sanctioned or rewarded (we're referring to unsupervised learning). It refines its production model by using the interactions with the discriminator in order to be able to create satisfactory architectural forms.

Once this learning phase is complete, AI is able to assist the architect. He/she can ask it to produce architectural forms that respect the parameters of their project (a certain ceiling height, using certain kinds of materials, a precise amount of pieces, etc.). According to the outcome, the architect can reconfigure (or not) the algorithm's settings until they get the form that they want. The iterative creation process where the "augmented architect" moves forward little by little, allows it to preserve their liberty and style: "By selecting the result of a model and by modifying it, before sending it the next model, the user remains in control of the creative process. This action shapes and orients each step of the plan, and moreover illustrates the desired human-machine interaction." (**Stanislas Chaillou**).

Below an AI generates different room layouts according to designated floor plans.
Source: AI & Architecture, Une Perspective Expérimentale, Stanislas Chaillou.



AI also has other advantages for architects. More specifically, it can analyze, in just a few seconds, the physical properties of an architectural form (the

108 Stanislas Chaillou, *AI+ Architecture, Towards a New Approach,*

amount of sunshine in a room, the acoustics of a building, etc.) as well as its style. This, among other things is what the startup Spacemaker offers its clients. It also uses Generative Design to optimize the creation processes. In addition, Spacemaker was able to significantly improve its architectural plans while reducing their construction time from one year to three months.

Using Generative Design, Autodesk created seat brackets that were **20% lighter and 40% more resistant** for General Motors. In this regard, this technique opens the door to wonderful architectural possibilities. Generative Design could contribute to creating low-carbon habitats, resilient structures and even organic buildings.

Invisible Cities

Our cities co-exist with "invisible cities". We can distinguish two types of "invisible cities":

- The Digital twin[109]: This is created using data collected and aggregated around an area, an infrastructure and/or a use (Online mapping, BIM, behavioral analysis platforms,). The digital twin reproduces an urban space. These twins are "invisible" because they are unnoticed by a city's inhabitants. Most of the time they only see them when it comes to economic outcomes (a price, an itinerary, a *nudge*) or urban outcomes (traffic fluidity, optimized infrastructures,).
- The digital city ("cité digitale"): This implies a compilation of social media and social sites. Unlike the digital twin, the digital city *creates* a city apart from the city. It is furthermore possible to walk around, meet other people and even visit areas in this digital city. In this case, the digital city is invisible because it is virtual.

Our cities and the "invisible cities" are deeply connected. The Arab Spring or even the Occupy Wall Street movement showed how a digital city could get involved in the real city. Inversely, urban phenomenons (congestion, sporting events, parades) all influence navigation applications as well as social media activity and content.

The first consequence of this interdependence is that "invisible cities" transform our urban uses and ultimately our sociability. For more on this point, please see King Wang Poon's contribution that shows how we can use digital technologies to enrich, not degrade, our urbanity[110].

What's more, these invisible cities have an intrinsic tendency to produce "transparent cities". In the publication *The Crisis in Culture* (1961), H.Aredt explained that invisibility is the way in which a surveillance system interacts with citizens: seeing without being seen. This idea was reiterated a few years later by M.Foucault in *Discipline and Punish* (1975) with the example of Panoptique

109 On this topic, see Thierry Gruzka's contribution: *The "Biology" of cities is yet to be invented*

110 Found in the "Recommendations" chapter

(prison architecture that allows the guards to watch the prisoners without them knowing). The invisible city is a part of the continuity of this political idea. But while the Panoptic controlled bodies, invisible cities monitor concsiousness: **peoples' personality or even their intention to do something** is transparent to well-trained AI. This surveillance relationship between our cities and the invisible cities is reminiscent of Vladrade, the city invented by Italo Calino:

"When the travelers arrived they saw two cities: one that rose above the lake and the other, inversely, that was reflected. One didn't exist or could happen in one Valdrade without the other Valdrade repeating it, because the city was built in such a way that every point had to be reflected by its mirror, and the Valdrade that is below the water contained not only all the grooves and carvings on the facades that were above the lake but even inside the apartments with the ceilings and floors, the perspectives from the corridors, the mirrors on the armoires. The inhabitants of Vladrade knew that each of their acts would be acted out itself in addition to its mirror image, which possessed a particular dignity to its images and wouldn't allow their consciences to abandon the act whether it be unintentional or because of forgetfulness"[111].

Similar to Valdrade, our cities are reflected in a lake of data (Data lake). With the one difference being that we don't have access to our reflection.

Overall, these "invisible cities" produce an invisible urbanism. Consumed by their smartphones, individuals are smombies that are no longer sensitive to urban beauty[112]. Over-optimized thanks to the digital twin, our cities become fluid, service-oriented and "user-friendly". "User-friendly" because in this case, the city functions the same way an ergonomic application does: frictionless[113]. Whereas a space without friction is often used but rarely inhabited. In this aspect, urbanity causes friction above all else. A city is characterized by its ability to cause and produce the unexpected. In this way, a city needs to stay a place where people and ideas meet, at the risk of sometimes causing sparks.

Digitizing cities needs to be accompanied by a digital "urbanization" (Sakia Sassen)[114]. Digital urbanization means offering solutions that open up a field of possibilities instead of a strict optimization itinerary. This means creating digital cities that **represent our identities** and that encourage exploration[115]. In other words, to materialize the "invisible city" to prevent our cities from dissolving[116]. This moreover, leaves enough space to **express** and surprise ourselves[117].

111 Italo Calvino, *Invisible Cities* (1972)

112 For this element, see the "Organic Architecture" section

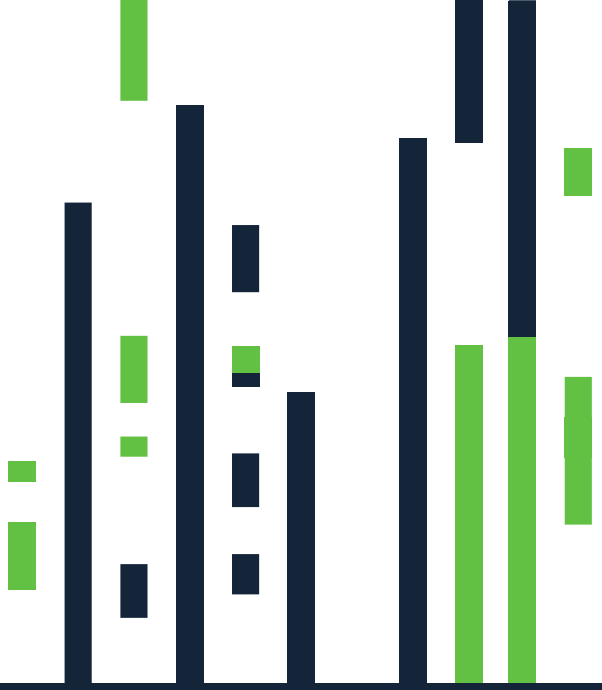
113 Richard Sennett, *Building and Dwelling: Ethics for the City* (2018)

114 Regarding this point, see Saskia Sassen's contribution in the "Recommendations" chapter

115 Alex Pentland concluded that social media limits the echo chamber phenomenon (Social Physics)

116 For more on this point see the "Organic Architecture" section

117 We will discuss this in further detail in the "Governance and Data" section



The City’s Biology is Yet to be Invented

Thierry Gruszka, Senior Technology Manager chez Cisco,
Paris Innovation & Research Lab (PIRL)

Information systems have been following a “discrete” revolution since the 2010’s. Their horizons have expanded thanks to the sensors that transcribe real world elements into numerical data. This new architecture integrates information networks, data centers, the internet and the cloud that provide ways to transmit and store information, as well as the computing power necessary for treating massive amounts of data that are varied and constantly updated. The impact and the potential is incredible and is applicable to almost every domain, including cities.

Citizens are living in cities that are progressively being outfitted with sensors that transmit all types of information: the “pulse” of the city. For municipalities, the ways they use this can range from infrastructure management, security, to even the well-being of residents and visitors. It is also a collective of information for urbanists that aim to take advantage of this powerful tool to better understand the city, its rhythm, its characteristics and watch its evolutions in real-time.

The appearance of the “Digital Twin”

Digital sensors, whether focusing on urbanism or humans “transmit” a multitude of datapoints constantly. These datpoints are transformed into information and carefully inter-combined, which result in the creation of a digital “twin” of the city, opening up a fabulous range of possibilities: understanding the city and its rhythms, its trends, what makes it unique; model it, forecast its evolutions, and weighing their impact using on-the-field tests that are transmitted in real-time to refine projects.

The digital service for inhabitants’ daily use

This qualified data participates in a complementary, different, or even new characterization of a city and contributes to the elements that could help improve everyday life for inhabitants, residents, the working population or visitors.

Over the past few years, several service operators, industrial companies, and startups worked with public entities that were in charge of managing the city to address these subjects, with results that ranged from promises to controversies. The primary themes that arose were Mobility and Transportation, Health and Energy, and also included the Environment, Leisure activities, Sports and Tourism, Standard of Living, the local economy, Participatory Living and Education.

The digital service for city planners

All of these projects and experiments translate the effervescence that indicates a plethora of elements that city planners can use to better understand the spaces, their usage and represent them with new arrangements, simulating options and variations and then observing the impact. Without a doubt, this is a virtual environment, but it incarnates the “digital twin” more and more and in

the long term could be precise and dynamic enough to create a fundamental reference point for projections or even predictions.

Professionals in this field have always known how to be progressive using information systems and their "computer assisted" functions in order to elaborate their work, construction and urban transformation. In addition, to facilitate the transition from one software to another, depending on their current creation or renovation project, they created BIM (Building Information Modeling), an interoperable standardized file that contains all the key information and details.

Moving towards a more dynamic and extended BIM

We can easily imagine combining BIM files with sensors and real-time generated data to create a "digital twin" which illustrates the infrastructure's activity, but we can also simulate these projects in the identical virtual reality, before starting the project. This would require a continuous iteration cycle wherein these sensors would contribute to this new "augmented" BIM.

Additional services using artificial intelligence algorithms could be complementary to these virtual environments to help predict certain elements, or even automate certain actions.

Digital can't and won't know everything

We aren't being delusional, we know that there are several drawbacks, risks and controversies at hand. These "abilities" will be slowed down in many ways, in at least two categories:

- Fear of "interference" which will require resource combination in the beginning of the project and training for best use of this software
- The ghost of "big brother" which looms over each initiative indicating that data is being collected and analyzed, even more so that it's mixed with artificial intelligence, knowing that at this point there is no guaranteed anonymization, respect for privacy, GDPR (General Data Protection Regulation) or any ethical happenings that make them suspect a potential misuse of data

The digital arena is definitely powerful and unexplored, but remains a tool that can be mobilized by its users to accomplish their goals. This moreover requires vigilance. However, the digital twin represents an improvement in the day-to-day lives of inhabitants, urban planners" goals, and society in general. Moreover, it does this by motivating people to properly outfit their systems with essential failsafes and being able to master the technology.

Digital Twins for real-life

For millennials and the generations to come, the virtual world is a part of their reality, just like the telephone was for the previous generation and electricity for those before them. It is plausible to consider that digital twins could be a

part of our daily life, first for material structures, and in the imaginable future to improve our living conditions, our health… But this goes a bit beyond this article.

Along with other sciences, observation helps us to better understand our environment and the world in which we are evolving. Bringing that back to the scale of a neighborhood, a city or an area, these dynamic digital representations offer us new ways to study and observe the principles and phenomena involved in this. Going beyond just urbanism that only deals with space configuration, a new discipline is being formed which is dedicated to studying the "behavior" of these spaces, like a living organism. The "biology of a city" is yet to be invented.

Thierry Gruzka *is the Senior Technology Manager at Cisco, Paris Innovation & Research Lab (PIRL). With a Masters in AI and Data Strategy, Patents in digital platforms, internet, multimedia and television, he is currently working on digital transformation, smart platforms and immersive spaces.*

RESILIENCE AND BIODIVERSITY

CONTRIBUTION

Opportunities of artificial intelligence for monitoring nature in cities,
Alison J.Fairbrass

Resilience

70% of cities are already dealing with the consequences of climate change. Climate change is characterized by three phenomena that are threatening our cities:

- An increase in average temperature from 2° to 7° by 2100 according to company initiatives/policies.
- Rising sea levels. In the case of a 3.2° increase in temperature (the average scenario), **275 million people** in the world would be directly affected by the rising sea levels and some cities would have to be completely redesigned (90% of urban zones are coastal).
- Extreme climate-related events (typhoons, torrential rains, droughts,). In 2019, natural disasters caused 232 billion dollars in damages throughout the world[118].

In this context, AI can be used to create more resilient cities. In other words, cities that are able to adapt and overcome these extreme natural phenomenons.

In Tokyo, Yutaka Matsuo used Web Mining to locate earthquakes in real time using data from Twitter[119]. The algorithm developed a 93% accuracy rate and is able to send alert messages much quicker than the Japan Meteorological Agency (JMA). To do this Yutaka Matsuo used *Machine Learning* in order to automatically analyze how relevant a tweet was to an identified event (in this case an earthquake). Moreover, the fact that "earthquake" or "shaking" appeared in a tweet wasn't enough to indicate that the author was feeling the shaking and that an earthquake was happening. So, AI was used to refine the semantic analysis and take into account a complex dataset (the number of words, the way they appear, etc.). Once a sufficient amount of tweets are ruled "relevant", the event is considered "existent ". The algorithm then uses statistical models to estimate the place and the length of the event. This algorithm is also able to estimate the trajectory of a typhoon in real-time and detect a great amount of other natural disasters. In this case, the Twitter user is considered as a "social sensor".

118 Weather, Climate & Catastrophe Insight, 2019 Annual Report, AON

119 Takeshi Sakaki Makoto Okazaki and Yatuka Matsuo, Tweet Analysis for Real-Time Event Detection and Earthquake Reporting System Development

Figure 9: Earthquake location estimation based on tweets. Balloons show the tweets on the earthquake. The cross shows the earthquake center. Red represents early tweets; blue shows later tweets.

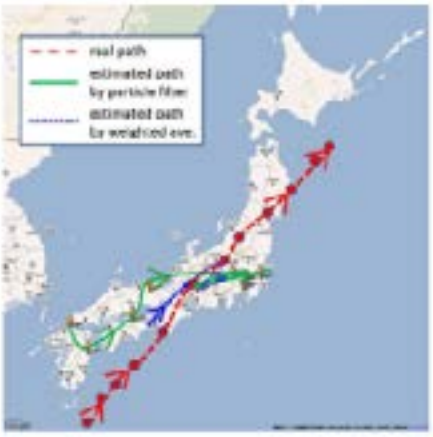


Figure 10: Typhoon trajectory estimation based on tweets.

Source : Takeshi Sakaki, Makoto Okazaki and Yutaka Matsuo, ***Tweet Analysis for Real-Time Event Detection and Earthquak Reporting System*** *Development,*

The idea of using smartphones as "sensors" is also utilized by the startup Climacell. By analyzing the quality of the signals emitted by smartphones and cross-referencing this information with a multitude of other data points (temperature, meteorological radars, humidity rate, video surveillance images,...), the startup is able to predict climate-related events (floods, tornadoes,...) **24-48 hours before they happen**. What makes Climacell unique is that they use "Weather of Things" (WOT) technology to refine their forecasting model[120]. The WoT uses connected objects as meteorological sensors. Combining *Machine Learning*, data from smartphones, connected vehicles or even surveillance cameras can provide precious climate information. The WoT has 2 advantages: 1) it enables the construction of a super-localized model that can analyze micro-climates 2) it can act as a complement or even a substitute for **expensive meteorological infrastructures**.

