FIELD ACTIONS SCIENCE REPORTS

FACTS REPORTS

Second semester 2017

ARTIFICIAL INTELLIGENCE AND ROBOTICS IN THE CITY

Coordinated by **Nicolas MIAILHE**

THE FUTURE SOCIETY

VEOLIA INSTITUTE

FIELD ACTIONS SCIENCE REPORTS

FACTS REPORTS
Second semester 2017

is published by
VEOLIA INSTITUTE
30, rue Madeleine Vionnet
93300 Aubervilliers - France
www.institut.veolia.org/en

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http://factsreports.revues.org/

Issuing Body
Field Actions Science Reports (FACTS)
is published by the Veolia Institute.
EISSN: 1867-8561

Contact:
facts-reports.ve@institut.veolia.org

Graphic Design
INCREA

Printed in France
with vegetable-based inks by an environmental printer (a member of Imprim'vert) on chlorine-free paper from well-managed forests and other controlled sources, certified in accordance with the standards of the Forest Stewardship Council.

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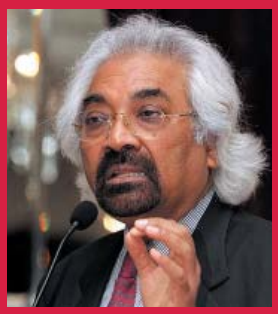
Sam Pitroda, Internationally respected telecom inventor, entrepreneur, development thinker
Nicolas Miailhe, Co-Founder and President The Future Society



Dr. Sam Pitroda is an internationally respected telecom inventor, entrepreneur, development thinker, and policy maker who has spent 50 years in information and communications technology (ICT) and related global and national developments. Credited with having laid the foundation for India's telecommunications and technology revolution of the 1980s, Mr. Pitroda has been a leading campaigner to help bridge the global digital divide. Dr. Pitroda served as Advisor to the Prime Minister of India on Public Information Infrastructure and Innovation, with the rank of a Cabinet Minister. He served as the Chairman of the Smart Grid Task Force, as well as the committees to reform public broadcasting, modernize railways, deliver egovernance, and other developmental activities.

Nicolas co-founded "The Future Society" at Harvard Kennedy School in 2014 which specializes on questions of impact and governance of emerging technologies. Under it, he co-founded in 2015 the "AI Initiative" dedicated to the rise of Artificial Intelligence which is now leading a global participatory debate on the governance of AI (http://www.aicivicdebate.org) among several activities. Nicolas has over fifteen years of professional experience working at the nexus of innovation, high technology, government, industry and civil society across Europe, America and Asia. He teaches at the Paris School of International Affairs, is a Senior Visiting Research Fellow with the Program on Science, Technology and Society at Harvard, and a Fellow with the Institute for Data Driven Design affiliated with the MIT Media Lab.

The world is experiencing a wave of extreme urbanization focusing some of the world's greatest challenges and opportunities onto cities. For millennia, humans have migrated to cities to connect because it promised creativity and mobility. In 1900, when the second industrial revolution of electricity and oil started to unfold, just 200 million people lived in cities, about one eight of the word population at the time[1]. Today, a century later, while we are entering what many experts call a "fourth industrial revolution" led by artificial intelligence (AI), robotics, gene-editing and neuro-technologies, more than 3.5 billion people live in cities. And the United Nations projections indicate the urban population will reach 5 billion by 2030 - 60 percent of the population- and 6.5 billion by 2050[2].

Cities are the main source of global economic growth and productivity, and they account for most resource consumption and greenhouse gas emissions. The ways in which developed, emerging and developing cities and countries collectively react to the combined tectonic shifts of urban explosion and the automation revolution will determine how well cities are prepared for sustained growth after the expansive urbanization wave passes. Managing urbanization on the one hand, and socio-technical change on the other, is thus central to usher the word onto a more sustainable development path.

In 2008, the number of mobile Internet users surpassed the number of fixed users, driven by the rapid spread of inexpensive mobile devices in the developing world. According to HIS Markit – a market research firm – there were over 4 billion smartphones in use worldwide in 2017, with 6 billion projected in 2020[3]. This is profoundly reorganizing our societies around mass mobile communication and distributed intelligence combining the power of machines and beings to the point of merger.

1 Urban population in 1900: "Human Population: Urbanization" (Washington, DC: Population Reference Bureau, 2007)

2 *World Population Prospects: the 2011 revision* (New York: United Nations, Department of Economic and Social Affairs, Population Division, March 2012), 1.

3 Arjun Kharpal, Smartphone market worth $355 billion, with 6 billion devices in circulation by 2020: Report https://www.cnbc.com/2017/01/17/6-billion-smartphones-will-be-in-circulation-in-2020-ihs-report.html

The disruptive upsurge has already unleashed a massive wave of transformation which will continue to grow, scale and accelerate. Improvements and convergence in machine learning and neurosciences combined with the "Big Data" and "Internet of Things" revolutions, and powered by the ubiquity of high-performance scalable computing are now propelling us into a new age of Artificial Intelligence. Humans are fast becoming a minority on line and the rise of mind-brain interfaces spurred by advances in neuro-technologies is poised to accelerate the merging of humans and machines further down the century. By 2020, there should be some 50 billion networked objects. This year, the torrent of data generated online exceeded 16.3 zettabyte (1 zettabyte equaling one trillion gigabytes) and is expected to grow to 163 zettabyte by 2025!

As we will see in this edition of the *FACTS Reports*, the promise the AI revolution hold to deliver sustainable urban development is immense; so too are the risks. Through a rich and diverse series of article and interviews of leading practitioners, scholars and experts, we have worked to combine forward-looking analysis, case studies and reports from the field. Our objective has been to provide a panoramic view of how the fourth industrial revolution is and will play out in cities. According to our analysis, it may prove to be a *creative destruction* raising incomes, enhancing quality of life for all and generating previously unimagined jobs to replace those that get automated. Or it may turn out to be a *destructive creation* leading to mass unemployment, privacy abuses, discrimination and loss of control over key collective decision-making processes. This depends on the velocity and magnitude of the development and diffusion of AI and robotics technologies. But it also depends on how societies react individually and collectively.

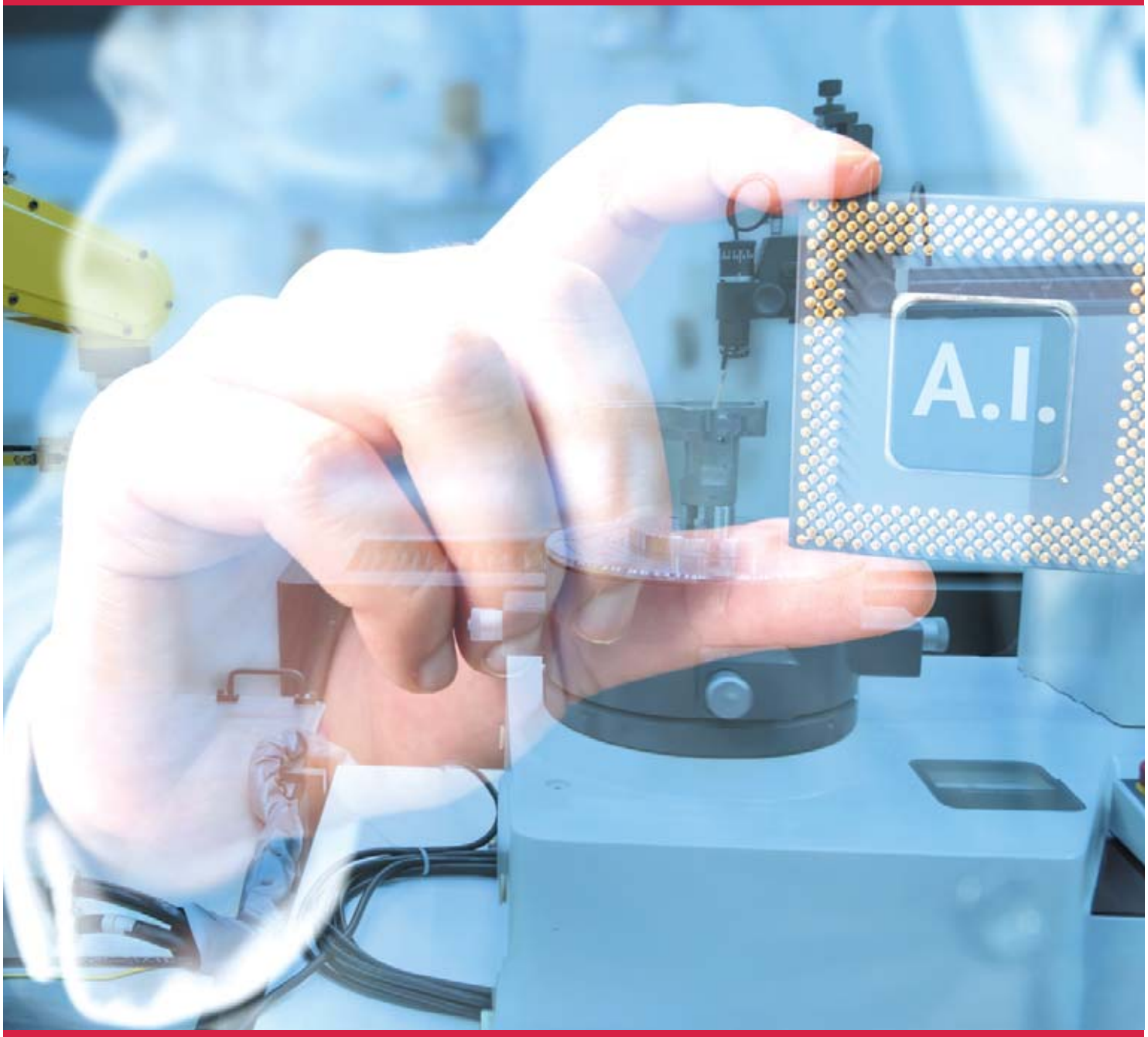
And policy choices will matter greatly. Though they stand to be at the epicenter of the automation revolution and benefit from it largely as compared to rural areas, cities alone will not be able to deal with it. Thanks to cities' dense data ecology, AI-powered software supporting businesses, governments and citizens will tap into the growing flows and stocks of reading to understand and predict our urban world. The latter has already started to morph into an "information infrastructure" fueling an "attention economy" with upsides, and downsides... Therefore, how we guide the integration of these historic forces will, to a great extent, determine the kind of world our children's children will inhabit by the end of this century.

Since the digital market fueled by AI and data –the AI market is expected to grow to 40 billion dollars annually by 2020- exhibits oligopolistic characteristics, such digital transformation effort will need to avoid excessive power concentration, and rein-in potentially adverse competition dynamics to prevent a race to the bottom. In this new environment, isolated countries and cities will find it more and more difficult to be able to stand on their own. The catch-all and IT industry-dominated imaginary of "Smart Cities" has undeniably gathered increasing attention over the past ten years. It has also disillusioned many, and severely under delivered. Despite its re-discovered enticing appeal, now that machine learning algorithms have demonstrated how Big Data can be harnessed, the smart city utopia still encompasses a large series of gaps, shortfalls and misguided assumptions and visions. In fact, precisely because the AI revolution relies so centrally on data, and demands that data be collected, stored, processed and circulated at scale to realize its potential, the automation wave will likely amplify the dangers of the smart city utopia.

More than ever, cities will have to manage the tension between a growing set of stakeholders to work out solutions; that too at a time when the boundaries between categories (human vs machine vs other lifeforms; private vs public; virtual vs real; firm vs market; consumer vs citizen vs user...) are blurring! This implies above all nurturing the creativity and knowledge of citizens, grassroots innovators, businesses and institutions. It also means inclusively orchestrating this knowledge into decisions through what Geoff Mulgan calls "a continuous process of argument, deliberation, decision and action in which government acts with the people, as well as for them". And crucially, it requires plugging into the complex and multilayered series inter-city networks and associations (regional and thematic) to draw the most of collaborative dynamics, forge multifaceted alliances to ultimately invent, test, customize, share and replicate new solutions. If the vision of intelligent cities can be achieved, we may even be able to forge a bridge to help democratize globalization, one the key challenges of our times. Alexis de Tocqueville insisted that liberty is always municipal. And yet we know today that it cannot be exercised without global reach. We also know it cannot be exercised away from the new data and intelligence ecology. On the contrary liberty, as well as a number of other cornerstone values, need to be baked firmly in it.

"THOUGH THEY STAND TO BE AT THE EPICENTER OF THE AUTOMATION REVOLUTION AND BENEFIT FROM IT LARGELY, CITIES ALONE WILL NOT BE ABLE TO DEAL WITH IT."

1. UNDERSTANDING THE RISE OF ARTIFICIAL INTELLIGENCE



Improvements and convergences in machine learning and neurosciences combined with the availability of massive datasets and the ubiquity of high-performance scalable computing are propelling us into a new age of Artificial Intelligence (AI).

The promise these developments hold is immense; so too are the risks and challenges. Most experts qualify the rise of AI as an industrial revolution at par with the three previous industrial revolutions of steam, then oil and electricity, and then computers.

Before exploring the transformative opportunities and challenges associated with the deployment of artificial intelligence systems in urban environments, it is important to define and contextualize this complex notion. It is also important to analyze the dynamics of the rise of AI –velocity and magnitude, the forces shaping it, its political economy and the main actors at the global level. That's the objective of this first Chapter.

We will discover that the AI revolution unfolds as a key catalyzer nested in the broader "digital revolution" which is already transforming cities into "informational infrastructure". That's the argument of Ricardo Alvarez. Indeed at the core of the notion of smart or intelligent cities lies the idea that the *digital* can be harnessed to render urban systems more efficient. While we were up to now talking about "Big Data" to refer to cities' ability to collect, store and process gigantic flows and stocks of data, actors now refer to "Artificial Intelligence" to point to cities' increasing ability to make sense of these troves of data through the use of machine learning algorithms.

That's a crucial shift which opens up avenues to optimize urban systems across functions (planning, delivery, monitoring, maintenance, etc.) and areas (transportation, healthcare, energy, finance, etc.). This shifts is political as it raises potentially contentious questions around the respective roles of the private versus the public versus citizens in the design and control of this new "informational infrastructure". AI technologies depend on large amount of high resolution data to feed machine learning algorithms. These data are collected, stored and processes by digital platforms which market exhibit quasi-monopolistic or at least oligopolistic tendencies because of scale effects and network effects associated with the collection and storage of data. Striking the right balance in sharing the value or mobilizing the expertise and financing associated with the required investment is not easy for municipal administrations. So public-private-people partnership seem inescapable but need to be carefully designed -and probably standardized- to facilitate the relationship between municipal governments and multinationals.

Margarita Boenig-Liptsin then looks at how cities on three different continents imagine themselves in the age of AI and envision the role of AI to solve urban problems and provide better quality of life to their citizens and constituents. She performs a comparative analysis of San Francisco in the United States, Kyoto in Japan, and Lviv in Ukraine. Margo examines these three cases through the lens of "sociotechnical imaginary" defined as a *"collectively held, institutionally stabilized, and publicly performed vision of a desirable future, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology"*.

Finally, as a practical example, Mathieu Saujot, Olivier Sartor and Laura Brimont walk us through the emblematic example of self-driving cars and how they could align mobility systems with the imperative of sustainability. To illustrate that case, Eng Huiling and Benjamin Goh walk us through the case of self-driving cars in Singapore. They analyze the City-State strategy to pioneer the deployment of autonomous vehicles harnessing a very unique cocktail: high urban density, knowledge-based economy, cutting-edge infrastructure, efficient government, a highly educated population and public-private partnerships.

Nicolas MIAILHE
Coordinator

THE THIRD AGE OF ARTIFICIAL INTELLIGENCE

Nicolas Miailhe
Co-founder and President,
The Future Society

Cyrus Hodes
Vice-President and Director for AI,
The Future Society

If the definitional boundaries of Artificial Intelligence (AI) remains contested, experts agree that we are witnessing a revolution. "Is this time different?" is the question that they worryingly argue over when they analyze the socio-economic impact of the AI revolution as compared with the other industrial revolutions of the 19th and 20th centuries. This Schumpeterian wave may prove to be a *creative destruction* raising incomes, enhancing quality of life for all and generating previously unimagined jobs to replace those that get automatized. Or it may turn out to be a destructive creation leading to mass unemployment abuses, or loss of control over decision-making processes. This depends on the velocity and magnitude of the development and diffusion of AI technologies, a point over which experts diverge widely.

Nicolas Miailhe is the co-founder and President of "The Future Society at Harvard Kennedy School" under which he also co-founded and co-leads the "AI Initiative". A recognized strategist, social entrepreneur, and thought-leader, he advises multinationals, governments and international organizations. Nicolas is a Senior Visiting Research Fellow with the Program on Science, Technology and Society (STS) at HKS. His work centers on the governance of emerging technologies. He also specializes in urban innovation and civic engagement. Nicolas has ten years of professional experience in emerging markets such as India, working at the nexus of innovation, high technology, government, industry and civil society.

Cyrus Hodes is passionate about drastically disruptive technologies, such as Artificial Intelligence, robotics, nanotech, biotech, genetics, IT and cognitive sciences as well as their cross-pollination and impacts on society. He is currently leading a robotics (Autonomous Guided Vehicles) startup and a biotech venture. In 2015, Cyrus co-founded the AI Initiative under The Future Society to help shape the governance of AI. Cyrus is a member of the IEEE Global Initiative for Ethical Considerations in Artificial Intelligence and Autonomous Systems.

KEYWORDS

- ARTIFICIAL NARROW INTELLIGENCE
- ARTIFICIAL GENERAL INTELLIGENCE
- ROBOTICS
- POLITICAL ECONOMY
- BIG DATA

INTRODUCTION

The definition of "Artificial Intelligence" is not easy and remains contested[1], especially given science's inability to nail a definition of "intelligence" accepted by all. Definitions abound and generally overlap by pointing to 'agents' (programs running on computer systems) able to learn, adapt and deploy themselves successfully in dynamic and uncertain environments. Intelligence in that sense intersects with autonomy and adaptability, through the ability to learn from a dynamic environment.

1 There is no standardized and globally accepted definition for what AI is. *"The choice of the very name "artificial intelligence" is a perfect example: if the mathematician John McCarthy used these words to propose the Dartmouth Summer Research Project – the workshop of summer 1956 that many consider as the kick-off of the discipline – it was as much to set it apart from related research, such as automata theory and cybernetics, as to give it a proper definition [...].There are actually many definitions for artificial intelligence. A first great group of definitions could be called "essentialist", aiming at defining the end-goal a system has to show to enter the category [...].Besides this – and often complementarily – are the definitions one could call "analytical", which means they unfold a list of required abilities to create artificial intelligence, in part or in whole. [...]".* Tom Morisse, "AI New Age, Fabernovel, February 2017 https://en.fabernovel.com/insights/tech-en/ais-new-new-age ; See also U.K. Government Office for Science, Report on "Artificial Intelligence: opportunities and implications for the future of decision-making", 2016 (page 6). See also https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/566075/gs-16-19-artificial-intelligence-ai-report.pdf

DEFINING ARTIFICIAL INTELLIGENCE

THE INTERSECTION OF BIG DATA, MACHINE LEARNING AND CLOUD COMPUTING

To understand the current renaissance of what we frame as "Artificial Intelligence," which is as old as computer science, we need to turn to the convergence of three trends: i) Big Data, ii) machine learning and iii) cloud super-computing. In that sense, the rise of AI is really a manifestation of the digital revolution. One of its central laws, predicted in 1965 by *Intel* chip manufacturer co-founder Gordon Moore, tells us that computing power doubles every two years, on an average, at a constant cost[2]. This exponential growth has resulted from continued technoscientific prowess in miniaturization, bringing about the age of micro- and, now, nano-computing with increasing power; and along with it, the possibility of smart phones and the "Internet of Things."

Coupled with the development of Internet communication protocols and machine virtualization, the digital revolution then made possible the availability of highly and easily scalable supercomputing capabilities on the cloud. From that point, the exponentially growing flow of high resolution data[3] produced day after day by connected humans and machines could be processed by algorithms.

These contexts finally made possible the flourishing of an old branch of computer science, called machine learning,[4] where algorithms are capable of automatically sorting out complex patterns out of very large data sets, either via supervised or unsupervised learning.[5] The convergence of two branches of machine learning in particular have demonstrated impressive results over the past five years: deep learning[6] and reinforced learning.

AI VS. ROBOTICS

To better understand Artificial Intelligence as an interdisciplinary field, it is useful to draw and analyze its boundary with robotics. In both cases, we refer to 'machines' (since an algorithm is a robot, hence the shortened word 'bot' to refer to conversational computer programs); but while robotics is mostly material in its manifestations, and operates at the intersection of mechanical engineering, electrical engineering, and computer sciences, artificial intelligence is mostly[7] immaterial and virtual in its manifestations. In order to simplify for analytical purposes, one can say that, in an "autonomous machine," the AI is the intelligence, and refers to cognitive functions, while robotics refers to motor functions.

Indeed, the boundary between cognitive and motor functions is porous, since mobility requires sensing/knowing the environment. For example, advances in machine learning have played a crucial role in computer vision. That said, relying on materiality as a differentiating criterion is useful because it carries major industrial consequences affecting the growth potential of autonomous machines: the more complex the motor functions, the slower the growth, and vice versa. The most popular symbols of the convergence between AI and robotics are self-driving cars and humanoid robots.

AI VS. NEUROSCIENCES

To then hone our understanding of the state of AI today and where it could go in the future, we need to turn to its relation with the interdisciplinary field

2 The first processors in the 1970s could carry out about 92,000 instructions per second. The processor in an average modern smartphone can carry out billions of instructions per second.

3 IBM estimates that 90 percent of the world's data has been created in the last two years. Looking at various application platforms, experts estimate that Spotify has 10 Petabytes in storage (1 Petabyte = 1 million Gigabyte); eBay has 90 PB; Facebook 300 PB; and Google 15 000 PB. For reference, the human brain has 2.5 Petabyte in storage. https://royalsociety.org/topics-policy/projects/machine-learning/machine-learning-infographic/

4 Short explanatory infographic from the Royal Society: https://royalsociety.org/topics-policy/projects/machine-learning/machine-learning-infographic/

5 *"There are many different kinds of algorithm used in machine learning. The key distinction between them is whether their learning is 'unsupervised' or 'supervised'. Unsupervised learning presents a learning algorithm with an unlabeled set of data – that is, with no 'right' or 'wrong' answers – and asks it find structure in the data, perhaps by clustering elements together – for example, examining a batch of photographs of faces and learning how to say how many different people there are. Google's News service uses this technique to group similar news stories together, as do researchers in genomics looking for differences in the degree to which a gene might be expressed in a given population, or marketers segmenting a target audience. Supervised learning involves using a labelled data set to train a model, which can then be used to classify or sort a new, unseen set of data (for example, learning how to spot a particular person in a batch of photographs). This is useful for identifying elements in data (perhaps key phrases or physical attributes), predicting likely outcomes, or spotting anomalies and outliers. Essentially this approach presents the computer with a set of 'right answers' and asks it to find more of the same. Deep Learning is a form of supervised learning".* U.K. Government Office for Science, Report on "Artificial Intelligence: opportunities and implications for the future of decision-making", 2016 (page 6).

6 Short explanatory video here from the Royal Society: https://www.youtube.com/watch?v=bHvf7Tagt18

7 AI refers to a program running on a computer, either embedded or on the cloud. It thus carries a very concrete material manifestation which we tend to forget at times.

of neurosciences. The renaissance of AI since 2011 is mostly attributed to the success of a branch of machine learning called "deep artificial neural networks" (also called deep learning), supported by another branch called "reinforcement learning". Both branches claim to loosely emulate the way the brain processes information, in the way that they learn through pattern recognition.

It is crucial not to exaggerate the current state of convergence between AI and neurosciences. To date, our understanding of the extremely complex biochemical processes that run the human brain remain far beyond the reach of science. In short, the human brain largely remains a "black box," and neuroscience knows how the brain functions mainly by correlating inputs and outputs. As such, there is not much that designers of algorithms can emulate *from*, especially given that machine learning still operates exclusively from the realm of statistics; that too on silicon-based computer systems, which are radically different from biological brains. A more meaningful convergence between the fields of AI and neuroscience is expected to unfold later this century, as we break into the "black box" and seek to understand the human brain in greater depth.

Owing to the very different evolutionary trajectories followed by artificial intelligence and our biological brains, two consequential differences should be singled out. First, humans can reliably develop pattern recognition and generalize transferable knowledge out of very few occurrences, but in general we struggle to replicate and transfer learning processes across educational subjects. Machines, on the contrary, require very large data sets[8] to achieve pattern recognition, and struggle to generalize knowledge. However, they excel at transferring and replicating pattern recognition at scale once it is achieved. Facial recognition is the most well-known example of this. Second, while autonomous machines that combine the most advanced AI and robotics techniques are still poor at reproducing very basic non-cognitive motor functions mastered by most animals (for example, walking or hand-manipulation), they are increasingly proving very adept at outperforming humans over a number of complex cognitive functions, for example, image recognition in radiology and computationally-intensive tasks.

ARTIFICIAL "NARROW" INTELLIGENCE VS. ARTIFICIAL "GENERAL" INTELLIGENCE

The penultimate boundary we need to explore to better delineate and understand what we mean by artificial intelligence is the frontier between *Artificial Narrow Intelligence* (ANI, also called "weak" AI) and *Artificial General Intelligence* (AGI, also called "strong" AI). For a majority of experts, AGI refers to an autonomous machine's ability to perform any intellectual tasks that a human can perform. This implies generalizing and abstracting learning across various cognitive functions. Transferring learning autonomously and nimbly from one domain to another has happened only very embryonically thus far[9].

According to experts, the most advanced artificial intelligence systems available today, such as the famous *IBM Watson*[10] or

8 As a matter of comparison, a child needs to be exposed to five to ten images of elephant to be able to recognize an 'elephant' while a deep neural networks requires over a million images.

9 See here the emerging field of "transfer knowledge" perceived by an increasing number of experts, including Google Deepmind as a potential path of accelerated progress in the coming decades. See here for example https://hackernoon.com/transfer-learning-and-the-rise-of-collaborative-artificial-intelligence-41f9e2950657#.n5aboetnm and https://medium.com/@thoszymkowiak/deepmind-just-published-a-mind-blowing-paper-pathnet-f72b1ed38d46#.6fnivpish

10 See https://www.ibm.com/cognitive/

Google's *AlphaGo*[11], are still "narrow" (weak), in the sense that they operate strictly within the confine of the scenarios for which they are programmed. Even if they are capable of generalizing pattern recognition, for instance *transferring* knowledge learned in the frame of image recognition into speech recognition[12], we are still very far away from the versatility of a human mind. This is expected to change with the convergence of machine learning and neurosciences in the coming decades, but experts disagree profoundly over the probability and timeline of the march towards AGI: some say it will never happen; some say it will take one hundred years or more; some say thirty; and some say ten[13].

Beyond the discord among experts, relying on the frontier between narrow and general artificial intelligence is problematic because of its very benchmark for measurement: human intelligence. Since we still have an imperfect understanding today of the complex processes driving the brain and the way human intelligence and consciousness manifest themselves, excessively relying on that boundary to gauge the transformative impact of the rise of AI could be risky. It could expose us to major blind spots, with supposed "advances" masking major socio-economic externalities which we need to anticipate in order to adapt. We recommend doing more research to delineate that boundary and map its surroundings as well as their evolution more precisely.

Beyond their disagreement, experts broadly agree on two levels. First the socio-economic impacts of the current rise of ANI will bring about serious consequences, generating new opportunities, new risks, and new challenges. Second, the advent of an AGI later this century would amplify these consequences by—at least—an order of magnitude. More research is needed to map and understand what these consequences would be as well as how they would play out socially and economically.

THE UNRESOLVED QUESTION OF CONSCIOUSNESS; AND SPECULATIONS OVER THE POSSIBILITY OF AN INTELLIGENCE EXPLOSION

The final boundary we need to explore to map the future terrain of AI is that of consciousness. Here, there is a broad consensus among experts: neither the most advanced AI systems currently existing, nor the ones that are expected to be developed in the coming decades, exhibit consciousness. Machines (programs running on connected and sensing computer systems) are not aware of themselves, and this "functionality" may never be possible. But, again, a word of caution: since science is still far from having explained the mysteries of animal sentience and human consciousness, that boundary remains more fragile that it seems.

"RELYING ON THE FRONTIER BETWEEN NARROW AND GENERAL ARTIFICIAL INTELLIGENCE IS PROBLEMATIC BECAUSE OF ITS VERY BENCHMARK FOR MEASUREMENT: HUMAN INTELLIGENCE. SINCE WE STILL HAVE AN IMPERFECT UNDERSTANDING OF THE LATTER, EXCESSIVELY RELYING ON THAT BOUNDARY TO GAUGE THE TRANSFORMATIVE IMPACT OF THE RISE OF AI COULD BE RISKY."

Finally, one speculative but highly consequential long-term scenario which constantly appears in mainstream media and across the expert community: "the technological singularity". According to that hotly contested scenario, popularized by the inventor, futurist, and now Director of Engineering at Google, Ray Kurzweil, the rise of AI could lead to an "intelligence explosion" as early as 2045. It would result from the emergence of an Artificial Super Intelligence (ASI): a self-recursive AI improving exponentially, which could follow relatively quickly (a few decades or less) the advent of an Artificial General Intelligence (AGI). If this scenario were to unfold, it would naturally carry with it potentially existential consequences for mankind and intelligent life[14]. We recommend nurturing a reasonable debate across the expert community, and society at large, over the possibilities and consequences of an ASI, to enable responsible investment choices and risk management. Framing the conversation in the right way will be critical: in this case, transparency and moderation will be key.

To be clear, the analysis we will carry out in the remainder of this article excludes the AGI or ASI scenarios. To narrow the definition even further for practical analytical purpose, "Artificial Intelligence" will henceforth mean machine-learning algorithms, which combine various techniques (e.g. deep learning), and are associated with sensors and other computer programs and algorithms. These sense,[15] comprehend,[16] and act[17] on the world, learning from experience and adapting over time.

11 See https://deepmind.com/research/alphago/

12 See https://hackernoon.com/transfer-learning-and-the-rise-of-collaborative-artificial-intelligence-41f9e2950657#.n5aboetnm

13 A detailed study of AI timeline surveys carried out by AI Impacts in 2015 concluded: *"If we collapse a few slightly different meanings of 'human-level AI': median estimates for when there will be a 10% chance of human-level AI are all in the 2020s (from seven surveys); median estimates for when there will be a 50% chance of human-level AI range between 2035 and 2050 (from seven surveys); of three surveys in recent decades asking for predictions but not probabilities, two produced median estimates of when human-level AI will arrive in the 2050s, and one in 2085. One small, informal survey asking about how far we have come rather than how far we have to go implies over a century until human-level AI, at odds with the other surveys. Participants appear to mostly be experts in AI or related areas, but with a large contingent of others. Several groups of survey participants seem likely over-represent people who are especially optimistic about human-level AI being achieved soon".* See http://aiimpacts.org/ai-timeline-surveys/

14 For more information, see Nick Bostrom, *Superintelligence: Paths, Dangers, Strategies*, Oxford University Press, 2014.

15 Computer vision and audio processing, for example, are able to actively perceive the world around them by acquiring and processing images, sounds and speech. Facial and speech recognition are two typical applications.

16 Natural language processing and inference engines can enable analysis of the information collected. Language translation is a typical application.

17 An AI system can take cognitive action like decision-making (e.g. credit application or tumor diagnostic) or undertake actions in the physical world (e.g. from assisted braking to full auto-pilot in cars).

CONTEMPORARY DYNAMICS AND MAIN PLAYERS

AI PERVASIVENESS

Unlimited access to supercomputing on the cloud — a market estimated to reach $70 billion in 2015[18] — and continued growth in big data, which has had a compound annual growth rate of more than 50 percent since 2010,[19] are the two key macro-trends powering the rise of Artificial Intelligence. AI systems are already profoundly changing the way we live, work, and socialize. On the market are virtual personal assistants, recommendation engines, self-driving cars, surveillance systems, crop prediction, smart grids, drones, banking and trading, and gene-sequencing machines. More and more multinationals are now shifting their business models to revolve around data and predictive analytics to be able to capture the productivity gains generated by the rise of AI.

This revolution is fueled on the one hand by the quest for technological solutions to address pressing global challenges, including climate change, growth and development, security or demography which increasingly unfold in urban environment. On the other hand, it is spurred by the continuing international strategic competition whereby nation-states fund science and early innovation in pursuit of technological dominance, which private global players then scale up, competing with others to become "go-to" platforms. Though the ambiguity of the definitional boundaries of "Artificial Intelligence" constrains the ability to generate a robust classification or ranking of most advanced countries in the field of AI, capabilities in the field of computer sciences and Information & Communication Technologies (ICT) can be used as a proxy. Accordingly, the U.S., China, Russia, Japan, South Korea, the U.K., France, Germany, and Israel are emerging as the dominant players in AI. Given their techno-scientific capabilities and their large market size, India and Brazil should also figure in this leading group, even if they are yet to translate potential into reality.

"MORE AND MORE MULTINATIONALS ARE NOW SHIFTING THEIR BUSINESS MODELS TO REVOLVE AROUND DATA AND PREDICTIVE ANALYTICS TO BE ABLE TO CAPTURE THE PRODUCTIVITY GAINS GENERATED BY THE RISE OF AI."

THE ROLE OF GOVERNMENTS

National governments have historically played, and will continue to play, a key role in spurring the rise of AI through the allocation of higher education, research & development budgets for defense, security, healthcare, science and technology (e.g. computer sciences, neuroscience, ICT), infrastructure (especially transport, energy, healthcare, and finance), and pro-innovation policies. AI is increasingly perceived as a source of technological dominance in the information age where cyber and physical worlds merge as hybrids, so more and more countries have or are in the process of releasing national strategies for AI.

In the U.S., where the term Artificial Intelligence was coined, and which has been a pioneer in the field since its inception in the 1950s, the Obama Administration led an inter-agency initiative last year on "Preparing for the Future of Artificial Intelligence."[20] This high-level initiative culminated with the release of a "National Research & Development Artificial Intelligence Strategic Plan,"[21] as well as two reports.[22] Historically, the U.S. Defense Advanced Research Project Agency (DARPA), and more recently the Intelligence Advance Research Projects Activity (IARPA), have provided long-term high-risk investment in AI, playing an instrumental role in most AI techno-scientific breakthroughs. Last year, the U.S. Department of Defense (DoD) unveiled its "Third Offset" strategy[23] with a total five-year investment of $18 billion[24]. To maintain technological dominance, this macro-strategy plans on bringing AI and autonomous systems to the forefront of all U.S. battle digital networks, operational, planning and support processes. DoD's operational goal is to make such processes faster and more efficient. In January 2017, a report published by a group of elite scientists which advises the U.S. Government on sensitive technoscientific matters confirmed the strategic importance of the rise of AI for defense capabilities[25].

Meanwhile, the Chinese Government unveiled an ambitious three-year national AI plan in May 2016. The plan was formulated jointly by the National Development and Reform Commission, the Ministry

18 https://www.accenture.com/us-en/_acnmedia/PDF-33/Accenture-Why-AI-is-the-Future-of-Growth.pdf

19 https://www.accenture.com/us-en/_acnmedia/PDF-33/Accenture-Why-AI-is-the-Future-of-Growth.pdf

20 https://obamawhitehouse.archives.gov/blog/2016/05/03/preparing-future-artificial-intelligence

21 https://www.nitrd.gov/PUBS/national_ai_rd_strategic_plan.pdf

22 Executive Office of the U.S. President, "Preparing for the Future of Artificial Intelligence", October 2016. And "Artificial Intelligence, Automation and the Economy", December 2016.

23 DEPSECDEF, http://www.defense.gov/News/Speeches/Speech-View/Article/606641/the-third-us-offset-strategyand-its-implications-for-partners-and-allies. The "First Offset Strategy" refers to the development of nuclear weapons, the "Second Offset Strategy" to precision guided munitions.

24 Mackenzie Eaglen, "What is the Third Offset Strategy", *Real Clear Defense*, February 2016. Note: this $18 billion five-year investment goes far beyond Artificial Intelligence. http://www.realcleardefense.com/articles/2016/02/16/what_is_the_third_offset_strategy_109034.html

25 JASON, The MITRE Corporation, *Report on Perspectives on Research in Artificial Intelligence and Artificial General Intelligence Relevant to DoD*, January 2017. https://fas.org/irp/agency/dod/jason/ai-dod.pdf

of Science and Technology, the Ministry of Industry and Information Technology, and the Cyberspace Administration of China. The government envisions creating a $15 billion market by 2018 by investing in research and supporting the development of the Chinese AI techno-industrial base. Anecdotally, the country surpassed the U.S. last year in terms of the number of papers published annually on "deep learning"[26]. The rate of increase was remarkably steep, reflecting how quickly China's research priorities have shifted.

Beyond U.S. and China, Japan, South Korea,[27] France,[28] the U.K,[29] and Germany are also in the process of developing specific plans and strategies in AI, robotics, and other complementary sectors.

THE PLATFORM BUSINESS

From the business perspective, we seem to be heading towards a global oligopoly dominated by a dozen U.S. (*Google*, *Apple*, *Facebook*, *Amazon*, *Microsoft* and *IBM*) and Chinese (*Baidu*, *Alibaba*, *Tencent*, *Xiaomi*) multinationals controlling AI.

For competition played on the global stage, the key factor for success is no longer the length of computer code, but the size of databases. As of now, AI needs to see millions of pictures of animals or cars to achieve actionable pattern recognition. Facebook has effectively relied on the nearly ten billion images published every day by its users to continuously improve its visual recognition algorithms. Similarly, Google DeepMind has relied heavily on YouTube video clips to train its AI image recognition software. In a way, consumers are used as commodities to train AI systems through their behaviors and interactions.

The efficiency of AI systems has also relied on the use of specific microprocessors, which are playing an increasing role in the IT infrastructure on the cloud. For example, the training phase of the deep neural networks has tended to rely on so-called "Graphic Processing Units" (GPUs), processors which were initially designed for video games and have become more powerful over the years[30]. For the implementation phase, digital giants tend to develop dedicated processors. Google, for instance, developed the "Tensor Processing Unit" (TPU), while Microsoft has repurposed "Field Programmable Gate Array" (FPGA).

These digital giants are building ecosystems around an "AI tap" that they control, and an intense competition is on to become the "go to" AI platforms which host consumers' and businesses' data. Selling AI through the "software-as-a-service" (SAAS) business model seems to be the route which Google and IBM have adopted. The start-up landscape is also very active in this area. According to CB Insight, the value of AI Mergers & Acquisitions (M&A) has increased from $160 million in 2012 to over $658 million in 2016, while disclosed funding rose from $589 million to over $5 billion over the same time period[31]. Nearly 62 percent of the deals in 2016 went to U.S. start-ups, down from 79 percent in 2012,[32] with U.K., Israeli, Indian, and Canadian start-ups following respectively. The AI market is expected to represent from $40 to $70 billion by 2020, depending on definitional boundaries[33].

Machine-learning algorithms require a vast amount of data to achieve efficient pattern recognition, so consumer markets' critical mass appears to be a crucial enabler of the establishment of AI techno-industrial bases, in tandem with technoscientific capabilities.

26 https://www.washingtonpost.com/news/the-switch/wp/2016/10/13/china-has-now-eclipsed-us-in-ai-research/

27 South Korea government announced in March last year a $863 million five-year R&D investment in AI. http://www.nature.com/news/south-korea-trumpets-860-million-ai-fund-after-alphago-shock-1.19595

28 France's government announced in January 2017 it is working on a National AI Strategy to be published in March 2017. http://www.gouvernement.fr/en/franceia-the-national-artificial-intelligence-strategy-is-underway

29 UK Government announced in January that AI would be at the center of its post-Brexit "Modern Industrial Strategy". http://www.cbronline.com/news/verticals/central-government/modern-industrial-strategy-theresa-may-bets-ai-robotics-5g-uks-long-term-future/. See also U.K. Government Office for Science, Report on "Artificial Intelligence: opportunities and implications for the future of decision-making", 2016 (page 6) https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/566075/gs-16-19-artificial-intelligence-ai-report.pdf

30 http://www.nvidia.com/object/what-is-gpu-computing.html . See also JASON, *Report on Perspectives on Research in Artificial Intelligence and Artificial General Intelligence Relevant to DoD*, (p. 7 & 15). Ibid.

31 CB Insights, "The 2016 AI Recap: Startups See Record High In Deals And Funding", January 2017, https://www.cbinsights.com/blog/artificial-intelligence-startup-funding/. Important note: these figures don't include the Chinese market.

32 Ibid.

33 http://techemergence.com/valuing-the-artificial-intelligence-market-2016-and-beyond/ ; and https://www.bofaml.com/content/dam/boamlimages/documents/PDFs/robotics_and_ai_condensed_primer.pdf

THE RELEVANCE OF INFORMATIONAL INFRASTRUCTURES IN FUTURE CITIES

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KEYWORDS

- SMART CITIES
- DIGITAL INFRASTRUCTURE SYSTEMS
- IOT
- MACHINE LEARNING
- FUTURE SOCIETIES

> "Building these programmable places is not just a matter of putting wires in the walls and electronic boxes in rooms... In the end, buildings will become computer interfaces and computer interfaces will become buildings."
>
> William Mitchell (1996)

INTRODUCTION

Cities around the world are installing digital architectures of sensors, computational cores and telecommunications in the urban fabric, transforming existing infrastructure systems into multi-functional informational and services platforms in the process. The fast pace of digitization is often hard for cities to fathom, many of which are challenged by a silent privatization of the informational value of public spaces and the under-development of the potential of 21st century digital infrastructures due to a mono functional non-inclusive process of design. This is compounded by the power behind large-scale data ecosystems, which when paired with technologies such as machine learning will have profound impact over our future urban services and lifestyles. Cities need to adapt their design mentality and institutional models, but it is through social participation, and open technology standards that true inclusive synthesis of the future digital systems that enable our interactions with cities and allow for the myriad of new services and experiences can be achieved.

Cities are created through an accretion process by which urban artifacts are layered and appropriated over the course of history to become the "collective memory of man" (Rossi, 1982). Our infrastructure systems, from streetlights and traffic lights to sewers and roads are emblematic examples of this process. While we traditionally think about this accumulation of urban form in terms of bricks, it has become evident that in our contemporary societies the informational space mediated by digital technologies has created a parallel reality composed of bits that is no less important to our everyday lives. While we live in physical and social spaces, we are increasingly interacting with them through digital media. This convergence of bits and atoms (Mitchell, 1996) demands a similar process of imagination and reflection on the contemporary synthesis of urban physical-digital artifacts on which we will deposit our human biography in the 21st century.

The process of technological imagination in cities is not new. Influential thinkers and architects such as the likes of Howard (1902), Le Corbusier (1935) and Wright (1935), led this exercise roughly a century ago. They lived through a fast changing world, where inventions such as the automobile, the elevator and the telephone were demanding a change of urban form. Moreover, societies themselves were experimenting profound transformations that emanated from the industrial revolution. As such the fundamental question of their time was "what is the ideal city of the 20th century? The city that best expresses the power and beauty of modern technology and the most enlightened ideas of social justice" (Fishman, 1982, pp. 3). Today, we are living a similar transformation. As post-industrial societies change into information and knowledge societies, the coin of trade also changes from bits to atoms. The creation of digital or "smart" infrastructures is our exploration, our process of looking at cities through their informational lens. Given the rapid pace of change that digital technologies exhibit, Fishman's question remains as relevant today as when he first wrote it if not more; lest not forget that while previous technologies had a dramatic impact in our modern cities, they did so at an enormous energy and environmental cost.

Today we're gradually realizing this "digital city" of ubiquitous computers that are so prevalent that they are invisible, effectively melding into the background while having a profound effect in our everyday lives (Wieser, 1991). Although the digital city is often referred to as a "smart city" – a label widely adopted by marketing departments of corporations and cities alike – its scope is much greater. Beyond a reductionist view of discrete solutions centered on digital technologies aiming at improving urban efficiencies, the digital city encompasses a deeper evolution of our existing infrastructures transforming them into informational systems capable of dynamically mediating the interactions between humans and their environments. Its manifestations are everywhere, from simple things such as the doors that automatically open when we enter a building to systems of great complexity such as smart grids or the dynamic traffic management systems deployed in cities like Singapore, Stockholm, and London[1]. At its core the digital city is a combination of mass deployed digital sensors embedded into our urban fabric, on our personal devices, in our automobiles and homes. These sensors are interconnected by telecommunication networks that transmit massive volumes of collected data to distributed computational architectures for processing and storage. The processed data then used to perform actuation cycles on a variety of connected systems and eventually delivered to people through mediated infrastructures or locative media.

These assemblages are constantly generating troves of data about our environments and our behaviors in them. The data collected is not without context, but rather sensed from urban environments, aggregated and analyzed across varying scales of space and time to reveal invisible patterns, hidden dynamics of "actions, transactions and interactions" in the city (Batty, 2013, p. 115). When assembled, urban data can create real forms of knowledge capable of having an effect on social life (Kitchin, 2014); as such it can be used for a wide range of purposes; from achieving better governance and policy making to creating optimizations in critical infrastructure, developing new types of services and designing novel urban experiences. However, for the vision of the "digital city" to become real we need to merge the urbanscapes with the infoscapes into a coherent new urban synthesis that layers many new physical-digital urban artifacts. In short digital technologies, which McLuhan described as an extension of our nervous system (McLuhan, 1964), will be integrated into large "internet of things" architectures that will surpass the Internet of humans (Evans, 2011) to form "digital nervous systems" of urban, even planetary scales (Mitchell, 1995, 2000, 2003).

While some researchers characterize "smart city" projects as examples of outward-looking policy promotion for the globalized economy that propose benefits through a variety of digital augmentations (Wiig, 2015), and question the self-congratulatory rhetoric surrounding them, their fuzzy definition and overall ideology (Holland, 2005). The vision of the "digital city" is often questioned as if it is a choice, but the fact of the matter is that we cannot deny the constant permeation of digital technologies into our urban environments. Given the fast pace by which these technologies evolve in capabilities, accessibility and cost; their introduction into our daily lives and realities is an almost inevitable outcome and as such I think the more relevant question is not whether *if* it will or should happen, but rather *how* it will and should happen? The historical impact in cities of technologies such as the automobile, the elevator or the telephone should be a warning that pushes us to a greater degree of agency and inclusion in defining how the next waves of technology adoption should play out again in the future.

1 http://ops.fhwa.dot.gov/publications/fhwahop08039/cp_prim1_08.htm

This is a relevant matter since the ongoing digitization and "upgrading" of traditional cities infrastructures has created a '$100 billion jackpot' (Townsend, 2013, pp. 19), one that has fueled an industrial race for the transformation of the next generation of urban infrastructures. Many companies have been selling cities a large array of applications that leverage their respective domain of technological expertise to solve specific urban problems such as congested traffic, waste collection and energy optimization. These solutions are in high demand from public officials who desire highly visible solutions to show to their constituencies. Most of the time the technologies deployed work under closed, proprietary platforms that are essentially "black boxes" to the cities that purchase them through licensing arrangements aimed at creating technological dependencies and data silos. The closed nature of these platforms is critical for companies in their pursuit to strategically control the flows of bits, atoms and electrons of cities in the following decades of explosive urban growth and reconfiguration (Townsend, 2013).

The aforementioned dynamic poses the risk of allowing a greater degree of privatization of public systems than what is socially desirable. This is compounded by cities not thinking about their digital infrastructures in terms of multi-functional architectures and which are still purchasing digitally enhanced single purpose solutions that are a reflection of the 20th century mono-functional infrastructure design mentality. It is often difficult for cities to realize that unlike traditional infrastructures, which are designed to function on their own, digital infrastructures grow in value by working with others since the value captured from the data they generate can expand dramatically when combined with more data. The intangibility of the digital aspects of their new infrastructure systems makes it hard for cities to quantify or even comprehend their true value and makes it easy for companies to claim ownership of the data generated using proprietary technologies. In this sense public infrastructure systems can become privatized both in terms of functional and informational control, even when formal "ownership" resides in city hall. In 1748 Giambattista Nolli illustrated the distinctions between public and private physical space in his famous *Pianta Grande di Roma* map, unfortunately in the "Digital City" distinctions between the public and the private are much more difficult to delineate.

The 20th century infrastructure design mentality also leads to a skewed "*solutionist*" perspective aimed at fixing things and finding solutions to existing discrete problems. Its single-mindedness permeates a culture of development that focuses on optimization of efficiencies rather than on reframing of possibilities. For example, we tend to evaluate "smart" solutions for traffic mainly in terms of vehicular flows optimization or "smart" light projects in terms of a achieving a certain level of energy savings and higher quality of light; and while seeking to optimize existing systems is a worthwhile endeavor, many of the solutions offered don't take into account the nuances of human behaviors and needs outside of their one-dimensional focus and therefore miss on imagining other possibilities to improve their role in the city. Little consideration is given to how technological possibilities could challenge the typological definitions of our infrastructure systems in the future, or furthermore how society might use these new types of infrastructures to synthesize new uses and experiences that don't address any identified problem, but that still hold potential value for citizens.

Leveraging digital technologies for the evolution of current infrastructure systems will not only require investments in R+D but also efforts of design, imagination and planning. Even more so, it will require a good deal of social involvement. Here some lessons of the smartphone era become valuable since they demonstrate that through design showcases, standardization of hardware, data structures, development platforms and marketplaces, the larger population can be empowered into creating a myriad of applications. This won't happen overnight; a gradual process of experimentation and social contestation over this new informational space will be needed for the system to thrive.

Governments and companies can help kick start this social imagination when showcasing examples of applications and uses for the new platforms. Appropriate conditions for a creative ecosystem can be fostered, by providing standardized modular sensor and computational architectures flexible for adoption by cities, giving open access to data, helping education and training programs, developing application-programming interfaces (APIs) and streamlined marketplaces of information and services. All of this is required by the greater society if they are to use the city for processes of experimentation and creation. After all, cities around the world differ dramatically in terms of local challenges, urban form, social composition, institutional arrangements, cultural sensibilities and economic possibilities. The conditions and needs of cities such as New York, San Francisco and London are seldom the same from the likes of Nairobi, Tehran and Beijing; therefore a profound recognition in their differences and nuances will be needed to synthesize and create the multiple variations of experiences, solutions and services sought by their populations.

Many of these variations will not be in the form of hardware but in software. The uniqueness of each scenario will require a combination of grounded cultural values and practices synthesized in in the form of code and algorithms, which in turn will power the intelligence behind the next generation of informational infrastructures, but with a local flavor. Given the amounts of data being generated at urban scales by these infrastructures; techniques utilizing various forms of machine learning and artificial intelligence, such as convolutional neural networks and deep learning will increasingly become a critical component in the development of useful applications.

These machine-learning techniques leverage computers capabilities for detecting unique 'hidden' patterns in aggregated data of various

kinds. Generally speaking, they do this by analyzing millions of data points used for 'training' purposes. Through this process computers gradually achieve the capability of calculating with a certain degree of probability the identification of basic patterns from raw data such as shapes, sequences, frequencies, order, color, etc. By stacking layers of patterns in a neural networked model, they are able to accurately identify patterns of greater complexity and so on. Some of these neural networks have so many layers that that we refer to them as 'deep' networks. They are capable of identifying patterns that even escape our human biology, which is why they are useful in the understanding of systems of great complexity. When computers utilize a type of recursive function commonly referred to as 'back propagation' they can integrate past results into their learning models as they sift through the data; in essence creating large probabilistic machines following a Bayesian model that continually learns and updates its 'beliefs' as it generates decisions based on the data inputs – the greater the data set, the more accurate the learning, the more powerful the decision –.

The patterns detected can range anywhere from extracting unique features that aid in the automation of humans tracking and face-recognition from video-data utilizing a variety of machine-vision algorithms; identifying unique sound signatures from audio to recognize speech patterns using natural language processing; detecting patterns of aggregated behaviors in traffic from GPS data or longer-term environmental change based on air quality data from particulate matter monitoring stations, to name a few. Machine learning technologies are at the moment creating a revolution in a wide array of data-intensive industries from media and finance to biotech, transportation and of course IT, they are behind many of the devices, interfaces and services that drive or digital lifestyles. However, technological shortcomings of machine learning must be acknowledged. For example, bias can be induced in machine learning models if the data is not representative enough, a known problem for example is video recognition algorithms that are very good at detecting persons of certain skin colors better than others simply because they were trained on data that didn't have enough representative samples from a general population. This is why properly curating of the data a core process. Also, it is important to recognize the conceptual and technological limitations of machine learning models for specific purposes. While there is a lot of speculative literature that romanticizes A.I., and while we have created machines that often surpass human beings in performing highly specific tasks (Bostrom, 2014) the truth is that we're far from creating truly intelligent computers capable of achieving human or near human level intelligence for a los of processes and scenarios.

Given the amount of data generated by our digitized urban environments, cities in the future will invariably leverage machine learning technologies to mine, understand and operationalize their data in order to maximize their benefits. But city hall cannot do it alone, as it often lacks the resources and knowledge to truly achieve this effort of conceptualizing the transformation of our traditional urban infrastructures into versatile intelligent cyber-physical artifacts for future cities, which is why involving enterprises and citizens in this task, is key. From history we learn ways to engage the public into appropriating and exploring the possibilities of a new typology of urban artifacts that mediate the connections between places and human activity, hopefully to help people exercise their right of collective power to reshape the process of urbanization (Harvey, 2003) in the informational space. In our era this collective process comes with a sense of urgency driven by information's natural tendency to grow (Hidalgo, 2015), which compounds the aggregation of power through monopolistic information control; a phenomena contemporarily exemplified by many of Silicon Valley's tech behemoths; lest we forget how often information has been misused as a social control tool by many companies, institutions and governments (Scott, 1998).

It is not my intention to signal that through technology alone the vision of the "digital city" will become a reality. For that, profound changes in institutional development, education, accessibility along with new business models and legal frameworks will be needed. To cite William Mitchell "As traditional cities have evolved so have customs, norms and laws governing rights to privacy, access to public and semi public places and exertion of control" (Mitchell, 1996, p.131) However I would argue that design exercises and technological demonstrations can be powerful instruments in triggering discussions that may be of relevance to the evolution of cities.

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AI AND ROBOTICS FOR THE CITY

Imagining and Transforming Social Infrastructure in San Francisco, Yokohama, and Lviv

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This article looks at how existing and planned AI and robotics projects in three cities – San Francisco (United States), Yokohama (Japan), and Lviv (Ukraine) – aim to extend or build social infrastructure to achieve a particular desired vision of city life. The author has chosen contrasting cases both to highlight how particular cultures' ways of thinking of the human-machine relationship matters for the kind of AI and robotics are envisioned and developed as well as to surface the core characteristics of AI and robotics-supported social infrastructure that transcend cultural, economic, and civic histories. San Francisco houses many of the entrepreneurs, software engineers, and multinationals that create AI and robotics in various markets, including applications for cities. Its proximity and relationship to Silicon Valley provides a "close to home" perspective of AI city imaginaries. Yokohama was selected as Japan's "Future City" and offers a perspective of government-named and-organized experimentation in the realm of AI and robotics to achieve the so-called "Society 5.0". Lviv provides a nearly opposite (to Yokohama) example in that the city is in its infancy envisioning how AI may transform its future, and grassroots organization drives the current projects.

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KEYWORDS

- SOCIO-TECHNICAL IMAGINARIES
- SOCIAL INFRASTRUCTURE
- ARTIFICIAL INTELLIGENCE
- ROBOTICS
- YOKOHAMA
- LVIV
- SAN FRANCISCO

INTRODUCTION

Efforts by cities around the world to engage artificial intelligence (AI) and robotics for their betterment aim generally to support or extend the "social infrastructure" of the city. Ideas about how the life of each city's resident ought to be constituted, supported, and improved through AI and robotics technologies guide these activities. At the same time, the new visions of AI-and robotics-enhanced cities expose changing social values and norms that we must examine to understand how their enactment may affect urban life.

The meaning of "social infrastructure" can be categorized in three iterations. Traditionally, social infrastructure referred to the subset of infrastructure assets that accommodate social services, for example: medical facilities, schools, community and sport facilities, local government facilities, water treatment, bus stations, parks, prisons and court houses. The term itself is curious because it applies "social," a term we usually associate with human interaction, to infrastructure, which is about physical organization as a means to provide a service. Thus, the services provided by social infrastructure (clean water, education, correction) in this original meaning of the word can be seen as material and institutional supports for a particular way of life. As social media companies became popular, the term "social infrastructure" took on a second and parallel meaning to describe internet services supporting integration of "social functionality" with their products and user interfaces (e.g. login through Facebook or Google; sharing; comments; ratings).

With the introduction of AI and robotics applications into the fabric of city life, social infrastructure is acquiring a third and broader definition. Mark Zuckerberg recently conveyed this broader and far-reaching definition when he revised the mission of Facebook to be to build the "social infrastructure" to support a global community (Zuckerberg 2017). Zuckerberg claims that Facebook technologies, in which AI plays a growing role, provide the foundation for (and are capable of) forging a global social order. For Zuckerberg as well as for other AI and robotics pioneers, AI and robotics are envisioned to have no bounds in their capability to inform and guide aspects of individual and community life. These technologies embody the contemporary promise of automation, which is the substitution of human cognitive and physical labor with mechanical (in this case "autonomous" and semi-autonomous algorithmic and robotic) work. Accordingly, more than just referring to physical assets or internet services, the most recent meaning of "social infrastructure" is the integration of greater autonomous capacity into material, institutional, or informational provision that enable and support society's functioning and wellbeing. The significance of this is that the key balance between the human and social on the one hand and infrastructural and material supports of society on the other hand is shifting, with consequences for who has responsibility for the emergent social order, who is helped and hurt in it, and whose values are built into it.

In this article, I look at how existing and planned AI and robotics projects in three cities – San Francisco (United States), Yokohama (Japan), and Lviv (Ukraine) – aim to extend or build social infrastructure in this third definition to achieve a particular desired vision of city life. I choose contrasting cases both to highlight how particular cultures' ways of thinking of the human-machine relationship matters for the kind of AI and robotics are envisioned and developed as well as to surface the core characteristics of AI and robotics-supported social infrastructure that transcend cultural, economic, and civic histories. San Francisco houses many of the entrepreneurs, software engineers, and multinationals that create AI and robotics in various markets, including applications for cities. Its proximity and relationship to Silicon Valley provides a "close to home" perspective of AI city imaginaries. Yokohama was selected as Japan's "Future City" and offers a perspective of government-named and-organized experimentation in the realm of AI and robotics to achieve the so-called "Society 5.0". Lviv provides a nearly opposite (to Yokohama) example in that the city is in its infancy envisioning how AI may transform its future, and grassroots organization drives the current projects.

I examine the projects through the lens of sociotechnical imaginaries, a theoretical framework developed by scholars of Science, Technology and Society (STS), a field specialized in understanding how and with what consequences people use the power of science and technology to re-make the world. In a 2015 work, *Dreamscapes of Modernity*, STS scholar Sheila Jasanoff defines a "sociotechnical imaginary" as a "collectively held, institutionally stabilized, and publicly performed vision of a desirable future, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology" (Jasanoff and Kim 2015, 4). Imaginaries of AI and robotics-enhanced social infrastructure highlight what local officials, entrepreneurs and publics consider to be a well-functioning and good city. They also draw attention to why, in the minds of the leaders, the envisioned social order ought to be supported by autonomous or semi-autonomous technology and technology leaders instead of by civic institutions or elected-leaders.

SAN FRANCISCO

AI and robotics applications in San Francisco are focused on solving the city's growing transportation problem. The promise of AI to process and deliver actionable insights from vast quantities of data, and of robotics to embody these insights into "smart vehicles," has fueled hopes that these technologies can drive recovery from the daily freeway gridlocks and unaffordable housing caused by expansion of the tech sector itself. In the minds of its leaders and residents, San Francisco's capacity to maintain its livelihood, diversity, culture, and international entrepreneurial reputation hinge in large part on its ability to solve the transportation problem.

In this context, AI and robotics provide a luring hope. Particular to the technology of AI is the confidence that its capabilities can surpass – and even be preferable to – human control and judgment (see, for example, Agrawal et al. 2017). Corporations like Google, Tesla, and Uber claim that self-driving cars can drive more efficiently and safely than people and that AI-analyzed information can guide individual and government decision-making especially in historically politically-charged areas, such as where and how to develop

transportation.[1] These claims tap into long-standing and self-proclaimed belief that Silicon Valley's political culture is defined by a distrust of political establishment.[2] This political culture and automation promise of AI and robotics technologies fuels an imaginary in which transportation made "smart" promises to restore to San Francisco the fluidity and diversity of people, ideas, cultures, and economic classes that have long defined it.

The prime example is the City of San Francisco's 2016 application to the US Department of Transportation's Smart City Challenge, in which it outlines the vision for AI and robotics to enable a new kind of social infrastructure transforming city life. The Vision Narrative illustrates the city's ideal "Shared, Electric, Connected and Automated Vehicles" (SECAV) model, which hinges on the replacement of single-occupancy vehicles with "shared and connected" vehicles. In the envisioned state:

SECAV services are fully optimized. Fatalities eliminated. Vision Zero goal met [zero traffic deaths in San Francisco by 2024]. Pollution, noise, costs, impacts minimized. Social equity and access significantly improved. Parking structures repurposed for affordable housing, streets become shared spaces for all (San Francisco Smart City Challenge 2016 Video).

In this vision, AI and robotics optimize transportation by maximizing the efficient use of resources such as energy, time, money, lives, and space. Like an electric car that must plug into an electric infrastructure of charging stations, the AI and robotics solution to San Francisco's problem of transportation plugs into an imaginary of social infrastructure plagued by human-created inefficiencies.

1 See, for example, "A History of BART: The Concept is Born," on the contention around the development of the multi-county Bay Area Rapid Transportation (BART) system in the 1960s.

2 For historical analysis of Silicon Valley's political culture and its relationship to technology entrepreneurs and culture, see Turner 2006 and O'Mara 2015.

"THIS POLITICAL CULTURE AND AUTOMATION PROMISE OF AI AND ROBOTICS TECHNOLOGIES FUELS AN IMAGINARY IN WHICH TRANSPORTATION MADE "SMART" PROMISES TO RESTORE TO SAN FRANCISCO THE FLUIDITY AND DIVERSITY OF PEOPLE, IDEAS, CULTURES, AND ECONOMIC CLASSES THAT HAVE LONG DEFINED IT."

The SECAV solution depends upon casting San Franciscans into atomized "roles" or narrow functions that each plays in the culture and economy of the city. "San Francisco," the Vision Narrative says, "is an ever-evolving community of thinkers, doers, runners, bikers, activists, neighbors, babies, students, entrepreneurs, cooks, up-and-comers and a thousand other roles" (San Francisco Smart City Challenge 2016 Video). The idea behind listing these roles is that each comes with a set of needs, consumption habits, and services that it contributes to city life. Such roles are necessary for AI-enhanced transportation to work according to the following best-practice scenario:

- A CAV [Connected and Automated Vehicles] microtransit provider hired by her weekly arts enrichment program brings Nicole's daughter home while she grabs a workout. Nicole can afford both the new multi-modal [CAV] services, gym membership and the weekly arts enrichment program for her daughter with the money she earns from [sharing] her car (San Francisco Smart City Challenge 2016 Video).

Here the technology enables the hypothetical (or perhaps real?) Nicole to outsource daily tasks, readjust how she spends time with her daughter, and reframe her economic standing in relation to personal health services and her daughter's education – all enabled by "her car" as part of the the AI and robotics-driven transportation revolution of the "Smart San Francisco City." The imaginary of AI- and robotics-improved social infrastructure in San Francisco transforms the meaning of "public" transportation from transportation that is provided by the local government in the service of all residents to all residents being themselves recast as "microtransit" consumers and providers. According to this imaginary, San Francisco life is optimized, economized, connected, and highly individualized. The technology solves the problem by helping to remove perceived human inefficiency, reinforcing an idea of citizens as "micro" role-based consumers and providers of services.

YOKOHAMA

One of the least common applications of AI and robotics to city life is being developed in Japan. It is a search for how these technologies can be used to maintain the economic vibrancy of Japanese society while its population steadily ages. This problem is felt acutely in Japan's city of Yokohama, which characterizes itself as having a "super-aging" population:

- the city is facing the issues of a super-aging society. According to one estimate, the number of senior citizens will reach one million [out of 3.7 million] by 2025. The most important thing for the creation of a vibrant city in such circumstances is economic activity (FutureCity Yokohama 2013).

As this statement suggests, beyond providing care, the problem of Japan's aging population is how to keep people's economic activity up as they age. The Japanese government, academics and industry leaders are thinking about the elderly's special needs (mobility, quick medical response, recreation) as they go about daily life in the city and imagining how AI and robotic might be used to address each one. For example, Fujitsu has developed

a product called "UBIQUITOUSWARE," a combination of core module (accelerometers, barometers, gyroscopes, microphone, magnetometers, vitals, GPS, temperature and humidity sensors) and a proprietary algorithm to analyze inputs from these sensors for applications that include monitoring patients, learning about their behavior, and providing more "intelligent care" via nudging human caregivers or integrating with AI-empowered robotic caregivers (Fujitsu 2017).

Residents of Yokohama are subject to experiments with these kinds of applications. The Japanese government has designated Yokohama to be Japan's "FutureCity" – the national site where public and private organizations can actively experiment with technologies to improve and sustain a particular kind of elderly experience in city life. The city is also a "regulation sandbox," where new and flexible policies are in place to encourage technological development (CNBC 2016). Yokohama was selected for this role because its demographics and other metrics are similar to those of other Japanese cities, with the argument that any solutions developed for Yokohama can be more easily transferred to other cities (FutureCity Yokohama 2013). In addition, Yokohama is already a technology hub in Japan. Japanese technology companies like Fujitsu are headquartered there and international companies are establishing branches there, such as Apple's new R&D center, whose focus is on AI research (Wuerthele 2017).

From the perspective of the Japanese government, this kind of experimentation with AI and robotics technologies for an aging population is not just a solution to a problem, but the active building of a new society called "Society 5.0." According to Japanese Prime Minister Shinzo Abe, Society 5.0 is a project name for a society literally and metaphorically (as indicated by the "4.0" to "5.0" designation borrowed from the practice of naming software versions) built upon Industry 4.0 technologies (AI, Big Data and IoT, sensors, and robotics) "to overcome the challenges coming from an aging society with low fertility" (CNBC 2016). The Japanese government's strong role in setting the goals (Society 5.0), sites (Yokohama) and rules (regulation sandbox) of experimentation with AI and robotics reveals holistic, concerted effort that prioritizes social development through economic activity.

Experimentation with AI and robotics solutions to the problem of aging population in Yokohama under the banner of Society 5.0 offers a unique imaginary of social infrastructure. Thinking from the perspective of technology solutions, the problem of aging in the city becomes an information problem: how to collect, analyze, and deploy back information to people and devices so that they can assist and enhance human function as people lose their biological abilities. AI is envisioned to make up an invisible, ever-present system of information exchange and analysis that enhances urban infrastructure to make it more possible for an aging population to live with greater pleasure and independence for longer, with specific ties to economic frameworks (access to services, consumption). In the Yokohama imaginary, AI and robotics can help to lay the foundation for an inclusive future urban society where technologies step in as "intelligent" crutches for human frailty.

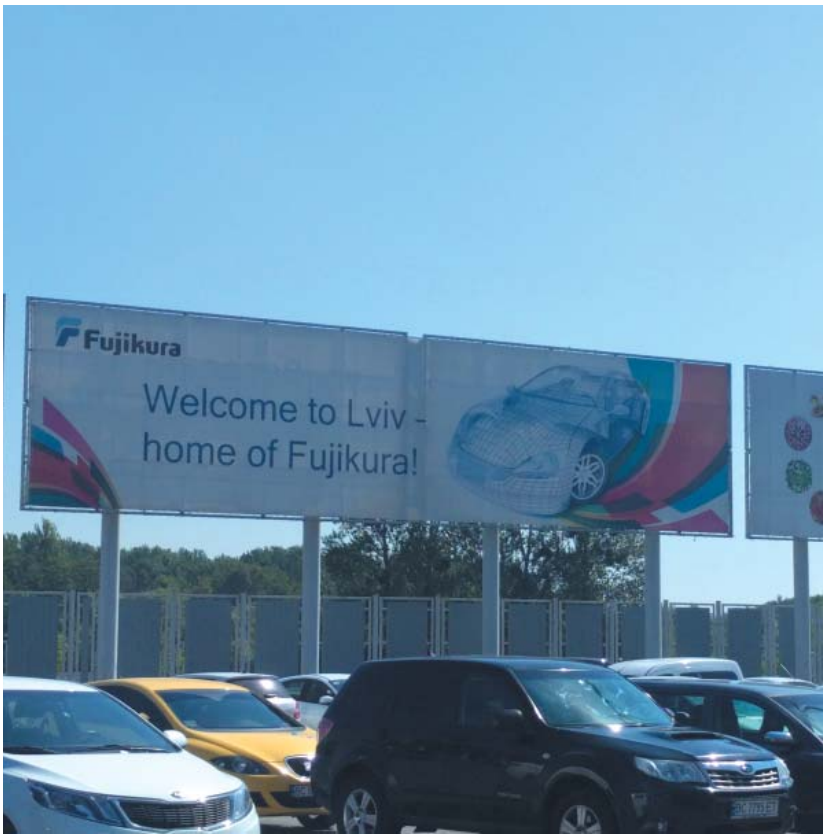
LVIV

In Lviv there exists the imaginary promoted by local technology entrepreneurs that emerging technologies such as AI and robotics can help Ukraine achieve the twin goals of greater national independence and overcoming rampant political corruption by developing the agricultural sector and the culture of innovation.

"FROM THE PERSPECTIVE OF THE JAPANESE GOVERNMENT, THIS KIND OF EXPERIMENTATION WITH AI AND ROBOTICS TECHNOLOGIES FOR AN AGING POPULATION IS NOT JUST A SOLUTION TO A PROBLEM, BUT THE ACTIVE BUILDING OF A NEW SOCIETY CALLED "SOCIETY 5.0."

Lviv is a center of development of information technologies specializing in IT "outsourcing" by providing skilled and less expensive IT services to foreign companies. AI and robotics services, such as data mining, real-time data science, and integrated deep learning, are a growing part of that activity. In addition to this work, one of the most promising applications of AI and robotics within Ukraine is considered to be the advancement of agriculture (interview Utkin). Agricultural technology projects with AI, such as "precision agriculture," use data analytics about water levels, soil acidities, weather, and fertilizer utilization to assist the farmer in maximizing crop yields. Ukrainian companies like BioSens, KrayTechnologies, and WattCMS, among others, are developing software for quickly checking chemicals in produce, drones for treating crops, and sensors for monitoring the ambient environment, respectively. These efforts tap into Ukraine's agricultural potential as a key part of its national identity – an identity that is mobilized today by politicians and business leaders as a key strategy in the pursuit of Ukraine's economic and cultural independence from Russia and as a means for improving livelihood in the country.

The development of these technologies for applications outside of the city, and sometimes even outside of the country, nevertheless directly influences urban life in Lviv. This takes place through the engineers who work in these industries and live in the city. Employees of the technology sector receive higher salaries than most other occupations in the city, tend to be younger, speak English fluently, and have the ability (documents and finances) to travel abroad. Catering to the IT workforce and to tourists (IT and tourism are designated by the Lviv's government as the two strategic areas for the city's development), the city in partnership with IT entrepreneurs is supporting the opening of trendy WiFi-outfitted cafes, restoring and modernizing its historic public spaces according to Western models, growing its educational institutions (especially for training technologists and entrepreneurs as well as the promotion of Ukrainian arts and culture), and building high-end housing.



Meanwhile, senior Ukrainian technology leaders that grew their businesses in the 1990s and 2000s (such as, Evgeni Utkin, Taras Vervega, Oleh Matsekh) are patrons of projects in Ukrainian cities that combine cultural and technological innovation. Direct investment is transforming spaces of traditional social infrastructure into spaces focusing on the new social infrastructure with AI and robotics. For example, a project to build an innovation center in Lviv's old tram station aims to give locals the physical, material and intellectual resources and skills they need to develop new technologies as well as to sustain their livelihoods in the city (Matsekh 2017; Kenigshtein 2016). AI and robotics technologies figure prominently in the priorities of this innovation center (Matsekh 2017).

Among the old and new generation in the technology sector there is a belief that growing its expertise in AI and robotics and expanding the culture of technological innovation in the city will lead not only to economic growth that gives Ukraine more independence and power but also helps to circumvent the corruption of the existing political system by substituting new forms of power for the old. In this way AI and robotics are envisioned to re-make the city's social infrastructure to support a more just and transparent civic life.

"IN LVIV THERE EXISTS THE IMAGINARY PROMOTED BY LOCAL TECHNOLOGY ENTREPRENEURS THAT EMERGING TECHNOLOGIES SUCH AS AI AND ROBOTICS CAN HELP UKRAINE ACHIEVE THE TWIN GOALS OF GREATER NATIONAL INDEPENDENCE AND OVERCOMING RAMPANT POLITICAL CORRUPTION BY DEVELOPING THE AGRICULTURAL SECTOR AND THE CULTURE OF INNOVATION."

CONCLUSION: COMPARING URBAN AI IMAGINARIES

Sheila Jasanoff and Sebastian Pfotenhauer show that innovation projects can be seen as self-diagnostics of what the city perceives to be troubling or in need of fixing (Pfotenhauer and Jasanoff 2017). In the case of AI and robotics, with the image of intelligent sensors keeping the metaphorical pulse of the city in real-time, the promise that the technology can be a tool for diagnosing and acting upon urban problems is an integral part of how the technologies are imagined to function. Comparing the three cities' self-diagnostic and corrective means, i.e. the way that AI and robotics are imagined to support social infrastructure, exposes important differences in how each city envisions the human collectives it aims to support via social infrastructure development.

In San Francisco, removing obstacles to efficiency means taking the human out of active participation in the driving system. Instead of defining humans as actors who control the technology, social infrastructure enhanced with AI and robotics increasingly treats human beings as information, as data points, and aspires to manage the productive and consumptive activities of these data points to achieve greater efficiency.

In Yokohama, the imaginaries of AI and robotics enhanced social infrastructures diagnose people's narrowing abilities and growing frailties. As a result of this framing, AI and robotics are brought in to do human tasks such as caregiving as well as to redefine city services around the needs of the elderly. The project of Society 5.0 is to use increasingly autonomous technology to build a new society around changing human needs, which nevertheless remain central.

In the Lviv imaginary the attractiveness of the AI and robotics lies in its promise to correct for the human tendency to corruptibility by substituting technological or technologist action for human and especially political action. Instead of inherent human inefficiency, as in San Francisco, the problem in Lviv is entrenched political culture inherited from the Soviet Union. This culture is perceived to have created the conditions in which it is difficult for people to make good, just judgments when they are put in positions of power. By virtue of their education and nature of their work, technologists are seen as the answer to breaking with this corrupt cycle. The Lviv case illustrates more starkly than the others that imaginaries of AI in the city are themselves a form of social infrastructure, i.e. they offer a systematic, normalized way forward for transforming the society from what it is today to the envisioned future state.

Since the days of its founding in the second half of the 20th c., one of the most poignant questions about AI and robotics has been the way in which intelligent technological systems interact with the people who make them. Would they, like Hal, choose to overthrow the human being or would they, like Siri, become intuitive assistants? Today, the integration of AI and robotics into the fabric of city life to address the most pressing urban challenges reveals the extent to which the culturally-specific relationship between human and machine is still central in driving how cities are imagining themselves as collectives of human beings with AI and robotics. Whether AI and robotics are being introduced to city life to solve the problem of transportation, ageing, or corruption, they reveal what is considered to be problematic with human collectives. The technology's promise lies in the ability to re-build social infrastructural supports of the city in ways that delegate more power to autonomous technological systems and depend less on human decision-makers, viewed as fallible for different reasons.

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ACCELERATING SUSTAINABLE MOBILITY
with autonomous vehicles

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KEYWORDS

- AUTONOMOUS MOBILITY
- SUSTAINABLITY
- AUTONOMOUS VEHICLES AND CARSHARING
- LEVELS OF AUTOMATION
- MAPPING

Autonomous mobility has great potential for transforming mobility, especially towards greater sustainability. But contrary to what advocates of autonomous mobility are saying, its future is far from certain: several different scenarios could play out, both in terms of how they develop and their impacts on the transport system.

Public authorities will have a key role to play in steering this technology towards the desirable scenarios and setting the conditions for the integration of autonomous mobility (planning road systems, regulating local mobility, supporting experiments and pricing services).

Early on, authorities need to determine under which conditions AVs can help them to achieve their sustainable mobility goals. The private sector also needs to examine how the technological and industrial solutions it develops will be integrated into a sustainable future mobility system. This shared vision of autonomous mobility should be developed with local and national public authorities.

INTRODUCTION

Over the last few years, autonomous mobility has received extensive media coverage. According to the projections of its advocates, connected and fully autonomous vehicles will be commercially available in about 10 years' time and will help to reduce traffic congestion and road deaths.

This optimism nevertheless tends to mask the uncertainties surrounding the future of these vehicles, especially technological uncertainties: we are still a long way from achieving full automation. Moreover, different scenarios and models for the development of this innovation may play out (shared taxi fleets versus individual vehicles), each with its own risks and opportunities. Faced with the need to ensure more sustainable, accessible and efficient mobility, public policymakers need to examine the way in which automation can help to transform mobility: to what extent will autonomous vehicles (AVs) contribute to reducing local pollution and decarbonising the transport sector? How will they limit the number of cars on the road and the amount of space they use? And will they improve accessibility for all and help to cut mobility costs?

The answers to these questions depend on the development pathway for autonomous mobility. Assuming that this pathway remains to be determined and that the local and national public authorities have a key role to play in shaping it, especially by defining the conditions for market entry, this Issue Brief presents the key structural components of autonomous mobility upon which public policymakers will need to act to ensure VAs become the drivers of sustainable mobility. The second part of this Brief illustrates the risks and opportunities of AVs for the transition to more sustainable mobility systems.

This article has received financial support from the French government in the framework of the programme "Investissements d'avenir", managed by ANR (the French National Research Agency) under the reference ANR-10-LABX-01.

1. WHAT KIND OF AUTONOMOUS MOBILITY?

We consider that the development of autonomous mobility will be structured by the convergence of different technological and service-based possibilities with individual and group demands (reducing congestion and pollution, guaranteeing the right to mobility for all, etc.).

1.1. HOW MATURE ARE AUTONOMOUS TECHNOLOGIES? *TECHNOLOGICAL POSSIBILITIES*

There are five levels of automation[1], defined by the growing capacity of a vehicle to carry out a range of manoeuvres without intervention from a driver, in a variety of different driving situations. Level 5 refers to a theoretical time horizon with autonomous vehicles in all situations.