Once a climate event is anticipated or detected, we have to be able to understand its urban impact: how would torrential rain or a cyclone affect a city with regards to its physical and social components? In order to answer these questions, the dutch company Cyclomedia developed a solution with a 3D immersive view. An urban planner, a municipal government or a company can see how the city would react to a climate-related event. For instance, it is able to simulate flooding and analyze how the water would spread throughout the city because of its gravitational network, blocked sewers and other parameters. Users would also be able to see the effects on urban planning (roadway elevation, green spaces, etc.) on an area's resilience. The City of Amsterdam specifically used this solution to more efficiently combat the overflow of its 165 canals. Also, in Tokyo the startup Agoop used *Machine Learning* to identify individuals' behavior during a natural disaster. To do this, the Japanese company gathered and analyzed GPS data from telephones (via its collaboration with Softbank and other companies). This technique enables, among other things, to calculate

120 The other unique aspect of the startup is the ability to offer companies an API that will allow them to understand climate impact on their economic activity

how much individuals "slow down" during a seismic event[121]. This information becomes particularly relevant once we are able to determine a correlation between individuals' trips and the economic activity of an urban area[122]. We could also, almost instantaneously, predict the economic consequences of an earthquake.

Overall, Urban AI can be used as a response to natural disasters. The use of drones or using *computer vision* on satellite images allows us to almost instantaneously identify the damage caused by a climate-induced phenomenon. This is exactly what **Orbital Insight did** during Hurricane Dorian. Based on the calculations of the predicted damage, **AI was able to assist and optimize decision-making**[123].

Biodiversity

At the end of nearly all of my meetings, I asked the same question to each of the specialistsI I interviewed: "What does your ideal city look like?" Though answers were varied widely, one element stood out almost-every time: nature. The ideal urban environment of the specialists I met is a biophilic city where vegetation flourishes and biodiversity is abundant. Interestingly enough, AI could be used to preserve, and even augment, urban flora.

The City of Copenhagen wished to plant 100 000 new trees by 2025. This initiative was a part of its "Climate Plan" that aimed to make the Danish capital the first carbon-neutral city in the world. For this, it collaborated with Spiio. This startup invented a sensor capable of measuring the luminosity rate, the ambient temperature as well as the humidity and soil nutrient level. Using this data, it can measure the health of the flora in real time and optimize its irrigation systems. Combine this with *Machine Learning,* and this technology could help save anywhere between 20-46% of water[124].

Elsewhere in the United States, Descartes Labs uses *Computer Vision* on **satellite images to automate tree mapping in a defined urban area**. This solution is even more interesting since these kinds of estimations are complicated and costly. However, satellite image counting doesn't give any kind of indication on the "green perception" that citizens have of their environment. In other words, a space's ability to satisfy individuals' biophilic needs[125]. In fact, an area can have several trees without having a lot of visible vegetation on display for its inhabitants. For this, the teams at MIT's Senseable City Lab developed a statistical method to quantify the part of vegetation on display in an urban

121 Measurement of human activity using velocity GPS data from mobile phones, Yasuko Kawahata, Takayuki Mizuno and Akira Ishii

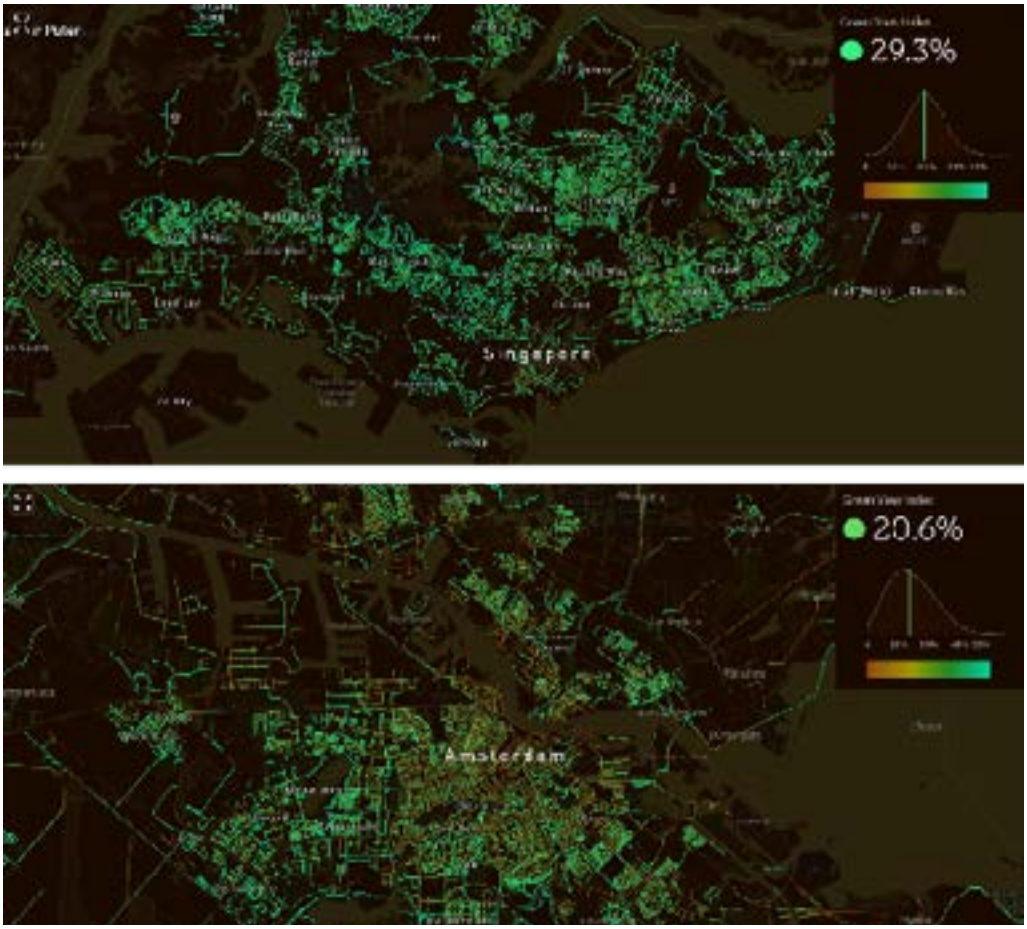
122 Just like Alex Pentland did, see the section "Augmented Urbanism"

123 For more information on this subject, please see the paragraph on Faster in the "Dot" section (Mobility)

124 Janani M and Jebakumar R, *A Study on Smart Irrigation Using Machine Learning*

125 Biophilia is 'the innate tendency to concentrate on life and its biological processes" (Created by Edward O Wilson)

landscape[126] (thanks to the Google Street View image analysis). This method enabled the creation of a **Green View Index** for cities. It is now possible to follow the tree canopy evolution while measuring "street greenery".



Below is the Green View Index of Singapore and Amsterdam: Source: ***http://senseable.mit.edu/treepedia***

This *monitoring* work is particularly important. Because of this, vegetation brings considerable benefits to cities and their inhabitants. It cools down streets[127], purifies the air, regulates humidity and contributes to individuals' relaxation[128].

AI can also be used to preserve an urban fauna. On this point, we invite you to read Alison Fairbrass' contribution.

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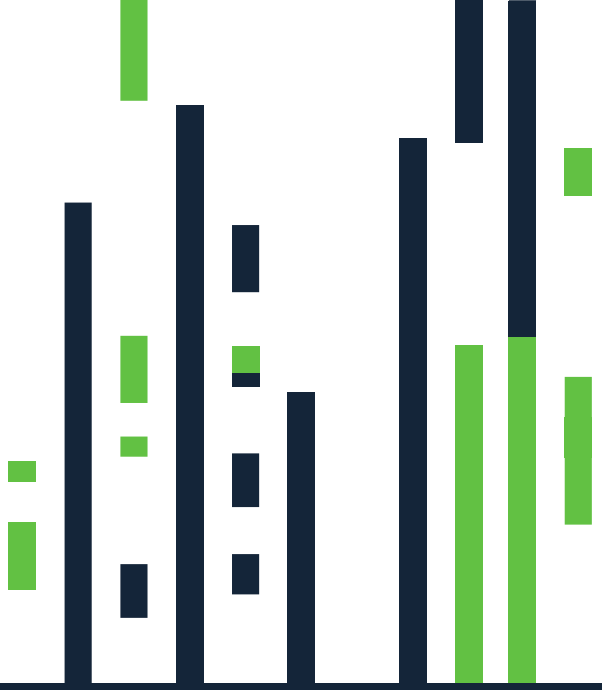
126 Xiaojiang Li, Chuanrong Zhang, Weidong Li, Robert Ricard, Qingyan Meng and Weixing Zhang, *Assessing street-level urban greenery using Google Street View and a modified green view index*

127 Tiziana Susca, Stuart Gaffin and Guido Raffaele Dell'Osso. Vegetation reduces the heat island effect and can contribute to lowering the temperature by 2°C in an urban space, *Positive effects of vegetation: Urban heat island and green roofs*

128 Frances E.Kuo and William C.Sullivan, *Environment and Crime In The Inner City: Does Vegetation Reduce Crime?* The presence of vegetation dramatically reduces the crime rate of a neighborhood.



Opportunities of artificial intelligence for monitoring nature in cities

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Summary

Urbanisation drives the conversion of natural to built environments and causes the destruction and fragmentation of habitats on which wildlife depend. Cities can also provide novel and diverse habitats which act as refuges for wildlife unable to persist in intensively managed agricultural landscapes. The nature in cities provides a range of valuable ecosystem services to urban populations which may support human health and well-being. Monitoring nature is resource intensive and is complicated in cities by difficulties of access to private land and safety and security concerns for surveyors and equipment. Environmental sensing technology provides opportunities to overcome some of these difficulties and facilitates the generation of large volumes of environmental data. Artificial intelligence (AI) methods enable this data to be turned into meaningful information about nature with the development of algorithms for detecting and classifying the sounds made by, and images of, wildlife and the natural environment. Cities can support the development of autonomous urban nature monitoring systems by combining AI methods and sensors connected to Wifi and power in the form of Internet of Things (IoT) systems. Areas of future research include the development of AI algorithms for a wide range of species that live in cities, scaling up IoT systems to the city-scale, and informing city decision-making with these new information streams.

The importance of nature in cities

Urbanisation can have destructive effects on nature, driving the conversion of natural habitats into built environments, causing the destruction and fragmentation of the habitats on which wildlife depend[129]. Conversely, due to the heterogeneous nature of how the land in cities is managed, cities can also support diverse wildlife and habitats[130,131], in particular those species that can no longer survive in intensive agricultural environment[132]. More than half of the world's population now live in cities[133]. Nature in cities can provide a wide range of valuable services to urban populations, including pest regulation, food production and air quality management[134] which may benefit the health and well-being of urban populations[135].

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129 Grimm NB, Faeth SH, Golubiewski NE, et al. Global change and the ecology of cities. *Science* 2008; 319: 756-760.

130 Perring MP, Manning P, Hobbs RJ, et al. Novel Urban Ecosystems and Ecosystem Services. In: Hobbs RJ, Higgs ES and Hall CM (eds) *Novel Ecosystems.* Oxford: John Wiley & Sons, Ltd, 2013, pp.310-325.

131 Aronson MFJ, La Sorte FA, Nilon CH, et al. A global analysis of the impacts of urbanization on bird and plant diversity reveals key anthropogenic drivers. 281(1780), **http://rspb.royalsocietypublishing.org/content/281/1780/20133330.abstract** (2014, accessed April 7, 2014).

132 Hall DM, Camilo GR, Tonietto RK, et al. The city as a refuge for insect pollinators. *Conservation Biology* 2016; 31: 24-29.

133 United Nations Department of Economic and Social Affairs. *World Urbanization Prospects The 2018 Revision.* 2019. New York: United Nations.

134 Gómez-Baggethun E and Barton DN. Classifying and valuing ecosystem services for urban planning. *Ecological Economics* 2013; 86: 235–245. DOI: **http://dx.doi.org/10.1016/j.ecolecon.2012.08.019**.

135 Marselle MR, Martens D, Dallimer M, et al. Review of the Mental Health and Well-being Benefits of Biodiversity. In: Marselle MR, Stadler J, Korn H, et al. (eds) *Biodiversity and Health in the Face of Climate Change*. Cham: Springer International Publishing, 2019, pp.175-211.

The current state of urban wildlife monitoring

Despite the potential importance of both cities for nature and nature in cities for urban populations, there are few examples of systematic monitoring of nature in cities. Wildlife is often difficult to monitor. It requires expertise to identify different wildlife species, often involves the use of technical equipment, and requires repeated surveys at multiple sites to monitor changes over time and space. In cities there are additional difficulties including access to private land and safety issues for surveyors and equipment[136]. Despite these difficulties, impressive datasets covering multiple species over several years have been compiled for a small number of cities. The Long-Term Ecological Research Projects in Baltimore and Phoenix, United States of America, have compiled datasets on birds, insects and plants in the cities since 1998[137][138]. The Urban Wildlife Information Network employs various monitoring methods, including camera traps, in cities following a shared protocol to produce long term data of terrestrial mammals from at least 24 cities to date[139]. This novel research structure departs from the traditional single-city approach by identifying the broad patterns of how wildlife respond and adapt to urbanization. These projects provide inspiring examples of how long-term monitoring of urban nature can be conducted.

New opportunities for urban wildlife monitoring

Environmental sensing technology, such as acoustic and camera sensors, is being increasingly used to collect information on wildlife and the natural environment[140][141]. Sensors can be deployed for long time periods, making it possible to generate large audio, image and video datasets. Artificial intelligence (AI) methods offer exciting opportunities for turning this data into meaningful information about the nature and wildlife recorded using sensing technology. AI methods have been developed that can detect and classify the sounds and images of a range of wildlife species[142][143] as well as eco acoustic measures

136 Farinha-Marques P, Lameiras J, Fernandes C, et al. Urban biodiversity: a review of current concepts and contributions to multidisciplinary approaches. *Innovation: The European Journal of Social Science Research 2011; 24: 247-271.*

137 Templeton LK, Neel MC, Groffman PM, et al. Changes in vegetation structure and composition of urban and rural forest patches in Baltimore from 1998 to 2015. *Forest Ecology and Management* 2019; 454: 117665. DOI: **https://doi.org/10.1016/j.foreco.2019.117665**.

138 Central Arizona-Phoenix Long-Term Ecological Research CAP LTER. Long-Term Monitoring and Experiments, **https://sustainability.asu.edu/caplter/research/long-term-monitoring/** (2020, accessed 22/01/2020).

139 Magle SB, Fidino M, Lehrer EW, et al. Advancing urban wildlife research through a multi-city collaboration. *Frontiers in Ecology and the Environment* 2019; 17: 232-239. DOI: 10.1002/fee.2030.

140 Gibb R, Browning E, Glover-Kapfer P, et al. Emerging opportunities and challenges for passive acoustics in ecological assessment and monitoring. *Methods in Ecology and Evolution* 2019; 10: 169-185. DOI: 10.1111/2041-210x.13101.

141 Glover-Kapfer P, Soto-Navarro CA and Wearn OR. Camera-trapping version 3.0: current constraints and future priorities for development. *Remote Sensing in Ecology and Conservation* 2019; 5: 209-223. DOI: 10.1002/rse2.106.

142 Christin S, Hervet É and Lecomte N. Applications for deep learning in ecology. *Methods in Ecology and Evolution* 2019; 10: 1632-1644. DOI: 10.1111/2041-210x.13256.