The key obstacle to developing high levels of automation is the complexity of interaction between AVs and traditional vehicles during the coexistence phase, as well as with other road users. This constraint implies reaching a certain level of driving data acquisition, developing high computing power and producing test protocols that compare AV algorithms with a wide range of situations.

Faced with these technological challenges, autonomous mobility actors are developing different strategies according to the skills and resources of their trade. These include: progressive learning through automation seen as additional automotive equipment (car manufacturers, Tesla); learning through shuttles used in dedicated lanes (urban transport operators); or more direct deployment, for example through fleets with safety drivers (Google Car, Uber).

Finally, digital mapping with a view to enabling autonomous mobility raises important questions of competition regulation and public safety, in that it is set to become a new digital infrastructure for mobility. In this context, the issue of which actor will impose its cartography is of real political importance.

Automation thus faces numerous technical constraints, which require substantial investments, such as the need to create dedicated AV zones or lanes, or to ensure accurate territorial mapping. Whether or not and under what conditions public action can remove these constraints will be decisive in shaping the development of autonomous mobility and thereby facilitating disruptive services.

1.2. WHO WILL BE ABLE TO AFFORD AUTOMATION? *ALIGNING POTENTIAL SERVICES WITH INDIVIDUAL DEMANDS*

One of the promises of autonomous mobility is that it will save the cost of drivers for public transport and taxis/private hire cars, making it possible to develop new mobility services that are not economically viable in the current context. This promise of economic gains raises the question of the cost of autonomous technologies, which is a key factor in determining the nature of services provided and their potential users: will it be an expensive niche market, or can services be developed with user costs on a par with those of public transport?

The existing literature anticipates that, eventually, the digital material required could represent a few thousand euros per vehicle and the cost per kilometre for an AV fleet could prove competitive in relation to other modes of urban transport. This projection depends on technological advances, on the capacity of actors to take advantage of returns to scale and on choices made regarding AV use: high speed, for example, implies greater computing power requirements and thus potentially heavier digital infrastructure, whereas vehicle sharing would reduce the cost per kilometre/user. Although there is considerable uncertainty about these factors, the huge investments made in this sector by numerous private actors seem to indicate that autonomous mobility services could be economically viable in the medium term.

The cost of autonomous mobility will also be determined by the regulatory framework imposed (subsidies, taxes, pricing schemes).

"CONTRARY TO WHAT ADVOCATES OF AUTONOMOUS MOBILITY ARE SAYING, ITS FUTURE IS FAR FROM CERTAIN: SEVERAL DIFFERENT SCENARIOS COULD PLAY OUT, BOTH IN TERMS OF HOW THEY DEVELOP AND THEIR IMPACTS ON THE TRANSPORT SYSTEM."

1 Level 1 and level 2 include respectively one and several simultaneous automated functions (e.g. steering and acceleration), while leaving supervision of driving to the driver. Level 3, conditional automation, means the driver is no longer required to monitor driving in some situations, but remains behind the wheel in case of need. Level 4, which is more obviously disruptive, refers to vehicles that no longer require a human driver in a significant number of driving modes.

1.3. WHICH AUTONOMOUS MOBILITY OFFERINGS WILL BE THE FIRST TO BE ROLLED OUT? *ALIGNING POTENTIAL TECHNOLOGIES AND SERVICES WITH GROUP DEMANDS*

There are several possible ownership and usage configurations for AVs (understood here at automation levels 4 or 5) that could theoretically coexist: traditional individual cars, individual cars that could be returned to a fleet when not being used by their owners (Tesla model), a private fleet of AVs, either shared (like UberPool) or not, or a minibus network run by a public transport operator, etc.

Management of the coexistence between AVs and other modes of transport will be crucial to the viability of these services: road system planning will be more favourable to some services than others; the first experiments will determine the general public's perception of this technology; network effects will give the first actors a head start, etc.

The public authorities will therefore have a critical role to play in ensuring an acceptable coexistence between AVs and the other modes of transport and, more broadly speaking, coordination with the rest of the mobility system.

1.4. WHAT DEMANDS, WHAT USES? *INDIVIDUAL AND COLLECTIVE DEMANDS*

The success of autonomous mobility will depend on tradeoffs between its costs and its benefits for users, especially in terms of comfort and time saved[2].

The ways in which AVs are used will also depend on the level of acceptance of a shared, collective mode of transport. Will the popularity of journey sharing gradually extend to society as a whole through AVs? Or will this be an obstacle?

Other challenges linked to uses will also structure the deployment of autonomous mobility: concerns about dependence on a technology perceived as unreliable, reluctance to give up driving, and opposition from other road users.

More fundamentally, will autonomous mobility be an extension of the individual mobility model, synonymous with comfort and in the future with connectivity (cars as a place of services and entertainment)? Or will it follow the "mobility as a service" model, synonymous with flexibility, in which it is the mobility service provided that matters, whatever the type of vehicle? Although

the public authorities cannot control all of the tools that shape this social and technical change, they nevertheless have a key role to play in influencing it.

2. WHAT ARE THE RISKS AND OPPORTUNITIES FOR SUSTAINABLE MOBILITY?

Figure 1 presents a set of risks and opportunities linked to autonomous mobility and organises them according to different dimensions. The five blue circles represent the determinants of energy consumption and greenhouse gas emissions[3] from mobility, while the purple circle shows social impacts. This section describes two visions in order to illustrate these risks and opportunities.

2.1. VISION 1: FULLY AUTONOMOUS AV FLEET (ITF 2015)

This vision, based on a modelling exercise like the one conducted by ITF (2015), reflects a radical public choice: "traditional" vehicles are prohibited in a town centre where an AV fleet is deployed[4]. Users have a strong incentive (or are even obliged) to share vehicles.

The impacts are very positive. Nine out of ten vehicles are removed from the road, freeing up space in urban areas. With a single regulator allocating travellers to available vehicles, it is also possible to significantly increase the vehicle occupancy rate and thereby reduce energy consumption per passenger. Intensive vehicle use could also be conducive to electric vehicle uptake: in comparison with internal combustion vehicles, electric vehicles cost more to buy but less to run.

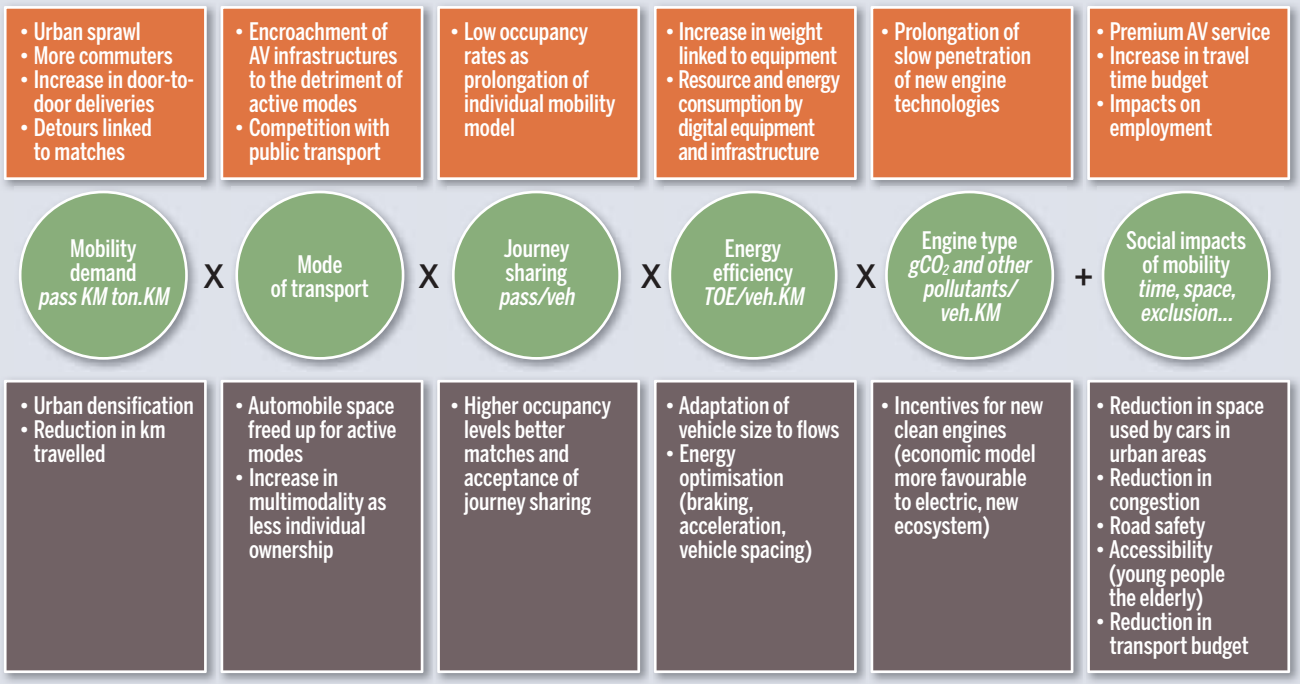
2 One of the promises of AVs is that they will enable passengers to use travel time for tasks other than driving. But AVs could also reduce journey times, for example if they help to reduce congestion.

3 Calculating total CO_2 emissions in a mobility system implies informing each circle (how many pass.km per mode, energy efficiency of each mode, etc.) and multiplying them.

4 International Transport Forum, 2015, Urban mobility system upgrade. The ITF scenario is tested according to three hypotheses: 100% of individual cars and buses are replaced either by a fleet of shared taxis (A), or by a fleet of traditional taxis (B); and a transition scenario in which traditional vehicles (50%) and AVs coexist (C). There are three taxi sizes (1-2; 3-5; 5-8) and an algorithm that allocates users to these services, ensuring that they meet acceptable time constraints.

Risks and opportunities of autonomous mobility

Risks for sustainable mobility - possible consequences of automation that will impact indicators in the green circles



Opportunities for sustainable mobility - possible consequences of automation that will impact indicators in the green circles

Figure 1

However, to meet mobility requirements, these vehicles operate intensively and it is difficult to reduce traffic volumes (number of vehicles kilometres travelled or 'veh.km') and road use levels[5]. Ensuring a high level of sharing appears to be essential to preventing rebound effects in terms of increased veh.km. Finally, this vision illustrates the risks associated with the transition period: assuming that AVs coexist with "traditional" vehicles, the reduction in the number of vehicles is smaller than in the first scenario, and traffic volumes increase[6].

2.2. VISION 2: WIDESPREAD REBOUND EFFECTS

In this vision[7], autonomous technology is used to improve individual mobility in terms of comfort and time saved. We also assume that congestion decreases through improved traffic flows. The indirect result of this improvement in individual mobility is that people move further away from their workplace, through a process of urban sprawl. AVs could also become a real living space (office, place to meet friends) and no longer just a means of transport. Consequently, the number of kilometres travelled could rise sharply, without any significant change to occupancy levels, which would result in higher energy consumption. In urban centres where the cost of parking is high, owners could send their vehicles to park in peripheral areas, thereby generating additional "empty" kilometres. Changes in online purchasing behaviour could be combined with automation to produce an increase in travel linked to deliveries; travelling shop services could develop, providing the cost of autonomous mobility is lower than that of a commercial lease. AVs could also compete with public transport and weaken their economic models.

These radical images of the future are not necessarily the most likely, but help to illustrate the risks and opportunities of AVs for sustainable mobility. The local and national public authorities have a key role to play in steering the development of this technology, whether in terms of regulation or in terms of industrial and infrastructure investment choices. But this requires foresight exercises that are open to the radical changes that could occur with autonomous mobility and that help to identify the conditions for their implementation and their implications for sustainable mobility. **This is the challenge of the "New mobility, clean mobility?" project currently underway at IDDRI.**

5 Results in terms of traffic (+6% veh.km for A, as transfer of bus users + detours + parking; +50% during peak hours for B with underground trains) and congestion (road use level relatively similar to the reference for A, but +80% for B without underground trains).

6 If we retain 50% "traditional" cars, only 2 out of 10 vehicles are withdrawn and the number of veh km in peak hours increases [A +35%; B +55%].

7 See, for example, the vision of Robin Chase, President of Zipcar: https://www.youtube.com/watch?v=DeUE4kHRpEk

AI, ROBOTICS AND MOBILITY AS A SERVICE: THE CASE OF SINGAPORE

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KEYWORDS

- AUTONOMOUS
- POLICY
- TECHNOLOGY
- SMART NATION
- PARTNERSHIP

INTRODUCTION

With a land area of 719 square kilometers and a population of 5.61 million (as of June 2016), Singapore is known to be one of the most densely populated country in the world. Land use for roads accounts for approximately 12% of Singapore's total land area. By 2030, Singapore's population is projected to reach 6.9 million, hence the demand to set aside land for housing, infrastructure, and amenities is expected to rise. While tools such as the vehicle quota system and road pricing system to control vehicle growth and manage road congestion have proven to be effective thus far, it is unlikely that these strategies can continue to sustain future needs.

Physical constraints also coincide with economic needs to be a more service-based economy, and the government has announced its plans to be a "Smart Nation" that leverages advances in digital technology to create a more liveable, innovative, and economically city. Five key domains have been identities – transport, home and environment, business productivity, health and enabled aging, and public sector services – as areas where technology can drive impactful solutions to address current and future challenges.

Economic needs under severe physical constraints have prompted Singapore to be an active adopter of the autonomous vehicle. Since 2014, Singapore set up the Committee on Autonomous Road Transport in Singapore (CARTS) to study autonomous vehicle applications, as well as regulations and implementation. From the onset, four application areas were identified: (1) fixed and scheduled services for efficient mass transportation, (2) point-to-point or mobility-on-demand services, (3) freight, and (4) utility operations.

Singapore is noted for being one of the first movers in embracing self-driving cars, but it also possesses natural advantages in doing so. The city-state's high urban density, limited workforce for commercial drivers, knowledge-based economy, modern infrastructure, efficient government, and a highly educated population makes it an attractive place to develop innovations in self-driving car technologies. With the insights gained from testing and evaluation of self-driving car technologies in collaboration with the private industry, Singapore is well-positioned to be a potential role model country in land transportation transformation and "smart town design of the future".

"SINGAPORE IS WELL-POSITIONED TO BE A POTENTIAL ROLE MODEL COUNTRY IN LAND TRANSPORTATION TRANSFORMATION AND "SMART TOWN DESIGN OF THE FUTURE."

STRIVING FOR MOBILITY UNDER LAND CONSTRAINTS

Singapore's plan for autonomous vehicles is unique in many ways. Firstly, Singapore continues to value public transportation for mass commute and does not view that the introduction of autonomous vehicles will render public transit obsolete in the near to mid-term. The city-state envisions autonomous vehicles to be employed as a complementary means of public transportation e.g., autonomous buses, for first-mile and last-mile travelling. Secondly, Singapore does not intend for autonomous vehicles as a direct replacement for human-driven cars; rather, the focus is on mobility as a service via ride-sharing and car-sharing.

Thirdly, Singapore is application-specific but remains technology-agnostic, partly because while Singapore is one of the first movers to embrace autonomous vehicle capabilities, the comparatively small size of the potential market limits her leverage to drive the technological decisions of manufacturers and developers. From the technological perspective, the highly build-up urban areas in Singapore may create urban canyons that limit the effectiveness of localization technologies. In addition, city driving is viewed as one of the more challenging tasks for self-driving cars. The ever-changing street map (e.g. pedestrians, cyclists, urban features) and stop-and-go traffic in a city environment may demand more advanced perception and sense-making technologies.

Nonetheless, Singapore remains an ideal option to implement self-driving cars. The Singapore government is a strong advocate for technology and innovation, and continues to attract high-tech talent and investments in high-end research and development. Next, Singapore has a robust physical and communications infrastructure, which are essential ingredients to enable test, evaluation and operationalization of self-driving cars. Furthermore, with the intent to alleviate the labour shortage for bus drivers in Singapore, autonomous buses can be deployed for first-mile and last-mile commuting. With possibly shorter headway between autonomous vehicles when coupled with V2V and V2I connectivity, road congestion may be alleviated if the number of vehicles on the road remains constant. In the long term, the concept of autonomous vehicles for transportation as a service may encourage car-sharing and ride-sharing behaviors, which favors Singapore's intent to control the number of vehicles on the road.

CURRENT LANDSCAPE

Private investments in autonomous vehicle developments have grown since the mid-2000s, and continue to accelerate today. The attractiveness of the potential benefits to be reaped from autonomous vehicle market has influenced the entry of new players and prompted existing players to move into new business areas. The vehicle marketplace is no longer solely dominated by the traditional automotive manufacturers. In recent years, we have witnessed the entry of new players ranging from technology developers to Tier-1 suppliers and even ride-sharing service providers. The traditional carmakers are also seen attempting to venture into the ride-sharing business.

At present, it is uncertain which market player will emerge as the ultimate winner, nor is it apparent on which technological pathway is the winning concept. With strong interdependencies among the technologies that enable autonomous driving, a diverse suite of technical expertise coupled with significant investment are essential, thus it is almost impossible or too risky for a single entity to develop it alone. In terms of deployment timeline, several market players have indicated the desire to launch a highly automated or fully autonomous vehicle by 2020.

In Singapore, several initiatives have been established between the government, research, academic, and industry communities. In August 2014, the LTA signed a Memorandum of Understanding (MOU) with the Agency for Science, Technology and Research (A*STAR), a

public sector agency that spearheads economic-oriented research, to jointly set up the Singapore Autonomous Vehicle Initiative (SAVI). The SAVI serves as a platform to oversee and manage research and development, and test-bedding of autonomous vehicle technologies, applications and solutions for industry partners and stakeholders. In January 2015, the LTA announced that the one-north district in Singapore as the first test site for autonomous vehicle technologies and mobility concepts. The test route was doubled from the original 6km to a 12km network in September 2016. As of October 2016, there were four distinct entities conducting autonomous vehicle proof-of-concept tests at the test site. In June 2015, LTA issued a Request for Information (RFI) to seek proposals on how autonomous vehicle technology could be harnessed as part of other land transport mobility concepts, such as mobility-on-demand and autonomous buses. The RFI also sought to understand the requirements, such as road and communications infrastructure, that are necessary to enable implementation of autonomous vehicle enabled mobility concepts in Singapore. Eight proposals were received in response to the RFI and the evaluation outcomes are progressively being released. In October 2015, a MOU was signed between the MOT and the Port of Singapore Authority to jointly develop autonomous truck platooning technology for transporting cargo between port terminals. The MOT also signed another MOU with Sentosa Development Corporation and Singapore Technologies Engineering Ltd to trial self-driving shuttle services across Sentosa.

In August 2016, LTA established a partnership with nuTonomy to test their shared, on-demand, door-to-door, first and-last-mile, and intra-town self-driving transportation concepts in one-north. In addition, nuTonomy also partnered Grab, a leading ride-hailing app in Southeast Asia in September 2016. The LTA also established a partnership agreement with Delphi Automotive Systems in August 2016. Delphi is one of the major Tier 1 supplier of vehicle technologies, and they will develop and test a fleet of fully autonomous vehicles including a cloud-based mobility-on-demand software suite at one-north. In October 2016, the LTA also announced partnership with the Energy Research Institute @ NTU, to develop autonomous bus technologies, which included a self-driving bus trial for fixed and scheduled services for intra and inter-town travel. The LTA and JTC also partnered with NTU to launch the Centre of Excellence for Testing and Research of Autonomous Vehicles - NTU (CETRAN) and test circuit at CleanTech Park in the Jurong Innovation District in August 2016. CETRAN

will spearhead the development of testing requirements for self-driving vehicles, and the test circuit will provide a simulated road environment for testing of the vehicles prior to deployment on public roads. As part of the five-year agreement with LTA, NTU will lead the research activities at CETRAN, collaborate with international testing, inspection and certification bodies, research institutions and industry, operate the test circuit, and evaluate the self-driving vehicle prototypes that are tested. The test circuit is expected to be operational by the second half of 2017.

TECHNOLOGICAL CONSTRAINTS AND OPPORTUNITIES AS SEEN IN SINGAPORE

As a city-state, Singapore has high population density. The country has been blessed with warm but stable weather, making it easier to test technology, but its high skyscrapers, underground tunnels, and extensive planting present challenges to sensor technologies. To realize capabilities in Autonomous Vehicle (AV), there needs to be a convergence of technologies in *perception, navigation, localization, sense-making and telematics*. At present, despite heavy investments in the ecosystem it is uncertain which technological pathway is the clear path forward.

a. Perception refers to the ability of the AV to sense its complex and dynamic driving environment. AVs typically have a suite of perception sensors, software that blends the sensors data from these, and further software that analyzes this information to enable the vehicle to perceive and sense-make in different environments.

b. Navigation and localization work in tandem to guide a robot from place to place. Navigational accuracy refers to the precision with which the autonomous vehicle can guide itself from one point to another. Localization accuracy is a measure of how well the vehicle locates itself within a map. Localization appears to present the greater challenges.

c. Sense-making refers to the process of understanding and interpreting the voluminous data the sensors on the AV collect continuously. AVs need to learn from their environment to decide the next course of action with little or no human intervention. Artificial intelligence plays a key role in this process.

d. Telematics combines wireless communications, information management, and in-vehicle computing to enable exchange of information. It enables AVs to continually update the state of their environment. Proposed AV systems particularly suppose that individual AVs will connect both with each other and the environment. They would use different communication technologies to communicate with the driver, other cars on the road (Vehicle-to-Vehicle, V2V), roadside infrastructure (Vehicle-to-Infrastructure, V2I), and the "Cloud".

CONCERNS TO JOBS

In terms of societal cost, there is a risk that certain jobs (e.g., taxi drivers, bus drivers, parking attendants, and valet parking attendants) could be eliminated or restructured as autonomous vehicles become prevalent. In addition, the revenue that the government collects from road taxes, parking fees, speeding fines, and incident management costs could be affected. Policymakerhave begun to examine how individuals in the affected job roles can be redeployed or retrained, as well as to review the current revenue mechanisms.

There are currently few schemes to address specifically the job loss that can result from autonomous vehicles, in part because the Ministry of Transport reckons that the full adoption of AV will occur only in about 10-15 years.[1] Dealing with job displacement therefore takes a more holistic approach towards both slow growth and a rapidly digitizing service economy. The government has announced the all-ranging SkillsFuture initiative, to provide Singaporeans with different types of training in order to adapt to different skills that employers require. As attested on the website, regardless of "where you are in life – schooling years, early career, mid-career or silver years – you will find a variety of resources to help you attain mastery of skills." Beyond re-training for citizens, the government actively assists companies in digitizing their operations in order to improve productivity and hence better scale up operations and hire more workers. The iSprint initiative announced since 2010 has helped 8000 SMEs improve their businesses through technological innovations.

Most recently, the government has pledged $100 million to the Global Innovation Alliance, a scheme to help Singaporeans gain skills to better find work abroad, and the new SkillsFuture Leadership Development Initiative, which provides specialized training for Singaporeans to better reach leadership positions in companies. The government has also accepted the recommendations by the Committee of Future Economy to focus on helping citizens better acquire "deep skills", with the government facilitating the matching between skills and employment—the setting up of IMDA's TechSkills Accelerator (TeSA) and a national jobs bank both aim to serve these functions of creating better employment opportunities for Singaporeans

GOING FORWARD

Singapore's journey into Autonomous vehicles plays into the city-state's natural advantages in climate, skills, modern infrastructure, and efficient government bureaucracy. Being the first-mover has attracted much buzz and excitement, especially with nuTonomy's test-drives in the One-North area, which is the first of its kind in autonomous vehicle testing in real-world city environments. However, the first-mover advantage might also be soon met with critical realities such as uncertainty over technological solutions, competition with traditional transport operators, or the loss of jobs for the most vulnerable citizens.

Nevertheless, unlike most autonomous pilots abroad, there is concerted coordination in Singapore between government, research agencies, and industry to get autonomous vehicles off the ground. Deep partnerships are essential for the autonomous vehicle to actualize the vision of a "Smart Nation", and the little city-state is seemingly on the right track to drive the technology forward. But its success will eventually lie in the adaptability of this stakeholders to adapt to changing needs of the economy and the underlying technology, without forgetting that the true adopters of the autonomous vehicle will be its citizens, who need to be adequately empowered and have fears allayed in order to fully embrace this groundbreaking technology.

"DEEP PARTNERSHIPS ARE ESSENTIAL FOR THE AUTONOMOUS VEHICLE TO ACTUALIZE THE VISION OF A "SMART NATION", AND THE LITTLE CITYSTATE IS SEEMINGLY ON THE RIGHT TRACK TO DRIVE THE TECHNOLOGY FORWARD. BUT ITS SUCCESS WILL EVENTUALLY LIE IN THE ADAPTABILITY OF THIS STAKEHOLDERS TO ADAPT TO CHANGING NEEDS OF THE ECONOMY AND THE UNDERLYING TECHNOLOGY, WITHOUT FORGETTING THAT THE TRUE ADOPTERS OF THE AUTONOMOUS VEHICLE WILL BE ITS CITIZENS, WHO NEED TO BE ADEQUATELY EMPOWERED AND HAVE FEARS ALLAYED IN ORDER TO FULLY EMBRACE THIS GROUNDBREAKING TECHNOLOGY."

1 https://www.imda.gov.sg/infocomm-and-media-news/whats-trending/2017/2/driverless-cars-picking-up-speed-in-singapore

2. AI IN THE CITY, THE AGE OF PREDICTION AND ANTICIPATION

In this second part, we perform a deep dive into some of the most interesting cases of the deployment of artificial intelligence systems in cities. AI can be essentially analyzed as a "prediction technology," the diffusion of which can drastically bring down the cost of processing historical data and therefore of making prediction for a wide array of crucial tasks such as risk profiling, inventory management, and demand forecasting.

Such a cost decrease can in turn favor reliance on prediction for a growing number of tasks and activities, including and not limited to banking and insurance, real estate and construction, health monitoring, and predictive maintenance for all types of equipment and complex infrastructure.

Antonio Neves Da Silva and Patrice Novo first presents "Hubgrade": Veolia's smart monitoring centers. With 15 centers already deployed in several cities across Europe, Asia and the Middle East, "Hubgrade" represents Veolia's lead program to harness the rise of artificial intelligence comprehensively in order to optimize resource consumptions across the board (water, energy, and waste management). In these centers, Veolia's analysts leverage real-time data coming for a multitude of facilities equipped with networked sensors and smart meters (from municipal water networks to waste collection systems, to buildings, to industrial sites, to district energy systems and more) through algorithms to optimize resource consumption of municipal, commercial and industrial clients. This transformative program also includes business model innovation by offering clients "consumption performance as a service". Squaring the AI revolution with the quest for sustainability, Hubgrade ultimate goal is to accelerate the transition towards the circular economy.

Stanislas Chaillou, Daniel Fink and Pamela Goncalves then analyze the disruptive impact of machine learning algorithms on the real estate industry through forecast and prediction. A feasibility study that used to take four hours and cost $10,000, is now getting automated, taking 5 minutes with greater accuracy for example. We then learn from Wesam Lootah, CEO of the Smart Dubai Office about their pioneering cooperation with IBM Watson to use AI to transform government services and customer care. Launched in 2016, "Saad" is for instance a service that allows users from the business community to ask questions to the government and get up-to-date answers on business licensing and registration process in Dubai. Earlier this year, the Smart Dubai Office and IBM unveiled an AI-roadmap to help accelerate the development of AI-enabled citizen services across Dubai and equip the next generation of professionals with sought-after skills around analytics, cloud, cognitive and blockchain technology.

We subsequently move to India where the social venture *MicroHomeSolutions City Labs* reports on a series of innovative grassroots projects implemented in Delhi to empower low-income communities through digital access to construction knowledge and microfinance solutions. Marco Ferrario, Rakhi Mehra, Swati Janu analyze how increasing smartphone penetration associated with the rise of AI could radically improve the quality/safety and affordability of low income housing.

With Frank Escoubes, we then explore how emerging collective intelligence platforms and methodologies increasingly rely on algorithms and are used at the core of municipal governance processes. The cost and the efficiency of involving citizens and stakeholders in the co-construction of solutions adapted to city challenges is poised to herald a new era in participative democracy.

Finally, Alessandro Voto analyzes how blockchains technology – a kind of secured public ledger that lets communities store records permanently across a network of computers –, and other distributed digital infrastructures are transforming the way cities are managed and governed. This fast developing range of algorithmically powered peer-to-peer networks are used to enable low-cost secure transactions and contract design/execution at scale without the need for intermediaries. Fueled by a vibrant eco-systems of entrepreneurs and venture capitalists, examples of applications abound beyond now famous crypto-currencies like Bitcoin –blockchain's first killer use-case.

Nicolas MIAILHE
Coordinator

HUBGRADE SMART MONITORING CENTERS:

measuring resource consumption and moving towards a circular economy

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Hubgrade in Madrid, Spain

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Patrice Novo completed his studies at the French graduate school of engineering Supelec and also has a Masters in Economics. He joined the Veolia group in 1998, holding various roles in operations and sales & marketing in the Energy division before moving to head up the group's Marketing Cities department. He defines the group's marketing strategy as well as managing the design and deployment of the Hubgrade monitoring centers in France and abroad.

KEYWORDS

- RESOURCE SAVINGS
- CIRCULAR ECONOMY
- URBAN METABOLISM
- DIGITAL REVOLUTION
- REAL-TIME
- CHANGE MANAGEMENT
- MACHINE-LEARNING
- ARTIFICIAL INTELLIGENCE
- INDUSTRY 4.0
- DIGITAL TRANSFORMATION
- OPERATIONAL PERFORMANCE

How can cities, businesses and industries boost growth in the face of resource scarcity? Firstly, they can start by measuring their consumption in order to manage it more effectively. Then, all of us can to move away from a linear model of consumption. We can accelerate this transition today, thanks to IoT[1], the digital revolution.
At Veolia, we are the first to monitor and to optimize water, energy and material flows in real-time. We are developing smart monitoring centers called Hubgrade relying on connected products and artificial intelligence. With these centers, we are creating new jobs and business opportunities to save resources. Hubgrade boosts energy efficiency and water conservation measures. It optimizes material recovery and maximizes the use of renewable energy. However, this is only possible, with the focus on the human factor.

1 IoT – Internet of Things

INTRODUCTION

Hubgrade is the name of Veolia's smart monitoring centers for water, energy and waste management. In these centers, Veolia's analysts leverage real-time data to optimize resource consumption of municipal, commercial and industrial clients. This innovation relies on a dedicated organization, disruptive digital tools and new business models.

Hubgrade is a tremendous opportunity to introduce a cultural change in our organization. We can revolutionize the way we operate and become more efficient. At the same time, we are offering new services and an enhanced customer experience to our clients.

We can equip each of these centers to manage data from a multitude of facilities: from municipal water networks to waste collection systems, to buildings, to industrial sites, to district energy systems and more. Today, we have 15 Hubgrades already accelerating the transition towards a Circular Economy. They guarantee us that no precious resources are wasted.

1. A CHALLENGE AND AN OPPORTUNITY

1.1 BOOSTING ECONOMIC GROWTH WHILE FACING RESOURCE SCARCITY

Global urbanization is increasing and cities are putting the planet under enormous pressure. Since the 1970s, humanity has been consuming more natural resources than the planet can provide and renew in a year.

Today, humanity actually needs one and a half planets to be sustainable. By 2050, at current rates, we would need almost three planets. Our demand for water, energy, food and goods is rapidly increasing**.** The Take-Make-Dispose model of the past has also led to extreme pollution, price volatility and biodiversity collapse. Besides the impact on climate change an on the environment, this causes evident effects on the economy and society. The challenge now is to decouple economic growth from resource consumption.

We need to move towards a Circular Economy where nothing is wasted. In practice, this means not only preserving energy and water, while minimizing waste. We also need to improve energy efficiency, increase recycling and boost renewable energies. Moreover, we need business opportunities to accelerate this change.

'Doing more with less' is conceptually simple but quantifying resource efficiency is more complex in practice.

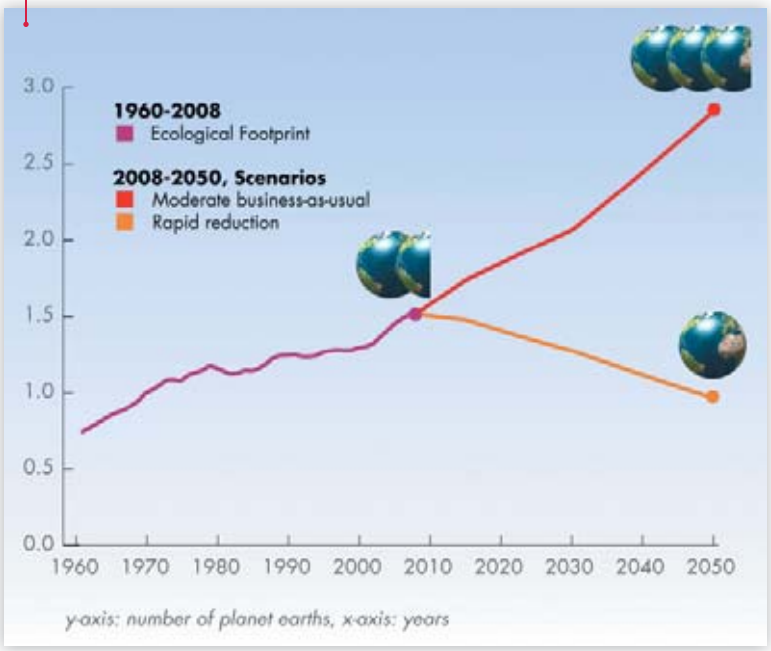
End-user

1.2 SMART URBAN METABOLISM: HIGHLIGHTING OPPORTUNITIES TO SAVE RESOURCES IN REAL-TIME

The new generation of data solutions allows us a deeper study of urban metabolism. Urban metabolism is a model representing the transformation of natural resources in products and services. This model quantifies economic value of what we use and what we waste.

Now it is possible to have a higher temporal resolution of consumption. This enables us to build smart urban metabolism models, using real-time data. Such virtual models represent the interconnectivity between different subsystems, which can be urban infrastructures, offices, schools, hospitals, industries and even households.

Ecological footprint - http://www.footprintnetwork.org



So, what are the benefits of smart urban metabolism models? These models make it is easier to replicate sustainable solutions to other subsystems. This happens when these subsystems have similar challenges. For example, an urban infrastructure needs to become more resilient, livable or even inclusive. The same applies to buildings and to industries that must become greener and more resource efficient.

The resources we are wasting will end up being either emissions or discharges to land or to water sources. In order to avoid such waste, a holistic approach on resource saving is required. Smart urban metabolism offers exactly that. It highlights the value of a subsystem's waste to other economic sectors. This facilitates a business transaction so that waste can be reused, recovered or recycled by other subsystems. Emissions and discharges also cost money and become evident opportunities to save.

These predictive models to analyze resource consumption are something very concrete to us at Veolia. We convert these models into performance contracts with our clients, with guaranteed savings. It may seem that we have always operated contracts like these. So what has changed?

Now, we can commit to save significantly more. We understand the value chain of resources outside our traditional operations. Sensors, smart products and other digital technologies extend our capabilities. Besides implementing and operating efficient systems, we engage end-users to play a major role in the solution. They take responsibility to change their behaviors because they foresee the benefits for them. Through smart solutions, citizens and other end-users receive the insight they need to save more.

Veolia cannot monitor every resource flow in a city, and that is not the point. However, we do commit to improve resource efficiency for the perimeter we operate. This is why the municipality of Pudong in Shanghai has chosen Veolia to manage its water networks.

More recently in Shanghai, Veolia launched a Hubgrade for Water, Energy and Waste management. We can now offer higher level of commitments to existing customers. We can also offer these innovative services to new clients all over China. This way, they too, can save even more.

2. HUBGRADE

2.1 WHAT IS HUBGRADE?

Energy and water savings, waste minimization and recycling rates, carbon emission reduction – Veolia has always tracked these key performance indicators. Now, we can track them in real-time and from anywhere we want. However, this requires a major organizational change.

For this reason, Veolia deploys a dedicated organization, digital tools and new business models. This is how we created Hubgrade, our smart monitoring center. Through Hubgrade, Veolia is bringing operational synergies to all our water, energy and waste activities.

In Hubgrade, we combine data management with our technical expertise on the field. This results in significant risk mitigation. At the same time, we are much closer and more responsive to customers needs.

Hubgrade is a real asset for change management to boost operation performance and to offer new services.

Hubgrades: Dublin, IRELAND; Paris, Marseille, FRANCE; Brussels, BELGIUM; Bilbao, Madrid, Barcelona, SPAIN; Birmingham, UK; Milan, ITALY; Amsterdam, NETHERLANDS; Dubaï, UAE; Stockholm, SWEDEN; Budapest, HUNGARY; Shanghai, CHINA; Sydney, AUSTRALIA

Hubgrade, smart monitoring center in Paris, launched 2016

2.2 HOW DOES HUBGRADE WORK?

Clients want control over costs and consumption, so their systems are fitted with sensors. These sensors transmit data in real time to Hubgrade. Then, our analysts manage this data to identify savings. This can result into immediate action or a roadmap for improvements.

We transmit recommendations to clients and our teams, depending on the type of contract. This helps them identify and prioritize resource saving measures. From an online dashboard, clients can monitor their own indicators and compare them to benchmarks. This way, they can clearly measure their progress and see the reduction in their bills.

As a result, clients and end users become more aware of how they can make savings.

2.3 DEDICATED TEAM OF EXPERTS

Hubgrade relies on a team of experts that share a common goal: improving resource efficiency together with operational units on-site and customers. In order to get the full potential out of Hubgrade, Veolia developed new engineering profiles:

- **Data analyst** with expertise in energy, water and waste management
- **Auditor-coach** who ensures operations on-site follow the analysts' recommendations
- **Systems expert** setting up the right data from sensors into the software applications

The capability of the Hubgrade team relies on the ubiquity of digital technologies. Hubgrade enables Veolia to respond quickly and in a targeted manner. Whenever there is an alert reported on the systems, there can be a work order generated.

The Hubgrade team can act remotely or dispatch a team on site. If this is necessary, they schedule an intervention and dispatch it to operational units. The customer can follow up all the process in parallel through a reporting application.

These new roles ensure the implementation of change management in our traditional activities. With this team, Veolia closes the loop on the resource value chain. Thus, Hubgrade guarantees we deliver more savings.

Hubgrade, a new organization to guarantee more savings

2.4 DIGITAL SOLUTIONS

Ensuring different systems communicate with each other is a major challenge in the digital transformation. At the core of Hubgrade, various systems are integrated such as EMS[1], Waste Management Platforms, Water Quality Monitoring and Control Systems, BMS[2], CMMS[3], Asset Management software, SCADA[4] systems, and even Carbon Footprint, Indoor Air Quality monitoring applications and more. These systems also cover functionalities such as financial analysis and benchmarking.

We also developed reporting dashboards to share with our analysts the most important information from digital systems. This helps them in decision-making and in communicating performance indicators to operational teams on the field. Additionally, we provide the client with an online access to reports, as well as awareness-raising information to end-users.

The way in which these systems work can be broken down into four stages:

- 1. Collection of information from sensors
- 2. Supply of information to databases
- 3. Data visualization through dashboards and reports
- 4. Reporting to operational teams, client and end-users

Hubgrade relies on statistical models, optimization algorithms, geographic information and forecasting tools. Data mining through meta-heuristic algorithms allows us to predict customer needs. We analyze correlations between consumption patterns and production profiles to identify improvements.

In addition, machine learning is making Hubgrade more powerful and autonomous. It brings new capabilities to help Veolia's clients switch to an "industry 4.0 mindset" by bringing them valuable information for the resources they need to operate throughout their entire production chain. In practice, we are not just looking at utilities anymore.

"HUBGRADE IS ALREADY A MAJOR "ONE VEOLIA" ACHIEVEMENT."

"CREATING NEW JOBS FOR THE ROLES OF ANALYSTS, AUDITORS AND SYSTEMS EXPERTS THAT OPERATE IN HUBGRADE AND INVESTING IN THEIR CAREER DEVELOPMENT IS A MAJOR HUMAN RESOURCES ACCOMPLISHMENT OF VEOLIA."

1 EMS – Energy Management Systems
2 BMS – Building Management Systems
3 CMMS – Computerized Maintenance Management Systems
4 SCADA – Supervisory control and data acquisition

We are analyzing the consumption at the heart of our customers' industrial process. For example, through machine-learning solutions, we can monitor the consumption of individual equipment. Moreover, we do not need meters for all of them.

We can apply this machine learning technologies to commercial buildings, too. One single high-frequency meter powered by machine-learning algorithms enables us to breakdown electric consumption per type of equipment: lighting, air conditioning, computers, appliances and others.

In the near future, with a single meter and some sensors we can even precisely measure the electricity use by each tenant. Our client will be able to send his tenants invoices for their individual consumptions without additional meters. These solutions will be cost effective enough for the complete switch from readings.

Crossing data, from customer activities and from ours, highlights the direct value we create for them. We monitor and report indoor air quality and comfort conditions in real-time. This way, customers know in transparency that quality is guaranteed, while consumption is kept to a minimum.

Through an online application, the circular economy seems more tangible. Clients know how much money they are saving. They can also check the emissions they reduced and the waste diverted from landfill.

2.5 INNOVATIVE BUSINESS MODELS

"Everything that can be digital, will be digital"[5]. This influences business models as well. We are adding a major layer of digital services on top of our core activities. Consequently, our business models have to change.

The unique value of the new digital component of our services has to be unleashed. For that, we need to integrate new business models in our offer. These are similar to the ones used in digital businesses. Moving from a TCO[6] model to a SaaS[7] model has influenced Veolia. We offer Performance as a service on top of our core activities.

Although sustainability demands a long-term view, product lifecycles are getting shorter. Anyway, it does not alter our mission. We just need to be continuously innovating as demand varies and clients' expectations change.

The first main real-time solutions with innovative business models offered by Veolia are applicable to all our energy, water and waste management activities:

- Monitoring, analysis and optimization
- Interactive reporting
- End-user apps
- Information modeling
- Predictive maintenance and condition monitoring

5 Deloitte, Smart Cities How rapid advances in technology are reshaping our economy and society Version 1.0, November 2015

6 TCO – Total Cost of Ownership

7 SaaS – Software as a Service

Hubgrade in Dubai

Hubgrade in Milan

"CHINA IS THE FIRST COUNTRY TO RECEIVE ALL THIS POTENTIAL WITH A HUBGRADE THAT DELIVERS ENERGY, WATER AND WASTE MANAGEMENT OPTIMIZATION TO MUNICIPAL, COMMERCIAL AND INDUSTRIAL CUSTOMERS."

Citizens of China

We demonstrate all of these services to clients when visiting a Hubgrade. Everywhere there are Hubgrades, we offer an enhanced customer experience. Hubgrade provides all the transparency clients expect to trust expertise in data and our commitment on results.

Shared Value creation[8]

Although one can argue that artificial intelligence will eradicate jobs thus harming society, this argument remains vague. We believe innovation is the best way to create societal value. It has been through artificial intelligence that we are improving safety conditions to innumerous workers in the field. This is the case with the implementation of our waste sorting solution I-Sorter. Workers received training and new career progression opportunities. This example is a real value lever for sustainability.

Creating new jobs for the roles of analysts, auditors and systems experts that operate in Hubgrade and investing in their career development is a major human resources accomplishment of Veolia. The main idea is to combine human and digital capabilities to boost a social and economic dynamic while preserving the planet.

Small and medium IT services companies are developing the digital tools we use in Hubgrade. With these SMEs[9] we establish partnerships with a long-term view. We commit to create this value and deliver it to our clients so they can keep sharing it with local communities.

3. OVER THREE MILLION DATA POINTS BEING MONITORED BY VEOLIA

Veolia monitors over three million sensors, from which one million are smart meters. The manner to leverage data from them is far from optimal. The good news is that Veolia is deploying Hubgrades worldwide in an industrialized way. We already monitor over 300 thousand data points in our Hubgrades.

Let us now discover how it all started.

Well, we started by optimizing buildings. Human beings spend 90% of their time in buildings[10] – that is why these are the first places where we need to save resources opportunity[11]. In our globe, buildings consume around 40% of energy, 25% of water and 40% of materials[12]. Simultaneously, they account for the biggest share of greenhouse gas emissions on the planet. This represents approximately 1/3 of the whole globe. To address carbon emissions and tackle resource consumption, Europe established an energy efficiency directive in 2012.

Back then, to address the challenges of our customers, Veolia started to develop new digital solutions for energy management. With these solutions, we generated an average 15% savings in energy consumption. This is the case of Indra Systems, one of our 160 Energy Performance Contracts, optimized via a real-time monitoring center. Indra, which is the IT and Defense systems leader in Spain reduced by 15% the energy consumption of its 65 buildings, together with Veolia.

In 2014, as part of the group's reorganization, Veolia took the opportunity to extent this acquired expertise in these smart monitoring centers, to its water and waste management activities, and created Hubgrade. The first Hubgrades also optimize, in addition to buildings, the efficiency of Waste-to-Energy facilities and the electricity consumption of wastewater treatment plants.

Today, Veolia's digital solutions apply to all our activities. We use them for route optimization in waste collection. With them, we reduce leaks in water networks. We also use them to improve the efficiency of buildings, industries and more.

Hubgrade is already a major "One Veolia" achievement. It enables us to address the needs of our customers very closely.

China is the first country to receive all this potential with a Hubgrade that delivers energy, water and waste management optimization to municipal, commercial and industrial customers. Thanks to Hubgrade, customers and citizens interact with us in real-time. We can now provide them with the services and information they need so that together we can do more for a sustainable future.

8 M. Porter & M. Kramer – Harvard Business Review – January February 2011
[Note: Creating Shared Value is not included in Corporate Social Responsibility, which is separate from profit maximization. CSV is rather a transition and expansion form the concept of CSR.]

9 SME – Small and Medium Enterprises

10 Source: https://www.buildinggreen.com/blog/we-spend-90-our-time-indoors-says-who

11 McKinsey – Resource Revolution 2011

12 Source: https://www.euenergycentre.org/images/unep%20info%20sheet%20-%20ee%20buildings.pdf

URBAN TECH ON THE RISE: MACHINE LEARNING DISRUPTS THE REAL ESTATE INDUSTRY

Featuring interviews of:
Marc Rutzen and Jasjeet Thind by Stanislas Chaillou, Daniel Fink and Pamella Gonçalves

Stanislas Chaillou, is an architecture master candidate at Harvard University as well as Director of the CitiX Initiative at The Future Society. He has previously worked for international renowned offices such as Shigeru Ban Architect, and Adrian Smith and Gordon Gill. He is also the recent winner of the American Architecture Prize (student category). Stanislas is a Fulbright scholar, an Arthur Sachs Fellow and Jean Gaillard Fellow at Harvard University.

Daniel Fink is a SMarchS candidate at MIT. He is director at Urban Agency and worked previously at Grimshaw Architects.

Pamella Gonçalves is a MBA candidate at MIT. She previously worked at Endeavor Brasil, as Head of Research and Public Policy.

KEYWORDS

- PREDICTION
- DATA ANALYTICS
- REAL ESTATE
- MACHINE LEARNING

The practice of AI-powered Urban Analytics is taking off within the real estate industry. Data science and algorithmic logic are close to the forefront of new urban development practices. *How close?* is the question—experts predict that digitization will go far beyond intelligent building management systems. New analytical tools with predictive capabilities will dramatically affect the future of urban development, reshaping the real estate industry in the process.

INTRODUCTION

In his introduction to 'Smart Cities,' Anthony Townsend raises the issue clearly: "Today more people live in cities than in the countryside, mobile broadband connections outnumber fixed ones and machines outnumber people on a new Internet of Things.[1]" *Yet neither the glossy marketing of major IT players such as IBM and Cisco nor the dystopian theories of critical scientists like Adam Greenfield admit that the digital revolution washing over cities has yet to be fully evidenced. Instead, over the last decade we have witnessed the slow emergence followed by strong growth of the computational paradigm applied to urban planning and real estate.*

As the travel and tourism sectors demonstrate, Big Data and machine learning can radically transform entire industries. Widespread disintermediation combined with newfound efficiencies have massively empowered consumers while destroying the traditional roles played by brokers and agencies. Similar trends are occurring in the real estate industry. Although the disruption is still elusive, transformation is underway. In fact, the fragmentation of the sector and the inertia of the profession maintain market opacity and mask reality.

The urban analytics realm has been growing steadily since the 1980s and the inception of personal computers. From a simple aggregation of data on the web to database scraping and filtering, the 90s saw a refinement of real estate-tech tools. With cloud computing and high-speed internet, online platforms are now bringing the potential of machine learning, neural networks,

1 Anthony Townsend, "Smart Cities: Big Data, Civic Hackers, and the Quest for a New Utopia."

and artificial intelligence[2] *to real estate market forecasting. Such tools have already disrupted traditional practices in other industries. Today, they are starting to challenge real estate, letting us wonder how close we are to a structural disruption of the whole real estate industry.*

2 Machine Learning explores the study and construction of algorithms that can learn from and make predictions on data, without being explicitly programmed. Deep Learning is part of a broader family of machine learning methods based on learning representations of data. It attempts to make better representations from large-scale unlabeled data. Neural Network is a statistical technique that is inspired by the way biological nervous systems, such as the brain, process information. It is used mostly for pattern recognition (reading images for instance) or data classification, through a learning process.

URBAN DEVELOPMENT AND THE URBAN REAL ESTATE LANDSCAPE

THE DEVELOPMENT OF AMERICAN CITIES

In the United States, the first cities were concentrated on the east coast, bringing together merchants trading with Europe. Two centuries of industrialization and the development of the service industry enabled cities to emerge and grow throughout the country, expanding the American domestic market. For most of the twentieth century, a clear majority of Americans pursuing the American Dream left crowded urban centers behind to build homes with backyards on the outskirts of cities. The most recent stage of the development of American cities observes a resurgence of urban life in parallel with the rise of the "knowledge economy," with innovation fueling an optimistic perspective on the prosperous future of cities[3].

Economics drives urban change. Access to public service goods (water, gas, electricity) and reduction of transaction costs (transport and communication) have influenced the location and pace of urban development. As a result, the role of government in city making has shifted over time from being passive and reactive to proactive, even pre-emptive.

Demographic changes helped. As shown in Figure 1, the number of US cities with more than 50,000 people has soared since the 1940s. Only the rise of social and environmental problems (traffic, pollution, and crime, amongst others) has forced the government to reconsider its role—it had to develop not only planning but deal-making capabilities whenever necessary. Its progressive involvement in urban development helped to reshape its goal of making cities attractive and healthy places for people to live.

THE REAL ESTATE INVESTMENT LANDSCAPE

For developers starting a project, the greatest challenge is often securing initial equity partners. Since those equity investors typically become the property owners, they bear much of the project risk. The market is densely concentrated. Today, as shown in Figure 2, equity funds constitute the main group of investors at around 40% of all properties. Blackstone leads this group with about 20% of the market. They are four times the size of Lone Star, the second largest player.

Although investors commit huge sums, their decision processes remain based on limited financial considerations. Our interviews with Real Estate Fund Managers validated this bias. The golden rule to date is to combine (1) the cheap purchase of land, (2) immediate signing of leasing contracts, and (3) optimal capital structure for the deal. The approach is then to mitigate development risk through basic asset portfolio diversification.

The former CEO of a leading traditional real estate development firm admitted that even when dealing with large, high-risk investment programs they would, at best, commission specialized market research to validate their assumed demand. Nevertheless, no structured forecast was conducted and urban analytics where ignored beyond elementary demographic data.

In fact, three main players—the Tenant, the Lender, and the Developer (as shown in Figure 3)—control the investment process. In a typical real estate investment, these three players manage the different time horizons of the transaction. As their financial logic prevails, they prevent the system from fully exploiting market research data and improving the overall economic performance of development projects.

Number of cities with more than 50,000 people in the US

Source: KIM, 1999

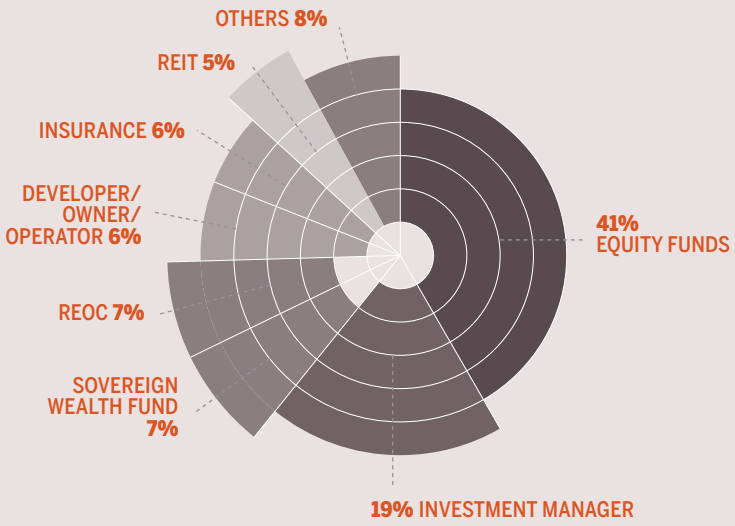
Figure 1

3 Sukkoo Kim, *"Urban Development in the United States, 1690–1990,"* Southern Economic Journal, Vol. 66, No.4.

While it is demonstrated that the access to public service goods and the reduction in transaction costs facilitate urban development, the quality and accessibility of these resources have influenced the decisions of individuals and companies to locate in certain places. Apartments located close to subway stations, for example, command a higher price than those further away. If such an observation is not new to the real estate industry, urban analytics are offering the opportunity to quantify and weigh the impact of proximity on the end price of any given property.

Outstanding questions remain: How can real estate data be used to improve the investment decision process and optimize returns? Can descriptive and predictive analytics result in greater efficiency and less uncertainty for the community at large?

Concentration of investors in total volume of US property



Source: Real Capital Analytics

Figure 2

The Real Estate Investment Landscape

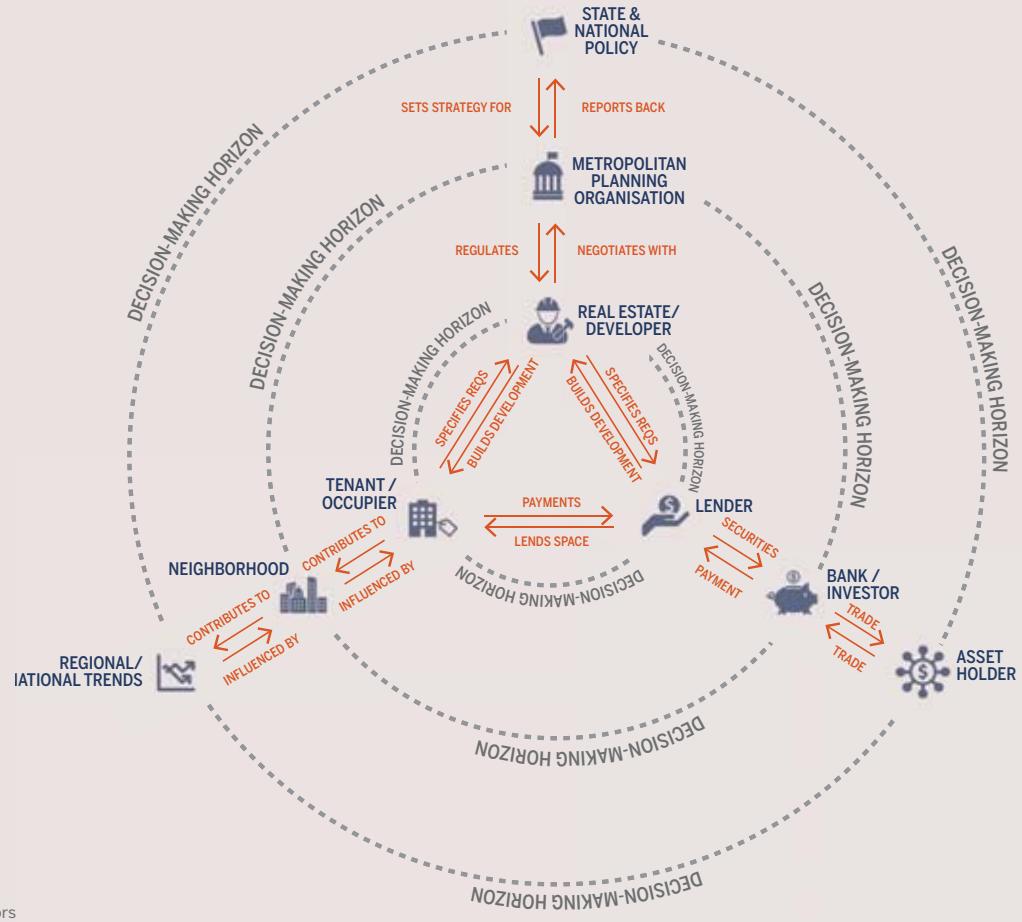


Diagram by authors

Figure 3

THE GROWTH OF DATA PLATFORMS

TOWARD ANALYTICS FOR REAL ESTATE AND URBAN DEVELOPMENT

New aspirations toward urban lifestyle and data science are driving the current boom in urban-centric technology companies. On one side, the renaissance of 'aspirational urban life' was initially described by journalist Alan Ehrenhalt in *The Great Inversion and the Future of the American City*. The concept was then supported by the foundational work of contemporary urban economists Ed Glaeser and Paul Krugman[4] who identified agglomeration effects in urban areas. On the other side, the current boom in data and analytics is both produced by, and descriptive of, cities. Variously referred to as the *Smart City movement, Urban Big Data*, or the *New Science of Cities*, this paradigm draws its pedigree from technocratic interest in computer-assisted social analysis promoted in the 1970s by the cybernetics and control systems movements. Current computational resources have enabled massive amounts of data on the urban realm to be recorded and analyzed.

These two phenomena—people moving to the city, and our newfound fidelity in recording and analyzing the city—coupled with a massive increase in the investment of global capital, have contributed to significant investment momentum in real estate tech firms: 2015 marked a record $1.5 Billion in venture capital to real estate startups, according to VC analyst firm CB Insights[5].

As Figure 4 suggests, the momentum in real estate tech has been growing, sometimes blurring the lines between its different facets.

4 Edward L. Glaeser, "Is There a New Urbanism? The Growth of U.S. Cities in the 1990s " http://scholar.harvard.edu/files/glaeser/files/is_there_a_new_urbanism_the_growth_of_u.s._cities_in_the_1990s.pdf
Paul Krugman, Masahisa Fujita, Anthony J. Venables, "The Spatial Economy, Cities, Regions, and International Trade"

5 CB-Insights, "Where Are the Top Smart Money VCs Investing in Real Estate Tech?", https://www.cbinsights.com/blog/smart-money-vcs-real-estate-tech/

Most new urban tech platforms have succeeded by either offering data at much finer granularity (*Compstack*, which provides details of specific real estate transactions to brokers) or aggregating large and diverse datasets in the same platform (*CoStar*, which aggregates large data sets at the zip code level for the entire country). Some firms leverage few datasets but aim for maximum accuracy (*Compstack*), while others touch many different sources of data to depict a holistic view of the market (*CoStar, Reonomy, NCREIF*, etc).

We can categorize the data being used into four main clusters: People, Place, Infrastructure, and Wealth.

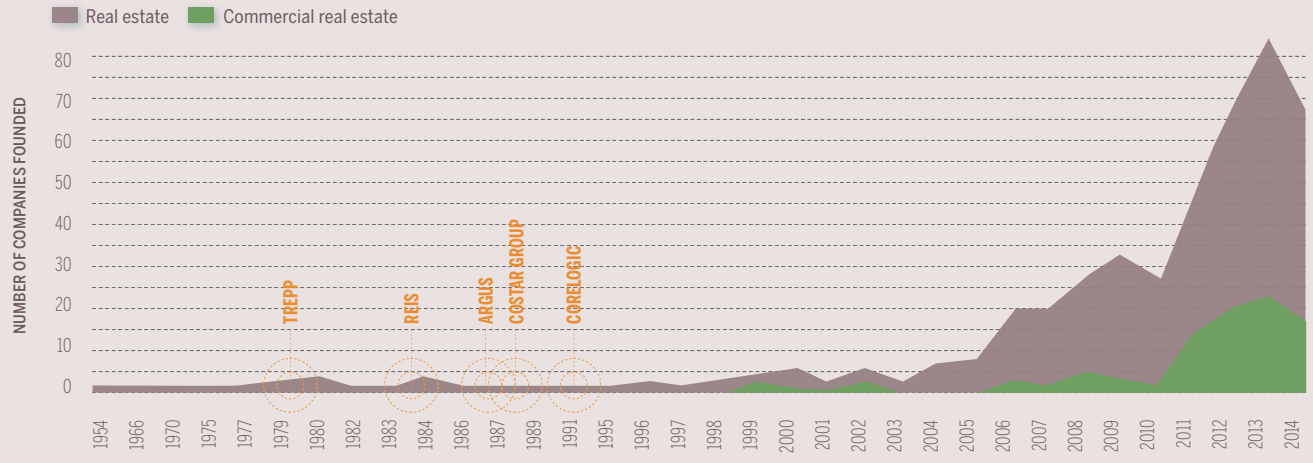
THE THREE DISRUPTION WAVES

AGGREGATION, ANALYTICS, AND PREDICTION

When data is collected, organizing and analyzing it is a critical step in unlocking its knowledge. Software and cloud-based platforms are now implemented for this purpose. By visualizing, filtering, analyzing, or even simulating future scenarios, the industry can assess market trends, financial assets, and design decisions. It can even predict potential future outcomes.

There is fierce competition among technologies to address the market: traditional software is challenged by new cloud-based platforms which enable automated data aggregation into large valuable databases. These platforms—even cheaper to maintain—are disrupting common

Timeline of Real Estate Tech Company Creation, 1954 to 2014



Source: CrunchBase Export Dec 2014, Commercial Real Estate Tech Analysis

Figure 4

practices. They are expected to disintermediate certain stakeholders, to enable crowdsourcing of a new kind of data, and to eventually offer brand new insights to the industry.

TRENDS AND FUTURE PERSPECTIVES

Mapping the inception of specific platforms and software is quite telling: it reveals the shift from 1990s-era software to the cloud-based platform wave of the early 2000s. In addition, the untapped market of predictive analytics is soaring. Real estate tech companies such as *SpaceQuant, Mashvisor, SMartZip, Enodo Score*, and *Zillow* all rely on large datasets for simulating future investment outcomes or assessing potential market trends.

However, as databases grow exponentially, existing software and platforms must adapt to handle such massive amounts of information. On the demand side, according to market research conducted by *Synthicity*, companies are not prepared to pay for and adopt those new tools. The "spreadsheet mentality" seems to be the default practice.

Regardless, the trend toward urban analytics applications seems irresistible. If data filtering, standardization, and privacy might hinder the growth of such platforms, the needs of larger entities such as cities or governments, which are already pressuring platform and software providers for their services, will counterbalance current practices in the industry.

PREDICTIVE ANALYTICS

THE EARLY STAGE OF DISRUPTION

The third and last "wave" of the real estate industry disruption began five years ago with the advent of machine learning. "Predictive analytics" is the name of this last phase. Companies such as *SpaceQuant, Enodo Score,* and *Zillow* have tried to tap into the potential of advanced statistical technics. New algorithmic logic enables predictions based on datasets aggregated over the past 20 years by government websites or large real estate data platforms such as *CoStar*. It is less a revolution of scale (volume of data, computational power, etc.) than a disruption of intelligence. The once-shortsighted real estate market can now use forecasting for a wide range of topics: from rent price forecasting *(Enodo Score)*, to tenant turnover in commercial real estate *(SpaceQuant)*, and mortgage default rate forecasting. The disruptive potential of predictive analytics relies on the growing time span of the predictions and their increasing granularity. As Marc Rutzen[6], CEO of *Enodo Score,* explains, the endgame is better accuracy in less time in real estate deal-making. In other words, a feasibility study that used to take, on average, 4 hours and 15 minutes for a cost of $10,000, is now automated, taking 5 minutes and functioning with greater accuracy.

THE UNDERLYING TECHNOLOGY

To understand the emerging real estate predictive analytics market, it is important to get a sense, albeit superficial, of the kind of technology at stake. Rutzen explains that the tools used are primarily based on statistical methods applied in a more sophisticated way. By using **machine learning, deep learning**, or **neural networks**, startups like *Enodo Score* take traditional statistical tools to a new level.

All of these advanced statistical methods follow the same process. First, a phase of "training" in which the machine is fed a dataset and "learns." In other words, it assimilates the dataset's complexity and tries to weigh the impact of each factor (house characteristics for instance) on the output value (house price). Following that is a "testing" phase in which the machine previously trained is tested against a set of data where the output is known. We observe here how accurately the algorithm predicts the output value. Once the machine is calibrated (after a certain number of iterations), it is ready to predict. This is the prediction phase, in which we use the algorithm to guess the output value of a dataset with unknown output value.

Rutzen adds:
"Once the machine is trained, and estimates of property values are generated, the UI [User Interface] allows for a feedback from our clients. Our model might not be able to take into account certain types of very granular information, such as wood-floor finish, but the feedback of our clients will ultimately be used to further train the machine, and adjust the model. The goal here is to increase the accuracy of the tool by giving it some flexibility. Actually, it is the true value of our platform!"

There is a great deal of effort put into the fine-tuning of the tool, in which user feedback, geolocation data, and other types of information are incorporated to increase the accuracy of the model. Overall, the statistical techniques described above are at the core of the current real estate tech momentum. They are methods developed over the past 20 years in data science that have proven efficient and reliable and are at the doorstep of the real estate industry today.

TIMESPAN AND GRANULARITY

The real estate industry has invested a great deal of effort into using simple regression models to complete short term analysis. The predictive precision of machine learning is pushing the boundaries of forecasting. From a few months to a five-year span, the ability to predict the future of deals is radically changing the perspectives of investors. Rutzen explains, *"Prediction is taking decision making to a whole new stage. By looking at the statistical meaning of the data,*

6 Marc Rutzen is the Co-Founder and Chief Technology Officer of Enodo Score, a predictive analytics platform for the commercial real estate industry that measures the institutional investment grade of multifamily properties. He directs the development and implementation of the platform, including front-end design and development, development of data sharing partnerships, beta testing, customer feedback and business development. Marc is a Licensed Managing Broker in the State of Illinois, and earned his Master of Science in Real Estate Development from Columbia University.

the real estate industry is now invited to look at the probability of deals success."

If predictive capabilities open new horizons to urban development and real estate, data accuracy is the heart of the matter. By constantly training algorithms, platforms such as *Enodo Score* will, over time, be able to predict prices with greater accuracy and detail. A good example is the gap between the local price average provided by *Zillow* and the average price per square foot for a given building forecasted over the next 5 years generated by *Enodo Score*. It predicts more precisely, and further into the future, than older platforms.

However, there is a trade-off between the time span and the range of predictions: *Enodo Score* is able to calculate a 5-year forecast, as they only focus on multifamily investment properties. If *Zillow* predicts only for the year to come, the range of property types they offer is much wider than their competitors. After interviewing Jasjeet Thind7, VP of Data Science at *Zillow*, the explanation is clear: the number of datasets is such that processing them and adapting the infrastructure to their ever-growing size makes it hard to achieve long time span prediction, accuracy, and a large set of property types. One has to focus on a property type to forecast far into the future, or to limit forecasting ability to embrace a wider range of property types. Either way, the accuracy of the model is paramount.

LIMITS

If forecasting should soon be game changing for the real estate industry, every company in this field is still struggling with the issue of reputation. The traditional approach of risk analysis—spending almost unlimited resources on feasibility studies—is still recognized as standard. Most investors and real estate players trust the old system and react with skepticism to *tech-evangelism*. Rutzen explains how hard it is to get the client to trust his platform's ratings. *Zillow*, which benefits from its primacy in this industry and around 70% of the market share, has been able to position its metrics as industry standards. The *Zestimate* Index, a metric that reflects the valuation of any given property in the country, is widely accepted among real estate professionals.

Another issue for predictive analytics is the integrity of the datasets. If large databases have been aggregated over time, it is often hard to judge the quality of the data. Also, users are sometimes invited by certain platforms, such as *Zillow*, to claim their own property and enter data themselves—data that is then factored into their predictions. The filtering of such data is a crucial and sometimes problematic step. In the age of data science, filtering methods are part of the art, and standard machine learning procedures allow firms like *Zillow* to "clean" the data before running their analyses. Thind affirms that after removing outliers and filtering the data, the quality of the prediction is reliable enough. As proof, Zillow regularly publishes their "scoring"—the accuracy of their predictions—on their website.

Lastly, the precision of the prediction depends to a large extent on the amount of data processed. Developing the infrastructure, or "pipeline," to catch up with the ever-growing size of data sets is more than challenging, as Thind explains. The open source tools integrate with difficulty; ensuring the robustness and scalability of the prediction tools is quite problematic.

CONCLUSION

The boom in urban data collection and its use in real estate technology shows that the traditional silo-ing of industry knowledge is fracturing. Key data links between data types and data providers means that more comprehensive analytics over the breadth of the urban development and real estate industry is possible. Furthermore, statistical predictive analysis and simulation, based both on trends in data platforms and the complexity of the phenomena being modeled, are gaining relevance. Initiatives such as SpaceQuant, Enodo Score*, and* Zillow *are forging new ways of forecasting and prediction at lower costs.*

With newly available analytic and simulation technologies combined with the opportunity of integrating datasets, the decision-making horizon for players is suddenly expanding. Conventionally finance- or urban planning-focused players are invited to begin considering wider inputs into their decisions.

As Rutzen asserts:
"I think predictive analytics have still a long way to go in real estate. I see, in fact, more forward-looking predictions. What we have today is—at maximum—predictions one year from now. I think our tool could predict a 5-year time span. 'What will the multi-family housing market be 5 or 10 years from now? How should I invest today if I want such returns in 5 years?' are questions that we should try to answer. A longer time span and greater granularity of the predictions—these are the big perspectives."

As our ability to simulate and predict increases and the cost of these efforts decreases, forecasting the future of urban development may be common practice in the coming decades.

7 Jasjeet Thind is the senior director of data science and engineering at Zillow. His group focuses on machine-learned prediction models and big data systems that power use cases such as Zestimates, personalization, housing indices, search, content recommendations, and user segmentation. Prior to Zillow, Jasjeet served as director of engineering at Yahoo, where he architected a machine-learned real-time big data platform leveraging social signals for user interest signals and content prediction. The system powers personalized content on Yahoo, Yahoo Sports, and Yahoo News. Jasjeet holds a BS and master's degree in computer science from Cornell University. https://www.crunchbase.com/person/jasjeet-thind

DUBAI'S ARTIFICIAL INTELLIGENCE ROADMAP - THE JOURNEY SO FAR

Interview of Wesam Lootah **By Nicolas Miailhe**
CEO at Smart Dubai Government Establishment

Wesam Lootah is the CEO at Smart Dubai Government Establishment. A committed and talented Emirati, Wesam has more than 18 years of experience in strategic leadership positions where he has leveraged Information Technology to create innovative channels and Smart Government infrastructure to improve the quality of public services for citizens, residents, visitors and businesses in Dubai. Wesam has worked in both government and the private sector in high profile organizations. From 2009 to 2012, Wesam was Vice President, Information Technology at World Trade Centre. Prior to that, he was Director, Information Technology at Emaar Properties. Wesam is not new to Smart Dubai Government as he was previously Head of Application Services from 2002 to 2007. During that time Wesam led the implementation of unified business process and ERP across Dubai Government entities. Wesam holds a Master's degree in Computer science and engineering from Pennsylvania State University and a Bachelor's degree from Ohio State University. Wesam is also an author with published research in Computer Security.

KEYWORDS

- CAPABILITY-BUILDING
- GOVERNMENT-AS-A-SERVICE
- SKILL DEVELOPMENT
- AUGMENTED INTELLIGENCE

INTRODUCTION

By Tarek Saeed,
Client Technical Advisor, IBM Middle East

Dubai is at the forefront of adopting transformative technology and has already embarked on its journey to transform into an artificial intelligence (AI) enabled city.

The journey started in October 2016 when Smart Dubai Government Establishment, Department of Economic Development and IBM collaborated to launch "Saad", an AI-based government service powered by IBM's AI capabilities. "Saad" is a service that allows users from the business community to ask questions and get up-to-date answers on business licensing and registration process in Dubai. An example of a question could be "Hi Saad, what are the documents needed to open a coffee shop in Dubai?"

"Saad" was equipped with AI capabilities, allowing it to understand natural language, ingest and comprehend massive amounts of data, learn and reason from its interactions, and provide solutions that will aid users in deciding on correct courses of action.

In February 2017, Smart Dubai and IBM have unveiled a first of its kind government-wide AI Roadmap. The purpose of the Roadmap is to help accelerate the development of AI-enabled citizen services across Dubai and equip the next generation of professionals with sought-after skills around analytics, cloud, cognitive and blockchain technology.

Smart Dubai and IBM also announced their plans to establish the "AI Lab" to become the AI center of competency in Dubai and to act as the vehicle to deliver the AI Roadmap through a number of initiatives.

Today, the Lab is enabling Dubai Government entities to transform existing digital government services into AI enabled services. It is providing skills training for government and private sector employees and local students; hosting workshops for entities and individuals to experiment and build prototypes; and offering go-to-market support for new services.

As the technology arm of Smart Dubai, the Smart Dubai Government Establishment leads the implementation of new technologies, including AI, by enabling shared services and infrastructure for the government and the city, while IBM contributes valuable skills training and technological expertise to support the implementation of the city's AI roadmap.

Acknowledging AI's potential to enhance and extend human capability can unlock

new streams of opportunities. Not only will AI augment human intelligence but, similar to any transformative technology, it will contribute to new forms of employment too. And right now, Dubai is one of the leading cities that leveraging its true ability to work in partnership with humans and create jobs for its people.

Nicolas Miailhe: Could you please explain what were the main objectives that led you to start working with IBM Watson on the "Saad" project? I suppose it is a mix of cost-effectiveness and enhanced efficiency: could you share a bit about your reasoning on this?

Wesam Lootah: AI is transforming industries, from healthcare to education. 80% of data is unstructured and AI can help drive insights for organizations and decision makers to make better informed decisions. Customer experience/insight is one of the most prevalent in the market today however as AI technology matures we expect to see a raise in other applications such as healthcare. A good example is IBM Watson who are the leaders in commercializing AI solution such as the one which is being used today by doctors to help treat cancer.

N.M.: Can you elaborate on at least one user experience (case) emblematic of the value generated by the service for business operators and citizens?

W.L.: Saad uses a cognitive advisor which helps business owners and entrepreneurs to get the right information at any time to start their business in Dubai. Saad is learning to provide more specific and personalized information about living in Dubai for the residents and citizens as well.

N.M.: How do you deal with liability risk in case of mistake/misinformation (say on tax or license regulations)?

W.L.: Saad is integrated with government entities internal systems which provides the latest updated data. The way Saad learns and trains is based on the government subject matter expertise who will continually teach Saad on new domains/subjects which is inquired by the end users.

"ABOVE INITIATIVES ARE FREE OF COST TO GOVERNMENT ENTITIES, TO INCREASE AWARENESS AND ACCELERATE THE PROCESS OF AUGMENTING AI SOLUTIONS INTO GOVERNMENT SERVICES."

N.M.: What is the payment model retained for the service? I suppose it is free of charge for business operators and subsidized by the Smart Dubai Office but what is the model of cooperation between the Smart Dubai Office and IBM Watson?

W.L.: Saad is currently free of charge for anyone around the world. Additionally, the Smart Dubai Office has created a center of excellence with IBM called the "AI Lab" where IBM provides AI expertise, enablement and training on AI technologies for government entities, plus implementing Proof Of Concept for various use cases of government entities. Above initiatives are free of cost to government entities, to increase awareness and accelerate the process of augmenting AI solutions into government services.

N.M.: How have citizens and business operators reacted to the service? Have you conducted quantitative surveys and qualitative interviews and if yes what were the results and main insights?

W.L.: The average number of conversation Saad was engaged in with the entrepreneurs and business owners between October 2016 and July 2017 was at 1,054 conversations per months. The Average number of questions asked to Saad between October 2016 and July 2017 jumped to 8,034 questions per month. And the average duration of conversation with Saad between October 2016 and July 2017 was 4.23 minutes per conversation

N.M.: Could you elaborate on the roadmap you have developed for AI-enabled citizen services and infrastructure? In particular, which services are you targeting and infrastructure in priority and why did you select these ones?

W.L.: The potential use cases which have selected by government entities is based on the complexity of the use cases (AI viability, quality of Data) and the impact of the service (strategic alignment/innovation/Happiness/financial benefits).

N.M.: The roadmap seems to be split into two parts: skills development and service deployment. Could you explain what led you to this innovative approach and what you are expecting from it.

W.L.: AI Lab's first strategy is to transform citizen engagement, by infusing AI into services, operations and disrupt business processes.
The main objectives of using this approach are:

1. Make Dubai the Happiest City / Increase Customer Happiness by transforming citizen engagement

2. Infusing AI in Government processes to:
   - Make efficient use of government resources
   - Reduce processing time
   - Support decision making
   - Reduce cost

3. Identify and avail "Dubai's Best" experts by leveraging AI to capitalize on the collective intelligence and experience of expert government employees

N.M.: Can you share more information on the AI Lab, its organization, operations and mode of operations?

W.L.: Smart Dubai Office (SDO) and IBM are partnering to launch the Smart Dubai Cognitive Lab, part of a joint program to develop Dubai's cognitive computing capabilities and prepare Dubai today to become the AI city of the future.
The main objectives of the Ai Lab:

1. SDO is investing in talent development for artificial intelligence in Dubai, by providing opportunities in skills training for government employees and university students to learn the technological and design-thinking best practices to innovate new cognitive solutions for the city.

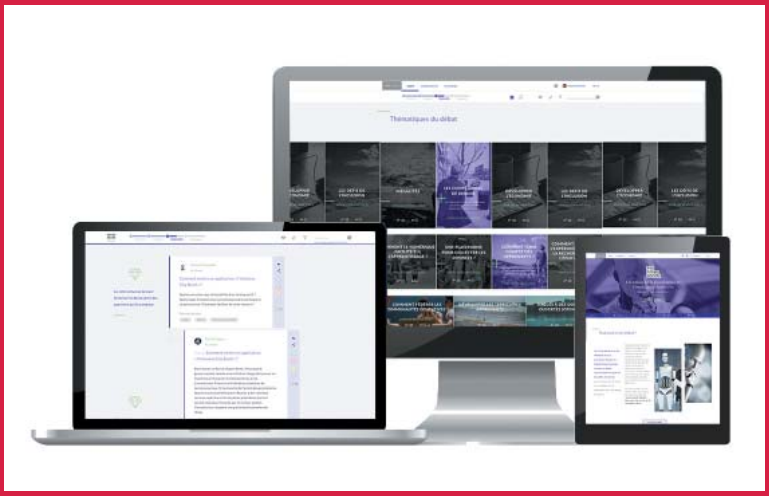
2. SDO is hosting workshops for the government to co-create, develop and prototype new ideas, and providing access to systems, tools and experts to enable entities to design and build cognitive solutions to improve city processes and services.