143 Wäldchen J and Mäder P. Machine learning for image based species identification. Methods in Ecology and Evolution 2018; 9: 2216-2225. DOI: 10.1111/2041-210x.13075.

of biotic sound that can provide proxy measures of biodiversity[144]. In cities, AI methods are being developed to process large urban nature datasets that are being generated using environmental sensing technology. The London HogWatch project is a large-scale urban camera trap survey focussed on urban mammals and their use of public green spaces and private gardens[145]. Both the London HogWatch project and the Urban Wildlife Information Network are using AI methods to process the vast amounts of images of urban mammals they are collecting.

Cities are the perfect environment in which to combine these new environmental sensing technologies and AI methods. The availability of power and internet networks means it is possible to develop Internet of Things (IoT) monitoring networks of connected sensors[146]. An example of such a system exists at the Olympic Park in London, United Kingdom, where a network of ultrasonic sensors are connected to the Park's local Wifi network and powered through lampposts. Two AI algorithms on-board each of the 15 sensors process the ultrasonic recordings by first detecting bat calls, and then classifying calls to bat species, with results sent to a cloud server and reported in near-real-time on a public website (**www.batslondon.com**).

The next steps of this technology is the development of new and existing AI methods for detecting and classifying, in acoustic and image data, a wide range of species that inhabit cities. The autonomous bat monitoring system in London provides a proof of concept of an urban IoT network for wildlife monitoring and needs to be replicated at a city-scale to better understand the resource and capacity requirements of a city-scale autonomous urban nature monitoring system. Finally, we need to understand how to use these new sources of data and information to inform decision-making in cities about nature.

144 Fairbrass AJ, Firman M, Williams C, et al. CityNet—Deep learning tools for urban ecoacoustic assessment. *Methods in Ecology and Evolution* 2019; 10: 186-197. DOI: 10.1111/2041-210x.13114.

145 London Institute of Zoology. London HogWatch: Twitter Account, **https://twitter.com/LondonHogWatch** (2020, accessed 11/02/2020).

146 Zanella A, Bui N, Castellani A, et al. Internet of things for smart cities. *IEEE Internet of Things journal* 2014; 1: 22-32.

Alison *holds a M asters in Conservation Science from Imperial College London and a BSc in Environmental Management from the University of Birmingham. She has also worked in the built environment industry with the* ***Green Collar sustainability consultancy*** *advising on BREEAM and ISO14001..*

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16. Fairbrass AJ, Firman M, Williams C, et al. CityNet—Deep learning tools for urban ecoacoustic assessment. *Methods in Ecology and Evolution* 2019; 10: 186-197. DOI: 10.1111/2041-210x.13114.

17. London Institute of Zoology. London HogWatch: Twitter Account, **https://twitter.com/LondonHogWatch** (2020, accessed 11/02/2020).

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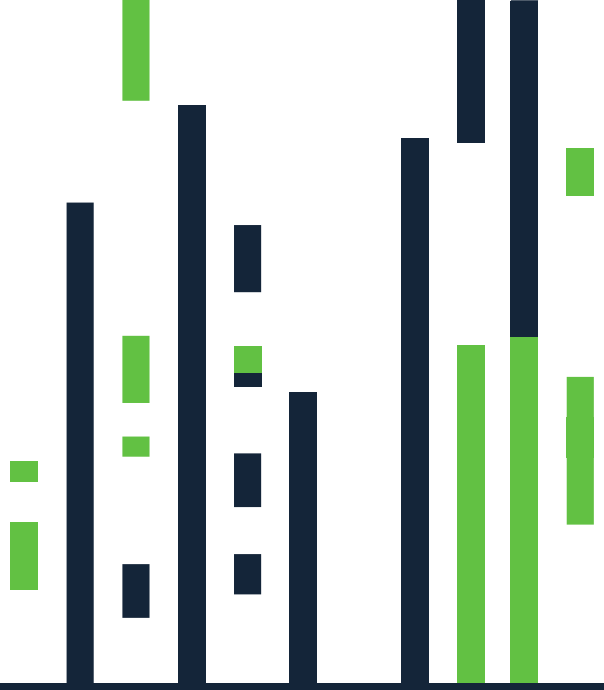
HEALTH AND SAFETY

CONTRIBUTION

Smart Governance Leverages Artificial Intelligence to Improve Citizen Services,
Eleonore Ferreyrol-Alesi, Dathena and Live With AI



Smart Governance Leverages Artificial Intelligence to Improve Citizen Services

Eleonore Ferreyrol-Alesi, Dathena and Live With AI

A recent study from the **World Economic Forum** shows there are 1.3 million people a week across the globe are relocating to cities – and by 2040, a staggering 65 percent of the world's population will live in cities. As the metropolitan population grows, it will become more difficult to deliver optimum services to citizens using traditional systems. Leveraging AI and its related technologies to create smart cities is a necessary step to ensure that city services are optimized to deliver the maximum efficiency, sustainability, safety, and security.

The ideal objectives of a smart city are to create a comfortable, convenient, and safe life for citizens. However, these objectives must be addressed while taking account of possible risks induced by smart cities, most notably security issues and social discriminations. Therefore, a smart city infrastructure is not complete without **smart governance**.

Smart governance intelligently employs technology to improve decision making through better **collaboration** among different stakeholders, including government agencies/departments and citizens. Artificial Intelligence (AI) and its related technologies – (Machine Learning (ML) and Natural Language Processing (NLP)) – are now being used by city governments across a wide range of services to solve more complex problems that impact the daily lives of its citizens.

When considering AI, city governments need to ensure that any solution they choose is explainable and tracks accountability. These two elements are important because they create trust and assurance that the technology will not impact individuals' civic rights, their right to privacy, and the security of their data.

How Can You Deploy AI Solutions to Bring Value to Citizens?

Smart cities make for safe cities. AI technologies improve processes, which can reduce crime and terrorism and allow government entities to quickly respond to threats and emergencies. For example, **in China,** the government uses AI and facial recognition to analyze and understand the mountain of incoming video evidence it collects to track suspects, identify suspicious behaviors, and predict crime.

In Los Angeles, California, *PredPol* (Predictive Policing) is used to predict and prevent crimes. It uses three data points – past type, place, and time of crime – to predict criminal behavior. These data points are fed into a unique algorithm, which incorporates criminal behavior patterns. A Deloitte **study** shows that *PredPol* has already decreased property crimes by 13 percent in selected geographies.

In addition, various U.S. courts and Corrections Departments are using AI algorithms to determine a defendant's "risk," such as the probability that an individual will commit another crime to the likelihood a defendant will appear for his or her court date.[147]

147 **https://www.wired.com/2017/04/courts-using-ai-sentence-criminals-must-stop-now/**

The "Black Box"

These risk-assessment tools improve the accuracy of human decision making, which helps better allocate finite resources. Yet, since not all the users have a comprehensive understanding of how the decisions are made, it can be perceived as a black box technology.

Typically, city governments do not write their own algorithms but have them developed by software providers or system integrators. As a result, government agencies and departments cannot audit or explain the models without assistance. And as the models improve and become more complex, they become even more difficult to understand. Therefore, it is important to build *explainability* into the model.

Explainability also addresses the concern regarding biased data, which can lead to unfavorable outputs and impact vulnerable societal groups. **The use of past data can also lead to erroneous outcomes that incorporate historical biases** and only favor certain citizen classes.

This raises the question of which data to be used, as in how to solve the unbalancing problem, but also which data can be used, does the individual have shared his consent to have his data used for that purpose?

As citizens across the globe are legitimately becoming more concerned about how their data is used and how it impacts their privilege of choice and right to privacy, it is important to choose AI technologies that ensure the privacy and security of personal and sensitive data. With its GDPR law, Europe has set a high standard of privacy over people's personal data; it might be a good lead to take inspiration.

What Approaches Exist to Mitigate These Risks?

It is important to be aware of AI risks and ensure that chosen solutions can maximize business impact while minimizing risks. A recent study from **Datarobot** shows an encouraging possible evolution as, in the next 12 months, 93 percent of respondents (technology executives) expect to invest more in AI bias-prevention initiatives. But it does beg the question: what can be done when unfair outcomes are identified and algorithm's relevancy put into question?

One way to tackle this problem and minimize unintentional biases is to ensure that the data and models are regularly reviewed and validated for accuracy and relevance. This is one of the statements of the MAS, Monetary Authority of Singapore, which has issued a set of principles to promote Fairness, Ethics, Accountability, and Transparency (FEAT) in the use of AI and data analytics in finance.

A key method to mitigating risk is to implement AI incrementally. To start, use it to adjudicate small claims disputes as an example.[148] This will help clear

148 However simple as a case may be, the defendant should always have the right to appeal to a human judge

the backlog of cases, allowing judges and lawyers to focus on more complex cases. Incremental implementation also provides time to educate citizens and users on the use of the solution to demystify AI and be clear on what it can, and cannot do.

Building Trusted Artificial Intelligence Solutions

An AI-based solution should not be deployed if there is no transparency or *explainability* in terms of how the results are achieved: systems must provide explanations for their outputs. This becomes even more critical in cases where an individual is convicted of a criminal offence; *explainability* is critical to ensuring justice.

Prior to implementing AI-based solutions/tools, solutions that can remediate identified issues should be identified beforehand. Also, all stakeholders, including citizens, should agree on an ethical code to ensure the models are defined and aligned with societal goals.

At the end of the journey, the most important question city governments regard the final outcome: what type of society do they want to build to enable citizens with better personal and professional lives?

Eleonore *is a project and change management leader with over 11 years' experience in Financial Services. She have been working in Singapore for the last past 7 years, a thriving hub for Artificial Intelligence. She started her career in the bank industry. With a consulting background, her different roles have also led me to establish a regional office and operations in Asia for a large corporation, work closely with startups in the region, and currently leading the client solutions activity at Dathena, a Singapore-headquartered deep tech company providing AI-powered data privacy and security solutions.*

Eleonore is also the co-founder of Live With AI think tank, which gathers thought leaders, researchers, decision-makers, from Asia and Europe, to lead working groups and research projects on the positive impacts of artificial intelligence on our society.

Dream Cities

In her contribution, Eleonore Ferreyrol-Alesi illustrated how AI can contribute to making our cities safer and illuminated the issues around these uses. Earlier on, we took a look at the risks that autonomous technologies can have[149]. Here, we would like to insist on the notion that was discovered in Montreal by Greg Lindsay, Director of Applied Research of the New Cities Foundation. We will delve into "dream cities".

The "Dream City" among other things, alludes to the field of psychometrics and to Michal Kosinski's works. This Stanford professor used *Machine Learning* to determine an individual's personality using only their Facebook "likes". The algorithm is able to estimate the psychological profile, the sexual orientation and even the individuals' ethnicity[150]. Afterwards, Mr. Kosinski's work was used by Cambridge Analytica. This startup collaborated with Donald Trump's campaign team in 2016. **In this context, it analyzed the Facebook profiles, and thus the personalities of more than 87 million American voters**. This data was then used to send targeted fake news messages to influence people to vote for Donald Trump. This was the **Cambridge Analytica** scandal.

Because micro-targeting is already being used for commercial and political purposes, American authorities suspect that it is also becoming a weapon for terrorists. In order to have more foresight on technological threats, The Army Cyber Institute imagined several cyberattack scenarios. In one of them, a maintenance engineer was manipulated by terrorists[151]. They used AI to identify his personality, indoctrinate him (with *fake news* and personalized messages) and finally, persuade him to give them access to urban infrastructures that he was supposed to be protecting.

Source : Army Cyber Institute

149 See the section "Autonomous Mobility" in the "Mobility" chapter

150 If an individual "liked" more than 300 pages on Facebook, it is possible to predict their psychological profile with 95% accuracy, their sexual orientation (93%), and their ethnicity (95%). *Private traits and attributes are predictable from digital records of human behavior,* Michal Kosinski, David Stillwell and Thore Graepel,

151 Brian David Johnson, *Engineering a Traitor* (2018)

Though fictional, the Army Cyber Institute's scenario is based on several real elements, one of which being the Cambridge Analytica scandal. What's more, in India, **the spread of fake news has already led to violence and even homicides**. In each of these cases, AI is used to manipulate one person or several people. Like dreams, an individual has a hard time differentiating what is real and what is imaginary : "we are going to lose the ability to perceive the world without AI" (Greg Lindsay[152]).

The "dream city" is a place where *fake news* influences our uses and actions: a rumor about a company with a **supply shortage begets a true shortage**, just like **a fake crime provokes homicides** and fake information about lax anti-terrorist policies leads to true acts of terrorism[153]. In this way, fake news has a self-actualizing dimension.

We want to emphasize that "dream cities" are, among other things, one of the consequences of "urbanization wars", which themselves are the consequence of contemporary "asymmetrical conflicts" (Saskia Sassen). In essence, *fake news* is one unconventional tactic that exploits urban fragility: "But the physical and human features of cities that pose complex obstacles for conventional military technology also make them more hospitable centre for insurgencies and unconventional tactics"[154].

Several initiatives, both public and private, were mobilized to fight against this phenomenon. This combat is even more complicated due to the fact that fake news is not a technological reality. It refers to a powerful psychological component[155] and reminds us of our civilization's roots[156].

The Immune System

Whether it's because of fake news, or taking control of autonomous systems, or even **data poisoning**, AI represents a growing menace for a city's security. Nevertheless, this technology can also be a precious resource for cities to fight against cyberattacks.

The contemporary paradigme of cybersecurity is that of an "immune system". Here we are referring to a "cyber immune system"[157]. This model uses two complementary components:

- The Firewall: This is the first line of defense. Similar to an epidermis, it filters external bodies. The firewall can estimate the danger of an element

152 Greg Lindsay used an example from the movie Inception to illustrate this concept. Leonardo Di Caprio (*alial "the extractor"*) cant trust his senses and his reasoning to distinguish dreams from reality

153 Brian David Johnson, *Engineering a Traitor* (2018),

154 Saskia Sassen, *Urban Capabilities: An Essay on Our Challenges and Differences*

155 We can cite at least 2: The "self-actualizing" prophecy (Robert K. Merton) and the "scapegoat" (René Girard).

156 We can't mention the fight against *fake news* without mentioning Plato's Allegory of the Cave

157 *Cyber Immunity, a Bio-Inspired Cyber Defense System,* Peter Wlodarczak

by its *signature*. Therefore, signatures have to be classified beforehand. Though it protects the system from the majority of attacks, the firewall can only fight against threats that have been *identified*.

- The anomalies detector: Contrary to the firewall that regulates using signatures, the anomalies detector inspects the system's behavior. This is where *Machine Learning* comes into play. The algorithm analyzes its systems protection mechanisms by emitting *patterns* (using unsupervised learning). The detector is then able to identify deviant behavior that potentially indicates an attempted intrusion. The benefit of this method is that it learns on its own and evolves.

The "cyber immune system" takes into account the porosity of the connected technologies. Instead of building an invincible city, it mimics real-life by detecting and rejecting pathogens. In London, Darktrace uses this technology to fight virtual infections. The startup also developed **" Antigena "**, a bio-inspired solution that fights against phishing emails (**94% of cyber attacks are circulated by email**) and protects their client's IoT network.

A Healthy City

One of the goals of Urban AI is to contribute to "healthy cities". This means cities that preserve our health and participate in our well-being.

Alex Pentland illustrated that it was possible to identify if an individual is healthy by using behavioral data. In fact, during the incubation period of certain illnesses, behavioral patterns of affected individuals vary slightly: they become a bit more "social". Inversely, during the height of the sickness, they logically stay home and limit their movements[158]. By cross-referencing this information with the geographic and time series data, they are able to create a forecast model of the virus spread[159]. Moreover, it is also possible to forecast the evolution of an epidemic using Google Trends data; In 2016, researchers were able to identify a correlation between the number of search requests with the keyword "Zika" and the number of patients that were affected by this virus[160]. In addition, by using Reality Mining, it is possible to estimate the probability that an individual could develop depression, and if they will be affected by air pollution, develop obesity or become a smoker[161].