3. SDO is supporting the delivery of new AI solutions for the city, by supporting entities to implement solutions developed in line with Smart Dubai's artificial intelligence roadmap.

THE ROLE OF (AUGMENTED) COLLECTIVE INTELLIGENCE
for municipal governance

Interview of Frank Escoubes
Co-President and Founder of Bluenove

By Nicolas Miailhe & Arohi Jain



Frank Escoubes is the Co-President and Founder of Bluenove. He has 20 years of experience in strategy consulting, including 8 years at Deloitte in Canada. In 2011, Frank created the collaborative web platform Imagination for People dedicated to social and societal innovation, of which Bluenove became the key financial partner. Frank joined bluenove in 2014 as Executive Chairman. He is particularly responsible for developments in collective intelligence through the launch of Assembl software and partnerships with major international institutions (European Commission, MIT, etc.). Passionate about creativity and economic development, Frank accompanies companies, clusters and cities around the world in the reinvention of their strategic framework. He actively puts in place the dynamics of collective intelligence and sources world experts. Frank has been an Ashoka Fellow since 2012.

KEYWORDS

- COLLECTIVE INTELLIGENCE
- CO-CREATION
- MOBILIZATION
- CITIZENS
- ARTIFICIAL INTELLIGENCE

In municipal governance around the world, the use of collective intelligence methods with dedicated tools and platforms is becoming the norm as a way to involve citizens, users and stakeholders in the design and implementation of policies. This new *"open policy making"* approach stands to benefit from the rise of artificial intelligence which can act as a cognitive agent to organize and summarize content, as well as a social agent interacting directly with participants. AI can also help fact check information and help generate automatic summaries and map concepts.

INTRODUCTION

Assembl is the first deliberative online platform specifically designed to facilitate massive collective intelligence. Based on a multiphase consultation approach, it helps mobilize many people to tackle a complex issue. Assembl focuses on collective argumentation, dynamic structuring of ideas and noise reduction. It aims to co-create a strategic deliverable within a short period of time, usually between six to ten weeks. The tool and its supporting methodology are developed by bluenove. Assembl originated with a partnership with MIT as part of an R&D program funded by the European Commission. This open source software is widely applicable to large businesses as well as public entities and civic groups.

The collective intelligence methodology enables creation of knowledge through interactions between community members and optimizes their engagement based on innovative facilitation roles. The motive is to structure the co-production of new knowledge. The platform allows for categorization, curation and synthesis of incoming messages within a formalized deliverable. This is conducted through a multi-stage process that is designed to promote deep content and dynamic structuring of ideas.

Assembl works to reduce noise and focus community contributor's attention to solve complex issues. This is done by organising and implementing four key facilitation roles within the platform; Harvester, the curator and extractor of ideas; Synthesizer, the creator of periodical synthesis on the proposals put forwards; Facilitator, the undertaker of community management, and; Knowledge Manager, the conductor of regular fact checking on the discussion content.

The consultation is structured as a four-phase methodology that takes the community through stages of Sense-making, Ideation, Exploration and Prioritization. The multi-phase consultation is framed around a mind map of key thematic that lie within the scope of the debate. During the Sense-making stage, participants can contribute through a simple multilingual open question interface online. They are also able to view other contributor's proposals and vote on these. Next, during the Ideation phase, the interface augments to a forum module enabling the community to have deep conversations on specific issues. This stage of the collective intelligence consultation is structured to engage the participants in a deliberative manner and develop well thought out insights. Third, the Exploration phase operates on a canvas module whereby a specific subject matter is structured in a polarised method to deepen the discussion. This acts as a funnel for the contributor's opinion on a topic as the choice is binary. Lastly, in the Prioritization phase, participants are given voting tokens with which they can express their preference for certain propositions drawn out of the prior phases. Ultimately, the outcomes with the most tokens voted on results in a set of actionable proposals that are crowd sourced and collectively supported by the community.

Given the rise of Artificial Intelligence methods in automatically analysing text, through Natural Language Processing (NLP) algorithms for example, Assembl is now increasingly relying on automated techniques to manage the gathering of collective intelligence. This is currently applicable with the functions of language translation as well as the role of the Harvester in collating discussion insights, and can be applied to many other aspects of the debate. AI can help progress collective intelligence through fact-checking information presented in the debate and ensure that participants remain well informed by intelligent crawling of data. In applying such artificial intelligence techniques, the process of mobilizing communities is augmented towards a more meaningful engagement at a larger scale, without the incurrence of substantial costs and time resources.

Nicolas Miailhe: What is collective intelligence and how can we use it with artificial intelligence technology to help revolutionise municipal governance?

Frank Escoubes: Collective intelligence is the ability to mobilize large communities of people to co-design solutions to complex issues. Co-creation means combination and multiplication of perspectives. Such methodologies require both an iterative process of new knowledge design and massive scale: tens or hundreds of thousands of people providing rich insights that inform and orientate public policy.

In municipal governance, the use of collective intelligence is critical to understanding how all interested parties can help co-design policy recommendations. This can also be referred to as *"open policy making"*, a notion closely related to the idea of deliberative democracy (inspired by Habermas among others). I believe that this is the only effective way to convene citizens as experts of their own contextual lives, and therefore as legitimate providers of inputs that are required to imagine the policies and programs of tomorrow.

Collective intelligence is indeed best described as deliberative democracy, where quality of ideas is somehow the end goal, whereas participatory democracy hinges upon the quantity of participants, most often failing to gather profound and heterodox thinking. I believe deliberative democracy will be the supporting paradigm behind future municipal governance. Of course, the quest for scale is calling for supporting AI-enhanced methodologies.

Arohi Jain: What are the key opportunities and benefits of using collective intelligence to guide governments on public opinion?

Frank: Many people tend to think of collective intelligence applied to democracy in the restrictive context of the legislative process. I, on the other hand, consider it to be highly relevant and applicable to the entire spectrum of public policy making, covering laws, policies and

programs. It should also cover all co-design stages of policy making, from evidence-based diagnosis to collective ideation to policy recommendations to policy evaluation. Each stage requires varied levels of maturity of contributors. It is also very important to not only mobilize citizens, who express themselves in their own names, but also all constituencies in civil society (non-profit organisations, NGOs, pressure groups, industry organizations, etc.) who represent the consolidated point of views of a given set of stakeholders.

Nicolas: In your experience, what have been the challenges in using this methodology to inform public policy?

Frank: The greatest challenge of collective intelligence lies in engaging citizen. It is extremely difficult to mobilize a large range of the population that has a diversified base of knowledge on specific public policy issue. This is compounded by the challenge of finding the right balance of key stakeholders and citizens to provide political legitimacy to the consultation.

Secondly, the digital divide factor is still a reality. Online consultations that are used to garner insights do have significant entry barriers. They need to be fertilized with offline events (interviews, workshops, meetings, World Cafes, beta-tests, etc.). This has operational and logistical consequences: open democracy is to be considered hybrid from the get go.

The final challenge is of a cognitive nature. In assembling the full spectrum of participants for a civic consultation, the difficulty lies in ensuring whether the stakeholders have access to the right level of information for a productive consultation. This could further imply that an educational exercise is needed prior to the consultation. The role of experts should not be underestimated as well. Open democracy is first and foremost a citizen training process and it has to be reconciled with the world of experts for insights, data, evidence-rich analyses, complex interpretation, scenario-planning, etc.

Arohi: How will the rising trends and drivers of artificial intelligence impact the way we gather collective intelligence?

Frank: There are several ways to employ artificial intelligence depending on the context of the consultation. In our case, we use a deliberative platform, Assembl, structured around threads of discussion that organically grow in and around various themes; the challenge lies therefore with natural language processing and generation. Over and above certain thresholds of participants, the multiplicity and diversity of user generated content calls for narrative text analysis through machine learning algorithms. In this case, artificial intelligence poses significant benefit in acting as a cognitive agent that can organize and summarize content (a.k.a. knowledge creation systems), as well as a social agent interacting directly with participants, through chatbots and virtual assistants, hence community activities.

Furthermore, artificial intelligence can help fact checking information presented in a collective intelligence exercise. In dealing with large number of people on a specific consultation, AI can ensure the participants remain well informed through intelligent crawling of data libraries and enable support or challenge the views automatically. This capability would otherwise be extremely time consuming for community managers.

Lastly, with the detail and amount of content generated while participants are discussing a specific topic during a debate, it can be challenging to keep everyone up to date. Here artificial intelligence can provide an elegant solution by generating automatic summaries of the debate and mapping concepts that provide participants with easily accessible capsule updates on the discussion.

Nicolas: How do you see the use of AI in collective intelligence evolving over the next three to five and then ten years?

Frank: Well, this is a difficult question given the challenge in understanding the evolution of AI itself! I believe there is great potential in using AI to reconcile public policy making by citizens and data analysis. In the medium term, we could design a data-centric collective intelligence system that uses the power of data interpretation by algorithms to nurture, inspire and navigate creative human recommendations. I suspect this will happen in the next 10 years.

Another element is related to how we use AI to enhance creativity of citizens. It is currently difficult to radically shift to new societal mechanisms and therefore if we could create a way in which AI could feed efficiently the creativity and co-designing processing for citizens that would be exciting.

"IN THE MEDIUM TERM, WE COULD DESIGN A DATA-CENTRIC COLLECTIVE INTELLIGENCE SYSTEM THAT USES THE POWER OF DATA INTERPRETATION BY ALGORITHMS TO NURTURE, INSPIRE AND NAVIGATE CREATIVE HUMAN RECOMMENDATIONS. I SUSPECT THIS WILL HAPPEN IN THE NEXT 10 YEARS."

ECONOMIC, SOCIAL AND PUBLIC POLICY OPPORTUNITIES ENABLED BY AUTOMATION

Nicolas Miailhe
Co-founder and President, The Future Society

The rise of artificial intelligence & robotics is expected to create a wealth of opportunities to sustain growth and development over the next decades. It could trigger a wave of productivity gains and fuel revolutions in healthcare, transportation, education, security, justice, agriculture, retail, commerce, finance, insurance, banking and more.

Nicolas Miailhe is the co-founder and President of "The Future Society at Harvard Kennedy School" under which he also co-founded and co-leads the "AI Initiative". A recognized strategist, social entrepreneur, and thought-leader, he advises multinationals, governments and international organizations. Nicolas is a Senior Visiting Research Fellow with the Program on Science, Technology and Society (STS) at HKS. His work centers on the governance of emerging technologies. He also specializes in urban innovation and civic engagement. Nicolas has ten years of professional experience in emerging markets such as India, working at the nexus of innovation, high technology, government, industry and civil society.

KEYWORDS

- PRODUCTIVITY GAINS
- RESOURCE MANAGEMENT
- INTELLIGENCE AUGMENTATION
- PREDICTIVE TECHNOLOGY
- PREVENTIVE MAINTENANCE
- HEALTH MONITORING

INTRODUCTION

According to a majority of experts, the potential benefits of the rise of artificial intelligence & robotics are of the same magnitude as the three preceding industrial revolutions. The expected wave of productivity gains triggered by automation has the potential to sustain growth and development over the next decades, counterbalancing the decreasing working-age population. How? By making decision-making processes and resource management of complex systems much more efficient through the systematic mining of the growing stocks and flows of data. By commoditizing expertise and prediction, the rise of AI could also radically enhance quality of life for all, through revolutions in healthcare, transportation, education, security, justice, agriculture, retail, commerce, finance, insurance and banking, as well as other domains. The benefits that can be reaped need to be better understood, supported, and governed.

A. EFFICIENCY OF PUBLIC AND PRIVATE MANAGEMENT

PLANNING, ALLOCATION AND MONITORING OF RESOURCES

The rise of AI and robotics could first and foremost translate into a revolution in the efficiency of decision-making processes for all actors, both public and private. This, in turn, could give rise to new forms of public-private partnerships. The ability of advanced machine-learning algorithms to mine the growing stocks and flows of data related to the planning and operations of complex systems at the micro or macro levels is likely to trigger a wave of optimization across domains – energy, agriculture, finance, transportation, healthcare, construction, defense, retail and many more – and production factors, including the weather, labor, capital, innovation, information and, of course, the environment.

AI can be essentially analyzed as a "prediction technology,"[1] the diffusion of which could drastically bring down the cost of processing historical data and therefore of making prediction for a wide array of crucial tasks such as risk profiling, inventory management, and demand forecasting. Such a cost decrease would in turn favor reliance on prediction for a growing number of tasks and activities, including and not limited to banking and insurance, preventative health care for patients, predictive maintenance for all types of equipment and complex infrastructure, and crop efficiency through the analysis of satellite or drone imagery.

The optimization potential in terms of resource consumption in complex dynamics is highly significant. Consider the case of energy and its associated carbon emissions. Google DeepMind has already demonstrated how its advanced machine-learning algorithms can be used to reduce energy consumption in data centers. Concluding a two-year experiment cross-analyzing over 120 parameters in a Google data center, DeepMind's artificial neural network worked out the most efficient and adaptive method of cooling and overall power usage. The outcome of the experiment went far beyond traditional formula-based engineering and human intuition. DeepMind claims that this method resulted in a net fifteen percent reduction in overall power consumption, potentially translating into hundreds of millions of dollars worth of savings per year.[2] And the company qualified this as a "phenomenal step forward" given how sophisticated its data centers already are in the field of energy consumption optimization. DeepMind claims that "possible applications of this technology include improving power plant conversion efficiency [...], reducing semiconductor manufacturing energy and water usage, or helping manufacturing facilities in general increase throughput.[3]

Similar predictive approaches are already applied to banking,[4] for product recommendations, advisory services and risk profiling, trading,[5] transportation, traffic management and logistics, healthcare, and meteorology. Firms like Ocado and Amazon are already relying on AI to optimize their storage and distribution networks, planning the most efficient routes for delivery, and making best use of their warehousing capacity. In healthcare, data from smart phones and fitness trackers can be analyzed to improve management of chronic conditions – including mental illnesses – as well as predicting and preventing acute episodes.

1 Ajay Agrawal, Joshua Gans, and Avi Goldfarb, "The Simple Economics of Machine Intelligence", Harvard Business Review, November 2016. https://hbr.org/2016/11/the-simple-economics-of-machine-intelligence

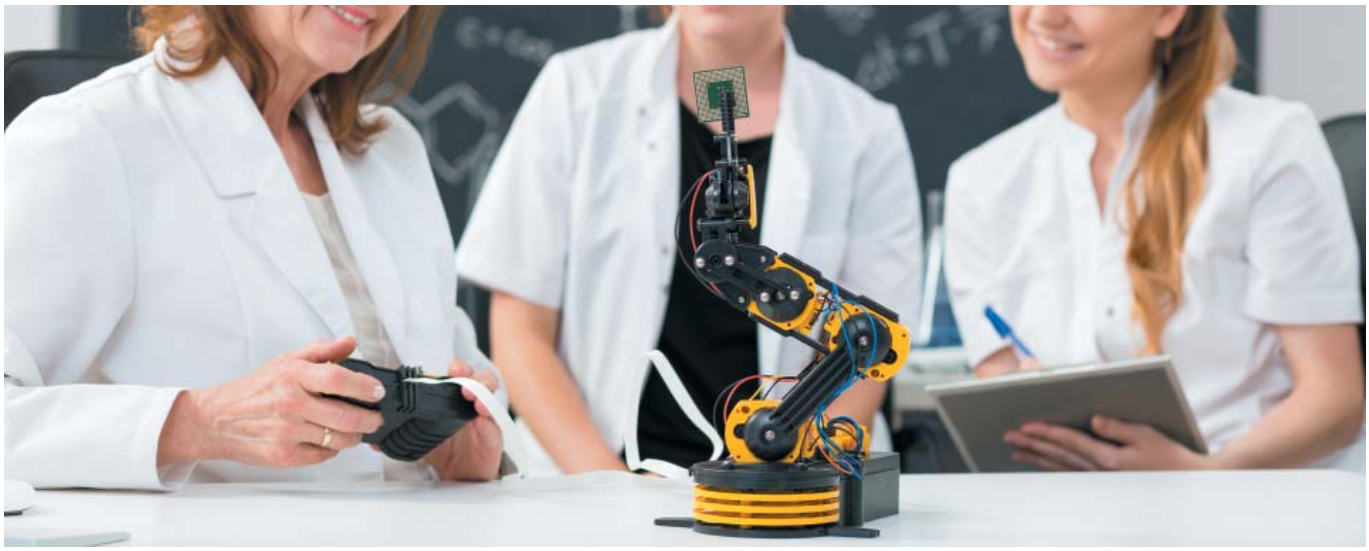
2 Considering that Google used over 4 million MWh of electricity in 2014 (equivalent to the amount of energy consumed by 366,903 US households), this 15 percent will translate into savings of hundreds of millions of dollars over the years. https://deepmind.com/blog/deepmind-ai-reduces-google-data-centre-cooling-bill-40/

3 For instance the industrial robotics company Fanuc has teamed up with Cisco to develop a platform to reduce factory downtime—estimated at one major automotive manufacturer to cost US$20,000 per minute. Based on machine learning, Fanuc Intelligent Edge Link and Drive (FIELD) captures and analyzes data from the manufacturing process to improve efficiency. Tantzen, B., "Connected Machines: Reducing Unplanned Downtime and Improving Service," October 6, 2015; and *FANUC*, "Manufacturing Automation Leaders Collaborate: Optimizing Industrial Production Through Analytics," April 18, 2016.

4 https://thefinancialbrand.com/63322/artificial-intelligence-ai-banking-big-data-analytics/

5 https://www.wired.com/2016/01/the-rise-of-the-artificially-intelligent-hedge-fund/

"AI CAN BE ESSENTIALLY ANALYZED AS A PREDICTION TECHNOLOGY, THE DIFFUSION OF WHICH COULD DRASTICALLY BRING DOWN THE COST OF PROCESSING HISTORICAL DATA AND THEREFORE OF MAKING PREDICTION FOR A WIDE ARRAY OF CRUCIAL TASKS SUCH AS RISK PROFILING, INVENTORY MANAGEMENT, AND DEMAND FORECASTING."



IBM Watson is researching the development of automated speech analysis tools running on mobile device to predict the onset of neurological (Huntington's, Alzheimer's, Parkinson's, etc.) and mental (depression or psychosis) diseases for earlier intervention and better treatment planning.[6] The field of "affective computing" aims more broadly at enabling computers to understand and simulate emotions.

DETECTING CRIMINAL AND FRAUDULENT BEHAVIORS

Machine-learning has also started to be used to detect early criminal and fraudulent behaviors, and to ensure compliance in innovative ways. One of the first uses of AI in banking was precisely for fraud detection through a continuous monitoring review of accounts activity patterns, with aberrations being flagged for review. With advances in machine-learning, we are now moving towards near real-time monitoring.

Last year, the banking multinational Credit Suisse Group AG launched an AI joint venture with Silicon Valley firm Palantir Technologies, whose solutions are widely used for surveillance and security, to detect unauthorized trading.[7] Credit Suisse started working with Palantir in 2011 after it suffered a $2.3 billion loss on unauthorized trading by Kweku Adoboli. The Zurich-based bank declared its objective is to adapt Palantir AI systems to monitor all employee behavior, so that it can catch breaches of conduct rules. Eventually, it aims to offer this service to other banks.

Besides trading, AI technologies are increasingly being used in the fight against terrorism, and for policing. The U.S. Intelligence Advanced Research Projects Activity is working on a host of programs relying on AI to enhance face recognition for identification[8] based on contextual information –spatial and temporal; or even to automatically detect and geo-localize untagged suspicious videos published online.[9]

Finally, the impact of fake news campaigns on recent elections has prompted Facebook to start working on using AI to help analyze the veracity of the trillions of posts made on the social network.[10] Facebook has started to rely on AI to detect words or patterns of words that might indicate fake news stories.[11]

B. A NEW WAVE OF PRODUCTIVITY GAINS AND GROWTH

Like other great technological revolutions in the past,[12] the largest set of opportunities created by the march of AI technologies results in their ability to trigger a new wave of productivity gains across domains. In this technological revolution, the lynchpins will be machine autonomy and automation[13]. The impacts will be

6 https://www.ibm.com/blogs/research/2017/01/ibm-5-in-5-our-words-will-be-the-windows-to-our-mental-health/

7 https://www.bloomberg.com/news/articles/2016-03-22/credit-suisse-cia-funded-palantir-build-joint-compliance-firm

8 https://www.iarpa.gov/index.php/research-programs/janus

9 https://www.iarpa.gov/index.php/research-programs/aladdin-video

10 http://www.forbes.com/sites/jasonbloomberg/2017/01/08/fake-news-big-data-and-artificial-intelligence-to-the-rescue/#db541e07a214

11 Peter Kafka, "Facebook has started to flag fake news stories", *Recode*, March 2017. https://www.recode.net/2017/3/4/14816254/facebook-fake-news-disputed-trump-snopes-politifact-seattle-tribune

12 Elizabeth Eisenstein, *The printing press as an agent of change*, Cambridge University Press, 1980; Robert Hoe, *A short history of the printing press and of the improvements in printing machinery from the time of Gutenberg up to the present day*, 1902. *And Growth and renewal in the United States: Retooling America's economic engine*, McKinsey Global Institute, February 2011.

13 "*Autonomy refers to the ability of a system to operate and adapt to changing circumstances with reduced or without human control. For example, an autonomous car could drive itself to its destination. Despite the focus in much of the literature on cars and aircraft, autonomy is a much broader concept that includes scenarios such as automated financial trading and automated content curation systems. Autonomy also includes systems that can diagnose and repair faults in their own operation, such as identifying and fixing security vulnerabilities.*
Automation occurs when a machine does work that might previously have been done by a person. The term relates to both physical work and mental or cognitive work that might be replaced by AI. Automation, and its impact on employment, have been significant social and economic phenomena since at least the Industrial Revolution". See Report on "Preparing for the Future of AI", Executive Office of the President, NSTC, October 2016 (page 10).

seen on factory shop-floors, service centers, and offices, through the automation of an increasing number of complex cognitive and physical tasks. The rise of AI also means new and more economically efficient forms of collaboration and complementarity between humans and machines. AI can be seen as potentially a new factor of production, enhancing the efficiency of the traditional factors of labor and capital, and creating a hybrid that is capable of creating entirely new workforces. In many cases, AI will be capable of outperforming humans in terms of scale and speed, and it will be capable of self-improvement.

Artificial intelligence can automatize and prioritize routine administrative and operational tasks by training conversational robot software ('bots'), which can then plan and manage interactions. Google's Smart Reply software can already draft messages to respondents based on previous responses to similar messages.[14] Newsrooms are increasingly using machine learning to produce reports and to draft articles.[15] Similar technology can produce financial reports and executive briefings. Robots using lasers, 3D depth-sensors, advanced computer vision, and deep neural networks, can navigate safely and work alongside warehouse and factory workers.

Artificial Intelligence can also generate significant productivity gains by drastically reducing the cost of searching large sets of data manually. This is particularly useful for the legal sector, for instance, where companies like *ROSS*, *Lex Machina, H5* and *CaseText* already rely on machine learning for natural language processing, combing through legal documents for case-relevant information. Thousands of legal documents can now be reviewed in a matter of days, as opposed to the traditional method which might take months[16]. In another vein, natural language processing can offer a way of interacting effectively with specialized domain-specific datasets, answering factual questions like IBM Watson Virtual Agent claims it can do[17].

Productivity gains will not reside solely in the replacement of humans with machines, but also through the advent of new forms of collaboration between humans and machines harnessing the complementarity of biological intelligence with digital intelligence. It is sometimes referred to as "intelligence augmentation." Such novel forms of human-machine teaming are likely to open up a wealth of opportunities for creativity and innovation, translating into higher productivity. One notable example concerns the use of radiology to detect breast cancer, where deep-learning algorithms combined with human pathologists' inputs lowered the error rate to 0.5 per-cent, representing a 85 per-cent reduction in error rates achieved by human pathologists alone (3.5 per-cent) or machines alone (7.5 per-cent)[18].

In terms of economic impact, Accenture published a report in 2016 analyzing twelve developed economies, and claimed that AI has the potential to double their annual growth rates, and increase the productivity of labor by up to 40 per-cent by 2035.[19] In January 2017, the McKinsey Global Institute published its own report on the future of automation. Their definitional boundaries differ from that of Accenture's report, and include robotics. Whilst McKinsey's estimate of automation's pace and consequences[20] is more modest, it still offers a very positive vision: automation could raise global productivity by as much as 0.8-1.4 per-cent annually.

Economists had been preoccupied with falling productivity growth rate[21] in recent decades. Attributed to a deficit in innovation, declining working-age population, flagging education attainment and wealth inequality, this productivity growth slowdown has had serious consequences, contributing to slower growth in real wages, and increasing long-run fiscal challenges.[22] According to the McKinsey Global Institute, the expected impact of automation technologies has the potential to match the imperative of high productivity growth needed globally to balance declining birthrates and aging, thereby enabling continued GDP growth.[23] That said, countries will react and absorb the automation wave unequally depending on demography, wage levels, productivity and socio-political appetite for growth and inequality. In principle, advanced economies that have been aging would absorb the impacts of automation more easily and rapidly than emerging economies with an aging workforce.[24]

14 https://www.blog.google/products/gmail/smart-reply-comes-to-inbox-by-gmail-on-the-web/

15 https://www.theguardian.com/media/2016/apr/03/artificla-intelligence-robot-reporter-pulitzer-prize

16 ABA Journal, "How artificial intelligence is transforming the legal profession", April 1, 2016.

17 https://www.ibm.com/watson/whitepaper/solutions-guide/

18 Dayong Wang, Aditya Khosla, Rishab Gargeya, Humayun Irshad, Andrew H. Beck, "Deep Learning for Identifying Metastatic Breast Cancer," June 18, 2016, https://arxiv.org/pdf/1606.05718v1.pdf

19 Mark Purdy and Paul Daugherty, *Why Artificial Intelligence if the future of growth*, Accenture, October 2016. www.accenture.com/futureofAI

20 James Manyika, Michael Chui, Mehdi Miremadi, Jacques Bughin, Katy George, Paul Willmott, and Martin Dewhurst, *Harnessing Automation for a Future that Works*, McKinsey Global Institute, January 2017. http://www.mckinsey.com/global-themes/digital-disruption/harnessing-automation-for-a-future-that-works

21 Measured productivity growth has slowed in 30 of the 31 advanced economies, slowing from a 2 percent average annual growth rate from 1994 to 2004 to a 1 percent average annual growth rate from 2004 to 2014.
Jason Furman, "Is this time different? The opportunities and challenges of artificial intelligence," remarks at AI Now: The Social and Economic Implications of Artificial Intelligence Technologies in the Near conference in New York, July 7, 2016

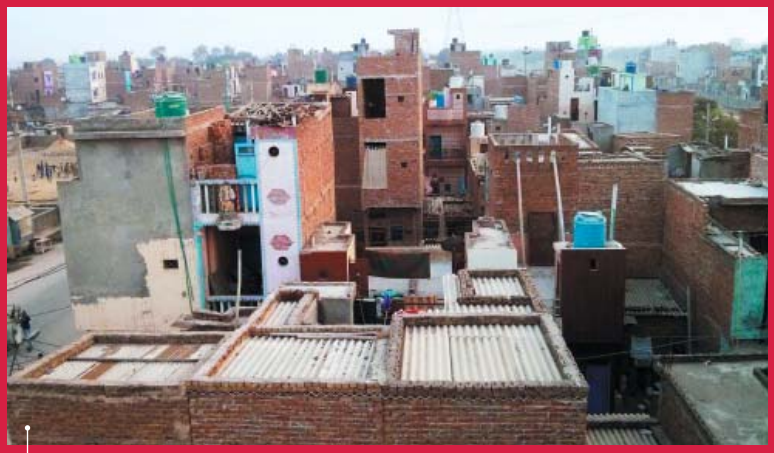
22 James Manyika, Michael Chui, Mehdi Miremadi, Jacques Bughin, Katy George, Paul Willmott, and Martin Dewhurst, *Harnessing Automation for a Future that Works*, McKinsey Global Institute, January 2017 (p. 95-103).

23 *Research from the McKinsey Global Institute has shown that even if global productivity growth maintains its 1.8 percent annual rate of the past half century, the rate of GDP growth will fall by as much as 40 percent over the next 50 years. On a per capita basis, the GDP growth decline is about 19 percent. In order to compensate for slower employment growth, productivity would need to grow at a rate of 3.3 percent annually, or 80 percent faster than it has grown over the past half century.*
Global growth: Can productivity save the day in an aging world? McKinsey Global Institute, January 2015.

24 James Manyika, Michael Chui, Mehdi Miremadi, Jacques Bughin, Katy George, Paul Willmott, and Martin Dewhurst, *Harnessing Automation for a Future that Works*, McKinsey Global Institute, January 2017 (p. 95-103).

DIGITAL TOOLS FOR LOW-INCOME HOUSING IN INDIAN CITIES

Marco Ferrario, Rakhi Mehra, Swati Janu
mHS CITY LAB



A self-built Informal settlement in Delhi. Source: mHS CITY LAB

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KEYWORDS

- INFORMAL SETTLEMENTS
- INCREMENTAL HOUSING
- URBAN RESILIENCE
- DIGITAL NETWORKS
- SOCIAL DESIGN
- LEAN METHODOLOGY
- USER TESTING
- MICROFINANCE

Through the ongoing work by the team at mHS CITY LAB, a social enterprise based in Delhi, the article looks at the possibilities offered by digital platforms across urban centres of global South in enabling lower income communities to self-build safer and better houses.

INTRODUCTION

mHS CITY LAB was founded in India as a social enterprise to develop innovation housing solutions for the urban poor. The vision has been to enable affordable and safe housing for housing living in informal settlements. mHS successfully implemented pilots with micro-finance agencies on housing and is currently incubating a series of digital tools for improving quality of the built environment. The interdisciplinary team works closely with organisation such as SAATH and SEWA, agencies such as the World Bank, financial institutions, micro-finance agencies and think tanks such as Centre for Policy Research.

DIGITAL ACCESS FOR INCLUSIVE CITIES

Within the current global buzz around 'smart cities', typical discourse on how technology could aid urban environments has centred on glitzy visualisations of high-rises, high speed rail or high speed internet. However, building cities of the global South where large populations lack basic amenities and housing requires a re-imagination of 'smart cities', centred on access for all. Here, the rise of Artificial Intelligence combined with massive digital penetration offers promising avenues to democratize access to knowledge and expertise.

The article explores the role technology can play in improving the resilience of cities in rapidly developing countries by improving the quality of self-built, incremental housing. It presents the insights from an ongoing project at mHS CITY LAB, a Delhi based social enterprise, to empower low-income communities through digital access to construction knowledge. It further evaluates potential of data driven, evidence based approaches and artificial intelligence in solving complex social problems facing the cities of global South.

The rapid penetration of smartphones and internet access in the emerging economies of the world is fast generating flows and stocks of data. This data can be analysed with machine learning algorithms to uncover new prediction and optimization patterns. Digital access has already enabled several African countries such as Tanzania, Uganda, Kenya and Ghana to leapfrog the typical digital development trajectory, skipping the incipient technologies of landlines or pagers. AI and big data here are opening up avenues in terms of financial inclusion, access to healthcare, legal services and other areas of expertise. The use of mobile money services such as MPesa has been hugely successful while other apps in the fields of agriculture, health and education have also had a significant impact on low-income communities (Poushter & Oates, 2015). The recent success of Juan Credit in Philippines demonstrates how deep learning techniques can be used to develop a credit scoring system for the unbanked population (Fintech News, 2017), lowering the barrier of access to capital.

In India, the recent Digital India[1] initiative aims to provide digital access to low income communities and rural areas. Local organisations such as Digital Greens[2] and initiatives such as Khabar Lahariya[3] have been using digital media as a medium to disseminate crucial information and news. Mobile platforms such as *Commcare* developed by the international social enterprise Dimagi are proving successful in reducing maternal and new born deaths in rural areas across India (Halabol, 2013). Like in other domains, machine intelligence leveraging data produced by increasing digital access can be harnessed to improve the quality of self-built housing in urban centres.

ROLE OF TECHNICAL EXPERTS IN SOLVING THE CHALLENGE OF URBAN HOUSING

From Hanoi to Lagos, Caracas to Mumbai, cities of global South are growing rapidly, accounting for most of the urban growth in the world today (UN DESA, 2014). Inadequate resources and planning mechanisms to accommodate for this upsurge in rural-urban migration have led to the proliferation of self-constructed informal settlements, called by different names such as slums, shanties, *barrios, favelas, kampongs, bastis* in different geographic locations. Built incrementally, these settlements provide affordable housing to millions but suffer from lack of basic amenities, overcrowding and poor quality of spaces (Davis, 2006).

This rapid growth of informal settlements in the cities of the global South has a specific impact at the household level: dwelling units are often poorly built and seismically unsafe structures. These neighbourhoods are the most vulnerable and at high risk from natural disasters and climate change induced stresses. The key reasons behind this can be traced to insecurity over land tenure, lack of finance, absence of building regulations and inability to access technical construction information. Even in cases where access to finance has been made possible, communities are seen building unsafe structures due to the lack of access to engineering and architectural expertise (mHS, 2011).

Traditionally, the role of an architect also included that of the contractor, project manager and engineer. With industrialisation, these roles came to be divided into separate professions, with a hyper-specialization of technical professionals in more recent times (Malone, Laubacher, & Johns, 2011). Lower income areas, however, are bereft of these specialized experts, such as architects or engineers. Incremental construction in such a context is directed completely by the local mason who plays the role of the contractor, designer and engineer. Due to the lack of skilled labour and adequate technical know-how, specifically on the concrete frame construction technology rampant in informal settlements across the global South,

"FROM HANOI TO LAGOS, CARACAS TO MUMBAI, CITIES OF GLOBAL SOUTH ARE GROWING RAPIDLY, ACCOUNTING FOR MOST OF THE URBAN GROWTH IN THE WORLD TODAY."

1 See http://www.digitalindia.gov.in/
2 See https://www.digitalgreen.org
3 See http://khabarlahariya.org/

"ACCESS TO CRITICAL CONSTRUCTION INFORMATION THROUGH DIGITAL PLATFORMS HOLDS THE POTENTIAL TO CREATIVELY DISRUPT THE CONSTRUCTION ECOSYSTEM IN EMERGING ECONOMIES TODAY."

DIGITAL TOOLS FOR INCLUSIVE HOUSING

NEED FOR SERVICE:

11%
skilled workers
Source: Government of India, 2008

lack of
professional
assistance

400 million
urban population
of India

76 million
live in dense
informal
settlements
Source: UNDP, 2009

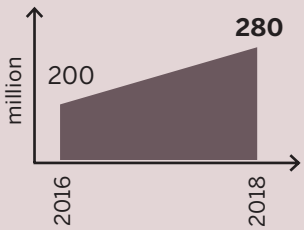
Improving the quality of **INFORMAL HOUSING** in Indian cities through **MOBILE TECHNOLOGY**

960.6
million wireless
subscribers

58% URBAN
42% RURAL

Source:
Telecom Regulatory Authority of India
Annual Report 2013-14.

Projected
smartphone
users in India

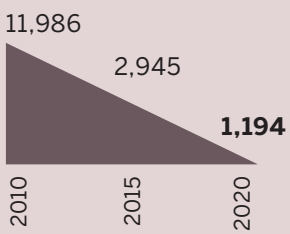


Source:
eMarketer, 2014
2 Billion Consumers Worldwide to
Get Smart(phones) by 2016.

60%
smartphone users
have **android OS**

Source:
Market share held by mobile operating
systems in India from January 2012 to
March 2015.Statista, 2015.

Average cost of a
smartphone (INR)



Source:
PriceBaba.com, 2014
India Android Consumption Report 2014.

typical structural flaws are easy to identify. Many of the construction malpractices could be avoided by access to basic technical inputs. This, however, is prevented by the socio-economic gap that exists between low-income communities and technical experts which in turn, poses one of the biggest challenges in building the resilience of our cities.

Thus, the relevance of technical professions in the cities can only be realised by rethinking their typical roles. It will involve capability-building at the levels of entrepreneurial masons who lie at the centre of the value chain. Technology offers a huge potential to bridge this knowledge gap and deliver construction expertise. Mobile phones have become an essential device in most households and smartphones are becoming increasingly affordable (Poushter, 2016). India had over 1 billion mobile subscriptions in 2016, with 1 in 5 using smartphones (IAMAI, 2016). The cost of android devices is projected at only 20 USD by 2020 and internet access is becoming more affordable with stronger 3G & 4G networks reaching the main cities.

Access to critical construction information through digital platforms holds the potential to creatively disrupt the construction ecosystem in emerging economies today - by providing Building Information Modelling[4] to underserved communities at a grassroots level. This calls for participatory governance and connecting key stakeholders to create impact at scale which the article explores next.

4 Building Information Modelling is an intelligent 3D model-based process that equips architecture, engineering, and construction professionals with the insight and tools to more efficiently plan, design, construct, and manage buildings and infrastructure

Pilot service at Saath's URC in Ahmedabad.
Source: mHS CITY LAB

DEMOCRATISING ACCESS TO HOUSING SOLUTIONS

To improve quality of low-income housing, the right to access technical assistance would need to be viewed as a preamble. Since 2010, the interdisciplinary team at the Delhi based social enterprise mHSCITY LAB have provided customised construction solutions to low-income communities. To scale its outreach, mHS is leveraging the medium of digital platforms to deliver complex technical information. In the form of easy to understand graphics and videos through accessible digital platforms, this information hold the potential to drastically improve the quality of informally built housing. Slum up gradation and resettlement projects in Indian cities have typically overlooked this need for access to information and focused on one-time standardised solutions. With construction in lower income areas largely being incremental and self-built, it is crucial to empower the communities at the household level by providing constant access to information and amenities. While other globally recognised problems in the social sector have been extensively researched and addressed, incremental housing is still an underserved process, mainly due to its invisibility within building plans and regulations. Its relevance in cities of the global South and provision of affordable shelter options to city dwellers, however, call for urgent action.

Informal settlements have attracted much attention from individuals and organisations working in the housing sector. The discourse, however, has focused on insecure land titles, scarce infrastructure, precarious livelihoods and the large number of temporal stakeholders. This has distanced such locations from a solution for improving the quality of informally built housing which could be scalable as well as inclusive. At mHS, it is envisioned that leveraging the proliferation of the digital medium – in the form of a construction toolkit on a digital platform – can overcome the complexities of informal settlements. With the scale and spread of digital tools, the vision is to offer algorithms for construction design and planning through intuitive user interfaces which can self-learn and evolve based on user inputs and experiences over time.

mHS's approach has been to follow a lean methodology with iterative feedback from users collected through multiple prototype tests on field. The digital tools are being developed for the three phases – before, during and after construction. Comprehensive architectural and engineering solutions have been coded into algorithms capable

of processing basic user inputs to generate detailed customized outputs, harnessing the potential of the collective intelligence of experts, communities and machines. The interface for each phase is being designed to be accessible through different digital platforms such as mobile phones and computers for an illiterate to semi-illiterate population who is at the threshold of adopting digital technology today.

Following several field tests and feedback through focus groups over the last year, the first tool for providing construction estimates is currently being tested as a pilot project in the city of Ahmedabad through two Urban Resource Centres (URC) of the community NGO Saath[5].