This information has two primary incentives. The first is to propose "preventative treatments". Augmented by AI, an individual could adapt their commute according to air pollution or other environmental factors that are identified as risks due to prior medical conditions. People will be taken care of before they show signs of depression. Seasonal Flus (and other infectious diseases) will be less viral because they will be better contained and campaigns against obesity

158 *Social Physics* (2014), Alex Pentland

159 *Ibid*

160 Yue Teng ETC, *Dynamic forecasting of Zika Epidemics Using Google Trends,*

161 Alex Pentland, David Lazer, Devon Brewer and Tracy Heibeck, *Improving Public Health and Medicine by use of Reality Mining*

will be more efficient because they will be more targeted[162]. In the case of an epidemic, **individuals will receive notification alerts if they are infected and it will be possible to identify geographic areas that are "at risk".** South Korea as well as Israel have used this method in particular during the COVID-19 crisis. In each of these cases, we're talking about "preventative medicine": wherein the patient is treated or admitted before the pathogen appears.

The other thing that is helpful about this information is to *augment* medical infrastructures. In the case of an epidemic or a pandemic, AI could help identify "patient zero"[163] and areas that are most affected before hospitals are completely saturated. In Canada, Bluedot aggregated and analyzed more than 100 data sets (official reports, aerial photos, articles, etc.) to inform and anticipate the arrival of an epidemic: The startup was one of the first structures in the world to anticipate the Coronavirus spread pattern. It is also possible to optimize the deployment of ambulances by processing emergency calls more efficiently. In Copenhagen, Corti used *Machine Learning* to develop a decision tree that would assist medical emergency services. The solution proposes the emergency operator a series of questions that helps them facilitate the conversation and automatically adapt to the answers that the caller provides. As the conversation continues, the algorithm estimates the probability that the person calling is going into cardiac arrest. It is just as important to quickly identify the pathology since the chances of a victim's survival goes down by 10% for every minute without assistance. 50 000 people die from cardiac arrest each year in France. Corti, which has been working with the City of Copenhagen and the City of Seattle, is currently adapting its technology to detecting strokes and developing new solutions (automatic detection of accidental calls and non-priority calls).

The "healthy city" opens the door to considerable progress. Though, it runs the risk of creating "normalized cities". In other words, cities wherein we eradicate the abnormal rather than the pathologen[164]. The individual that demonstrates deviant behavior is considered sick, and the micro-targeted campaigns will incentivize (or force them) to have a more "average" morphology. More than health, it becomes a question of statistics. A healthy person is a median. In this sense, the "normalized city" is that of the Modulor, the standardized individual conceived by Corbusier to prototype his architectural forms.

162 Adyasha Maharana and Elaine Okanyene, *Use of Deep Learning to Examine the Association of the Built Environment With Prevalence of Neighborhood Adult Obesity*

163 *Ibid*

164 Georges Canguillhem, *The normal and the Pathological* (1966)

DATA GOVERNANCE

CONTRIBUTIONS

It's OUR data !,
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Data fiduciaries: a sensible governance for smart cities,
Philippe Beaudoin, co-founder and VP of Research at Element AI

The situated citizen, Marius Hartmann,
Chief Advisor at the Danish Business Authority

It’s OUR data!

Understanding the risks and benefits of sharing data calls for regulation

Luc Julia, Chief Technology Officer and SVP Innovation at Samsung

In the past two decades a few companies strove to get your data to become huge successes. It's only in the last few years that we all started to realize that they were using us and that we maybe weren't getting much value from the "exchange" they are claiming we're having. Or do we? It actually took a few catastrophic events for some of us to quickly understand that the Internet is a public place with lots of memory. From a job lost because of some indecent exposure or a few stupid tweets that it was pointless to try to hide, to the deportation of undocumented immigrants because they felt safe to share their lives on social networks.

Some tech experts are saying it for a long time, there is no such thing as privacy on the Internet, just emphasizing what Mark Zuckerberg, the CEO of Facebook, said back in January 2010: Privacy was no longer the "social norm". If the information isn't exposed by the platforms themselves for their own benefits, it's the hackers cracking hundreds of millions of accounts that will, one day or another, do the job since the platforms do not really make too much effort in protecting our data. The latest story about Google storing passwords in plain text since 2005 is just anecdotal.

GDPR, the European General Data Protection Regulation, was a first step, in May 2018, to make companies liable for potential data breaches. It not only forced some companies to take security more seriously (at least they told us so) but it also had a huge educational effect on people for them to understand the consequences of their activities on the Internet. After fighting back for a little while, it's now very trendy for all the tech companies to claim that "it's your data" and that you have the full control of it. Even Zuckerberg now claims he wants to build a belief in a privacy focused communications platform… Maybe because California's own version of GDPR, the California Consumer Privacy Act took effect January 1st, 2020.

It's not difficult though, among all the penitent speeches we recently heard, to distinguish which are the ones that are more or less sincere and the ones that are just triggered by some marketing needs to continue as much as possible with the business model that made them billionaires by encouraging users to actually give more and more data up.

Again, educating by explaining what data is being collected and how it's being used is key. But more importantly, to build, or rebuild any kind of trust, these platforms now need to provide easy to use tools for the users to really exercise full control on their data by choosing with whom it's being shared, and giving them the ability to really erase any of it at any level of granularity they want.

Because both in Europe and the US people are now getting more aware of the issues, building ethical platforms following these simple principles is now a trend. But as we saw earlier, these centralized platforms are easy targets for massive data breaches. That's why it might be interesting to consider another approach that I'm calling "small data". The idea is to collect less data, at least in centralized places such as data centers. It would not only prevent any temptation from the platform owners to peck on the data, but it also would become much less attractive to the hackers.

Small data, in addition to solving some of the privacy issues we just talked about, is also helping with scalability since the current tendency of collecting “big data” is bringing us straight into the wall. There is an often overlooked ecological aberration with our current centralized platforms: The data centers are consuming an enormous amount of energy, a large percentage just to keep the servers cool, to operate. Today global data centers use about 500 terawatts a year, which would be enough electricity to run the city of Paris for more than 6 years!

In a more and more connected world, with many more connected objects in our upcoming smart cities for instance, technologies such as 5G, because of its low latency, would allow small data coming from clusters of heterogeneous devices to be analyzed right at the edge instead of being centralized, saving about 60% of power right away, and, as a side effect, making it even more complicated and less rewarding for hackers to crack. But the biggest advantage would be to make us more responsible and able to protect and control OUR own data since it’ll be right with us.

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From Conflict to Cooperation

"Urban data" is the cornerstone of Urban AI. Thus, adjacent issues on regulation revolve around data governance issues. Several specialists simultaneously expressed their fears, reflections, and hopes on the topic.

The process of creation and use of "urban data" is complex as it is a multisectoral one. Let's take a look on behavorial analysis in the context of Cityscope application in Andorra[165]. Territorial data was produced by the City of Andorra as well as behavioral data that was collected by a telecom company (Andorra Telecom). They were then aggregated and analyzed by a research lab (the MIT Media Lab) before being re-treated by the City of Andorra. Everything revolves around a real aspect, which is anonymized: the citizen. The number of actors involved in the process naturally led to tension around "urban data". It concerned the general public, personal interests, and public and private entities.

This intrinsic tension around urban data often leads to conflicts. The example of testing autonomous cars represents this phenomenon well. Several cities experimented with autonomous mobility solutions on parts of their territory without ever having access to the data that was generated (this, in particular was the case of Pittsburgh and Uber). Generally, municipalities rarely have access to their city's digital twin. On top of this, there is a lack of transparency on open data that is used in the private sector. Institutional actors that were interviewed highlighted the advantages of open data. Municipal services are often the first users of these data, which enables them to create innovations for the city. However, cities only have a small amount of visibility on private-sector projects that are using open data for their research and experimentation.

Here we see that this tension can become conflictual when one of the actors in the urban data creation value chain tries to have exclusive ownership of the information. In this way, *collaboration and openness* are the first steps towards balanced and democratic data governance practices. This principle implies technological alignment between the different participants. The city, businesses and research institutions all need to speak the same language in order to communicate and collaborate. In San Francisco, the independent non-profit Open Transport Partnership created SharedStreets, an open-source map archive. The digital maps of different mobility providers did not mesh well together, and even less so with the city's maps. First and foremost, they didn't share the same computer language. In addition, they didn't all collect the same kinds of data (some analyze fleet information, others road status, and the amount of red lights, etc.). For this, SharedStreets is an interoperable software that facilitates the data transfer from one map to another. It then becomes possible to superimpose the maps. Mobility companies (Uber, Lyft, Via) can also freely share, or in the case of a bid for projects, can share the data on their fleet with the cities (average vehicle speed, highly-solicited areas,). Inversely, the city can communicate information (road closure, new traffic lights,) that would automatically be integrated into the company's IT system.

165 See Ariel Noyman's contribution in the "Urbanism and Architectures" chapter

Other similar initiatives are fleurishing throughout the world. The Department of Transportation of the City of Los Angeles (DTLA) created a "Mobility Data Specification". This software was created via a partnership with 4 other American cities (Seattle, San Francisco, Santa Monica, Austin), Bird, Lime and the Harvard Kennedy School. The "Mobility Data Specification" allows the DTLA to communicate with its micro-mobility partners (using API's). It can create real-time models of information about their fleet, check if bicycles and scooters are parked in the appropriate areas and make sure that they are well-distributed throughout the area (to avoid high-concentration in one area or another). The DTLA can even interact with its partners to mobilize their fleets in case of exceptional circumstances. Moreover, the City of Los Angeles is able to incorporate micro-mobility into its urbanism and its mobility planning versus adapting to the changes. Created as an "open-source" technology, **LADOT's software was downloaded and used by more than 70 cities around the world within only one month of launching it**. This project led to the creation of the Open Mobility Foundation, a *consortium* of cities and businesses that share their resources to create management tools for collaborative and open urban mobility.

SharedStreets and the "Mobility Data Specification" are not just regulatory tools. They open up the door to an open collaboration between the city's actors. They also demonstrate that cooperation *between* cities is possible and preferable. In each of these cases, "urban data" provides a reason to come together, rather than be divided.

From Serfdom to Autonomy

The digital era is often compared to the feudal era. Moreover **Gaspard Koenig** wrote in *La fin de l'individu:*

"If we want to understand the digital spoilage that we are subject to today, you can read George Duby's writings about the economics of the Middle Ages. In the beginning of the previous millennium, the glebe's serfs delivered their production essentials to their lords in exchange of "free services" that were more or less real: protection from war or access to the city's most basic facilities"[166].

Like a serf, the modern man exchanged his liberty and his intimacy for "free services" (interacting with their friends, figuring out how to get places, watching videos).

How can we abolish this digital servitude? One of the main elements for doing this is technological. In today's setup, AI functions in a centralized and closed circuit. Algorithms collect and analyze users' data. In addition to being energy-hungry, this model is, in essence, intrusive. However, there are alternative learning methods that are more respectful of privacy. This, in particular, is the case of **Federated Learning**. This practice makes "small data" systems possible

166 We can also see this metaphor in Element AI and Nesta's whitepaper: *Fiducies de Données, un nouvel outil pour la gouvernance des données*

(Luc Julia), which are decentralized and protect citizens' privacy. On this point, I suggest you review Luc Julia's contribution.

Additionally, the issue of data governance undoubtably resonates with politics. Regulating AI implies creating a contract of trust between its stakeholders and citizens. If we want the web, and our "smart cities", not to become a space of discord where "Man to Man is an arrant Wolfe"[167], we need to rethink our social contract. This must expand the virtual world. In this way, The City of Montreal co-wrote with its citizens **an agreement** on digital issues that defines the use of data in a public space. This agreement guarantees the fundamental principles (digital sovereignty, the right to experiment, personal/individual rights …) which guarantees a respect for the city. The project Go Boston 2030 that was previously mentioned[168] also represents a similar process. In this case, the city, citizens, businesses and academic institutions got together to discuss and define a common political project around autonomous mobility.

The problem with digital serfdom is also judicial. In his *New Deal on Data*, Alex Pentland calls for "the private property of data". Each citizen could be the sole-owner of their own personal information. In other words, they could 1) anonymously store their data in a place that belonged to them, 2) distribute or sell it (on a data market) and have access to it and decide how it will be used, 3) be able to, at any moment, extract it from a use that they deem inappropriate and delete it.

This position has been criticized for not taking into conisderation the fluid and immaterial nature of digital. While it is easy to draw a square of land, it is much more complex to delmiit a data[169] (because of the plethora of actors that are involved in its value chain). In this context, the notion of "Data Fiduciaries" is preferable to that of a "Data Bank".

167 Hobbes *Leviathan* (1651)

168 See the "Mobility" chapter

169 *Bottom-up data Trusts: Disturbing the "one size fits all" approach to data governance,* Sylvie Delacroix and Neil D.Lawrence

Data Fiduciaries: a sensible governance for smart cities

Philippe Beaudoin, co-founder and VP of Research at Element AI

The development of smarter cities is a project accented with challenges of varying natures, be they social, economic, or technological. An inevitable aspect of these cities, however, is how they will establish their data collection to augment their capabilities of accomplishing their missions for their constituents. This data can be derived naturally from many different places, like cameras, microphones, applications installed on their smartphones, etc. This data, even though it is necessary for municipal improvements, are potentially sensitive and collecting them can affect citizens in a variety of ways. In this context, it is crucial that we ask ourselves questions about data governance mechanisms. Data fiduciaries [170] are mechanisms that, when correctly used, have the potential to give users control over their data again.

Our current technological environment has gotten us used to a model wherein the collection and storage of data is carried out by companies that provide services, which entail a concentration of data in the hands of a small number of very big companies. Due to this, users are now excluded from the decision-making process regarding how their personal data is used.

Just like the very public Cambridge Analytica affair illustrated, today's data can be acquired using online profiling, it can be purchased by third-party providers or even inferenced using aggregated data sets. The complexity and the lack of transparency of the data accessing process makes it practically impossible for users to understand and manage the risks that they are exposed to when they consent to their personal data being used.

On the other hand, when data is collected and managed by service providers, data fiduciaries are an alternative model that has been studied and proposed by a number of international experts in data governance,automated learning, privacy rights and public politics. This is a model wherein a third party provider uses common-trust laws and aims to promote public interest in:

- Offering citizens more control on their personal data
- Improving access to data and favoring innovation
- Fixing asymmetrical power issues between companies, governments and citizens
- Reinforcing privacy rights and human rights; and
- Allowing the public to share the value of data and artificial intelligence

What is a data fiduciary?

Concretely, a data fiduciary is a structure that brings together three entities: the constituent, the fiduciary (trustee), and the beneficiary. The constituent is the person that owns or produces the data, the fiduciary is the legal entity that is in charge of the prudent and diligent administration of the data entrusted to them, and the beneficiary is the entity that wishes to use the data, for instance, to provide a service. A data fiduciary should be guided by a contract that clearly

170 *Les fiducies de données: une gouvernance renforcée des données qui responsabilise le public*, white paper, Element AI et Nesta, 2019. **https://hello.elementai.com/les-fiducies-de-donnees.html**

defines its goals, the rights and requirements for the data being managed, the decision making process, as well as the necessary aspects for a functional relationship and the creation of a relationship of trust between the fiduciary and the constituant.

To give an example, we can imagine a citizen- the constituent- that wishes to increase the quality of public transportation overall in their city. He or she would accept to transfer their geo-localization data from their mobile phone to a fiduciary that, according to the agreement, would accept to share their data with a private company or an association- the beneficiary- who will develop an application to augment the efficiency of bus services.

One of the primary advantages of this model is in the data sharing and what it can offer constituents. This sharing allows us, for instance, to centralize the administration process of relationships between beneficiaries. Rather than agreeing to the"terms and conditions"- which are often quite vast- of all the service providers, constituents can trust the fiduciary that will act according to the fiduciary agreement, and therefore, in the best interest of the constituents. This mutual sharing also allows them to establish a balance of power between the users and the service providers, which allows for the users to collectively negotiate the use terms for their data.

From theory to practicality

Though they offer a promising governance model for data, putting these data fiduciaries to use can have a few issues, particularly in the context of smart cities. In fact, some of the data collected- for instance images of public spaces taken by cameras- cannot be attributed to a sole constituent. Several technical challenges must also be resolved when it comes to transmission, treatment, security and supervising how the data is to be used. Implementation of pilot data fiduciary projects are essential for us to better understand these differing challenges.

In 2018, the Open Data Institute (ODI) announced a partnership with the office for artificial intelligence for the United Kingdom to pilot three data fiduciary projects that focus on illegal wildlife trade, reducing food waste and improving municipal services.

Today in 2018, Sidewalk Labs, one of the affiliates of Alphabet, offered to create an independent "civic data fiduciary" to help manage the data collected in the case of developing their smart city project in the heart of the city of Toronto. Even though Sidewalk Labs brought attention to the concept of data fiduciaries, their proposal was criticized for lacking details, the fact that it didn't take into account the community's opinions and because it did not include any obligations for the fiduciary. The example of Sidewalk Labs clearly illustrates that, if they want to be accepted by the public , this new form of data governance must be correctly implemented.

Conclusion

We must remind ourselves that this isn't the first time that society successfully created a collection of mechanisms that is able to reduce problems related to the concentration of power. These approaches to democratic regime governance -for instance the separation of power- allowed us to preserve individual rights and promote public good while still offering an environment that catalyzes innovation and economic growth.

The model of a data fiduciary represents a very important first step towards recognition of technologies that are based on the collection of data needs to respect proportional obligations due to the risk that they represent for users.

In fact, this model reflects the current public aspirations when it comes to data governance: fair representation, equal rights, accountability and justice. These characteristics have the potential to create an environment in which smart cities could be socially acceptable and peaceful.

Though data fiduciaries may entail a few implementation problems, they remain undeniably a promising innovation that deserves an important investment.[171]

171 Data trusts: reinforced data governance that empowers the public, white paper, Element AI & Nesta, 2019. **https://hello.elementai.com/data-trusts.html**

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Materializing Digital

Earlier on, we spoke of the necessity of "materializing the invisible city". This process is, in reality, at the heart of urban data governance. The invisible city is supported by digital infrastructures: smart grids, acoustic sensors and even video surveillance . The *design* of these sensors reminds us of their functions. The retina of a camera and the microphone of a sound detector indicate what they are used for. Even though this principle tends to be forgotten due to the abstract nature of the data, a wifi box or a magnetic detector come from the *incarnation* of a technological use. In a certain way, these sensors can be mobilized. The city of Copenhagen has equipped the *Google Street View Car* with air pollution sensors. This collaboration with Google allowed for the Danish capital to optimize the deployment of *IoT* at a lower cost. These digital infrastructures are therefore discrete, evanescent but still visible.

The smartphone is also a powerful digital infrastructure, however, it escapes the principle of intelligibility. It is impossible to know that a telephone call produces meteorological data, or that a tweet can become a social sensor, or that a path can be an indicator of economic growth. With the smartphone, digital infrastructure is disappearing from the urban landscape. It is becoming invisible. Here, technology logically responds to Mark Weiser's principle "the most profound technologies are those that disappear".

We mentioned earlier that the invisible city produces "invisible urbanism". It is interesting to note that digital infrastructures are at the two extremities of the process. The smartphone collects data then serves as a tool for "optimizing" our cities: "The logic of the smart city is the transformation of the standing-reserve into infrastructure. And the logic of infrastructure is that it remains unseen. As a result, the bias in smart city growth has been invisibility- the capturing of data into standing-reserve, and the reassertion of that data is a seamless and efficient as functionality"[172].

With invisible infrastructures, and by extension, invisible cities, the individual becomes a storable resource[173]. Their behaviors, interactions and uses are conserved and exploited. The urban citizen *is* urban data. To reverse this paradigm we have to embody the digital. In other words, (re)*incarnate* data. We illustrated how an interface could respond to these conditions[174]. However, in the case of data governance, it's not enough to see the invisible city, we need to invest in it. The interface must become *interactive*. On this point, I invite you to read Marius Hartman's contribution below.

Although valuable, the concept of interface is not enough to guarantee a balanced and democratic data governance. For this, it must be thought of as a complement to the reflexions on "Data Fiduciary" . Each of these concepts make it possible to appropriate urban data.

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172 Catherine Di'Ignazio, Eric Gordon, Elizabeth Christoforetti, *Seamful Interfaces for A Community-Centered Smart City*

173 *Ibid*

174 See the "Organic Architecture" section of the "Buildings and Infrastructures" chapter

The situated citizen

Marius Hartmann, Chief Advisor at the Danish Business Authority

A successful city plan acknowledges that a city is formed by its inhabitants and users. The narrow winding streets of pre-industrial architecture were not planned *per se*, but rather formed by the flow of pedestrians and small carts; the flowing waters of daily life carved out the necessary urban pathways. These areas of cities still attract visitors from far away and are often among the most exclusive areas.

However, these spaces were lively and somewhat unruly, spawning the need for a technological infrastructure to control this. The boulevard offered solutions to both effective traffic and suppression of revolt. The neat straight lines drawn through the city centres offered a more readily available oversight to the local government and in many ways still resonate the understanding of what shapes a smart city. Most strategies towards utilizing citizen data take the rationalizing perspective of the boulevard rather than the windy unruly paths of its citizens.

From a very real perspective, the Smart City has always existed as expressed by its technological infrastructure adapting to the needs and habits of its intelligent users. These needs and habits have historically evolved in great variation due to cultural traits formed by factors shaped by geolocation, culture, and weather patterns. The buzz of a bazaar is a melting pot of stalls and traffic, in which the noisy trade of groceries may coëxist with areas of relaxation. However this type of city planning has not often been acknowledged, addressed, or transformed by the digital domain.

The lacking efforts of public authorities to provide digital infrastructure has allowed this diversity to be hampered by commercial actors. The digital domain of the city today is owned by commercial actors, cities have within the digital domain not only allowed other parties to take ownership of the digital infrastructure, but also allowed social media to infiltrate the physical space by means of the mobile platform. The field has transitioned straight to a default-privatised state without the usual intervening public ownership phase or conscious franchising.

Go to any city today and you will see it. The city is designed first for the enterprises, second for their basic needs such as wide carriageways, later for the collective, and almost never for the individual. The individual seems caught in by a commercial looking glass from which they venture into digital passageways controlled by big tech companies. The planning of the digital boulevards of the Smart City rests firmly with a few companies. The life, feelings and interest in the physical space around them seem to come second to most users. Anyone watching people cycling with a mobile phone will recognize that this scenario is not an exaggeration. People gather around the digital cathedrals of commercial platforms tapping into citizen data which has been monopolised by a private technological oligarchy. We would never allow whole neighbourhoods to be taken over by organizations instilling their own rules, why do we allow this to undergo unchallenged when it comes to the digital domain? The digital twin of citizen life seems orphaned by public planning and great value both to citizen life and public interest is lost from it.

The Smart City must provide the infrastructure to allow its users to live freely and interact with the physical space they inhabit and share. The Smart City should be an interface that can reflect its users and provide an augmented dimension of the digital life. Why not demand that all visual or auditory displays be open to individual digital services? This could be done in respect to the individual. The sharing of the physical domain already gives us the rules to abide to: as an individual you can choose what to convey to the world about yourself. You can lock your door to your physical space; the same should apply to your sharing of data. The citizen and the digital collective share a bidirectional relationship of equals; the citizen controls their personal data, how it is used, and how it is shared with and by the digital collective, and also determines directly which digital collective data products are “evented” back to them.

A Smart City is a city in which the inhabitants influence individually and control collectively their surroundings; the digital domain allows a city to support the life of its citizens, and this starts by providing a network open to the unruly services and interests of its citizens. A network open to wireless interaction should have connected properties of the city surface that can manifest the hybrid space between digital services and physical location. An open network should be a commercially and culturally neutral bazaar; room is provided and the inhabitants and users determine fluidly its utilisation, such as allocating room for stalls and areas of relaxation created by small merchants. In doing so the city will again become a location to be situated in, not merely a layer of transportation or a necessary backdrop to commercial interests. We must allow citizens to drive the planning of our cities and share the physical space with them by means of a visible, prominent, open, and accessible data layer.

The Smart City utilizes the combined intelligence of its citizens to allow the growth of a new digital melting pot of the life lived in its physical domain. The situated citizen is a revival of the city space to form and evolve cultures to a scale fit for humans.

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CITIES

This chapter is made up of 5 stories of cities about Urban AI. The publication for Montreal was written after a meeting with Yoshua Bengio (founder of Mila), Martin Guy-Richard (Director of the Intelligence department of the City of Montreal), Véronique Dufort (Head of the open data team), Myriam Côté (Previous directress of AI for Humanity at Mila) and Aurélie Hélouis (Coordinator of Technology Transfer at Mila).

CONTRIBUTIONS

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Future cities evolve into AI platforms and Sejong is already there,
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Building a Data Driven City,
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Algorithms Management: How Local Governments Can Use AI and Related Technology Responsibly and Equitably

Jeff Thamkittikasem, Director of New York Mayor’s Office of Operations

As we enter the third decade of the 21st Century, local governments have embraced many of the various technology-supported analytic methods that have been the drivers of innovation in the private sector. The role of predictive modeling, dynamic mapping and data visualization, and open-source and open-data platforms has become cemented into the way cities do business. New York City, like many American cities, relies on data collected through the course of agency operations to evaluate performance in service delivery, analyze new policies and strategies, and strive to make the lives of New Yorkers better.

Given the role technology and data play in the City's operations, it comes as no surprise that emerging methods of analysis and decision-support practices, including artificial intelligence (AI), appeal to City agencies as an efficient and innovative approach to solving problems and improving service delivery. But as is also the case in the private sector, AI and other related algorithmic tools are not perfect, and may come with some complex downsides. It has been shown amply in research that such techniques may not just import problematic data or decisions of the humans who develop them, but can actually exacerbate those problems, often in ways unforeseen by human developers. Too often governments are not recognizing that this trade-off exists; we believe we must openly acknowledge it in order to properly respond to it.

Governments have a responsibility to ensure all residents are treated fairly and equally. In New York City, Mayor Bill de Blasio's focus on equitable outcomes for all New Yorkers makes clear the responsibility of local government not only to understand, but also correct inequity wherever it exists. We believe that responsibility extends to all parts of governance, including the use of AI, other algorithmic systems, and data generally to make decisions. This begs the question: How can local government ensure the responsible and equitable use of these practices?

In New York City, the answer to this question is centralized management. In 2019, Mayor de Blasio signed an executive order creating a new position within the Mayor's Office of Operations: the Algorithms Management and Policy Officer (AMPO). Created in response to a recommendation from the City's Automated Decision Systems Task Force, the new position responds to a widely understood need for an administrator to oversee how agencies use algorithms, including those underlying AI. Previously, no existing agency or body was situated or empowered to provide this sort of holistic, centralized management.

The opportunities and challenges presented by the use of AI in government are unique, testing the bounds of traditional approaches to public sector management. Besides being (or being perceived to be) highly complex, these technology-supported tools have the potential to take a number of familiar government management challenges—for example, data quality issues, policy decisions, decision-making priorities, or human error—and amplify them. For this reason, our solution was to establish the AMPO role, a position crafted to promote innovative opportunities while addressing these risks.

The AMPO's mandate envisions a full circle of management practices. To begin with, the AMPO is responsible for providing City agencies with formal guidance for identifying and reporting on the algorithmic tools they use, including those associated with AI. They are further responsible for reviewing agency tools and the underlying algorithms in use and, in the longer-term, establishing review protocols prior to implementing new models or tools. Finally, the AMPO will establish the forums and platforms by which agencies will communicate information about and the logic behind their tools to the public, and through which the public can learn more about AI and algorithmic tools in general.

To enable this full-circle management, the AMPO role was designed to be:

- Interdisciplinary: When agencies rely on algorithms (including those associated with AI) to help them make decisions, those actions are not just about data and technology. They're also about policy, legal frameworks, laws and statutes, and about the myriad political and administrative contexts that inform how agencies do business. This means that managing algorithms cannot be confined to the technological space. The AMPO and their team will need to be versed in these other frameworks, and must understand the effects they have on agency operations, agency technologies, and their use.
- Centralized: New York City has more than 350,000 employees serving more than 8.5 million residents. To address the needs of these residents, New York City's government is composed of myriad agencies that have widely varied missions. Despite efforts to improve coordination, agencies can sometimes conduct their work and innovate in silos, which can hinder creative thinking and, in worst-case scenarios, impede optimal service delivery. The AMPO will serve as a centralized resource for agencies and the public alike, creating a shared language about government use of AI and related algorithmic tools.
- Transparent: Government must be transparent and accountable to the people it serves. With complex technology-supported practices, effective communication and education may be challenging. That's why a central tenet of the AMPO's work is public engagement. The AMPO will be responsible for creating avenues for the public to comment on and access information about the City's tools, and for guiding agencies in preparing and making such information accessible. To accomplish this, the AMPO will undertake initiatives to educate the public about algorithms and their uses. Without education to facilitate a common understanding of these methods, information shared with the public cannot be truly transparent. Additionally, the AMPO will be supported by an Advisory Committee, composed of members of the public who will advise the AMPO in policy development and serve as an additional channel for sharing information.
- Adaptable: Advances in AI and other related technologies often outpace the ability to fully understand these capabilities and their potential effects. At the same time, efforts to directly manage specific technologies through legislation or other regulatory action are at perpetual risk of not being able to keep up with a changing landscape, and, as such, becoming

irrelevant. That's why we've built flexibility into our solution. As the AMPO develops agency guidance, they will be responsible for periodic review and modification to those guidelines to ensure they address concerns that are contemporaneously important.

In New York, we believe AI has tremendous potential. Smarter, more efficient analysis can lead to faster and more reliable decision-making, and therefore better service delivery for New Yorkers. But efficiency cannot come at the expense of fairness. Cities should avail themselves of AI and other algorithmic tools to support decision-making, but only if they are prepared to do so responsibly. Responsible use means protecting residents from decisions based on problematic data or inequitable outcomes, and where possible, proactively aiming to reduce inequities. That responsibility requires active management and dedicated resources to help agencies use and review technology-driven tools better and to help the public understand how those tools are being used.

Other cities may experiment with different forms of management, but regardless of form, it is clear to us that an interdisciplinary, centralized, transparent, and adaptable management framework is essential if government is to continue embracing new technology and techniques. In New York we are proud of the work so far, and are excited for the new era of management practice.

Jeff Thamkittikasem *is the Director of the Mayor's Office of Operations, an office dedicated to enhancing government efficiency and effectiveness. Previously, Thamkittikasem served for four years as Chief of Staff at the New York City Department of Correction (DOC). During his time at DOC, Thamkittikasem led many progressive reforms, including dramatically reducing the use of punitive segregation and increasing incarcerated individuals' access to educational and job-preparation programming in New York City jails. Prior to joining the Administration and returning to public service, Thamkittikasem co-founded and served as Managing Partner and Vice President of Sentinel Strategy and Policy Consulting, where he provided strategic and operational guidance to a wide-ranging array of clients and developed a strong cohort of data analysis experts. The firm served public and private-sector clients in the US and abroad. Previously, Thamkittikasem has served as senior advisor and Chief of Staff for US Customs and Border Protection, where he directed various emergency response events. His public service began in New York City, where he worked for the NYC City Council. Thamkittikasem holds a Master's of Public Administration degree from Columbia University's School of International and Public Affairs, a Master's degree in Sociology from Stanford University, and Bachelor's degrees in Political Science and International Relations from Stanford University.*

Smart Cities and AI – Enabling the “smart” citizens

Laurence Liew, Director for AI Industry Innovation at AI Singapore

The ultimate goal of any smart city effort must never be about the technology or proof of the technology. The smart city serves only one purpose and that is to improve the lives of its citizens. Technology is a means to that goal.