The centres are enabled by the pilot to provide critical pre-construction information to aid low-income communities in financial planning of their house construction project. Typically, homeowners in the communities where the centres are situated find themselves unprepared for the eventual construction cost of their houses due to incremental procurement of smaller material quantities and daily payment of labour wages. The actual cost always overshoots their initial guesswork or the mason's crude estimates, resulting in last minute loans or incomplete structures. Access to a planning and tracking tool through their local NGO centres is now enabling them to plan their finances and estimate the number of cement bags and bricks, weight of rebars and truckloads of sand they need to buy. Based on simple user inputs such as location, type and size of plot, number of floors, sanitation configuration and quality of finishing, the responsive service generates detailed information on material quantities, costs, labour and project timelines. The pilot is proving critical in developing the application based on user feedback and identifying the most effective channels for dissemination of the service.

5 SAATH URCs provide services such as information support in documentation for Identification cards and awareness on government welfare schemes.

"BASED ON SIMPLE USER INPUTS SUCH AS LOCATION, TYPE AND SIZE OF PLOT, NUMBER OF FLOORS, SANITATION CONFIGURATION AND QUALITY OF FINISHING, THE RESPONSIVE SERVICE GENERATES DETAILED INFORMATION ON MATERIAL QUANTITIES, COSTS, LABOUR AND PROJECT TIMELINES."

User testing by mHS CITY LAB team in Delhi.
Source: mHS CITY LAB

INFLUENCING SOCIAL BEHAVIOUR THROUGH SOCIAL DESIGN

A key challenge to implementing the pilot has been in influencing consumption and investment behaviours in the informal communities in favour of safer and healthier structures. With most households in informal settlements struggling to make ends meet, long term planning and sustainability are not top priorities. Tenure insecurity added to the need to establish their status within the community has been observed in many cases for aspirations by households to invest on larger rooms and facade aesthetics as a higher priority than structural safety. Understanding the aspirations and behaviour behind construction decisions of low-income communities is, hence, a key factor to be able to catalyze the quality and safety of housing.

An important research focus has also been on identifying the most effective distribution channels for dissemination of information in low-income communities. While technology is a great enabler with immense potential to reach millions, it can also act as a barrier to those who have not adopted it yet. Even with rapid penetration of smart phones, given the context in question, reaching everyone today requires leveraging existing networks and more person-to-person interactions. The pilot project has experimented with networks of E-kiosks deployed via grassroots organisations with a large emphasis on door to door awareness, community workshops and service trials.

Delivering high tech solutions in Indian cities also requires an understanding of the prevailing low tech networks and leveraging them as an intermediary technology. mHS plans to employ the technology of Interactive Voice Response as an avenue to reach existing basic mobile phone users while they make the transition to smartphones.

DATA ANALYTICS TO INFORM THE CONSTRUCTION ECOSYSTEM

A substantial incentive of leveraging digital technology is in its potential to generate very large volumes and stocks of data which can then power advanced machine learning algorithms. India undertook the Aadhaar program in 2009 to provide a centralised, mobile and unique identification number to every resident Indian based on algorithmic correlation. Mired in recent controversies over questions of privacy and its mandatory enrolment for certain welfare schemes (Doshi, 2017), it is a mammoth task that brings to light the potential and the challenges in handling data analytics of a billion. While requiring a clear policy for its implementation, it offers immense potential to favour access to basic services in urban environments with the rise of artificial intelligence technologies.

Similarly, monitoring and analysing transactions and behavioural patterns through advanced analytics backed by machine learning algorithms creates manifold opportunities – from connecting key stakeholders involved in informal construction to involving the government in effecting policy changes directed at building resilience in vulnerable settlements. Two such important stakeholders in influencing incremental construction are material suppliers and financial institutions interested in providing micro-finance for housing.

Notwithstanding the set-back to the Microfinance Industry in India in 2011, today there is renewed interest in serving the untapped market of low-income housing. Micro Finance Institutions (MFI) and Housing Finance Companies (HFC) in India have been driven by a tremendous growth of almost 60% in just the last year (PTI, 2016). Material suppliers such as cement companies similarly need to be involved to achieve impact at scale to dramatically improve the incremental construction ecosystem in Indian cities. The Digital Tools project aims to take these stakeholders along as the next step on the successful completion of the pilot project this year. The data generated from user profiles listing their credit worthiness, needs and preferences is invaluable information to the stakeholders looking at serving this lower income segment. Another valuable contribution lies in the tool's potential to map vulnerable settlements to inform resilience building initiatives, especially in pre-disaster preparedness.

"THE ENVISIONED SCALE OF THE COLLECTIVE INTELLIGENCE THAT DIGITAL TOOLS CAN BRING TO THE CONSTRUCTION ECOSYSTEM NEEDS TO BE AS MASSIVE AS THE URBAN CHALLENGES FACING DEVELOPING COUNTRIES."

The envisioned scale of the collective intelligence that digital tools can bring to the construction ecosystem needs to be as massive as the urban challenges facing developing countries, if state agencies can adopt the tools and incorporate the mechanisms at field and policy levels. With user feedback playing a critical role in effecting change, user assistance would need to be furthered by facilitating financial access and tenure security. mHS CITY LAB is hopeful in its vision to inform policy for greater inclusion of low income neighbhourhoods in Indian cities through its Digital Tools project. The next few years will be critical in evaluating the impact of digital technology and data in empowering low-income communities by bridging the knowledge gap.

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BLOCKCHAINS AND THE CIVIC NERVOUS SYSTEM

Alessandro Voto
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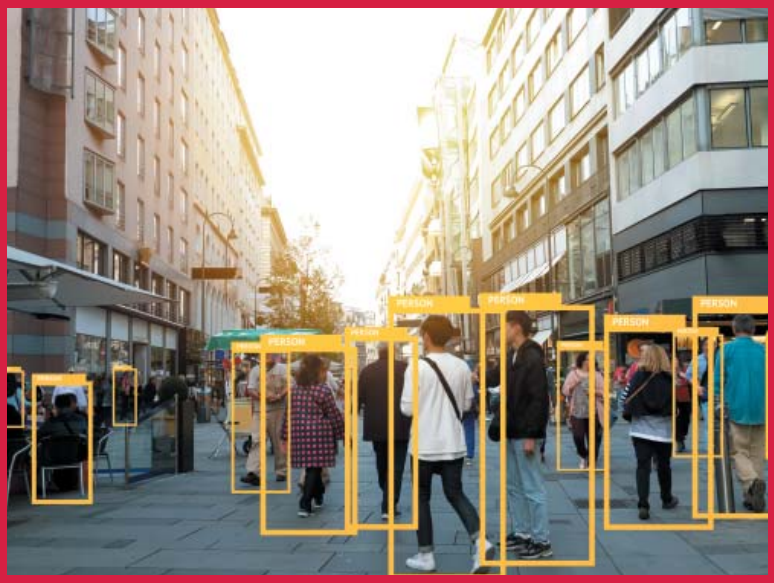

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In this article, Alessandro Voto takes us on a journey to explore how the rise of Blockchains protocol will transform city management enabling more distributed city governance and the emergence of a range of new urban services where machines and humans collaborate in new ways to store, move and transact. Projected to operate at a fraction of the cost of centralized protocols, those new services will be particularly adapted to underserved populations by providing mobile and secure identity for them and the value that they create.

KEYWORDS

- BLOCKCHAIN
- BITCOIN
- SMART CONTRACTS
- CRYPTO-CURRENCIES
- SELF-GOVERNING PROTOCOLS
- DIGITAL IDENTITY
- DECENTRALIZED CITY MANAGEMENT
- GOVERNMENT-AS-A-SERVICE

INTRODUCTION

In a departure from the centralized "brain" of traditional city politics, blockchain-based civic nervous systems will distribute political intelligence and economic agency to the edges. Humans won't be the only ones making decisions and acting on them. Machines and artificial intelligence agents will be equal contributors in the smart city symphony of the future.

The city is a distributed organism. Its inhabitants work symbiotically to turn raw materials into life-sustaining products and services for the greater whole. To move and protect the value they generate together, people depend on civic infrastructure like laws, markets and contracts. Together, these tools and their enforcers act like a city-wide nervous system, letting communities reliably respond to emerging needs and painful attacks.

Until now, we needed centrally-managed government and enterprise institutions to manage the records and processes behind this infrastructure at the city scale. In exchange, however, we gave these institutions the power to artificially limit our interactions so that they could extract profit or censor activities they deemed inappropriate. Furthermore, they became convenient targets for data breaches and third-party manipulation.

Recent advances in technology stand to eliminate the need for centralized bureaucracies, connecting peers directly to help them track and execute economic and social agreements themselves. One such technology, known as a blockchain, uses these direct links as a hedge against centralized civic power.

Blockchains are a kind of shared database that lets communities store records permanently across a network of computers. Any peer can submit a record for others to store in the chronological, synchronized chain alongside other's records. The records and their relative order are protected with bank-grade encryption to ensure they can't be altered, deleted, or forged by any single party on the network.

Blockchain technology will facilitate brand new kinds of cooperation within and across cities. It will extend trustworthy institutional protections and financial services to marginalized and poor people worldwide. It will reinvent the way we manage physical city infrastructure and digital community structures. What follows is a brief glimpse into the future of a blockchain-based civic nervous system.

URBAN IDENTITY UNBUNDLED

Civic participation begins with identity and citizenship. Whether it's a person, a corporation, or a device, unique identifiers help us extend our trust to the right groups and protect ourselves from malevolent actors. For this reason, one of the most important functions a blockchain can serve is to manage personal and organizational identity information.

Currently, drivers licenses, passports, social media profiles, and other forms of institutional identity are what makes you *you*. Without them, it's difficult or impossible to access financial services and legal protections. Worldwide, the United Nations estimates that there are 1.5 billion people who currently live without formal identity, excluding them from the urban services and protections it provides.

With blockchain-based identity services, anyone can cheaply establish a unique digital identifier. They can then start associating data about their activities and relationships with the identifier through subsequent transactions on blockchain. Each additional tamper-proof record helps paint a higher-resolution picture of one's trustworthiness. Since anyone on the network with a copy of the blockchain can access these records, urban denizens can easily find and establish ties with new collaborators according to strict and verifiable criteria, all without a central identity manager.

Blockchain projects like Consensys' Uport and Blockstack Labs' namesake identity system will open up entirely new possibilities for identity management. City schools and mentors will pass unforgeable learning badges to their students, letting students port micro-credentials to new geographies and educational venues.

"THE CITY IS A DISTRIBUTED ORGANISM. ITS INHABITANTS WORK SYMBIOTICALLY TO TURN RAW MATERIALS INTO LIFE-SUSTAINING PRODUCTS AND SERVICES FOR THE GREATER WHOLE. TO MOVE AND PROTECT THE VALUE THEY GENERATE TOGETHER, PEOPLE DEPEND ON CIVIC INFRASTRUCTURE LIKE LAWS, MARKETS AND CONTRACTS. TOGETHER, THESE TOOLS AND THEIR ENFORCERS ACT LIKE A CITY-WIDE NERVOUS SYSTEM."

Organizations will have their own blockchain personas, with their civic and environmental impact audited and visible to others. Even municipal robots will have their identity tracked to ensure they are performing up to code and not deviating from their duties.

The notion of citizenship will scale past administrative hurdles as blockchain transactions reveal rich information about people's contributions to their community. Once-vulnerable migrant populations will earn "global citizenship" beyond national borders through applications like Bitnation. Since blockchains don't necessarily require static, formal identity information to participate usefully in them, we might also see minimum-viable-identity governance systems and one-time-use ID's that expand access to services for people deeply concerned about their privacy and security.

Whether through rich self-sovereign identities or disposable personas, blockchain-based identity will let people lay true claim to their data and, importantly, their wealth.

CIVIC VALUE NETWORKS

Bitcoin, a digital form of currency, both introduced the concept of a blockchain and became its first killer use case. Bitcoin has a software-defined money supply, released first to "miners" that use their personal computers to process new transactions for the network. Once the coin is mined, its owner can pass it along by submitting a transaction record to miners for inclusion in the public blockchain. All of this is done without formal identity using only cryptographic addresses to hold and move funds. By logging transactions across a massive network of pseudonymous peers instead of a central payment processor, anyone with an Internet connection can accept or send the currency without fear of censorship or rent-seeking middlemen.

Bitcoin and other so-called "cryptocurrencies" will open flows of value between city residents and global partners that challenge long-standing borders and regulations. The global poor and the ultra-elite alike will use these frictionless networks to access international investment opportunities and banking services never afforded to them before.

Since all payments can be traced back to the accounts that initiated them, people and organizations will opt to associate their "true" identity with their accounts to hold themselves and others accountable for spending money. City governments will have their own accounts, known in blockchain parlance as wallets. Citizens will fund government wallets with transparent tax contributions, authorize spending as a crowd, and carefully audit transaction ledgers to minimize corruption and wasteful spending. NGO's will do the same with tools like Bitgive to help philanthropists track their impact on developing urban centers.

Since Bitcoin, developers have spawned many so-called "cryptocurrencies" like it. Dogecoin, for example, was a bespoke currency that gained success from its playful branding marked by poor language translation and Shiba Inu dogs. Others reinforced serious beliefs of financial sovereignty, like the Sioux Indian Tribe

did with it's own cryptocurrency called Mazacoin. In cities of the future, people will hold their wealth in a great number of tokens, each with their own transaction rules, backing assets, and community connections. Some will be fully fungible to encourage massive investment, while others will be limited to singular uses.

Projects will issue tokens to track people's contributions to resource pools and help meter access to them. La'Zooz, a blockchain-based ridesharing app, provides tokens to drivers for offering rides that are redeemable for rides from others in the future. Transactive Grid, Solar Coin, and the Energy Web Foundation are three projects aimed at establishing renewable energy microgrids where neighbors can pay each other for spare electrons without passing through a central energy company.

Though today's early blockchains require slow confirmation across the network to maintain security, new developments in the field will soon allow parties to transact offline at lightning speed, settling with the greater network only when necessary. This technique, known as a payment channel, will enable micro-payments to flow between people with little to no transaction cost. This means Internet user can pay WiFi router owners for access on a per-byte basis. Polluters might pay per carbon emission. Muralists might receive donations per glance from eye-tracked onlookers.

Low-cost financial flows will also make municipal crowdfunding easier, transforming the city's form with help from its residents. With a growing total market capitalization of over $80 billion as of May 2017, there will soon be a great deal of frictionless liquidity available to pull from. With this in mind, a blockchain real estate investment company called FOAM imagines a world where architects can propose new real estate projects like a Kickstarter campaign, then allow investors from anywhere to effortlessly gain an equity stake in their production. Investors and other stakeholders could then vote on matters related to the project, making each city project an experiment with decision-making built directly into its structure. This brings us to the next blockchain

DISTRIBUTING THE SMART CITY

In a departure from the centralized "brain" of traditional city politics, blockchain-based civic nervous systems will distribute political intelligence and economic agency to the edges. Humans won't be the only ones making decisions and acting on them. Machines and artificial intelligence agents will be equal contributors in the smart city symphony of the future.

To harness the trusted security of a blockchain in a smart city context, developers will hold more than just static information and asset registries on-chain. They will also store bits of computer code called smart contracts to perform complex operations without relying on a single third party to execute them. First coined by legal scholar Nick Szabo in 1994 and later implemented through a blockchain protocol called Ethereum, smart contracts act as a robotic escrow agent and notary, to which people can send assets and data if they agree to the contract's terms. No one can change the agreement, censor people from interacting with it, or prevent it from executing, unless explicitly specified in the code itself.

"TO HARNESS THE TRUSTED SECURITY OF A BLOCKCHAIN IN A SMART CITY CONTEXT, DEVELOPERS WILL HOLD MORE THAN JUST STATIC INFORMATION AND ASSET REGISTRIES ON-CHAIN. THEY WILL ALSO STORE BITS OF COMPUTER CODE CALLED SMART CONTRACTS TO PERFORM COMPLEX OPERATIONS WITHOUT RELYING ON A SINGLE THIRD PARTY TO EXECUTE THEM."

With this powerful new ability, cities can replace tedious bureaucratic processes with transparent and efficient decentralized applications. We will see land rights, trade agreements, incorporation documents, voting systems, and more re-invented to be self-enforcing, freeing up costly labor while opening up new opportunities for collaboration that would otherwise be costly to arrange. Ethereum even has an easy-to-follow tutorial on its site for "how to build a democracy on the blockchain", complete with voting, membership, and asset control processes. As cities experiment with simple governance tools like these, they will share their best practices as open-source "governance as a service" applications.

Machines will engage in smart contracts alongside humans, not just running the code, but even deciding when and how to invest wealth allocated to them or take on jobs opportunistically. FIlament, a Reno, Nevada based blockchain company, is already creating embeddable mesh networking chips to let machines buy each other's time and resources through smart contracts in rural and urban environments. Machines might some day "own themselves", opening up for capital investment and information from humans and bots only when necessary to fulfill their hard-coded duties.

Blockchain technology hold immense potential for reinventing the way we build, manage, and trade within and across cities. Civic designers will be tasked with designing these unstoppable systems with an eye to human needs, preventing blockchain uses that reinforce old models of injustice. A new civic nervous system is about to wake up, and it's up to us to teach it the future we want.

3. WILL WE SUCCEED IN MAKING THE AI REVOLUTION WORK FOR EVERYONE?

Is this time different?" is the question that expert worryingly argue over when they analyze the socio-economic impact of the AI revolution as compared with the previous industrial revolutions of the 19th and 20th centuries.

This Schumpeterian wave may prove to be a creative destruction raising incomes, enhancing quality of life for all and generating previously unimagined jobs to replace those that get automatized. Or it may turn out to be a destructive creation leading to mass unemployment abuses, or loss of control over decision-making processes. This depends on the velocity and magnitude of the development and diffusion of AI technologies, a point over which experts diverge widely. Policy-makers need to invest more resources to develop a finer understanding of the very notion and dynamics of the AI revolution. Moreover, societies' and cities abilities to shape the AI revolution into a "creative destruction" and diffuse its benefits to all will mostly depend on how societies react, both individually and collectively.

Technology is certainly not destiny and policy as well as institutional choices will matter greatly. Making the AI revolution work for everyone will require the reform and the potential reinvention of social security, redistribution mechanisms, as well as education and skill development systems, to allow for repeated and viable professional transitions. Policy and regulatory frameworks will also need rebalancing to protect the most vulnerable from socio-economic exclusion, to prevent algorithmic discrimination and privacy abuses, to ensure control and accountability, as well as to avoid an exacerbation of wealth and opportunity inequalities.

To discuss the challenges of governance in the age of AI, Geoffrey Delcroix from the French Data Protection Agency (CNIL) introduces a prospective scenario featuring Lille, a French city, in 2027 which has recently introduced a civic chatbot powered by Artificial intelligence. In a second article, Geoffrey presents different innovative data governance scenarios that cities could embrace to capture the upsides of the Big Data revolution striking the right balance between private and public interests. Yves-Alexandre de Montjoye then dives deeper in the analysis of the privacy challenge posed by the rise of machine learning algorithms. He discusses the limit to de-identification techniques in the age of machine learning algorithms which enable massive correlation at scale and outlines possible solutions based on privacy-by-design approach.

With Laurent Alexandre, we then discuss the geopolitics of AI, analyzing global power dynamics, the new competition between Europe, America and Asia and approaches to governance and regulation. Subsequently, Samer Hassan and Primavera de Filippi discuss the challenges associated with the increasing prevalence of algorithms at the center of governance process. As we rely more and more on digital platforms to live, work and socialize, the code that is used to run these programs becomes the new law. It forms a new regulatory system impacting us all on a daily basis. And as the autonomy of these algorithms develops with the rise of machine learning, new types of risks emerge in terms of fairness and due process. Designing algorithms becomes a political process whereby we need to embed and adapt our values in the code.

Andy Palanisamy addresses the dynamics and challenges of the march towards automated vehicles in how they can help address global mobility needs. While calling for a realist approach where we don't over emphasize the contribution of autonomous cars vis à vis mass transit systems, Andy argues that cities provide an appropriate environment for self-driving cars. That's because of their density combined the maturity of ride sharing platforms which should lead to the rise of mobility-as-a-service solutions.

Finally, with Roland Ries, Mayor of Strasbourg, we discuss how cities can embrace the rise of new digital platforms powered by algorithms and respond to the challenges they pose. Grounded in pragmatism, he advocates for a balanced approach whereby cities work in tandem with other governance layers to mitigate the toxic effects of deregulation while leveraging the potential of these new shared services to do more with less and address citizens' needs, including in terms of jobs and purchasing power.

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THE POLICY CHALLENGES OF AUTOMATION

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KEYWORDS

- UNIVERSAL BASIC INCOME
- PERSONALIZED EDUCATION
- ACTIVE LABOR MARKET PROGRAMS
- TECHNOLOGICAL UNEMPLOYMENT
- JOB AUTOMATION
- STEM EDUCATION

According to our analysis, making the AI revolution work for everyone will require systemic reforms, and the potential reinvention of social security, redistribution mechanisms, as well as education and skill development systems, to allow for repeated and viable professional transitions. Policy and regulatory frameworks will also need rebalancing to protect the most vulnerable from socio-economic exclusion, to prevent algorithmic discrimination and privacy abuses, to ensure control and accountability, as well as to avoid an exacerbation of wealth and opportunity inequalities.

INTRODUCTION

"Is this time different?" is the question that economists and experts worryingly argue over when they analyze the socio-economic impact of the AI revolution as compared with the other industrial revolutions of the 19th and 20th centuries. This Schumpeterian wave may prove to be a creative destruction raising incomes, enhancing quality of life for all and generating previously unimagined jobs to replace those that get automatized. Or it may turn out to be a destructive creation leading to mass unemployment, hollowing out of the middle class, and to abuses or loss of control over key decision-making processes. This depends on the velocity and magnitude of the development and diffusion of AI technologies, a point over which experts diverge widely. But technology is certainly not destiny and policy as well as institutional choices will matter greatly.

A. ADAPTING SOCIAL SECURITY AND REDISTRIBUTIVE MECHANISMS

CREATIVE DESTRUCTION OR DESTRUCTIVE CREATION?

The most discussed set of policy challenges associated with the rise of AI refers to the impact of automation on jobs and inequalities, with some scholars positing the potential "hollowing out" of the middle classes. Experts agree that the automation wave fueled by AI will profoundly impact employment patterns and business processes. How is this time different from previous waves of technological disruption? Whether this "Schumpeterian wave" proves to be a *creative destruction* like those that have come before – resulting in higher average incomes and generating previously unimagined jobs to replace those that get automatized – or turns out to be a *destructive creation*, leading to mass unemployment, depends on the velocity of the development and diffusion of AI technologies over the coming decade. Here, there is significant uncertainty amongst scholars.

Along with President Obama's former Council of Economic Advisers Chairman, Jason Furman's, paper published in July 2016[1], and the White House report on *Artificial Intelligence, Automation and the Economy* published in December 2016[2], the McKinsey Global Institute report on *Harnessing Automation for a Future that Works*[3], released in January 2017, concluded that the fundamental shifts in the labor force caused by automation technologies would be "*of a scale not without precedent*.". In their 2014 book entitled *The Second Machine Age*, Eric Brynjolfsson and Andrew McAfee had on their part argued that we are facing an unprecedented inflection point between the first machine age, based on the automation of physical tasks through mechanization, and a second machine age, based on the automation of cognitive tasks through digital technologies[4].

Results of studies on the impact of job automation conducted over the past five years have differed quite radically in their assessment and projections: a report from the OECD published in June 2016[5] – focused on its 21 Member countries and centered around "tasks" as a unit of analysis – concluded that a modest average of 9 percent of tasks are automatable. There are predicted to be notable differences between different countries' trends[6]. The 2013 study of Frey and Osborne on the future of employment,7 which focused on the broader concept of "occupations," had raised alarm bells with its conclusion that about 47 percent of jobs in the U.S. were susceptible to automation over the next two decades. Another report by Citibank,8 building on the Frey and Osborne study as well as on data from the World Bank, focused on 50 countries and concluded that, on average in OECD countries, 50 percent of the jobs were susceptible to automation. This number was particularly high in India (69% susceptibility) and China (77% susceptibility). Analyzing more than 2,000 work activities across 800 occupations, McKinsey's most recent report concluded that "*about half the activities people are paid almost $15 trillion in wages to do in the global economy*

1 Jason Furman, "Is this time different? The opportunities and challenges of artificial intelligence," remarks at AI Now: The Social and Economic Implications of Artificial Intelligence Technologies in the Near Term , conference in New York, July 7, 2016.

2 *Artificial intelligence, automation, and the economy*, Executive Office of the President, December 2016. https://obamawhitehouse.archives.gov/blog/2016/12/20/artificial-intelligence-automation-and-economy

3 James Manyika, Michael Chui, Mehdi Miremadi, Jacques Bughin, Katy George, Paul Willmott, and Martin Dewhurst, *Harnessing Automation for a Future that Works*, McKinsey Global Institute, January 2017 (p.97).

4 Erik Brynjolfsson and Andrew McAfee, *The second machine age: Work, progress, and prosperity in a time of brilliant technologies*, W. W. Norton & Company, 2014.

5 Melanie Arntz, Terry Gregory, and Ulrich Zierahn, *The risk of automation for jobs in OECD countries: A comparative analysis*, OECD Social, Employment and Migration working paper number 189, OECD, May 2016

6 For instance the share of automatable jobs is 6% in Korea vs. 12% in Austria.

7 Carl Benedikt Frey and Michael A. Osborne, *The future of employment: How susceptible are jobs to computerisation?*, Oxford Martin School, September 17, 2013.

8 *Technology at Work v2.0: The future is not what it used to be*, Citibank, January 2016.

"OUR ANALYSIS OF THE MOST RECENT LITERATURE POINTS TO THE LIKELY NEED FOR PROGRESSIVE TAX POLICIES TO REBALANCE THE LABOR TO CAPITAL SHIFT THAT IS LIKELY TO BE SEEN IN THE AI REVOLUTION, IN ORDER TO PROTECT THE MOST VULNERABLE FROM SOCIO-ECONOMIC EXCLUSION, AS WELL AS TO AVOID AN EXPLOSION IN INEQUALITIES OF WEALTH AND OPPORTUNITIES."

have the potential to be automated. [...]. While less than 5 percent of all occupations can be automated entirely, about 60 percent of all occupations have at least 30 percent of constituent. More occupations will change than will be automated away."[9] The report also concluded that activities most exposed include "physical activities in highly structured and predictable environments, as well as the collection and processing of data."

Moving forward, it is paramount that more research is conducted to understand the factors of job automation at more a granular level, in particular across timeframes, sectors, wage levels, education levels, job types, and locations. Reports have hitherto mainly pointed to a continuation, if not an accentuation,[10] of the skill-biased displacement trend,[11] mitigated by the ability of AI and automation technologies to replace high-skill cognitive tasks which exhibit high degree of routine.[12] Some low-skilled tasks requiring advanced hand-dexterity will also remain in demand, at least in the short term. Studies have also highlighted the loss of jobs for some workers in the short-run, but to a substantial degree the time-frame of displacement depends on institution-specific policy responses.

POLICY MATTERS: MAKING THE AI REVOLUTION WORK FOR EVERYONE

Societies' ability to shape the AI revolution into a *creative destruction* and diffuse its benefit to all mainly depends on how they collectively react to it. Technology is certainly not destiny, and policy as well as institutional choices will matter greatly. Our analysis of the most recent literature points to the likely need for progressive tax policies to rebalance the labor to capital shift that is likely to be seen in the AI revolution, in order to protect the most vulnerable from socio-economic exclusion, as well as to avoid an explosion in inequalities of wealth and opportunities. We believe, however that "taxing robots" per se[13] may not be the best option, and could be counterproductive if implemented narrowly, potentially slowing growth and triggering legal challenges.

Systemic policy responses will be required, including reform, and potential reinvention of, Social Security and redistributive tax. Education and skill development systems will also need reforming to enable for repeated and viable professional transitions. Given the difficulty in predicting areas of greater impact and to disaggregate AI-driven automation from other factors (e.g. other technological changes, globalization, reduction in market competition, workers' bargaining power, past public policy choices), policy responses will initially have to target the whole economy, until targeted strategies become more effective, and monitoring and evaluation practices have been designed.

9 *Harnessing Automation for a Future that Works*, McKinsey Global Institute, January 2017 (p. vi). MGI scenarios suggest that half of today's work activities could be automated by 2055 or 20 years earlier or later depending on the various factors, in addition to other wider economic conditions.

10 It's what Erik Brynjolfsson and Andrew McAfee have called "super-star biased technological change" in their book *The Second Machine Age*. "*It's the fact that technologies can leverage and amplify the special talents, skill, or luck of the 1% or maybe even the 100th of 1% and replicate them across millions or billions of people. In those kinds of markets, you tend to have winner-take-all outcomes and a few people reap enormous benefits and all of us as consumers reap benefits as well, but there's a lot less need for people of just average or above-average skills*". http://www.businessinsider.com/erik-brynjolfsson-2014-1

11 For instance, the OECD 2016 study estimates that 44 percent of American workers with less than a high school degree hold jobs made up of highly-automatable tasks while 1 percent of people with a bachelor's degree or higher hold such a job. Melanie Arntz, Terry Gregory, and Ulrich Zierahn, *The risk of automation for jobs in OECD countries: A comparative analysis*. Ibid. See also *Artificial intelligence, automation, and the economy*, Executive Office of the President (p. 13 and 14)

12 *Harnessing Automation for a Future that Works*, McKinsey Global Institute, Ibid. Also see *Artificial intelligence, automation, and the economy*, White House Report. Ibid. (page 23).

13 In a very recent interview Bill Gates advocated for it as a way to slow down the pace of automation and fund professional transitions. See http://fortune.com/2017/02/25/bill-gates-robot-tax-automation-jobs/

As large swathes of the workforce will be exposed to significant insecurity in the anticipated transition, the reform and enhancement of safety nets has often been suggested as a priority. However, raising minimum wages might paradoxically accelerate automation trends, if used indiscriminately. The opportunity to provide a Universal Basic Income (UBI)—in essence providing a regular, unconditional cash grant—which would revamp social welfare programs in a "post-secure-wage society" driven by automation, is now a feature of political agendas on the Left[14] and on the Right.[15], of course with different contours and degrees.

Economists are archly divided on the matter. Proponents, including Thomas Piketty,[16] see UBI as a way of simplifying the current bureaucratic system, and making it more efficient and fair. UBI is seen as a solution to address the looming automation wave, by favoring work as opposed to unemployment, which has been demonstrated to favor dangerous spirals of marginalization. Attacking mainly the "unconditionality" criteria, opponents[17] denounce an excessively radical and unrealistic approach to reforming existing safety nets. They argue that unconditionality could be counter-productive, resulting in increased, not decreased, income inequality. This camp also argues that UBI could potentially de-incentivize work which they also see as a pillar of social integration.

Interestingly, Finland recently announced a UBI experiment this year,[18] which should provide valuable evidence to move the debate forward. An experiment is also on the cards in the Netherlands though, interestingly, the mention of "universal income" has recently been abandoned[19]. In a 2016 referendum, Switzerland rejected, with a 77 percent majority, plans to deploy a monthly $2,555 universal income for all adults.[20]

Besides the UBI, a large variety of more moderate policy options are also on the table. These include strategies to tighten labor markets and pressure wages upward; and the possibility of strengthening workers' collective bargaining power, thus creating new and innovative ways to make workers' voices hear. Such policies aim to rebalance AI-driven concentration, which it is argued could lead to a monopolistic or oligopolistic market. Other available policy options seek a shift in scale rather than in nature of existing societal safety nets. They include the strengthening of existing unemployment insurance schemes to be more targeted or attuned to local environments, or to have their boundaries extended to include, for instance, people who decide on their own to quit their job[21] to pursue training or transition to entrepreneurship. Work-based reform options also include modernizing overtime, employment contracts, with work-sharing programs and temporary work-based training being encouraged[22].

Finally, to make the AI revolution work for everyone, policy-responses will have to find innovative ways to ensure that a more mobile and insecure workforce has fair access to credit as well as healthcare and retirement benefits. Such benefits have been hitherto largely dependent on employers' contributions, either directly or indirectly – with limited portability when people seek professional transitions, or choose to adapt their employment contracts (e.g. including part-time jobs and entrepreneurship). Challenges to existing employment practices will involve systemic policy change.

"BESIDES THE UBI, A LARGE VARIETY OF MORE MODERATE POLICY OPTIONS ARE ALSO ON THE TABLE. THESE INCLUDE STRATEGIES TO TIGHTEN LABOR MARKETS AND PRESSURE WAGES UPWARD; AND THE POSSIBILITY OF STRENGTHENING WORKERS' COLLECTIVE BARGAINING POWER. OTHER AVAILABLE POLICY OPTIONS INCLUDE THE STRENGTHENING OF EXISTING UNEMPLOYMENT INSURANCE SCHEMES, MODERNIZING OVERTIME, EMPLOYMENT CONTRACTS, ENCOURAGING WORK-SHARING PROGRAMS AND TEMPORARY WORK-BASED TRAINING."

14 In the recent French Socialist Party primary elections held in January 2017, the large victory of Benoit Hamon has essentially been credited to his ability to bring the progressive deployment of a universal basic income as a his flagship measure. See also Andy Stern and Lee Kravitz, *Raising the Floor: How a Universal Basic Income Can Renew Our Economy and Rebuild the American Dream*, June 2016.

15 Charles Murray, "A guaranteed income for every American", WSJ, June 2016. https://www.wsj.com/articles/a-guaranteed-income-for-every-american-1464969586 ; See also Matt Zwolinsky, « The Libertarian Case for Basic Income », December 2013. https://www.libertarianism.org/columns/libertarian-case-basic-income

16 Provided UBI targets low wages. See « Pour un revenu universel crédible et audacieux », Le Monde, 25 Janvier 2017. http://piketty.blog.lemonde.fr/2017/01/25/pour-un-revenu-universel-credible-et-ambitieux/

17 Jason Furman, "Is this time different? The opportunities and challenges of artificial intelligence," remarks at AI Now: The Social and Economic Implications of Artificial Intelligence Technologies in the Near Term, conference in New York, July 7, 2016.

18 in which 2,000 unemployed people between the ages of 25 and 58 will receive a guaranteed sum – a "basic income" – of €560 a month for two years whether or not they find work. See Sonia Soda, "Is Finland's basic universal income a solution to automation, fewer jobs and lower wages?", Guardian, February 2017. https://www.theguardian.com/society/2017/feb/19/basic-income-finland-low-wages-fewer-jobs?CMP=share_btn_tw

19 Deployed in 20 Dutch municipalities, the experiment will allow small groups of benefit claimants to be paid $825 a month while continuing to earning what they make from work. See Daniel Boffey, "Dutch city plans to pay citizens a 'basic income', and Greens say it could work in the UK", Guadian, December 2016. https://www.theguardian.com/world/2015/dec/26/dutch-city-utrecht-basic-income-uk-greens

20 See http://www.bbc.com/news/world-europe-36454060

21 That's what French presidential candidate Emmanuel Macron has proposed for instance. See https://www.contrepoints.org/2016/11/13/271472-macron-veut-autoriser-chomage-aux-salaries-demissionnent

22 A more detailed description can be found in the White House report *Artificial intelligence, automation, and the economy*, Executive Office of the President. Ibid. (p. 34-40).

B. THE CASE FOR 21ST CENTURY EDUCATION AND SKILL DEVELOPMENT SYSTEMS

REINVENTING ACTIVE LABOR MARKET PROGRAMS

As we have written above, the wave of automation caused by the AI revolution will displace a very large amount of jobs across domains and value chains. The U.S. "automated vehicle" case study analyzed in the White House 2016 report on *Artificial intelligence, Automation, and the Economy* is emblematic of what's at stake: 2.2 to 3.1 million existing part- and full-time U.S. jobs are exposed[23] over the next two decades, though the timeline remains uncertain. In particular, between 1.3 and 1.7 million heavy truck drivers are threatened. And this is not trivial, for the profession has symbolized in the collective imaginary the manifestation of the American dream of empowerment, liberty and social ascension whereby less-educated people could make it into the middle class[24].

The automation wave calls at least for higher investment and probably the need to reinvent active labor market programs in the coming decades[25]. Such investment should logically be funded by fiscal policies targeting the capital. The 2016 White House report on *Artificial intelligence, Automation, and the Economy* gave an interesting order of magnitude applied to the case of the U.S.: "*increasing funding for job training in the U.S. by six-fold—which would match spending as a percentage of GDP to Germany, but still leave the U.S. far behind other European countries—would enable retraining of an additional 2.5 million people per year*"[26].

AI and other digital technologies offer real potential to innovate new approaches to job-search assistance, placement and hiring processes in the age of personalized services. The efficiency of matching labor supply and demand can be tremendously enhanced by the rise of multi-sided platforms and predictive analytics. The case of platforms such as *LinkedIn* for instance with its 470 million registered users is interesting as an evolution in hiring practices. Tailored counseling and integrated re-training programs also represent promising grounds for innovation.

This, however, won't be enough. A lot will have to be done to create fair and effective life-long skill development/training infrastructure and mechanisms capable of empowering millions of people to viably transition jobs, sectors and potentially geographies – that, too, several times in a lifetime. A lot will also have to be done to address differential geographic impacts which exacerbate income and wealth disparities. Effectively enabling the workforce to be more mobile –both physically, legally and virtually- will be crucial. And this implies of course systemic policy approaches which encompass housing, transportation, licensing, taxes and, crucially in the age of AI, broadband access -especially in rural areas.

To lay solid foundations for this profound transformation, we need more research in at least three complementary areas: first, to devise mechanisms of dynamic mapping of tasks and occupations at risks of automation and associated employment volumes. This mapping of the workforce supply is needed at the macro but also crucially at the micro levels where labor market programs are deployed. Integrated with that, we also need more granular and dynamic mapping of the future jobs/tasks, workplace-structures, associated work-habits, and skill-base spurred by the AI revolution. This mapping of the demand side will be key to innovate, align and synchronize skill development and training programs with future requirements in anticipation, that too on the right timescales. And finally, we need more policy research on the dynamics of professional transitions in different labor market conditions.

To maximize intended impact, create necessary space for trial-and-errors strategies, and to scale up solutions that work, we recommend implementing robust data-driven evidence-based approaches. These approaches should be based on experiments and centered on outcomes in terms of employment but also in terms of earnings. We also recommend exploring new forms of people-public-private partnerships involving civil society as well as new outcome-oriented financial mechanisms such as Social Impact Bonds for instance which could help scale up successful innovations.

A REVOLUTION IN EDUCATION?

Understanding components and drivers of AI-labor complementarity and navigating that evolving understanding nimbly to transform primary, secondary and professional education will be capital in the coming decades. Because of the large impact of the rise of AI on economies and societies, this implies of course for all countries - almost as a sovereignty imperative, the need to invest in developing AI-related workforce. It is needed to support advances in the field of fundamental research, in the engineering, and of course in the applications, business and socio-political aspects. And the field is by definition interdisciplinary with expanding confines towards biology, cognitive and brain science. Because of the central role of data in developing and training machine learning algorithms, boundaries between fundamental research, applied research, engineering

23 Though the figures exclude new types of jobs that may be developed in the industry. See *Artificial intelligence, automation, and the economy*, Executive Office of the President. Ibid. (p. 15-17)

24 Sean Kilcarr, "Defining the American Dream for trucking... and the nation, too", *Fleetowner*, April 2017

25 OECD member countries outside of the U.S. spent, on average, 0.6 percent of GDP on active labor market policies in 2014. The U.S. spent just 0.1 percent of GDP, less than half of what it did 30 years ago. OECD, "Labour market programmes: expenditure and participants", *OECD Employment and Labour Market Statistics* (database), 2016. http://stats.oecd.org/viewhtml.aspx?datasetcode=LMPEXP&lang=en#

26 This assumes $6,000 per person training/reemployment cost, and an increase in Workforce Innovation and Opportunity Act funding from today's $3B to $18B, to match Germany's spending as a fraction of GDP, with all new funding spent on training. See *Artificial intelligence, automation, and the economy*, Executive Office of the President. Ibid. (p. 33).

and higher education are likely to blur[27]. We are already seeing a trend whereby fundamental research in AI is shifting away from universities and government laboratories to the biggest technology companies. Academics worry about what they call a "brain drain"[28] which could damage the quality of public research and education down-the-line.