The use of Artificial Intelligence (AI) as an enabler for various countries' smart city effort is well documented. Use cases which Singapore has done or is doing include traffic management, healthcare, aging population enablement, smart citizenry services, education, finance, cybersecurity, defense and others.

AI is a useful and powerful tool and needs to be viewed as part of a larger country-wide smart city (or smart nation) effort and the potential ethical and governance issues some of these AI systems might bring must be considered. Building smart cities requires not only technology and infrastructure but also human capital – the AI scientists, AI engineers, data engineers, IT, domain experts and many others. However, an often neglected aspect of many smart city efforts are the citizens themselves, the users of these smart city services and products.

AI Singapore is Singapore's effort to accelerate the adoption of AI in its ecosystem and to deepen AI research capabilities. Announced in May 2017, AI Singapore has started 40 AI projects for the industry and is on track to complete 100 AI projects as part of our **100 Experiments** (100E) programme. The **AI Apprenticeship Programme** (AIAP) has trained 75 AI Engineers to date and is on target to train 200 AI engineers over the next 2 years. We have plans to scale up both 100E and AIAP with the initial successes shown thus far.
However, we have not neglected the main users of AI – citizens or the general public who are neither AI engineers, scientists nor even programmers.

AI Singapore's most popular outreach programme is our **AI for Everyone** (AI4E) – a 3-hours face-to-face workshop to educate and de-mystify AI for anyone from students to working adults and the elderly. AI4E is conducted two or three times per month on our premises or at a partner's location. The typical turnout is between 120 – 400 attendees depending on the location. From Jan 2018 to Dec 2019, we have exposed more than 7,000 Singaporeans to AI. We are putting in place plans to educate up to 100,000 Singaporeans or more over the next 5 years.

The next-generation of citizens will be the main users of our Smart City solutions and to address this, AI Singapore has launched **AI for Students (AI4S)** and **AI for Kids (AI4K)** to educate as many students from upper primary to universities as possible in basic Python programming and AI. We have more than 13,000 students enrolled in the AI4S programme and the number is growing.

These talent and outreach programmes, which were not originally planned, were created in response to our interactions with the industry, professionals and workers. When we first executed the 100E programme, we faced much resistance and pushback from workers who were afraid that AI would displace them; managers who did not know how to start an AI project or business owners who were skeptical about AI. To address these issues, we created these outreach and talent programmes to educate and de-mystify AI. While we do not

shy away from the fact that AI is disruptive, it also opens up the possibilities of better jobs and increased efficiencies to those better equipped to embrace it.

In the preceding one year, the number of AI projects proposals we have received has increased. As the demand for our popular AI4E programme increases, we had to triple the number of trainers as well.

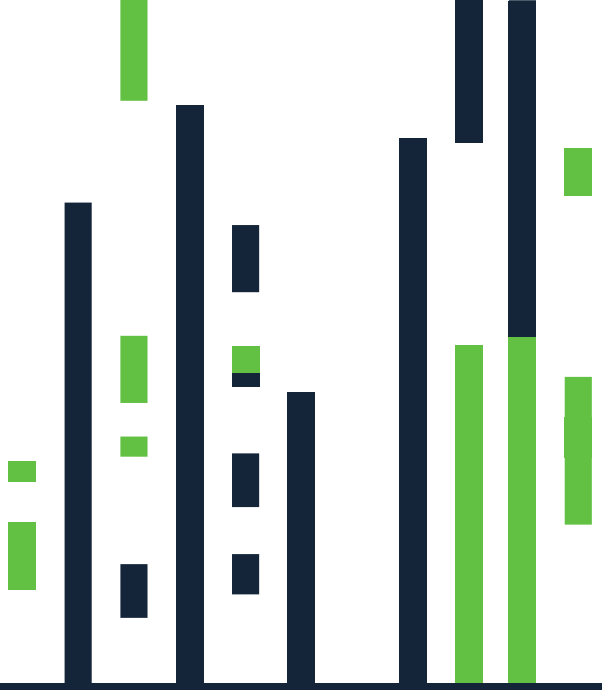
In order to be an AI-enabled Smart City, we will have to keep our citizens AI-aware and our workforce AI-ready.

Laurence *is the Director for AI Industry Innovation at AI Singapore and is driving the adoption of AI by the Singapore ecosystem through the 100 Experiments and AI Apprenticeship programmes.*

A visionary and serial technopreneur, Laurence identified and introduced Singapore's enterprises to:

- *Linux and open source in 1999, by being the first RED HAT partner and authorized training centre in Asia Pacific*
- *High Performance Computing (HPC) Cluster in 2001, by building A-STAR's IHPC first computer cluster (most of the initial HPC clusters in NUS, NTU, SMU were built by Laurence and his team)*
- *Grid Computing in 2003, by building and operating Singapore's first Grid platform – IDA's National Grid Pilot Platform*
- *Cloud Computing in 2007, by architecting both the Cloud business and technology for then Singapore Computer Systems' Alatum Cloud (now owned by Singtel)*
- *Open Source Analytics in 2011, by building Revolution Analytics Inc business in Asia and R&D team in Singapore. Revolution Analytics was acquired by Microsoft in 2015.*

Laurence graduated from National University of Singapore (NUS) with First Class Honours in Engineering and holds a Masters in Knowledge Engineering from NUS.



Future cities evolve into AI platforms, and Sejong is already there

Jaeseung Jeong, Master Planner of Sejong Smart city national pilot project
and Head of Graduate School of Future Strategy in KAIS

Prologue: A city is a great invention, but has a lot of things to fix.

In South Korea, the commuting time for urban people exceeds 100 minutes per day on average. It takes an average of 48.1 minutes to go to work and 53 minutes to go home, and to be worse 134.7 minutes for office workers in Seoul. It is ranked the first among OECD countries. When we estimate our work life as 30 years, we are throwing 14,400 hours (about 600 days) on roads and streets. Considering that your bodies become tired and your minds are exhausted in the subway and bus during commute, this damn city is out of control. How can we change cities to return one-third of the average sleep time (6 hours) to citizens?

In "Sejong," the national pilot smart city in South Korea , first of all, we are to make the public transportation system much smarter than it is now. Artificial intelligence should control traffic lights to control traffic flows by observing and manipulating the flow of pedestrians and cars and minimizing the waiting time for people or cars to stop. If self-driving cars become more popular and routine, you can sleep or work in the car during commute.

If you make it easy to connect to a network so that you can use your work computer at home, you can work from home without worrying about security for a few days a week. If 5G mobile communication systems become more common and video conferencing becomes much smoother than it is now, the home activities of not only office workers but also single-person companies and freelancers will increase significantly in this city. In this way, artificial intelligence will become part of the city.

Cities are increasingly evolving into AI platforms.

Every platform in the world is a "bowl that holds human life". The platform, which is the basis for recording and processing the trajectories of human-generated activity, is the foundation of human civilization. Platforms are becoming increasingly important as platform companies analyze data of humans and have a huge impact on their lives.

In the past decade, smartphones have grown rapidly as a platform for digital civilization. Humanity has created a huge mobile civilization as people's every move, texts and drawings left on social media, and various personal information are accumulated and processed in it. Particularly, South Korea is the first rank for internet user rates and mobile phone user rates among nations. Thus, as the Internet of Things (IoT) becomes more common, houses have evolved to be a platform in Korea. TVs, laptops, CCTV, refrigerators, boilers, scales, etc. exchange information among others and predict how to provide home or urban services that may be needed for us. A.I. based smart home manages energy efficiently and manages family life conveniently and safely. In the era of "Platform War", the ultimate platform will be the city. A huge device called smart city will smartly care for all areas of human society, such as health, safety, education, culture, and transportation. In the end, the platform of human civilization will expand to the urban scale and we experiment this concept in Sejong.

The prediction that a city will become a platform also means that there will be a company or country selling the city. A country that can elaborately build an urban ecosystem, such as the "Comprehensive gift set of technology," will dominate the world. If you think of a company that has dominated the world with a concept of 'smart phone,' there is no doubt about it as well. We, smart city master planner team in South Korea, are planning to bring smart cities to the world with the support of Korean government. Korea is the country that has accumulated the most experience in building new cities in the middle of the 20th century.

City should be an AI platform for happiness of individuals

Why are countries so enthusiastic about smart cities? It is because urban civilization is no longer sustainable. Separation of workplaces and homes causes heavy traffic jams. Environmental pollution and crime increase have already exceeded the limit. With this competitive education, it seems impossible to cultivate creative and diverse talents for next generations, and the separation of 'food-producing rural areas and consumption-only cities' has caused numerous environmental problems on a global scale.

What we need to know is that the most important value of future cities is the platform will pursue for "human happiness." Unlike the ubiquitous-city that pursued efficiency or convenience for town management companies and municipalities, the Internet of Things, big data, and artificial intelligence should contribute greatly to the happiness of citizens in smart cities. The goal of Sejong is to 'make the happiest city in the world through smart technology'.

To build a city that serves as a bowl for a happy human civilization, we must first deviate from the concept of civil engineering centered on 'construction and development.' We need to value data and turn it into a technology-driven thinking for services. To capture the essence of humanity's urban civilization and the essence of human happiness in the city, humanistic reflection is desperate. We need to start building a sustainable urban civilization with science, technology, humanities, social sciences, and arts. And artificial intelligence is in the center of them.

National pilot city, Sejong Smart City, is its first attempt

How can we create a sustainable city that will contain a new civilization? How can we regenerate the big city where people live together? We define a smart city as a city that serves as a platform to provide customized prediction services that improve the quality of life and happiness of urban residents by analyzing all phenomena, movements, and citizens' behaviors in the city through artificial intelligence. In other words, it means that the city will be reborn as a "space to care for citizens" using the fourth industrial revolution technology. The reason for this thought is that information technology, which is the result of the digital revolution, may have developed rapidly in recent years, but it is because convergence technologies that can be used in manufacturing and distribution fields have developed together. For example, the Internet of Things has made it possible to data all the phenomena happening in cities and the actions of citizens, making the society where digital technology can be applied.

In Sejong for the near future, a breakthrough is expected in medical services. The patient's condition is monitored at home using telemedicine and sent the info to the hospital, so even if you don't go to the hospital, your doctor can provide you with remote medical treatment. Better treatment is possible now than patients who have been having an interview with a doctor for just 5 minutes at a general hospital. What kind of treatment can a healthcare-centered smart city, Sejong, provide to emergency patients? When an emergency occurs to the citizens, the drone flies for the most urgent first emergency within 3 minutes before the emergency vehicle gets through the complicated road and arrives. It helps the guardians in the immediate vicinity to provide first aid. Following the arrival of the ambulance, all imaging and examinations are performed in the emergency vehicle transporting the patient. While on the way, a doctor waiting in the hospital checks the patient's condition in the emergency car and instructs emergency treatment. That way, as soon as you arrive at the hospital, you can get into urgent surgery.

In Sejong, smart governance will also be possible, which quickly collects citizens' opinions on local issues and manages them according to their will using smartphones. By developing an app for citizens, they ask public opinion there, and city councils, city halls, and local parliamentarians perform administrative activities that reflect citizens' intentions. In the past, it was difficult to implement it because it was hard to identify and there was a risk of hacking, but now biometrics and blockchain technology will make this possible.

To solve the urban problems, we are supposed to build a virtual city which can be created on a computer to capture the phenomenon in the city to find a solution. This is the so -called "digital twin." In Sejong, we believe that helping citizens to discover urban problems and to solve urban problems may improve citizens' happiness. To do this, it is most important to form a community among citizens, and artificial intelligence is used to help make this possible at low cost and to effectively read citizens' minds.

What is most important is data

In the philosophy of Sejong masterplan, the strategy for success is 'data and artificial intelligence.' To read citizens' needs, to understand their minds, and to provide the services they want, we need to obtain data about citizens from them. Thus, all smart cities try their best to get various city data. We are designing the data platform to have data and analyze them with artificial intelligence to provide urban services. There is no city like this in Korea yet, and even in Europe, the application of artificial intelligence is at a very early stage.

For instance, in Sejong, self-employed people who prepare to open a cafe want to get people's mobile data, but are not sure where and how to get it. But we are planning to provide them with people. In addition, it is possible to create any new value with various data created by individuals, and there is no intermediary agency to mediate data transactions. To elaborate national policies on a global scale, we are supposed to share data generated by our city with other cities in our country and even with other countries.

In the masterplan of Sejong, we propose that the establishment of data exchanges and data agencies will be an opportunity to adapt Korea to data capitalism and mature social trust. Just as building nationwide internet networks in the late 1990s at the very early stage of the internet era was a catalyst for the development of IT technology in South Korea, the establishment of exchanges and agencies will make a crucial contribution to leaping into a data powerhouse. We suggest that, if a next-generation network such as 5G is established, it is even more urgently needed.

South Korea is a country where e-government is very developed, but there is little data of quality there. Efficient analysis or trading of data is even more lacking. However, Since 2017, the websites of 25 government departments and 376 government agencies in Korea have been integrated into one, providing all policies, announcements, publications, and statistical information through a single window. When the Data Authority is established and a data exchange is created, there are some things to do initially. First, the data standards must be properly established. Fragmented data without standards are useless. The Agency needs to establish standards and establish and manage protocols that are compatible.

To this end, new laws and institutions will need to be revised to promote innovations. Current data-related laws in Korea are anachronistic, making them unsuitable for hyper-connected, intelligent network-based data societies. The privacy should be thoroughly protected, the use of various data should be promoted, and the subjects themselves should be thoroughly secured so that citizens do not avoid it.

From 'Selection and Concentration' to 'Connection and Convergence'

The most envious thing about Sejong, the national smart city pilot city, is the environment in which the central government can attempt innovative applications of mobility, energy, education, healthcare, governance, culture and shopping to this city all at once. In fact, energy data, when combined with mobility data, can create enormous synergy. Health care and education data are essential to governance, so combining them can create new urban services with artificial intelligence.

Some people asked me if I have any plan about what to choose and concentrate on smart cities of Korea. My answer is that the city is a whole bowl for life that should not be selected and concentrated. They have thought that we do not have sufficient resources to support the applications of mobility, energy, education, healthcare, governance, culture and shopping, jobs areas to one single city from a municipality. However, we believe that 'connection and fusion' is the future of the city and with current resources we can accomplish this concept for the near future. Now we got started with confidence. Sejong will be the first attempt and hopefully success to accomplish synergetic convergence of artificial intelligence for mobility, energy, education, healthcare, governance, culture and shopping for human happiness and city sustainability in the concept of 'smart city.'