In the *2016 Economic Report of the President*[29], the White House summarized: "*college- and career-ready skills in math, reading, computer science, and critical thinking are likely to be among the factors in helping workers successfully navigate through unpredictable changes in the future labor market*".

Basic literacy and math will more than ever represent the crucial foundation of employability, especially with the accentuation of skill-based job displacement; as will be the quality of early-education since "catching up" will become more difficult; or the need to generalize access to secondary education which should include proven alternatives such as apprenticeship, creative and vocational training[30]. Diversifying and enhancing STEM curriculum beyond computer science to include computational thinking, data science, creativity, innovation and entrepreneurship also appears to be a required evolution.

But beyond that, education will need to change more profoundly and attract the required talent to develop and diffuse innovatively new pedagogies; including centered on emotional intelligence as well as tapping into the power of personalized learning and affective computing. Innovative public-private-partnership should also be explored to favor the emergence of the most effective learning environments and to incentivize good quality investment at scale. But policy-makers will probably retain a key role to ensure innovation diffusion to most, if not all.

As the "online-to-in-person" learning continuum grows more mature, the contours of teachers' role are also very likely to evolve: from that of content providers towards that of content curators, educators, coaches and mentors able to guide learners along personalized path adapted to labor market needs. Crucially, civic education will also need to evolve to equip future citizens with data and AI literacy as well as adequate understanding of trends and stakes, including related to the governance of AI and other emerging technosciences. As we have seen in this study, the serious ethical and political choices abound regarding how societies will decide to collectively embrace the rise of AI. Forging consensus will not be easy, especially considering how the rise of income, wealth, geographic and opportunity disparities may unravel the social fabric both in developed and in emerging countries.

27 The case of Yann LeCun is emblematic. A pioneer in machine learning, computer vision, mobile robotics and computational neuroscience with a long career in academia in France and in the U.S., he joined Facebook as Director of AI Research in 2013 while retaining his position of Professorship at New York University, and simultaneously starting a research partnership between Facebook and New York University's Center for Data Science. He also convinced Mark Zuckerberg to let him run Facebook AI Research operations from New York City creating a dedicated lab there a few blocks from NYU in addition to the laboratories in Menlo Park CA and London. See https://www.facebook.com/yann.lecun/posts/10151728212367143

28 Richard Waters, "AI academic warns on brain drain to tech groups", *Financial Times*, November 2016. https://www.ft.com/content/298e2ac0-b010-11e6-a37c-f4a01f1b0fa1

29 The White House, Economic Report of the President 2016, Chapter 4.

30 Research in the U.S. suggests that apprenticeship fetches a significant premium at a given skill level—as much as $300,000 over a lifetime. Debbie Reed, et al. An Effectiveness Assessment and Cost-Benefit Analysis of Registered Apprenticeship in 10 States. Mathematica Policy Research, 2012.

MARIANNE RELOADED: a design-fiction scenario that speculates on the roll-out of a new generation of civic bots

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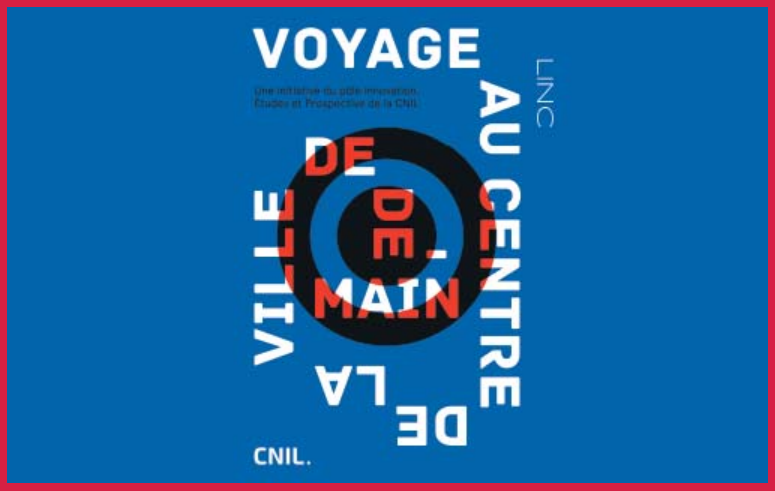

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The team focuses on three missions:
. explore emerging trends at the frontier between digital technologies, ethical issues and data
. exchange ideas and act as the main point of contact for innovation ecosystems (the team works with startups, labs and academics around those topics)
. experiment with innovation methods and produce or co-produce demos, proof of concepts and prototypes relating to privacy issues.

The team publishes on various topics (connected vehicles, chatbots, robotics, AI, connected objects, drones, digital health, algorithms, etc.). All articles are available from LINC (https://linc.cnil.fr/), the platform for CNIL's innovation and future-focused media.

The Platform of a City, the fifth IP Report, is an exploration of the issues related to smart cities and data uses in urban planning and services. It contains recommendations, in particular regarding the different tools that can be used in the future to create meaningful and controlled uses of personal data for general interest purposes.

KEYWORDS

- CIVIC TECHNOLOGY
- CHATBOT
- CYBERSECURITY
- FUTURE STUDIES
- MUNICIPAL GOVERNMENT

It's late 2027 and the residents of the city of Lille meet Marianne Reloaded, artificial intelligence in a civic bot that brings residents and elected officials closer together. Marianne is a harbinger of a new era of trust in politics. Launched by private company Civitar, its roots lie in a crowdfunded campaign that saw the city's inhabitants collectively fund and design the template. The people of Lille can now use the interface's instant messaging feature to pass on their opinions, complaints and suggestions directly to the city council, which can keep in touch with what people think with unparalleled ease and fluidity.

INTRODUCTION

Everyone is familiar with the term "Smart City." But what realities lie behind it? Smart cities have triggered intense international competition between all the big digital players and cities everywhere are competing to get in on the act. For smaller places, smart cities represent above all a chance to experiment with participative initiatives. These two approaches can appear mutually exclusive: one closed and top-down, the other open and flat with unlimited possibilities. But isn't the challenge of the smart city to find ways to make these two approaches coincide?

Seeking ways to answer this question and avoid a sterile debate of dichotomies, we decided to take an approach founded in imaginary worlds and works of fiction. Once the outline shape of our future cities was settled, two workshop sessions were held. Attended by leading figures and actors from urban ecosystems, experts, local government leaders and legal experts, they tried to imagine and design various fictional services that could nonetheless be realistic possibilities for 2027, as well as looking at the political and legal issues each raises.

The third scenario, titled Marianne Reloaded, takes place in the city of Lille in northern France and is intended to shine a light on the public debates, challenges and controversies surrounding the crowd-sourced city. It is 2027. In Lille, the end of the year is marked by the arrival of a new political reality, heralding a resetting of democratic processes. The new and more transparent form of city governance

has emerged from a process of co-construction involving local government and residents. The participation-driven component accounts for over a third of Lille's total budget and residents participate overwhelmingly in choosing spending for the year ahead. Driven by the emergence of ground-breaking technology initiatives, direct resident participation in the decision-making process is expanding constantly.

SOME INSPIRATION FROM SCI-FI

8th Wonderland, dir. Nicolas Alberny and Jean Mach (2010)
People create an ideal virtual state on the internet. They meet weekly via webcam, voting each time on a referendum to structure and regulate their community.

Octavia's Brood: Science Fiction Stories from Social Justice Movements (2015)
A collection of short stories exploring the links between speculative fiction and pacifist movements, offering readers utopian and dystopian visions of far-reaching social transformations put in place through innovative governmental structures.

Her, dir. Spike Jonze (2013)
Samantha is the female voice of an AI system that adapts to the character of every user. She draws the hero into a spiral of virtual love before abandoning him, alone and rudderless as he faces up to his emotions.

MARIANNE RELOADED: IDENTITY CARD

Company: Civitar (subsidiary of a leading provider of urban data visualization)

Target public: all users of public services in the city of Lille

Key functions: direct communication with the city council, organizing and catalyzing resident participation, helping to mediate between groups in the community, special interest groups and local actors

Technologies used: chatbots, holograms, sensors, augmented street furniture, integrated into the instant message services that are successors to WhatsApp, Messenger and the rest

Business model: the city pays a modular license fee to Civitar based on the amount saved thanks to recommendations from the civic bot

Delivery channel: push service via instant messaging apps and special booths scattered around the city

"BY COMPARING FEEDBACK FROM USERS WITH LOCAL ADMINISTRATIVE DATA AND INFORMATION GATHERED BY THE CITY'S SENSORS, THE COUNCIL IS ABLE TO OPTIMIZE ITS DECISION-MAKING PROCESSES IN REAL TIME, ANTICIPATING RESIDENTS' NEEDS DISTRICT BY DISTRICT."

It's late 2027 and the residents of the city of Lille meet Marianne Reloaded, artificial intelligence in a civic bot that brings residents and elected officials closer together. Marianne is a harbinger of a new era of trust in politics. Launched by private company Civitar, its roots lie in a crowdfunded campaign that saw the city's inhabitants collectively fund and design the template. The people of Lille can now use the interface's instant messaging feature to pass on their opinions, complaints and suggestions directly to the city council, which can keep in touch with what people think with unparalleled ease and fluidity.

As well as on smartphones, the service is delivered via dedicated booths where it presents as a hologram of a mature Marianne figure who talks directly with users. By comparing feedback from users with local administrative data and information gathered by the city's sensors, the council is able to optimize its decision-making processes in real time, anticipating residents' needs district by district.

In addition to an identity card for this imaginary service, as a way of describing the public policy issues, and in an attempt to highlight the controversies surrounding the use of tools and services of this type, we also wrote a fictional press article that gives a platform to the views of the service's critics and backers.

LILLE: RESIDENTS AND NIGHT OWLS AT LOGGERHEADS ON MARIANNE RELOADED

" The city of Lille's civic bot is a hot story in the popular press. Outrageous misuse of public funds or canny investment with real benefits for daily life? It's a game of table tennis where both sides justify their positions with equal vehemence.

Our revelations a few months ago about Civitar's spending sent shockwaves through the city. The company responsible for operating the Marianne

Reloaded civic bot was spending a third of its total budget on communications campaigns. Residents of Lille who had contributed to setting up the partially crowdfunded service were scandalized.

Aït Ben Lahcen, a long-time Civitar staffer, agreed to answer our questions. "You've got to put these revelations and their impact on public acceptance into perspective. Conflict between Civitar and the project's critics led by ALPB, an association of Lille's bar owners, are inevitable. Artificial intelligence gets a bad press. We wanted to answer people's anxieties proactively, communicating in ways that are completely open and transparent."

But residents who have already massively backed the project find this promotional zeal unconvincing.

"If I give money to a project it's because I support it. Trying to win me over now is looking at the issue entirely the wrong way round," complains Jeanine Fabre, who contributed money to the Marianne project.

"It's not so simple," replies Civitar's head of public affairs. "It's easy to get people interested in a novelty, but keeping them engaged over the long term is a different matter." A large part of the communications budget was spent on hackathons organized with the city council. The two days of intensive scrutiny, one focusing on the program's security, the other one on commercial uses for the data collected, are vital for oversight of a tool designed for and by the people of Lille.

These arguments fail to convince the project's detractors. Locals have used Marianne to complain about the noise made by beer drinkers in the city's bars. Marie-Christine Deckaert, president of ALPB and owner of a bar popular with students from the nearby university, feels fingers are being pointed as the result of "a vendetta of the small-minded" against her profession. The bar owner feels that "soulless technology" shouldn't be used to regulate problems with local residents. Although Marianne has been a draw for tourists, it seems mostly to have been a magnet for complaints. She bemoans the fact that "people with a complaint don't even bother talking to us about it anymore." She maintains that the civic bot has had an immediate negative impact on business and has filed a complaint with the police, claiming that local residents have gamed the system by making noises close to the noise nuisance sensors.

But Marianne sees a brighter future for all. It suggests restricting opening hours at the city's bar on examination nights, increasing the number of quiet nights for locals, and extending them on

days when local residents are traditionally absent from their homes. The exact shape of the proposed solution will depend on the data collected. Aït Ben Lahcen concludes on an optimistic note: "These teething troubles are simply a reflection of people's interest in seeing city services move to embrace artificial intelligence." ❞

We feel that this mini-scenario highlights four challenges to public policy and ethics that the potential roll-out of this type of service would entail:

- to what extent can public decision-making be automated?
- how to avoid hacking of machine-learning installations?
- what citizen controls to establish over these digital mechanisms?
- how to resolve the difference between private interests and the public interest?

SMART CITIES AND INNOVATIVE USES FOR PERSONAL DATA:

scenarios for using data to restore the balance between public and private spheres

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Geoffrey Delcroix manages innovation, research and foresight projects at the Department for Technology and Innovation of the French Data Protection Authority (CNIL). A graduate in political sciences, geopolitics and defense, Geoffrey Delcroix began his career as a consultant and researcher in the Futuribles team, an independent center for contemporary world study. He then headed up the foresight unit at the French Ministry of the Interior's foresight and strategy team before joining CNIL in 2011.

The team focuses on three missions:
- explore emerging trends at the frontier between digital technologies, ethical issues and data
- exchange ideas and act as the main point of contact for innovation ecosystems (the team works with startups, labs and academics around those topics)
- experiment with innovation methods and produce or co-produce demos, proof of concepts and prototypes relating to privacy issues.

The team publishes on various topics (connected vehicles, chatbots, robotics, AI, connected objects, drones, digital health, algorithms, etc.). All articles are available from LINC (https://linc.cnil.fr/), the platform for CNIL's innovation and future-focused media.

The Platform of a City, the fifth IP Report, is an exploration of the issues related to smart cities and data uses in urban planning and services. It contains recommendations, in particular regarding the different tools that can be used in the future to create meaningful and controlled uses of personal data for general interest purposes.

KEYWORDS

- OPEN DATA
- PERSONAL DATA
- INFORMATION COMMONS
- FREE FLOW OF DATA
- PUBLIC-PRIVATE PARTNERSHIP

In the face of the contradictory imperatives of the smart city — personalizing everything while respecting the right to privacy, optimizing without rejecting — and in response to the new landscape, particularly the arrival of major data companies, the challenge now is to produce new models for regulating city data, ones that respect individuals and their freedoms.

INTRODUCTION

How should data that offers powerful added value for the general interest, but is collected and used by private actors, be shared with public actors while respecting the rights of the businesses that collect and process the data as well as the rights and freedoms of the individuals concerned? This is the question that laws and public policies are currently trying to answer. Other sections in La plateforme d'une ville *(The Platform of a City, available online in French only[1]), published by the Innovation and Foresight unit at CNIL, the French data protection authority, describe how the digital city's new services rely increasingly on personal data that is collected and processed for commercial ends by private actors.*

This data, which does not fall within the natural ambit of a public service (whether directly managed, under concession, etc.), does nonetheless interact profoundly with issues of public service and can be invaluable in the delivery of a public service mission.

At present, a number of different tools are being developed by the various stakeholders in this debate. All these tools have serious limitations but also represent real opportunities. Each relies on achieving the right balance of rights and obligations between the various actors involved.

These tools can be characterized according to two features. First are the legal obligations they impose on private actors: among the four proposals described below, some could be rolled out within existing legislative frameworks whereas others would require new legislation before they could be put into practice. Then

1 https://linc.cnil.fr/la-plateforme-dune-ville-explore-les-enjeux-de-la-smart-city

comes the question of data granularity: in some cases very fine data, including personal data, is sent to the public actor; in others, the public actor can access data only once it is aggregated and anonymized.

In a previous report, Partage !*[2], we showed how a traditional regulatory model in isolation has little chance of being effective, and that a regulatory posture adapted to these platforms requires a new and more dynamic balance that would employ a palette of regulatory mechanisms, which would provide a range of levers to impact: the balance of power between actors (market); technical systems and architecture (technology and design); ground rules (regulator and standards); and, lastly, self-determination and returning power to the individual (empowerment).*

By combining the two features (legal obligations and data aggregation) with the four regulatory levers, we obtain a matrix of four distinct scenarios that represent as many possible futures, as alternatives or in combinations, for new forms of data sharing.

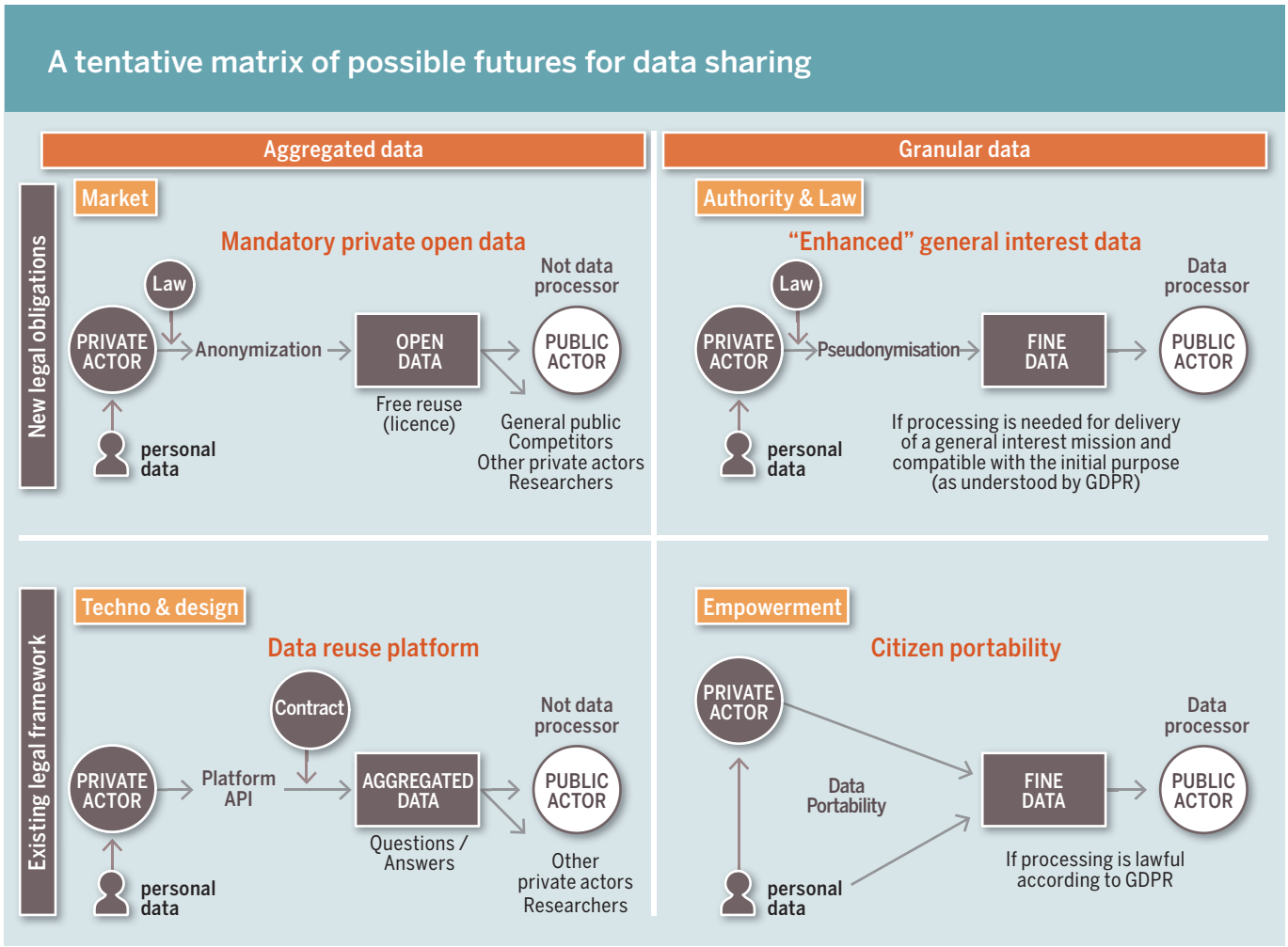
These scenarios offer different options for dividing the challenge of exploiting fine data and reassigning the capacity to take action in the general interest, redefining the balance of power between public and private actors within the realm of public service.

They differ in how they allocate responsibility for personal data protection, which can lie with either the private or the public actor. Whatever the scenario, the challenge is to establish best practices guaranteeing that the rights and freedoms of the people providing data are respected.

Without making any judgments about one or other of these mechanisms, setting out the basic structure of each and highlighting their potentialities serves to identify the questions raised in terms of protecting people's personal data.

2 See the Innovation & Foresight report *Partage ! Motivations et contreparties au partage de soi dans la société numérique* (Share! Motivations and counterparties to sharing the self in the digital society). In French only
https://linc.cnil.fr/fr/dossier-partage

A tentative matrix of possible futures for data sharing



GENERALIZING OPEN DATA FOR THE PRIVATE SECTOR

Acting on balances of power and creating the conditions for effective self-regulation might involve setting up mandatory private sector open data policies for data with proven impact on the efficient operation of the market or policies in the general interest.

Private actors would be under a legal obligation to provide open data access to certain data they hold, for example as provided for under two French laws, the so-called "Macron Act" and the Act for Energy Transition.[3] In order for this process to meet personal data protection requirements, in most cases implementation would involve anonymization processes that comply with certification requirements.[4]

The advantage of this mechanism is that data can be reused without restriction, by competitors, public bodies, researchers, citizens, etc. However, it is not without its drawbacks. Anonymization comes at a price: financial for the private actor and in terms of the loss of dataset information for other users; public actors will not have access, for instance, to the very fine data that contributes to the success of general interest missions. Private actors remain in control of the quality of the datasets retrieved.

EXTENDING GENERAL INTEREST DATA BEYOND PUBLIC SERVICE CONCESSIONS

To change the ground rules is to take the view that overriding higher interests justify delineating the intangible limits society has set on ethical and political subjects. In this scenario, the issue is allowing and regulating reuse of personal data by public actors for certain purposes in the general interest, but without infringing the rights of individuals. This would involve extending the scope and modalities of the emerging notion of general interest data. Currently, general interest data is limited in France to companies operating public service concessions. It would in this scenario be extended to private actors, with the exclusion of their contract relations with public authorities.

CNIL – Five BY Five – ©Léa Chassagne

This data is currently anonymized by the private actor prior to being made available as open data. The idea would be to open the way for certain fine data to be provided to public actors for public service missions; the public actors would then be responsible for data anonymization where it is made available as open data.

A balance of interests should make it possible to avoid harming the interests of a private actor that had invested in proprietary data processing and also to avoid violating individuals' right to privacy, as they would have consented to data processing within the context of a specific service. Public authorities become responsible for data processing and must respect all applicable rules (legal basis, purpose limitation, compliance to all data protection principles, etc.).

Such a mechanism would offer the advantage of resetting the balance of powers between certain private actors and public authorities, which would form an effective lever for successfully accomplishing general interest missions without any infringement of the rights of individuals. The drawback with this scenario is its burdensome nature: for private businesses obliged to restitute data and for public organization users responsible for personal data protection.

This scenario has a number of backers. In the wake of France's Act for a Digital Republic, which set out the broad lines, and the 2015 report on general interest data by the French Ministry of Economy[5], similar hypotheses have been developed by the European Commission in its work on the free flow of data[6] and in Luc Belot's report to the French parliament[7], which calls for the definition and identification of a "territorial interest data" category.

3 Act 2015-990, August 6, 2015, for Growth, Activity and Equal Economic Opportunities, and Act 2015-992, August 17, 2015, for Energy Transition for Green Growth

4 See Article 29, Working Party (European Union) 05/2014 opinion on Anonymization Techniques

5 CGEIET and IGF. Report on general interest data, September 2015. https://www.economie.gouv.fr/files/files/PDF/DIG-Rapport-final2015-09.pdf

6 Commission staff working document on the free flow of data and emerging issues of the European data economy. Accompanying a document on Building a European Data Economy, January 2017

7 Luc Belot. *De la smart city au territoire d'intelligence[s]*. Report to the prime minister on the future of smart cities, April 2017

PERMITTED REUSE UNDER CONTROL OF PRIVATE ACTORS

In regulatory terms, acting on systems and architectures is simply to keep step with current technical transformations in the data economy. This might involve using legal and technical measures to regulate the emergence of platforms for data access and sharing. Responses to open data, data lakes and mass anonymization might follow the API model, with data taps and differential privacy.

Private actors could use tools such as APIs etc., to set up a platform for reusing their data that would enable the reuser to exploit some data without actually processing it: the reuser would interrogate a database held by the private actor and receive only the answer, not the full dataset. Properly designed, such a system would enable rich data exploitation while minimizing the risks of infringing individual rights. In addition to anonymization, the platform could deploy two further types of tools:

- legal: a contract must govern what reusers may or may not do; for example, a clause prohibiting a partner from attempting to reidentify people and thereby compromise their anonymity, as well as clauses detailing how liability is to be apportioned;
- technical: real-time audits, controls, checks and log analyses to deliver dynamic risk analysis, for example to limit the chance of database inference attacks.

The advantage to private actors of such a mechanism, which would not need new legal obligations, is that they would not be required to open up their data en masse and would not have to bear responsibility for personal data protection. The drawback of this scenario is the cost to private actors of developing and maintaining a platform, although this could also offer new opportunities and revenue streams via the sale of anonymized data.

ENACTING CITIZEN PORTABILITY

The new regulations governing personal data protection offer everybody the opportunity to determine how their data is used and empower citizens to participate in missions of general interest.

The General Data Protection Regulation (GDPR) introduces a right to data portability that promotes the reuse of personal data by a new processor, without any obstruction by the initial processor, and under the exclusive control of the person concerned. This arrangement, which will enable users to migrate from one ecosystem of services to another (competing or not) bringing with them their own data might also enable them to opt in to citizen portability to benefit general interest missions.

Communities of users could exercise their portability rights in relation to a service in order to provide a public actor with access to their data for a specific purpose relating to a public service mission. The public actor is then responsible for data processing and is therefore also required to respect the principles of data protection.

Such a mechanism would have the advantage of creating new datasets for use in public service but without imposing new legal restrictions on private actors. The drawback for this scenario is the critical mass required as widespread acceptance and participation will be needed to constitute relevant datasets. The incorporation of simplified, innovative and non-restrictive opt-in systems should help ramp up participation levels.

"IN A MORE FUTURE-FORWARD VISION, A PROCESS SUCH AS THIS COULD LEAD TO BOTTOM-UP CREATION OF AN INFORMATION COMMONS, BUILT BY INDIVIDUALS IN THE GENERAL INTEREST. THIS WOULD ENTAIL BUILDING GOVERNANCE PROCESSES FOR THE INFORMATION COMMONS, PERHAPS IN THE FORM OF PUBLICALLY OWNED AND MANAGED LOCAL DATA CORPORATIONS."

In a more future-forward vision, a process such as this could lead to bottom-up creation of an information commons, built by individuals in the general interest. This would entail building governance processes for the information commons, perhaps in the form of publically owned and managed local data corporations.

CNIL takes the view that any adjustments to the balance of power between private and public actors concerning city management and intended to improve public policy must go hand in hand with greater oversight of public authorities. They will be required to adhere to GDPR[8] and specifically the notion of legitimate purpose in regard to reuse of the data provided.

REGULATION THROUGH THE COMMONS AND A DEDICATED GOVERNANCE STRUCTURE

In the face of the contradictory imperatives of the smart city—personalizing everything while respecting the right to privacy, optimizing without rejecting—and in response to the new landscape, particularly the arrival of major data companies, the challenge now is to produce new models for regulating city data, ones that respect individuals and their freedoms.

Innovative and efficient regulatory methods are an interesting area, for example commons-based production and governance of city data, with the establishment of new governance structures for

8 General Data Protection Regulation (GDPR) is the commonly used name for the European Union legal framework, adopted in 2016, on the protection of natural persons with regard to the processing of personal data and on the free movement of such data: http://data.europa.eu/eli/reg/2016/679/oj

this data. Adoption of these types of mechanisms would also deliver valuable tools for aligning with the European GDPR, for instance in terms of the core notion of consent.

DEFINING THE COMMONS

In 2014 Valérie Peugeot addressed the question of data in the smart city from the commons perspective, suggesting "moving beyond the strict boundaries of personal data to examine digital data as a whole [...] inspired by Elinor Ostrom's work [...] to develop a data sphere for the commons, by which is meant data that can be categorized as a collective resource, and that falls neither within the property regime managed by public authorities in the narrow sense, nor within the market system." The commons system relies on management of the relevant resource by a community, which structures its governance rules around what is termed a bundle of rights. Valérie Peugeot suggests extending the commons to data in the public sphere, data produced under share-alike licenses (Wikipedia, OpenStreetMap, etc.) and certain data produced by private businesses. To go further in the direction of commons-based production, it will probably ultimately have to include open data reference data and general interest data as defined in the Act for a Digital Republic and other public interest data as may be defined by future legislation. We could cite as an example data held by major data companies such as Waze, collected from users on a data-for-services basis.

These businesses, which claim to work in the general interest, would then cease to restrict the general interest to the sum of their clients' private interests, allowing public authorities access to reuse the data that they themselves exploit. The recommendations outlined above (extending the notion of the general interest data and activating citizen portability) could be of use in enabling this approach to develop.

This approach, based on the commons and moving beyond the open data mindset, has been gathering strength in recent years. CNNum (the French Digital Council), in an opinion issued in April 2017 on the free flow of data in the European Union, suggests mechanisms for data sharing[9]: "Member States could encourage different players to share their data on a voluntary basis in order to contribute to a research program, an industrial project or a public policy, either occasionally or on a long-term basis. The pooled data could be collected by a public body and be aggregated before being reused or redistributed [...]." Regarding general interest data held by the private sector, the report suggests invoking a general interest motive to require the data to be handed over, notably for the purposes of managing public sectoral policies, providing information to citizens, and economic development. There is no infringement on property rights where data is handed over only to public authorities or is reused for non-commercial purposes. In cases of reuse for commercial purposes, the report states that indemnity payments are the only solution that avoids structurally undermining private actors. And here we have one of the key challenges of the commons-based approach, which is currently relatively conceptual: there is undoubtedly an interest for the sum of all parties, but the gain for actors who are currently in a position of strength in terms of data is more uncertain. The aim is therefore to find a way to maximize value to society as a whole but without disincentivizing the actors responsible for creating this new data.

GOVERNING THE COMMONS TO BETTER PROTECT PERSONAL DATA

Commons for the city cannot be constituted without establishing modes of data governance. In its opinion, CNNum gives the sectoral example of the US Bureau of Transportation Statistics, which aggregates air traffic data from US airlines. But others go further, suggesting trusted third party actors for a given territory, which would offer shared governance tools able to enforce compliance, particularly with personal data protection rules. This is the type of model put forward by Datact in the form of its publically owned and managed local data corporations (*Régies de données*)[10], third-party legal entities with governance shared between the city as public actor and its various stakeholders—a true commons of the city but also a data interrogation and processing system allowing data flows to the various actors requiring them to be opened and closed on demand. This third-party actor would facilitate data flows between the various stakeholders, acting as a hub and monitoring the admissibility of data processing purposes. It would also ensure that applicable licenses were respected and personal data protected by providing mechanisms for registering consent.

Such an arrangement would also make it possible to move beyond the mindset of automatic anonymization of city data. It would be possible, as proposed by the Open Algorithms project[11], to allow certain actors to use data without possessing it and in full compliance with the rights of individuals. A management tool of this kind would offer the advantage of opening up city data and resetting the balance of power between the public actor and private actors not bound by contracts to the public sector. It would provide interested small businesses, collectives, residents and non-profits with a means to reappropriate ownership of the city commons, and most importantly it would allow data reusers that wished to process personal data to ask for explicit informed consent from the individuals concerned.

9 CNNum, Opinion of the French Digital Council on the Free Flow of Data in the European Union, April 2017, (in English) https://cnnumerique.fr/wp-content/uploads/2017/05/OpinionCNNum_FFoD_ENG-1.pdf

10 *Concevoir une régie de données territoriales - Vers une nouvelle fabrique de services urbains*, (Designing publically owned and managed local data corporations - Towards new methods for imagining city services), dossier produced by Le hub, Chronos and Datact, in *La gazette des communes*, May 2014

11 http://www.opalproject.org

SOLVING ARTIFICIAL INTELLIGENCE'S PRIVACY PROBLEM

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We are unlikely to see any 'general AI'—machines that could learn the way we do and successfully perform a large range of task—anytime soon

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KEYWORDS

- PRIVACY
- DATA ANONYMIZATION
- PSEUDONYMIZATION
- DE-IDENTIFICATION
- LARGE DATA-SETS
- IDENTITY
- K-ANONYMITY
- UNICITY

Artificial Intelligence (AI) has potential to fundamentally change the way we work, live, and interact. There is however no general AI out there and the accuracy of current machine learning models largely depend on the data on which they have been trained on. For the coming decades, the development of AI will depend on access to ever larger and richer medical and behavioral datasets. We now have strong evidence that the tool we have used historically to find a balance between using the data in aggregate and protecting people's privacy, de-identification, does not scale to big data datasets. The development and deployment of modern privacy-enhancing technologies (PET), allowing data controllers to make data available in a safe and transparent way, will be key to unlocking the great potential of AI.

INTRODUCTION

A world we could have only envisioned a few years ago is becoming a reality. Cars are learning how to drive themselves and are expected to heavily reduce traffic accidents and transform our cities[1]. Machine learning algorithms have started to reshape medical care and research. Physicians are already using them to identify high-impact molecules for drug development[2] and to accelerate skin cancer diagnosis, reaching an accuracy on-par with dermatologists in the lab[3]. A recent report by McKinsey found that 45 percent of all work activities could soon be automated using artificial intelligence (AI)[4]. AI is changing our economy and will have a radical impact on how we work, live, and interact.

Developing solutions allowing AI algorithms to learn from large-scale, often sensitive datasets, while preserving people's privacy is one of the main challenges we are facing today.

1 https://www.wired.com/2016/10/heres-self-driving-cars-will-transform-city/

2 https://www.technologyreview.com/s/604305/an-ai-driven-genomics-company-is-turning-to-drugs/

3 Esteva, A., Kuprel, B., Novoa, R. A., Ko, J., Swetter, S. M., Blau, H. M., & Thrun, S. (2017), Dermatologist-level classification of skin cancer with deep neural networks. *Nature, 542* (7639); 115-118.

4 McKinsey Global Institute (2016), The age of analytics: Competing in a data-driven world, *McKinsey.*

However, despite what the popular press would have us believe, AI bears very little resemblance to human intelligence (or Skynet for that matter). This is unlikely to change anytime soon. Instead, experts in its most popular branch, machine learning, have spent decades training a large ecosystem of advanced statistical models to **learn from data**. These are crafted for specific tasks such as inferring human emotions from text messages[5]; e.g. if a certain combination of words express a positive, negative or, neutral tone; or detecting and classifying cancerous lesions in pictures the way a dermatologist would. We are unlikely to see any 'general AI' — machines that could learn the way we do and successfully perform a large range of task — anytime soon[6]. Access to rich and large-scale datasets will thus be crucial to the development of AI in the coming decades.

This is particularly visible when considering the latest "advance" in AI: Deep Learning. Techniques very similar to Deep Learning (i.e. Deep Neural Networks), have been around for a long time. Neural Networks date back to the 1950s, and many of the key algorithmic breakthroughs occurred in the 1980s and 1990s. While the increase in computing power[7], in particular the advent of GPUs, has contributed to the recent success of deep learning, most of the increase in accuracy is arguably due to the availability of large-scale datasets[8]. As in Peter Norvig's seminal article in 2009[9], one can notice the unreasonable effectiveness of data: corpora of millions of speech records, hi-res images, and human metadata.

Other examples include the use of large-scale Facebook data to build "psychometric profiles" of 220M American citizens by Cambridge Analytica[10]. Their work in identifying an individual's gender, sexual orientation, political beliefs, and personality traits has been credited to have influenced the 2017 US presidential elections[11]. However, the research that underpins part of their work[12] as well as a lot of the analysis that has been made public[13] is fairly simple technically. Here again good accuracy e.g. on personality traits could be achieved with a lot of data and a simple linear regression.

While fueling fantastic progress in AI, this data and its collection and use by AI algorithms also raises privacy concerns that need to be addressed. The vast majority of this data, such as Facebook Likes, is personal. Produced by individuals going through their daily lives: making calls, visiting the doctor, using the GPS on their phone or car, etc. it contains detailed and often sensitive information about people's behavior, medical conditions, travel habits, and lifestyles and can be used to infer further information.

"DEVELOPING SOLUTIONS ALLOWING AI ALGORITHMS TO LEARN FROM LARGE-SCALE, OFTEN SENSITIVE DATASETS, WHILE PRESERVING PEOPLE'S PRIVACY IS ONE OF THE MAIN CHALLENGES WE ARE FACING TODAY."

AI has immense potential for good but the continuous access to always larger and richer datasets it requires will only be sustainable if this can be done while preserving people's privacy. Developing solutions allowing AI algorithms to learn from large-scale, often sensitive datasets, while preserving people's privacy is one of the main challenges we are facing today.

Historically, the balance between using the data and preserving people's privacy has relied, both practically and legally, on the concept of data anonymization. Data anonymization is achieved through a series of techniques used to disassociate an individual's record from their identity in a particular dataset. If the data cannot be associated with the individual to whom it relates, it cannot harm that person.

In practice, datasets are rendered anonymous through a combination of pseudonymization and anonymization (also called de-identification). The former, pseudonymization, is the process of replacing clear identifiers, such as names or account numbers, by pseudonyms. This is only the first line of defence as pseudonymization alone has been shown to not be sufficient. In the late 1990s, the Massachusetts Group Insurance Commission released "anonymized" data containing every hospital visit made by state employees. The then governor of Massachusetts, William Weld, assured that GIC had protected patient privacy by deleting identifiers. By using the public electoral rolls of the city of Cambridge, MIT student Latanya Sweeney was able to re-identify (linking data back to a person) the medical records of the governor using his date of birth, sex, and postcode and sent his medical records to his office[14].

The second line of defence, de-identification, was then developed to prevent re-identification, allowing once again for data to be used while preserving people's privacy. The first de-

5 Liu, B., 2012. Sentiment analysis and opinion mining. *Synthesis lectures on human language technologies*, *5*(1), pp.1-167.

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12 Kosinski, M., Stillwell, D. and Graepel, T., 2013. Private traits and attributes are predictable from digital records of human behavior. *Proceedings of the National Academy of Sciences*, *110*(15), pp.5802-5805.

13 https://medium.com/@d1gi/cambridge-analytica-the-geotargeting-and-emotional-data-mining-scripts-bcc3c428d77f

14 Sweeney, L., 2000. Simple demographics often identify people uniquely. *Health (San Francisco)*, *671*, pp.1-34.

identification criteria, k-anonymity[15], and an algorithm to achieve it, were proposed directly after Latanya Sweeney's attack. A dataset is said to be k-anonymous if no combination of user attributes (e.g. year of birth, sex, and postcode) are shared by fewer than *k* individuals. This makes it impossible to uniquely identify a specific person in the dataset as any information collected will always lead us to a group of at least *k* individuals. Datasets can be modified in various ways to make them k-anonymous: values in the dataset are coarsened (e.g. by recording the age range of a person rather than their exact age), certain attributes (columns) or users (rows) can be removed, etc. These principles of generalisation and deletion along with others underpin all algorithms designed to enforce k-anonymity. Extensions of k-anonymity, such as l-diversity[16] and t-closeness[17], have furthermore been proposed to protect against more complex inference attacks.