*Professor **Jaeseung Jeong** is currently a professor at the Department of Bio and Brain Engineering and the Head of Graduate School of Future Strategy in KAIST (Daejeon, South Korea). He received his Ph.D. from the Department of Physics in KAIST. He has been working as a postdoc associate at the Department of Psychiatry, School of Medicine in Yale University (New Haven, USA) and as an assistant professor at the Department of Psychiatry, College of Physicians and Surgeons in Columbia University (New York, USA). His research topics include brain dynamics of decision-making, computational modeling of neuropsychiatric disorders including depression, addiction, and dementia, Brain-Robot Interface (BRI), and Brain-inspired Artificial Intelligence. He has written more than 85 research articles in prestigious scientific journals including Nature, Nature Medicine, Nature Communications, and so forth. He was selected as one of 'Young Global Leaders' from World Economic Forum (WEF a.k.a. Davos Forum) in 2009 and received several awards from scientific communities. Recently, he has been selected and working as the master planner of Sejong Smart city national pilot project since 2018.*

Building a Data Driven City

Richard Dib, Head of AI and Data chez Smart Dubai

Mega cities are on the rise - in 1990, there were ten “mega-cities” with 10 million inhabitants or more, which were home to 153 million people. In 2018, there were 33 mega-cities worldwide, home to more than half a billion people. Today, more than 55% of the global population is urbanized, and by 2030 the U.N. projects that 60% of the global population will be living in cities.

As cities grow there will be an increasing pressure to explore the objectives of economic, social and environmental sustainability, while exploring how urban infrastructure and services can reach a level of efficiency as never seen before, hence the emergence of Smart Cities.

This movement towards Smart Cities is getting more traction, as more and more cities are driving their investments into new technologies and data utilization approaches. In order to respond to the rise of urbanization the cities of the future will be built upon data and integrate with big data platforms.

When it comes to innovation and transformation, Dubai has always been an active global player. In 1970 the city was a small sea faring settlement of approximately 80 thousand people. Today the emirate belongs to the “very high human development” group of countries and its population has burgeoned to around 3.5 million people. In terms of technology acceptance, the society enjoys some of the highest technology adoption rates in the region and the government is focused on driving innovation and technology to enhance quality of life.

This quest for quality of life and happiness gave birth to “Smart Dubai”. It was born out of the visionary approach of H.H. Sheikh Mohammed Bin Rashid Al Maktoum, Vice-President & Prime Minister of the UAE, and Ruler of Dubai, who wants to make Dubai the happiest city on Earth. Since that moment, Smart Dubai’s mission is to leverage the power of emerging technologies and data, and understand how these technologies can be implemented across all industries of the city in order to make sure the citizens, residents and visitors of Dubai have efficient, seamless, safe and personalized city experiences, leading to happier people in the city.

When it comes to Data, this city asset was positioned from the beginning and by design as a central piece of Smart Dubai strategy. This resulted in the publication of Dubai Data Law in 2015 which mandates the sharing, use and reuse of data. The goal of the Dubai Data Initiative is to ensure that the city can benefit from its data, fuelling the city into its digital transformation and leading a new approach in data management for cities.

The Smart Dubai Data journey started first with the public sector by setting a set of standards covering elements of data use, data sharing and data governance. In order to enforce compliance of the standards the role of Data Champions surfaced across the city in order to embrace this cultural change. Data Champions also known as change agents, are a community of public sector organization leaders, leading the implementation of Dubai Data initiatives within government entities and ensuring organisational compliance with the Dubai Data Law. Through the involvement of the data champions and

mainly through gamification programs such as Data First – The City's Data Challenge, the city started to identify, prioritize, classify and publish datasets on Dubai Pulse which will result in creating value from the city data.

Dubai Pulse, "the digital backbone of Dubai", is one of the first initiatives to be launched by Smart Dubai in early 2017. Dubai Pulse is an integrated platform that hosts the city's most valuable and powerful datasets to help empower decision-making and solve city challenges using data. The role of Dubai Pulse is to ease the exchange of data between government organizations by breaking the siloes and allowing each government organization to have a holistic view of the city from a data point of view. Also Dubai Pulse is accessible by residents of any country across the globe as it is the open data portal. Finally, Dubai Pulse is a Big Data platform on a city level that offers a full suite of tools a Data Scientist would need to analyze the data and generate data insights that would help residents, business owners, city planners, and city leaders to make data driven decisions or data driven policies.

In 2018, Smart Dubai initiated collaboration with the private sector and in early 2019 launched the Dubai Data Private Sector Engagement Strategy and Policies, which aims to enable a data ecosystem, foster stronger partnerships between public and private sector entities, and drive Dubai's ambition toward becoming a data-driven city. One of the key findings of this strategy was to build a data marketplace that would host data from both the public private sector and encourage exchange of data. Currently, Smart Dubai has been working on designing and building a decentralized data marketplace in addition to working on the regulatory framework that will help this marketplace to run in a trusted manner and building the right community of stakeholders that will be utilizing the data marketplace. It is expected that the data marketplace will be launched later in 2020 which will be an addition to the already existing Dubai Pulse and will position data at the center of the city economy.

As more data is being ingested on Dubai Pulse, Smart Dubai launched the Data Science Lab in early 2019 that seeks to develop data science skills in the emirate and foster collaboration among Dubai's data science community to identify and explore use cases that will help deliver insights and foster the growth of a data ecosystem. The Lab is a production line for use cases, which engages with real-world problems solvable through data science with the aim to create economic and social benefits. In addition to the Lab, Smart Dubai has built a Data Science Community that extends beyond Smart Dubai's walls by involving a wider community of data experts and stakeholders. The Dubai Data Science Community is being kept active through Open Meetups, Hackathons and Data Challenges that solve city wide data challenges.

In alignment with the National AI Strategy, Smart Dubai has also launched its own AI Roadmap to identify and implement AI use cases across many industries and building capability within government. The biggest success in the AI field up to date has been the AI Chatbot - Rashid. Rashid is the city concierge of every person around the world wanting to know about Dubai. Rashid can answer any question with regards to establishing a new business or getting a visa, or enrolling a child in school.

Noticing the need for policies and legislation for the ethical implementation of AI, Smart Dubai developed the Ethical AI Toolkit to set clear guidelines on the ethical use of the technology, and prevent having a fragmented, incoherent approach to ethics, where every entity sets its own rules. Moreover, Smart Dubai launched the AI Ethics Board, bringing together leaders from the technology industry, academia, and government policy experts and practitioners to help the government and private sector develop AI systems that balance innovation with social service, as well as outline a future path for enabling AI regulation.

In conclusion, building a data driven city would require to address the following elements and push them to a mature stage. First, would be to start by setting a data regulatory framework. Second, would be to build the technical infrastructure that would host the city data so it is ready to be analyzed, helping the city's leadership make data driven policies, the business owners make data driven decisions, and the city to maximize value generation from data. Next, would be to foster a data driven culture within organizations which can be done in several shapes and forms such as gamification. Also, would foster the collaboration between the public & private sector in delivering city-wide use cases in a trusted environment. Finally, to clause the loop to promote the achievement of the city-wide use cases that would trigger more people and organizations to join the data movement within the city. This cycle when applied to other cities needs to be tailored as each city has different needs and priorities.

Richard Dib *is leading the Data Science stream within Smart Dubai charged to promote Dubai as a globally recognized Center of Excellence and testbed environment for advanced data science and cultivate a data science community in Dubai.*

Richard is also Head of Business Development for Dubai Pulse within Smart Dubai, helping the city of Dubai into its digital transformation and making Dubai the Happiest City on Earth. Prior to that, he was a Senior Advisor part of Nexgen Advisory Group helping Cities to embrace their digital transformation. Also Richard has heavily been involved with Telecom & Media Players in Europe and in the Gulf region where he developed Next Generation Products & Services Strategies and Go-To-Market Strategies. Richard, with a Masters Degree from Telecom Bretagne (École Nationale Supérieure des Télécommunications de Bretagne), is leveraging his strong business skills, his consultancy background and his product design thinking and creating value out of Emerging Technologies and 4th Industrial Revolution.

This section was written after meeting Martin Guy-Richard (Director of the Intelligence Department of the City of Montreal), Véronique Dufort (Head of the open data team), Yoshua Bengio (founder of Mila), Myriam Côté (Previous Directress of AI for Humanity at Mila) and Aurélie Hélouis (Coordinator for Technology Transfer at Mila).

How the City of Montreal plans on using AI in the Years to Come

Last May, the city of Montreal won the ***Canadian Smart Cities Challenge****. The metropolitan area of Québec brought home a 50 million dollar prize that would allow them, among other things, to create and deploy their own AI. In this context, how can one of the smartest cities in Canada use this technology?*

Open and ethical data

The city of Montreal possesses a portal of open data through which roughly 330 data sets are available (with, over time, the capacity to integrate the entirety of the city's data. It is moreover possible to access information relating to criminal activity, the environment and even to the city's infrastructures. "At first we did that (leaving the data as open source) for transparency reasons. Now, we also want to open up the data for strategic reasons. That means that we'll think about the kinds of applications that are made possible by this data (*open with purpose*)"(V.D). This open data allowed startups like Transit (mobility aggregator) and Local Logic (Real Estate data analysis) to train their algorithms and refine their AI. In addition, it is interesting to note that the City of Montreal in and of itself is a user of this portal: "The City of Montreal is made up of 19 neighborhoods. Due to this complexity, the portal is also a means for improving our organizational efficiency." This tool allowed the City of Montreal to have less information silos (something that public institutions are often criticized for) and to move towards transverse governance practices. "Because of the movement of things, we became a team that had a vision of the entirety of the City of Montreal" (V.D).

In addition to centralizing existing data, the City of Montreal also opened up by creating new data. For this, each year, the City of Montreal offers inhabitants the application **Montréal Trajet**. For 1 month (from mid-September to mid-October) it anonymously records its users daily commutes (on the condition that they consent to it). The municipal government was then able to analyze how the people of Montreal used the space and determined if its infrastructures were adapted to their uses (with the possibility to change where the stop lights were located, crosswalks, etc.).

Overall, opening up this data shouldn't work against the security and the well-being of the citizens. "It's not enough to have transparent data. It also needs to be ethical" (V.D). In other words, the data portal shouldn't give information about the private lives of the people of Montreal (like someone's address), or release information that may put the city in danger (how much time a fire station takes to get ready). By collaborating with the other actors of the city, the

City of Montreal also worked on elaborating an agreement that was designed to offer a better management of numerical data.

..An AI that serves Citizens

For the past 3 years, the City of Montreal had its own AI department (for Business intelligence and Artificial Intelligence- equipped with 18 people.. and counting). The city had hoped to create smart systems to improve the day to day life of its citizens. For this, the City of Montreal was working on developing an AI that could detect unforeseen obstacles: "For construction, authorities had to plan detours. But there were a few instances where vehicles were blocking these detours. This quickly led to heavy traffic. We wanted to be able to use *computer vision* (image recognition) to automatically detect unexpected obstacles and be able to propose an alternative itinerary for people in Montreal" (Martin Guy-Richard).

The obstacle detection project is, in reality, a long-term strategy. The City of Montreal has identified 13 priority construction sites where they wanted to use AI throughout the next 5 years. We also see projects linked to crowd movement analysis (anomaly detection, sicknesses, violence, etc.), to automatic retranscription (to optimize emergency call centers) and automatic recognition for the city's archives.

In order to address construction sites, the City of Montreal plans on proceeding in an ecosystemic way. Since September 2019, it uses a laboratory at Mila (Insitut Québécois d'Intelligence Artificielle, please see below for more information). This partnership allows them to benefit from expertise in AI from one of the biggest *Machine Learning* centers in the world. This implantation in this incredibly innovative space will be an opportunity to exchange and create synergies with major tech companies (Samsung, Microsoft, Element AI, etc.). Moreover, the City of Montreal also plans on collaborating with the **CRIM** (Centre recherche Informatique de Montréal), one of the most prestigious research centers in applied IT in Canada.

What can we learn from the Montreal Model?

This willingness to use collaborative intelligence towards AI is indicative of Quebec's DNA. Like Monique Savoie shared with us (the founder/directress of the Société des Arts Technologiques): "Quebec is a bit like a survival lab. The culture of storytelling and the network is very strong here". Here, collective intelligence (and AI) are here to serve the citizens, in a very concrete way.

Not every city has the financial means and the technological maturity that is sufficient enough to develop their own AI. In this way, the example of Montreal shows us that local institutions can maintain decision-making capabilities while running an open data campaign that has been well-thought out rather than circumstantial.

Mila: The Brain of Montreal

A space for openness and collaboration

Mila is largely responsible for Montreal's international reputation in the AI sphere. Founded by Yoshua Bengio in 1993, Mila maintains an impressive ecosystem: Tech giants (Google, Facebook, Samsung, and even Microsoft), the unicorns of the future (Element AI) as well as innovation departments of international companies (cortAIx for Thales and Quantum Black at McKinsey) are all united in this exceptional place. This density was primarily created to facilitate synergies between Mila's variety of members. "It's a place to exchange and where people interact and share ideas" (Aurélie Hélouis). Moreover, there are several mutual spaces throughout the building where you can play ping pong, have a beer or work together. This layout is also representative of a willingness to work on collective and open research projects.

Something else that is unique about Mila: there is a strong link between universities and companies. Mila has roughly 350 researchers that work directly with partnering businesses. There can even be moments when professors can even transition and work with one of the collaborating companies. This was the case of Simon Lacoste-Julien, a tenured professor for the Université de Montréal and the Director of the research lab for deep learning at Samsung. This is a win-win situation that allows companies to benefit from the scientists' expertise in AI (which is rare in the current job market). In exchange the scientists can continue their university contracts without having to worry about the financial details.

Transitioning towards a more Human-centered AI

Mila aims for more than just technological excellence, it aims to collaborate with companies and universities to work on social and environmental issues. "We want to create impactful projects" (Myriam Côté). This ambition appears in Mila's projects: "we are shooting to make using natural resources more efficient by using systems that are able to predict the demand and the amount of production possible [...] We're also working on using AI to best forecast climate changes by ourselves. **One of the major goals of this project is to give each person the possibility to see how they will be affected, directly, by climate change"** (Yoshua Bengio). Another example is with the startup Imagia, a member of Mila that is supported by Yoshua Bengio himself. Imagia uses AI to improve the process of cancer testing and offers personalized treatments to combat this pathogen. At first, this Montreal startup was specialized in oncology, and they progressively expanded their expertise to neuro-degenerative diseases.

As a human-centered organization, Mila also hopes to build "Responsable AI". This means an inclusive AI (like their project **Biasly AI**, among others) that is respectful of individual liberties. For this, Mila is one of the co-signers of **Montreal's Declaration for Responsable AI**. This is an initiative led by the Université of Montreal that aims to define AI research and its uses. "Powerful tools like AI should be used to save lives and improve the human condition. However, they can also become weapons exploitation and servitude" (Yoshua

Bengio). This is where it becomes important to create responsable AI, and also “responsible humans”. Now more than ever with AI, “each one of us is responsable for and before everyone” (Dostoievski).

RECOMMENDATIONS

CONTRIBUTIONS

Urbanized Technology,
Saskia Sassen, Robert S Lynd Professor of Sociology at Columbia University

Civilizing our Smart Cities : AI for Social Fabric,
King Wang Poon, Director of the Lee Kuan Yew Centre for Innovative Cities

In Copenhagen, I met Stephen Alstrup, CEO and co-founder of SupWiz. At the end of our conversation (which was mainly about chatbots that were being used by municipal governments), Stephen reminded me of the story *The Emperor's New Clothes* by Hans Christian Andersen.

In this story, the Danish writer illustrates an empereur that is so worried about his wardrobe that he completely abandons his kingdom and his subjects. After understanding this, 2 con men present themselves as the best tailors in the land. They tell him that they are capable of making an outfit that is so beautiful that only clairvoyant spirits would be able to see it. Intrigued, the emperor asks the two foreigners to make the outfit. A few days later, the conmen came back empty-handed but presented him the outfit saying: "here is the outfit: what do you think of it?". The emperor does not see anything, but doesnt want to look like a fool and says that the clothing is magnificent. When it came to his court's opinion, they reflected what their emperor told them: "splendid!", "marvelous!", "ravishing!". Reassured by their general reaction, the emperor decided to showcase his outfit throughout his kingdom with his new garb. The laymen are shocked when they see their emperor proudly strutting through the streets, naked! No one dared to say a word until a child, popping out from the crowd, yelled out: "the king is naked!". Laughter starts to take hold and soon the entire crowd can hardly contain themselves "he doesn't have clothes at all!". Humiliated but proud, the king decides to continue the parade clothed in his invisible tunic.

For Stephen Alstrup, certain cities are similar to Andersen's emperor: trying to appear "smart", they put on a show, only to end up looking naked.

So how can we use Urban AI without ending up naked? How can we avoid falling into the "smart city" trap?

We have seen several best practices during this world tour. First and foremost on urban data. We saw that it was possible to work together to achieve an open and democratic data governance. To do this, urban actors need to re-think the social contract and agree upon a collective political vision. To do this it is essential to inform and to educate the citizens on the issues that digitization presents[175]: "Again, educating by explaining what data is being collected and how it's being used is key" (Luc Julia[176]). Moreover, urban actors have access to excellent concepts and tools to best use the data. The "data Fiduciaries", "data banks", and *federated learning* as well as the development and exploitation of *open source* algorithms are precious resources. Once again, collaboration is key. First, between collaborators but also between cities. During my entire trip around the world I kept seeing this fundamental idea of urban collaboration. In Montreal with Monique Savoie (pioneer in the Art Numérique and founder of the Société des Arts Technologiques), who **confided in me that her ideal city was "the world"**, in addition to my visit of the Biennale of Architecture & Urbanism in Seoul which was dedicated to the theme "collective cities"[177]. SharedStreets

175 For this component, Lawrence Liew's contribution is rich in information

176 See Luc Julia's contribution, *It's OUR data !*

177 This Biennale was co-organized by Rafael Luna whose contribution can be found at the end of the "Buildings and Infrastructures" chapter

and the Mobility Data Specification of Los Angeles opened the door to this kind of urban collaboration.

Each city is unique, and consequently, results in a *unique* use of Urban AI. This is why it's important to take into account the historical and social context of an area before deploying this technology. Moreover, there are some similarities between cities. It is therefore possible to use what Carlos Moreno called "urban trajectories". The *roboat*[178] project developed in Amsterdam, can also be relevant for cities like Hamburg or Venice. Likewise, the biodiversity management tools developed by UCL[179] in London can be interesting for cities like Singapore and Montreal as well as urban planning for Kendal Square[180] can inspire other academic HUBs, like that of le Plateau de Saclay in Paris. Mapping urban trajectories is therefore essential. It brings to light the city's future and opens it up to new perspectives. In Singapore, Fabien Clavier also illustrated the possibility of using unsupervised learning to study similarities. History, philosophy, urbanism and other more traditional sciences will also be a big help to this kind of work.

We have long since insisted on the notion of "invisible cities". It is essential to better understand the complexities of Urban AI. To fight this phenomenon, an interactive interface should be used rather than digital infrastructures (and invisible infrastructures). However, several companies propose urban interfaces that actually serve as a collection point for personal data. This reminds us that interfaces, like AI, are just a tool, and not an end in themselves[181]. They should be used to assist a project, not to be the project itself. As Joy Bonaguro told me, Chief Data Officer of the State of California: "AI is just a tool in a constellation of tools".

Le Corbusier said that statistics was the pegasus of the urban planner. He called for us to "use statistics as tools to build sewers, water canals, gas, electricity, telephones, compressed air, tires, etc"[182] to "show us the past and transport us to the future"[183]. Likewise, Urban AI has the potential to become, in its own time, the pegasus of cities. Flying around the world, Pegasus is also a creature that, with a flick of his hoof, created the Fountain of Hippocrene, the source of inspiration of ancient poets. Urban AI is not just a Archimedian point with which we "view the world"[184], it is also an instrument that is at the service of the poets of cities.

This report revolves around two contributions that respond to and clarify one of the major issues of Urban AI: (re)urbanizing technology to avoid it from de-

178 See the "Organic Architecture" section in the "Buildings and Infrastructures" chapter

179 See Alison Fairbrass' contribution at the end of the "Resilience and Biodiversity" chapter

180 See the "Augmented Urbanism" section of the "Urbanism and Architecture" chapter

181 For more on this point, we invite you to see the interview with François Chollet **https://smartworld-ai.com/there-is-nothing-about-ai-that-is-anti-democratic/**

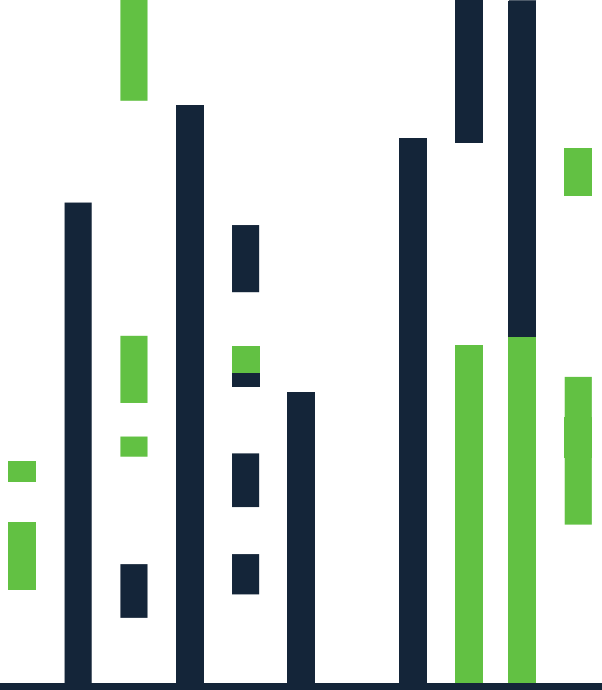
182 *Urbanisme,* 1947, Le Corbusier

183 *Ibid*

184 *Ibid*

urbanizing our cities. Saskia Sassen explains to us what that means and King Wang Poon shows us how to do it.

As we have tried to illustrate during this report, technology can, and should, be urban. Our survival and our humanity depends on it. Consequently, and even before being a concept, the term “Urban AI” is a call for sustainable and human-centered use of technology.



Urbanized technology

Saskia Sassen, Robert S Lynd Professor of Sociology at Columbia University

Redefining urban intelligence?

The first phase of intelligent cities can be very exciting. The city becomes a living laboratory for smart urban technologies that can handle all the major systems a city requires—water, transport, security, garbage, green buildings, and clean energy. The act of installing, experimenting, testing, or discovering—all of this can generate innovations, both applied and those that exist mainly in the minds of weekend scientists.

While recognizing the role of technology as a driver of urban innovation, we must accept their capacity to "de-urbanize" cities. By de-urbanizing I mean a whole range of activities that take over diverse conditions which have long been partly dependent on people's engagement with diverse aspects of their neighborhoods and cities.

From experimentation, discovery, and open-source urbanism, we could slide into a managed space where "sensored" could become "censored."

One way of putting it is that what stands out is the *extent* to which these technologies have not been sufficiently "urbanized." It also signals a lack of genuine technical innovations: such urban insertions of technologies often are too generic to function well in a city. They might be fine in all kinds of applied situations, but not in a city.

A city is a domain with multiple vectors in play. That means that to insert technologies in a city can go well beyond standard infrastructure. It might require a variety of innovations, some of which would connect to people, recognize their needs and adjustments to novel types of urban space marked by the fact that they are engaging messy urban settings. And it means that the needs of city residents need to be recognized and acted upon.

Technologies are "de-urbanized", first, when they have not been made to work within a particular urban context. It is not feasible simply to plop down a new technology in an urban space. There is a long list of failures that comes out of that. Consider the sharply varying kinds of architecture and building types that have evolved around the world in response to the need for increased density. Masdar looks nothing like Songdo. And compare Dubai and London: both have dense centres but they are built in very different styles.

This means that technology systems that might work in one city might not be desirable in others, or would have to be dramatically reworked to be practical elsewhere. We need to push this urbanizing of technology further, and in different directions.

Second, technological systems, such as those that might be proposed as part of a Smart Cities program, can wind up "de-urbanizing" a city or an urban area because, even though they might be interactive, they tend to be closed systems. This is a point often overlooked but one I see as critical. Because cities are open and incomplete systems this can be a major challenge to engineers who aspire to generate closed systems –which are essential to many operations—as we can see, for instance in the case of airplanes.

A third aspect that is rising fast in certain countries, notably China, is the rapid expansion of massive surveillance of citizens. Even if in milder or more benign ways, surveillance has also become a critical function in many of the most "advanced *democracies*" across the world. In the long run this may have the effect to silence what I like to refer to as a city's "capacity to have speech." By this I mean the broad and very diverse range of languages, customs, engagements, a working city tends to have.

'Cityness' and its many incarnations.

Instead of relying on technology as a barometer of urban progress, I would argue that the emphasis should be on the interaction between technology and the diverse needs of a city. I use the "the notion of cityness" to mark something more encompassing and complex than urbanity.

"Cityness" is a bit of an abstract term and is one way of opening up the category and allowing for more variability in what constitutes urbanity. This generates a whole field for research and interpretation, and invites us to reposition Western notions of how technology can help cities. It also signals that we need a very broad range of types of intelligence, not just the self-evident ones such as technical innovations.

The city is not just materiality: there are people, practices, subcultures, a conglomerate of diverse elements. Hence technical innovations should include a very broad range of interventions. "Cityness" interprets urban space "as a complex space that thrives on diversities and tends to triage conflicts into a strengthened civicness. It puts in motion capabilities that get constituted as hybrids—mixes of the material and social physics of a city. In other words, "cityness" captures the ways in which an urban space expresses its civic intelligence, manifests its unique characteristics and negotiates threats and conflicts.

To put it briefly, it enables the city to talk back and bring into the picture the diversity of settings and neighborhoods that constitute the urban condition.

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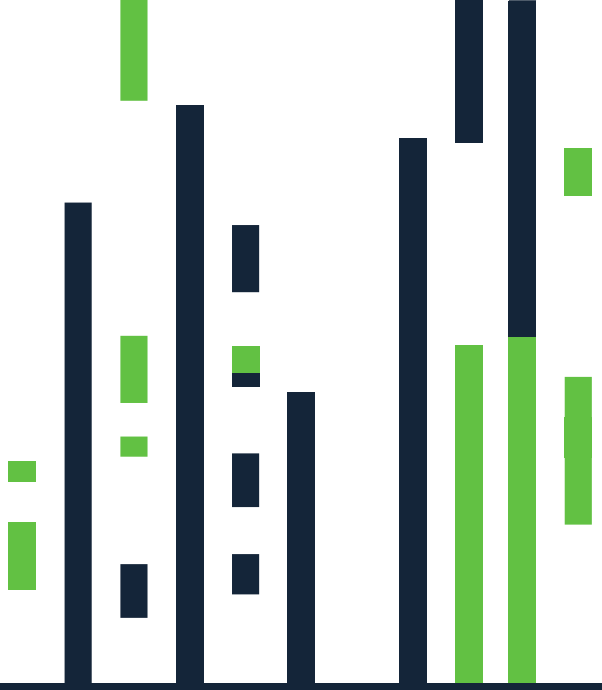

Civilizing our Smart Cities: AI for Social Fabric

King Wang Poon, Director of the Lee Kuan Yew Centre for Innovative Cities

Something is ominously missing in the discussions about AI and smart cities. There is a lot of excitement about how AI can transform industry. There is also much worry about the risks it poses to individuals. There is however much less focus on how we can use AI to strengthen the social fabric of our smart cities and citizens.

This omission does not augur well for the future, especially when our cities are under siege. Globally, online, and within the city, the forces dividing us are threatening to overwhelm the forces binding us. Our cities could unravel as a result. Through the ages, people moved to and stayed in cities in search of a better future. Cities embodied those hopes because we found it worthwhile to work with – and not against – each other. Such hopes will crumble if our cities unravel, with unfathomable consequences for our societies.

Three Ways AI Can Help

Smart cities must not let this happen. We must invest in AI that can strengthen the social fabric. But if there has been little focus – much less initiatives – so far, where do we begin? We can draw inspiration and adapt from related fields for a start.

A first way, for example, is to use AI to help citizens better understand each other's needs and difficulties. This is particularly urgent in our current social and political climate, where we seem more likely to be upset than understanding of each other's differences and difficulties.

Smart cities can invest in AI to bridge this. It is not uncharted territory. After all, companies and governments are already investing in AI to understand people better so as to personalize marketing, healthcare, dating, services, and experiences. Research has also found – for better or for worse – that social media algorithms can be better at predicting people's preferences than their spouses.[185] We can adapt from these. For example in education, we could use AI to help teachers tailor the curriculum to follow each student's strengths (instead of the other way round as it is done now); and in healthcare, we could design diet and exercise programs according to each citizen's different levels of motivation.

A second way is to use AI to build a helpful city. Across all aspects of urban life, smart cities can invest in AI to better match citizens who need help with citizens who can help.

Again we can adapt from what exists: platforms such as Uber and AirBnB already match demand and supply across many sectors. We can do the same to match demand and supply for all kinds of help. The United Hatzalah in Jerusalem shows how much we can achieve if we do so. It has 5000 trained volunteer first responders of different races, religions, and nationalities. When a call for help is received, the closest first responders are rapidly matched and dispatched.

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185 See **https://www.scientificamerican.com/article/the-internet-knows-you-better-than-your-spouse-does/**; and **https://www.wired.com/2015/01/facebook-personality-test/**

They often reach the caller within 90 seconds. Once they arrive, they render help, regardless of the race, religion, and nationality of the life in need. Since its founding in 2006, these volunteers have saved 3.5 million lives.[186]

A third possible way to use AI to strengthen the social fabric is to invest in AI to spot and nurture each other's unique talents. Management guru Charles Handy calls this our "golden seed".[187] He believes the "greatest gift" we can give to someone is to "identify… what they are good at, plant that in them and cultivate their talents" so that they will succeed.[188]

We can do this in school, at work, and at home. In the Lee Kuan Yew Centre for Innovative Cities at the Singapore University of Technology and Design, we are collaborating with unions, companies, schools, and government to do so. Taking advantage of the fact that AI disrupts and transforms jobs task-by-task and not job-by-job, we pinpoint what tasks a person is good at, and how AI can augment what they do. For example, in our partnership with France-Singapore think tank Live with AI (who are also a contributor to the White Paper), we studied how we can use AI to automate and augment tasks in eight occupations across four industries. We then recommended how we can design human-centered jobs that people will find more valuable, meaningful, and fulfilling in the years ahead.

Conclusion

These three ways represent potential starting points for how we can invest in AI to strengthen the social fabric of our smart cities. They safeguard our cities, so that our cities do not unravel, and also safeguard our citizens' hopes of a better life. But these are not all that they can do.

In *Islamic Empires – Fifteen Cities that Define a Civilization*, Justin Marozzi writes that the word "civilization" comes from the Latin words for "citizen" (*civis*) and "city" (*civitas*). He argues that:

"[A] city civilizes – it removes men and women from a savage, barbarian life – and that without cities there is no such thing as civilization. It is within cities… that humankind has realized its greatest potential: excelling in the arts and sciences, exploring the human condition and leaving an indelible literary legacy."

Thus, when citizens are more understanding, helpful, and nurturing towards each other, we are building more than a stronger smart city. We are also building a kinder and more civilized one.

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186 See **https://israelrescue.org/**

187 What Charles Handy calls the "golden seed" – see **https://www.penguin.co.uk/books/111/1118373/21-letters-on-life-and-its-challenges/9781786331953.html**

188 **https://www.hrzone.com/engage/managers/academic-insight-charles-handy-on-leadership-work-and-well-being**

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