This combination of pseudonymization and de-identification worked quite well for about 15 to 20 years. However, modern datasets, and especially the datasets used by AI, are very different from those used in the mid 90s. Today's datasets, coming from phones, browsers, IoT, or smart-cities, are high-dimensional: they contain for each individual hundreds or thousands of pieces of information about him and the way he behaves. Mobile phone metadata contain all the places where an individual has used their phone, sometimes for years. Web browsing data contain every single pages you have visited while a human genome is composed of approx. 21,000 genes.

This fundamentally changes the ability of anonymization methods to effectively protect people's privacy while allowing the data to be used. Following several high-profile re-identification of behavioral datasets[18] [19], the concept of unicity was introduced in 2013 to evaluate the effectiveness of anonymization in modern datasets. Unicity, estimates the fraction of users that are uniquely identified by a number of randomly chosen pieces of information an adversary could have access to. A study based on mobile phone metadata, showed that just 4 points—approximate times and places—are sufficient to uniquely identify 95% of people in a dataset of 1.5 million individuals[20]. This means that knowing where and when an individual was a mere 4 times in the span of 15 months is, on average, sufficient to re-identify them in a simply anonymized mobile phone dataset, unraveling their entire location history.

Originally obtained in a European country, these results have now been replicated several times. A 2015 study looks at a dataset of 1M people in Latin America[21] while another replicates the results on a dataset of 0.5M individuals in a third country[22]. In 2015, the same methodology was applied to bank transaction data (credit and debit cards). This study, published in Science, concluded that 4 points — date and place of a purchase—were here again sufficient to uniquely identify 90% of people among one million credit card users[23].

While pseudonymization and simple anonymization utterly fail to protect people's privacy could generalisation, deletion, and other methods throw people off the scent again? Unfortunately, for both mobile phones and credit cards data, the answer is a resounding 'no'. The same is likely to be true for other large-scale behavioral datasets such as browsing, IoT data etc. The above studies demonstrate that adding noise or reducing the spatial or temporal resolution of data makes identification only marginally more difficult. Indeed, even in a very low-resolution mobile phone dataset[24], 10 points are enough to find a person more than 50% of the time[25]. Surprisingly perhaps, in the credit card study, knowing just 10 instances of when an individual has visited any one of 350 stores in a two-week period would result in a correct re-identification 80% of the time[26]. Deletion has mathematically the same marginal effect on the likelihood of re-identification.

These results has let researchers to conclude that "*we have currently no reason to believe that an efficient enough, yet general, anonymisation method will ever exist for high-dimensional data, as all the evidence so far points to the contrary. The current de-identification model, where the data are anonymised and released, is obsolete*"[27]. An opinion shared by President's [Obama] Council of Advisors on Science and Technology who concluded that anonymisation "*is not robust against near-term future re-identification methods. PCAST does not see it as being a useful basis for policy*"[28].

15 Sweeney, L. (2002). k-anonymity: A model for protecting privacy. *International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems, 10*(05), 557-570.

16 Machanavajjhala, A., Gehrke, J., Kifer, D., & Venkitasubramaniam, M. (2006, April). l-diversity: Privacy beyond k-anonymity. In *Data Engineering, 2006. ICDE'06. Proceedings of the 22nd International Conference on* (pp. 24-24). IEEE.

17 Li, N., Li, T., & Venkatasubramanian, S. (2007). t-closeness: Privacy beyond k-anonymity and l-diversity. In *Data Engineering, 2007. ICDE 2007. IEEE 23rd International Conference on* (pp. 106-115). IEEE.

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21 U.N. Global Pulse. Mapping the risk-utility landscape of mobile phone data for sustainable development & humanitarian action, 2015.

22 Yi Song, Daniel Dahlmeier, and Stephane Bressan. Not so unique in the crowd:a simple and effective algorithm for anonymizing location data. ACM PIR, 2014.

23 de Montjoye, Y. A., Radaelli, L., & Singh, V. K. (2015). Unique in the shopping mall: On the reidentifiability of credit card metadata. *Science*, *347*(6221), 536-539.

24 With the resolution reduced by a factor of 15 both temporally and spatially, approx. 15km² and 15 hours.

25 de Montjoye, Y. A., Hidalgo, C. A., Verleysen, M., & Blondel, V. D. (2013). Unique in the crowd: The privacy bounds of human mobility. Scientific reports, 3, 1376.

26 de Montjoye, Y. A., Radaelli, L., & Singh, V. K. (2015). Unique in the shopping mall: On the reidentifiability of credit card metadata. Science, 347(6221), 536-539.

27 de Montjoye, Y-A and Pentland, A, Response to Comment on "Unique in the shopping mall: On the re-identifiability of credit card metadata", 351, 6279, 1274--1274 (2016)

28 https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/PCAST/pcast_big_data_and_privacy_-_may_2014.pdf

To make the matter worse, modern datasets are not only impossible to anonymize but also extremely rich. In the past, it was sufficient to look through the data to assess the potential damage of re-identification (e.g. whether these are medical records or fairly innocuous data). Sometimes sensitive information could even be removed to make the data "non"-sensitive (e.g. removing the fact that people might have watched specific movies). As we have seen in the Cambridge Analytica example, this doesn't work anymore with modern high-dimensional datasets. Their richness means that the sensitivity of the dataset might not be directly visible but instead come from what can be inferred from it. To assess the sensitivity of the data, one would needs to guess what an algorithm could possibly infer about an individual from his data, now or in the future. For instance, it has been shown that personality traits[29], demographics[30], socioeconomic status[31,32], or even loan repayment rates[33] can all be predicted from seemingly innocuous mobile phone data. This "risk of inference" in big data renders comprehensive risk assessments incredibly challenging — some would say impossible — to perform.

With the traditional de-identification model failing us how do we move forward training machine learning models on large-scale datasets in a way that truly preserves individuals' privacy?

Back in the 90s, when the first de-identification algorithms were developed, data transfer was exceedingly costly. Anonymizing the dataset once and for all and sending a copy of it to the analyst was the only feasible solution. 20 years later with internet, the cloud, and arrays of GPU powered machines, this is no longer the case. Data controllers can easily grant remote, tightly controlled and monitored access to datasets for training purposes instead of sharing the "anonymized" raw records — bringing algorithms to the sensitive data instead of the sending data to the algorithms.

For example, the OPen ALgorithms (OPAL) project[34], recently funded by the French Development Agency (AFD), is based on this framework. Led by the Computational Privacy Group at Imperial College London, in partnership[35] with Telefonica and Orange, OPAL aims to allow third parties to safely use the geolocation data through a questions-and-answers model. In short, the platform allows third-parties, such as researchers, to submit algorithms that will be trained on the data. The privacy of individuals is ensured through a series of control mechanisms put in place. For example, the platform validates the code before training the model; it ensures that only aggregated results sometimes with a little bit of noise are returned[36], ensuring that no single individual can be identified; and it records every interaction in a tamper-proof ledger ensuring auditability of the system. The combination of access-control mechanisms, code sandboxing, aggregation schemes, etc allows OPAL to guarantee that data is being used anonymously by machine learning algorithms and that even if the data itself is only pseudonymous.

Recognizing the issue, several other privacy-enhancing technologies (PET) are being developed to allow datasets to be used in a privacy-conscientious way through a mix of access-control, security based, and auditing mechanisms. Google's DeepMind is, for instance, developing an auditable system to train machine learning algorithms on individual-level health data records from the National Health Service[37] in the UK. Their 'Verifiable Data Audit' ensures that any interaction with the data is recorded and accessible to mitigate the risk of foul play. The French government also developed a similar solution, the Secure Data Access Centre (CASD)[38], to allow researchers to build statistical models using public surveys and national censuses through remote access and smartcard technologies.

AI and machine learning could revolutionize the way we work and live. Their potential is however crucially dependent on access to large and high-quality datasets for algorithms to be trained on. The way we have historically found a balance between using the data in aggregate and protecting people's privacy, de-identification, does not scale to the big data datasets used by modern algorithms. Moving forward, it is both crucial for our algorithms to be trained on the best available datasets out there and to do so in a way that truly protects the privacy of the individuals. The successful future of AI requires us to rethink our approach to data protection. Solutions like OPAL are at the forefront of this effort, forming the bedrock of safely using large-scale sensitive data for the public good.

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30 Felbo, B., Sundsøy, P., Pentland, A. S., Lehmann, S., & de Montjoye, Y. A. (2015). Using deep learning to predict demographics from mobile phone metadata. *arXiv preprint arXiv:1511.06660*.

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35 *Other partners include: Data-Pop Alliance, MIT and the World Economic Forum*

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37 Suleyman, M., Laurie, B, (2017), Trust, confidence and Verifiable Data Audit, *DeepMind Blog*, https://deepmind.com/blog/trust-confidence-verifiable-data-audit.

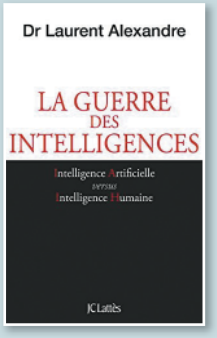
38 Centre d'accès Sécurisé aux Données, CASD, https://casd.eu/en.

"THE COMBINATION OF ACCESS-CONTROL MECHANISMS, CODE SANDBOXING, AGGREGATION SCHEMES, ETC. ALLOWS OPAL TO GUARANTEE THAT DATA IS BEING USED ANONYMOUSLY BY MACHINE LEARNING ALGORITHMS AND THAT EVEN IF THE DATA ITSELF IS ONLY PSEUDONYMOUS."

THE GEOPOLITICS OF AI AND ROBOTICS

Interview of Laurent Alexandre
by Nicolas Mailhe

In this interview, Laurent Alexandre explores the geopolitical issues raised by the rise of AI and robotics. He takes a harsh view of how Europeans have fallen behind in this sphere, and paints a picture of a new type of conflict.



Laurent Alexandre is a urological surgeon and co-founder of the Web Doctissimo site. He is fascinated by the issues raised by artificial intelligence, robotics and transhumanism. His latest book, *La Guerre des Intelligences* (JC Lattes, 2017), has just been published. His previous publications are *Les robots font-ils l'amour ?: le transhumanisme en 12 questions* (Dunod, 2016), and *La Mort de la Mort* (JC Lattes, 2011)[1].

1 The War of Intelligence; Do Robots Make Love? Transhumanism in 12 Questions; Death of Death.

KEYWORDS

- ARTIFICIAL INTELLIGENCE
- ROBOTICS
- GEOPOLITICS
- DIGITAL GIANTS
- NEUROTECHNOLOGY
- AUGMENTED INTELLIGENCE
- EDUCATION
- EUGENICS
- TRANSHUMANISM
- GAFAMI
- BATX
- INDUSTRIAL STRATEGY

Nicolas Miailhe: We're hearing a lot about an artificial intelligence revolution. What exactly is it?

Laurent Alexandre: A combination of vast databases, increasingly powerful computers and machine-learning algorithms, produced mainly by the American and Chinese digital giants, has accelerated the progression of artificial intelligence at a speed that's surprised even its promoters, the heads of Google, Apple, Amazon, Facebook, Microsoft and IBM. Google and Facebook, in particular, didn't see it coming. The first industrial revolutions were a challenge to our bodies, while AI focuses on our minds.

"THE FACTOR THAT IS GOING TO RADICALLY STEP UP THE AI TSUNAMI OVER THE NEXT 20 YEARS IS THE DEVELOPMENT OF BRAIN-COMPUTER INTERFACES. THIS CRUCIAL NOTION HAS BEEN SEIZED ON BY SILICON VALLEY, PARTICULARLY ELON MUSK WITH THE LAUNCH OF HIS NEW STARTUP, NEURALINK."

N.M.: What power issues are linked to this major revolution?

L.A.: The industrialization of intelligence, whether biological or artificial, is turning the very foundations of political and social organization upside-down. The production of intelligence will be the source of all forms of power in the future. The battle for control over semi-strong AI will become key. It will ensure victory in industrial battles—there are no longer any sectors that do not depend on it. The example of the automobile industry's self-driving car is just the beginning. Medicine is undergoing a revolution, with doctors taking a subsidiary role to computers. The same applies to banking and even agriculture. Semi-strong AI will also make it possible to paralyze an adversary by immobilizing their economy and army. The fact is that we don't know how to regulate the geopolitical competition that will drive us to use AI to take a leadership role, regardless of the risks. Regulating AI will become a crucial challenge for international law, and will transform geopolitical strategies.

N.M.: Will machines become more intelligent than humans?

L.A.: Artificial intelligence is a very important theme for the future of humanity, but if you ask the top one hundred specialists about it, their opinions differ hugely! There's never been such a lack of consensus among experts in the whole history of technology.

Elon Musk, the inventor of Tesla and Space X, is pessimistic and worried, as is Jack Ma from China, the founder of online retail store Alibaba. Tim Cook, the head of Apple, and Facebook's Mark Zuckerberg, on the other hand, never refer to the risks of AI. IBM's senior management also takes a reassuring line and denies that it could acquire human capacities.

N.M.: What's the "new frontier" for AI?

L.A.: The factor that is going to radically step up the AI tsunami over the next 20 years is the development of brain-computer interfaces. This crucial notion has been seized on by Silicon Valley, particularly Elon Musk with the launch of his new startup, Neuralink. The idea is to insert devices via veins in the neck and avoid opening the cranium. The devices are designed to position themselves between the neurons and veins so they can boost the neurons and provide access to databases or the cloud. If Elon Musk wants to win the battle of the self-driving car, he has to call on artificial intelligence. He sees the possibility of a fusion between human and machine as the only solution. He believes there's no future for the neuronal brain: only a mixed brain will be able to survive.

N.M.: With what geopolitical consequences?

L.A.: Further down the line, we'll discover a new geopolitical reality corresponding to this new neuro-technological complex. And worthy sentiments risk losing us the battle. A variation on the slogan "jobs for robots, life for us" proposes task specialization. Technical professions are likely to become the exclusive domain of artificial intelligence, with humans in charge of activities requiring empathy, care and kindness: "the data tsunami for them, love for us" seems to be a sensible approach. Since we can't compete in terms of computing power, we'll turn our focus to

managing emotions. For example, in medicine this will mean that we'll let AI process the billions and billions of biological data, particularly genetic data for treating children with leukemia, while the nice nurses will be able to develop their people skills further than they can today.

The situation between AI and us is equivalent to the Ricardian law of specialization, known as the law of comparative advantage, posited by David Ricardo in 1817 based on the wine and textile trade between Portugal and England. Concentrating on what we do best is rational from a microeconomic viewpoint, but dangerous if we specialize in an area that is fragile or likely to diminish our technological and thus our geopolitical power. Holding the hands of sick children is of course fundamental, but it should not lead us to overlook another battle: the fight for neuro-technological power.

N.M.: So what will 21st century geopolitics look like in the light of AI and robotics?

L.A.: Eventually geopolitics will no longer be territorial—China against California, India against China, etc.—but will reside mainly in the neuro-technological complex. We need to prepare ourselves for fierce power battles inside the huge complex that will link our brains to the AI embedded in the internet. There will be plots, power grabs, secessions, manipulations, traitors and malevolence that will make the Wannacry and Petya viruses of spring 2017 seem harmless in comparison. Right now, AI is non-existent in psychological and emotional terms, but this is a temporary situation and should not lead us to specialize human brains in "care" and abandon the neuro-technological field to silicon brains: it would be as suicidal as having your defense industry specialize in producing fireworks during the atomic bomb era.

As shocking as it may seem to my generation, the battle within the neuro-technological complex will become key to our survival as a biological species. Evidently, the kindness of pediatric nurses is essential, but it would be suicidal if the whole of humanity specialized in the emotional sphere. It's unlikely that AI will always remain aligned with us and instilled with Judeo-Christian ethics. We have to be kind, it's the basis of our humanity. But that's not all there is. The *Game of Thrones* of the neuro-technological complex will be no less violent than the TV version: ensuring that our biological humanity still plays a role in it implies knowing how to do something other than stroking the cheeks of sick children. No digital Maginot line will protect us lastingly if we're weak. Ricardo was right in 1817; he couldn't be more wrong in 2017.

Humanity's capacity to unite on the basis of common values, shared progress and the refusal to entrust everything to silicon brains is our life insurance against the emergence in 20, 200 or 2,000 years of hostile and malevolent forms of AI.

N.M.: Let's look at some less dramatic issues. Can we really regulate AI development?

L.A.: Competition between businesses and between states means that we can't bring AI research to a halt. This makes the possibility of regulation extremely complicated. Elon Musk recently issued a stark warning about AI and demanded strong American regulation, but the Trump administration doesn't seem particularly concerned by the issue, preferring to focus on growth and employment. However, and most importantly, the immediate reaction from several Silicon Valley bosses was to say that it would mean the USA leaving the field clear for China to become the leading world power.

N.M.: But our societies don't really seem ready for this revolution...

L.A.: A debate is emerging over unemployment and jobs along the lines of "AI and robots are going to replace people." This is not a rational fear in the short term, for at least two reasons. The first is that it assumes we will immediately have multi-purpose robots, which won't be the case on a large scale before 2030 at the earliest. Repetitive industrial jobs are indeed under threat, but it will be many years before we see the widespread availability of multi-purpose robots capable of replacing a cleaner. Unlike the AI development trajectory — which can appear explosive as Moore's law continues to hold sway, driven by the ongoing progress of nanoelectronics — robots have developed on a more linear path. The second reason is that we're deluding ourselves, as usual, if we believe that automatization will result in the end of work: a wealth of new professions are still to be invented. In 1930, the mayor of Palo Alto, in California, wrote a letter to the US president, Herbert Hoover, imploring him to take measures to regulate the technology that was going to destroy American society and jobs. We know what happened next: Palo Alto became the epicenter of Silicon Valley and thus of the world economy.

N.M.: Does that mean we can hope that AI produces a new wave of "creative destruction" that generates more jobs than it destroys?

L.A.: Just like with the previous industrial revolutions, we can imagine which professions will disappear; drivers, for instance. But we can't tell what tomorrow's professions will be. There are plenty of examples of professions today we wouldn't have dreamed of 30 years ago: digital marketing, webmasters, app developers, and so on. By definition, we can't know the professions of the future. If we could, entrepreneurs would already have grabbed the opportunity! It's also true that our societies think in terms of a status quo, without seeing that we will be able to use AI to do new things in the decades and centuries to come: conquer the cosmos, delay death, augment our brains, etc.

N.M.: Can we expect inequalities to soar?

L.A.: Since AI will be cheap whereas human intelligence is expensive, the least talented and least innovative people risk being left behind. So reducing inequalities depends on reducing intellectual inequalities. And the best way to do it is by using traditional methods: education and training. But it won't be enough. I'm convinced that we'll use technology to enhance our intellectual capacities. Democracy will not survive if the current gaps between IQ and intellectual capacities persist. In a society where AI is practically free, there's room for people who are flexible, enterprising and creative. And not everyone is! It's not politically correct to say so, but it's a reality. The least talented people will struggle significantly and we will need to help them.

N.M.: Should the domination currently being established by the Chinese and Americans in the AI race be a concern to Europeans?

L.A.: France and Europe have become digitally dependent: today we're dependent on the USA, tomorrow it'll be China. We mustn't bury our heads in the sand. We export our best minds to the USA — such as Yann Le Cun, Facebook's AI director, a Frenchman educated in France — and import AI via our smartphones each time we use our favorite apps. We won't make any progress if we continue to fail, whine and put in place legislation that offers consumers a very high level of protection but is hostile to manufacturers. We have to face facts: if we're a digital Cinderella, it's not because of a global plot or the digital giants cheating. It's because the giants are excelling and we're lousy. For the last 30 years, we Europeans have been blind to the internet and AI revolution. It's been 20 years of governments and regulatory authorities like the CNIL *[French National Commission for Data Protection and Liberties]*, which fail to understand that a major revolution is under way. Our US and Chinese competitors, on the other hand, have a perfect grasp of the situation and have rolled out a coherent model. They're very determined. As for us, we have 28 pieces of separate legislation, equivalent to 28 CNILs. We have always prioritized consumer protection to the detriment of building up an industrial base capable of launching us into the digital revolution. If we prevent European firms from creating, exploiting and monetizing industrial-scale databases, we will never have powerful AI players, because machines need data to learn. And AI and robotics are inextricably linked. We shouldn't fool ourselves.

N.M.: How can Europe catch up?

L.A.: I'm convinced that making way for a new generation is vital. At the very least, we have to stop having political leaders who don't understand anything about technology and the data economy. Jean-Claude Juncker, the European Commission president, boasted earlier this year that he doesn't have a smartphone. Honestly, how are we meant to get anywhere like that? Until Europe appoints a geek at its head, we're not likely to have an adequate governance model. We need to climb out of the hole of denial we're in, assess the situation efficiently and get to work. Otherwise we'll go under!

N.M.: Is our legislative model too restrictive?

L.A.: The French and Europeans have based their thinking on the idea that any AI produced by IT services companies would be code-based. We have consistently failed to grasp that large consumer-focused platforms harvesting vast amounts of data are what's needed. But we don't have any. We do, of course, have some successful IT companies, like Atos, but they are still far removed from the end user and so don't harvest the necessary wealth of data. If Europe wants to produce AI, it needs to provide its industrial players with the means to harvest and exploit billions of data items. It has been concerned exclusively with consumer protection and competition law without ever really trying to create a large single market for data.

N.M.: So your solution is based on two actions, liberalizing the data market, and radically changing our education and training models, is that it?

L.A.: Exactly, on a Europe-wide scale. Europe is in a state of relative decline, whereas it was the world center of telecoms just 15 years ago! It has trouble understanding that it's being left behind by history and losing its power. In France, when people discuss Google and its omnipotence, the main question they ask is where the company is paying its taxes. The real challenge is to create European digital giants. Protectionist solutions are no good.

THE EXPANSION OF ALGORITHMIC GOVERNANCE:
From Code is Law to Law is Code

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KEYWORDS

- CODE-IS-LAW
- BLOCKCHAIN
- SMART CONTRACTS
- CRYPTOCURRENCIES
- SELF-GOVERNING
- PROTOCOLS

"Code is law" is a form of regulation whereby technology is used to enforce existing rules. With the advent of Blockchain and Machine Learning, we are witnessing a new trend, whereby technology is progressively taking the upper-hand over these rules.

INTRODUCTION

We are spending increasing amounts of our lives interacting within platforms, whose user base belittle that of existing nation states. And yet, their governance is very far from the values of democratic countries. Instead, they are governed by software and algorithms that regulate our interactions. As put by Lessig, "Code is Law", a form of regulation where private actors may embed their values into technological artifacts, effectively constraining our actions. Today, code is also used by the public sector as a regulatory mechanism. This brings a variety benefits, mostly related to the ability to automate the law and to enforce rules and regulations a priori, i.e. before the fact. Yet, regulation by code also comes with important limitations and drawbacks that might create new issues related to fairness and due process. Blockchain technology comes with many newfound opportunities of turning law into code. By transposing legal or contractual provisions into a blockchain-based "smart contract" with a guarantee of execution, these rules are automatically enforced by the underlying blockchain network and will, therefore, always execute as planned, regardless of the will of the parties. This, of course, generates new problems related to the fact that no single party can affect the execution of that code. With the widespread adoption of Machine Learning, it is possible to circumvent some of the limitations of regulation by code. ML allows for the introduction of code-based rules which are inherently dynamic and adaptive, replicating some of the characteristics of traditional legal rules characterized by the flexibility and ambiguity of natural language. However, the use of ML in the context of regulation is not devoid of any drawback: data-driven decision making has shown implicit bias that discriminate minorities, and ML-driven laws may damage traditional principles such as universality and non-discrimination.

I. FROM CODE IS LAW TO LAW IS CODE

We are spending increasing amounts of our lives interacting within platforms, whose user base belittle that of existing nation states, e.g. Facebook enjoys more than 2 billion users, Youtube 1 billion, and Instagram 700 million users. And yet, their governance is very far from the values of democratic countries. Instead, they are governed by software and algorithms that regulate our interactions and online communications through obscure rules embedded in source code, and elaborated by a handful of private actors.

The digital environment opens up the doors to a new form of regulation — by private actors — which might try to impose their own values by embedding them into a technological artefact. As stated by Lessig (1999), "Code is Law": code is ultimately the architecture of the Internet, and — as such — is capable of constraining an individual's actions via technological means.

As more and more of our interactions are governed by software, we increasingly rely on technology as a means to directly enforce rules. Indeed, as opposed to traditional legal rules, which merely stipulates what people shall or shall not do, technical rules determine what people can or cannot do in the first place. This eliminate the need for any third party enforcement authority to intervene after the fact, in order to punish those who infringed the law. Software ultimately ends up stipulating what can or cannot be done in a specific online setting, more frequently than the applicable law, and possible also much more effectively.

An emblematic example of that are digital rights management (DRM) schemes, transposing the provisions of copyright law into technological measures of protection (Rosenblatt, *et al.*, 2002), and thus restricting the usage of copyrighted works (*e.g.*, by limiting the number of possible copies of a digital song that can be made). The advantage of this form of *regulation by code* is that, instead of relying on *ex-post* enforcement by third parties (*i.e.*, courts and police), rules are enforced *ex-ante*, making it very difficult for people to breach them in the first place. Besides, as opposed to traditional legal rules, which are inherently flexible and ambiguous, technical rules are highly formalized and leave little to no room for ambiguity, thereby eliminating the need for judicial arbitration.

Today, regulation by code is progressively establishing itself as a regulatory mechanism adopted not only by the private sector but also by the public sector. Governments and public administrations increasingly rely on software algorithms and technological tools in order to define code-base rules, which are automatically executed (or enforced) by the underlying technology. This is the case, for instance, of the *No Fly List* in the U.S., which relies on data mining to make predictive assessments about potential threats to national security (Citron 2007), or the use of computer algorithms to support judicial decision-making and determine jail sentences or paroles (O'Neil 2016).

Relying on technological tools and code-based rules as a means to regulate society brings about a variety benefits, mostly related to the ability to automate the law and to enforce rules and regulations *a priori, i.e.* before the fact. Yet, regulation by code also come with important drawbacks that might ultimately disrupt some of the basic tenets of law.

On the one hand, in contrast to traditional legal rules, which must be appreciated by a judge and applied on a case-by-cases basis, code-based rules are written in the rigid and formalized language of code, which does not benefit from the flexibility and ambiguity of natural language. On the other hand, the architectural implementation of online platforms ultimately depends on the specific choices of platform operators and software engineers, seeking to promote or prevent a certain type of actions. Just like any other technological artifact, code is not neutral, but inherently political: it has important societal implications, insofar as it might support certain political structures or facilitate certain actions and behaviors over others (Winner 1980).

"INDEED, AS OPPOSED TO TRADITIONAL LEGAL RULES, WHICH MERELY STIPULATES WHAT PEOPLE SHALL OR SHALL NOT DO, TECHNICAL RULES DETERMINE WHAT PEOPLE CAN OR CANNOT DO IN THE FIRST PLACE. THIS ELIMINATES THE NEED FOR ANY THIRD PARTY ENFORCEMENT AUTHORITY TO INTERVENE AFTER THE FACT, IN ORDER TO PUNISH THOSE WHO INFRINGED THE LAW."

II. NEW CHALLENGES TO LAW IS CODE: BLOCKCHAIN & MACHINE LEARNING

Blockchain technology — the technology underpinning Bitcoin — is an emergent technology that comes with many newfound opportunities of turning law into code (De Filippi & Hassan, 2016). With the advent of "smart contracts" (*i.e.* software deployed on a blockchain-based network, like Bitcoin, and executed in a distributed manner by a distributed network of peers), blockchain technology could revolutionize the way in which people coordinate themselves and engage in many economic transactions and social interactions (Tapscott & Tapscott 2016). Indeed, transposing legal or contractual provisions into a smart contract can give rise to a new set of code-based rules with a "guarantee of execution". These rules are automatically enforced by the underlying blockchain network and will, therefore, always execute as planned, regardless of the will of the parties.

A smart contract can be implemented in such a way as to make it possible for multiple parties, humans or machines, to interact with each other. These interactions are mediated by a blockchain application, controlled exclusively by set of immutable and incorruptible rules embedded in its source code. As such, smart contracts increase the applicability of *regulation by code*, by making it possible for people to formalize contractual agreements and economic transactions into a set of predetermined code-based rules, which are self-executing and self-enforcing. And to the extent that blockchain-based networks and associated smart contracts do not rely on any central server, they cannot be arbitrarily shut down by any single party – unless specifically provided for in their code. This further exacerbated the problem related to the rigidity and formality of code-based regulation, in that it becomes harder for any single party to upgrade the code or even just to affect the execution of that code.

"AS LAWS ARE INCORPORATED INTO A CODE-BASED WHOSE RULES DYNAMICALLY EVOLVES AS NEW INFORMATION IS FED INTO THE SYSTEM, IT MIGHT BECOME DIFFICULT FOR PEOPLE TO NOT ONLY UNDERSTAND, BUT ALSO QUESTION THE LEGITIMACY OF THE RULES THAT ARE AFFECTING THEIR LIVES ON A DAILY BASIS."

Machine Learning (ML) allows software to acquire knowledge from external sources and to learn or do things that it was not explicitly programmed to do. The availability of growing amounts of data ("big data"), along with the recent advances in neural networks and data mining techniques, has led to the widespread adoption of Machine Learning in several online platforms. With ML, it becomes in fact possible to circumvent some of the limitations traditionally associated with r*egulation by code*. While these platforms are still for the most part governed by a set of rigid and formalized code-based rules, ML allows for the introduction of code-based rules which are inherently dynamic and adaptive – thus replicating some of the characteristics of traditional legal rules characterized by the flexibility and ambiguity of natural language. Indeed, to the extent that they can learn from the data they collect or receive, these systems can evolve constantly refining their rules to better match the specific circumstances to which they are meant to apply.

However, the use of ML in the context of regulation is not devoid of any drawback. Data-driven decision making has already been proven to be implicitly biased, and consequently unfair (Hardt, 2014). Allegedly "neutral algorithms" systematically discriminate minority groups in their generalizations, showing results which may be catalogued, for instance, as racist or sexist (Guarino 2016).

Moreover, if implemented into law, the dynamicity of these rules could undercut notions of universality (*i.e.* "all are equal before the law") and non-discrimination. As laws are incorporated into a code-based whose rules dynamically evolves as new information is fed into the system, it might become difficult for people to not only understand, but also question the legitimacy of the rules that are affecting their lives on a daily basis. And as more and more of these rules can be customized and adapted to the profile of each individual user, the basic principles of universality and non-discrimination that characterize the current legal system might be forever lost.

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THE CHALLENGES OF THE MARCH TOWARDS AUTONOMOUS VEHICLES

Interview of Andy Palanisamy
Solutions Deployment Lead, Ford Mobility
By Nicolas Miailhe

In this interview, Andy Palanisamy walks us through the dynamics and challenges associated with the rise of self-driving vehicles. He also discusses the limits of the technology in addressing 21st century mobility needs around the world.

Andy Palanisamy is a seasoned technology, public policy, and strategy professional with over 16 years of multi-sector experience. After spending well over a decade leading and supporting various technology research initiatives for the US Department of Transportation, Andy is taking a leadership role at Ford Smart Mobility. He brings a deep understanding of technical and public policy issues associated with cutting edge transportation/mobility tech initiatives such as autonomous/connected vehicles (pretty much everything under the umbrella of Intelligent Transportation Systems). Andy is also heavily involved in the development and mentoring of next generation transportation leaders through his roles at Young Professionals in Transportation and as the Director of Mobility – The Future Society at Harvard Kennedy School. Andy finished his Bachelor of Engineering (Civil) degree in India before moving to the US in 1997 for his Master studies at West Virginia University. He recently earned a Master in Public Administration from the Harvard Kennedy School.

KEYWORDS

- SELF-DRIVING CARS
- MASS TRANSIT SYSTEMS
- AUTONOMOUS VEHICLES

Nicolas Miailhe: How do you see the timing of the rise of AVs and their massive deployment and what are the key challenges (robotics for vehicles seems mature unlike in the case of humanoids)? We talk a lot about 2022 as a key threshold: what do you think?

Andy Palanisamy: First let me caution you with these kind of projections. Because there are several components to this. One is the evolution of technology; the other one is the policy. Technology seems to be maturing much faster than policy. There is a lot of momentum behind the development of the autonomous vehicle technologies (AV), be it in the Silicon Valley or in the traditional manufacturers around the world such as in Detroit here in the U.S. or in Munich in Germany for instance. And probably too much hype over their capabilities and the development trajectory across autonomy level, from 1 to 5 (full autonomy). What is sure is that from an industrial perspective, 2020 is literally around the corner considering that manufacturers are already planning the production of the models which will be rolling out in 2018. So I think we are seeing a clear disconnect between the picture that the media is painting and what the reality is!

That said, the march towards autonomous vehicle will be relatively slower. And you will certainly not see Level 4 and level 5 vehicles coming into consumer market right away; it looks more like 2025 and 2030. There are very few players working in the level 4 & 5 space which require the mastery of an entire informational eco-system beyond the vehicle itself (i.e., Waymo). You see, the frontier between research and certification for road deployment at scale may be blurred by the big media attention but it is still there. And of course the insurance industry willingness and ability to adapt to this new paradigm will also be a key driver of the market penetration pace. Including in terms of how they are going to work out the configuration and prices of the transfer of liability away from drivers! Frankly a lot of questions are still unresolved regarding liability coverage and getting a green light for a pilot or small scale deployment of a few thousand vehicles is vastly different from market standardization affecting hundreds of millions of vehicles! So we should remain prudent.

Therefore I believe we are likely to see an incremental introduction of these vehicles with varying levels of autonomy on the market, starting with certain market segments which offer more favorable conditions. The first one would be urban transit and freight where scale and corporate management of fleets will facilitate risky investments and complex transition; while it may be more difficult for individual vehicles.

N.M.: It's more and more argued that the best case (especially on the economics side) for a mass dissemination of AVs is individual cars in cities (where ride sharing meets self-driving to enable "mobility-as-a-service") despite big apparent challenges posed to AI challenges (traffic density and diversity): do you agree and why so?

A.P.: Well, I partly agree and partly disagree. I agree with your hypothesis that cities, with their density, scarcity of space (especially parking) and plasticity (including in the consumption's habits of their citizens!), offer an ideal environment from an "economy of scale" point of view. This environment could enable the right articulation between AVs and ride-sharing business models to provoke a drastic drop in cost of miles travelled. But one of the key assumptions of mobility-as-a-service, or MaaS, is automation powered by AI and robotics. That includes traveling but also planning, dispatch and payment. And that's a challenge. Unifying payment systems and data sharing systems for instance will not be easy, because of competition. Achieving this will probably require harmonization at the national or regional levels. Same for creating the favorable incentives and regulation whereby the right eco-system emerge enabling several providers to operate side by side without toxic monopolistic situations.

N.M.: What are the key challenges? We often hear about the difficulty to bring all actors and stakeholders around common standards, especially on the sharing of data. What are the key obstacles to the establishment of data commons: competition dynamics? The fact that most ride sharing companies are not listed which gives opacity a premium?

A.P.: Stakeholders' ability to create a data commons –that is a standardized protocol to share public and private data- is indeed going to be a key part in that equation. And it's not going to be easy. At least in the U.S. context! Unifying payment systems is already a challenge so I let you imagine the challenge of orchestrating a meaningful collaboration between all big players. And let's not underestimate disparities in terms of expertise between large metropolis and small cities to deal with these issues. Public-Private Partnership can help fund and accelerate the needed capability-building to modernize & digitize transit agencies by leveraging financial markets and taxpayer money. What is really important in my view is to position the customer experience at the center of everything because if customers feel the friction, they will go back to what makes their lives easier, that is driving their cars, which they have been doing for so long!

N.M.: To what extent can the rise of autonomous vehicles and of mobility-as-a-service support the ecological transition and reduce carbon emissions?

A.P.: There are two schools of thoughts on the environmental question. One school basically says that when AVs come to maturity,

we'll be able to run transportation systems in a much more efficient way, minimizing traffic jams and reducing carbon emissions. The other school says that with the cost of travelling dropping, then people will travel around more. That's why it's so important that the transition towards AVs and MaaS coincides with the shift to cleaner platforms, such as electric vehicles to accompany the rise of renewable energy sources. But there will be investments required by cities to adapt their infrastructure including for charging; otherwise the adoption will be slow.

N.M.: How about other labor intensive cases besides personal transportation, where municipalities could save money such as waste collection, delivery by drones, but also to some extent ambulances, and perhaps even fire fighters?

A.P.: On the medical side, some communities are experimenting the use of drones to deliver medical supplies between hospitals such as fluid samples. In Iceland, they have started to use autonomous drones for freight delivery since at times the distance over water is much less that on road. Para-transit systems for non-emergency situations are also good candidate for the use of AVs to cut costs and allow more disabled people at effectively have access to the service.

N.M.: The US is far ahead of any countries worldwide in terms of AI while many U.S. cities suffer from a chronic lack and/or obsolescence of mass transit systems: do you think that this paradox makes US cities ideally placed to lead on the revolution of AVs?

A.P.: Public transit systems and agencies in U.S. cities are indeed chronically underfunded. Even in New York for instance. And most of the innovation in transportation in the U.S. is still driven by private companies addressing single-occupancy vehicle needs. So we haven't really innovated on public transportation systems if you ask me. Because we are not investing! We need to rebalance this and that's not going to be easy because levying taxes is never an easy thing to do in in the U.S.

N.M.: And so to address that challenge, what should be the articulation, role and split of competences between cities, metropolitan areas, States and even the federal government (esp. on R&D funding, product/solutions standardization but also subsidies to large projects)?

A.P.: That's a great question and certainly our federal system generates fragmentation which does not always serve the cause of standardization and facilitates upscale of viable solutions. Better articulating the contribution and responsibilities of the various stakeholders from the local to the national is certainly critical. That said, we have had a quite successful tradition in the U.S. where the federal government is capable of mobilizing long term patient capital for high-risk, i.e. disruptive research and development. National security has often served as a conduit for this. The Defense Advanced Research Agency (DARPA) success story in particular has become a model in articulating productive cooperation between the federal government, academia and the private sector which other countries are trying to emulate now to spur disruptive innovation. I have heard that President Macron is even proposing to create an equivalent for the European Union! With DARPA, public money has been used to seed a number of technoscientific breakthroughs and industry domains including autonomous vehicles. The "Urban Grand Challenges" it held in 2004, 2005 and 2007 (Nota: this event required teams to build an autonomous vehicle capable of driving in traffic, performing complex maneuvers such as merging, passing, parking and negotiating intersections) is widely acknowledged as a breaking point for the rise of autonomous vehicles. It generated a lot of competition among the best brains in the country and beyond; it also generated great collaborations between some of the best Universities in the country and auto-makers. And therefore, as a whole, that effort accelerated the development cycles of autonomous vehicle technologies a great deal. In 2015 and 2016, the U.S. Department of Transportation somehow borrowed the "Grand Challenge" concept from DARPA and led a "Smart City Challenge". There, the goal was not only to galvanize the industry but also to incentivize cities to step forward and form consortium with private companies and academia to develop and test disruptive urban transportation systems including autonomous & connected vehicles whereby vehicles and the infrastructure talk to each other. The Challenge clearly created a conduit for new forms of public-private collaborations. It was a big success and is somehow emblematic of a good articulation of responsibilities between the national and local levels, between the private and the public with the objective of transforming transportation systems using the latest technologies. 78 cities applied; 7 were selected as finalists and worked intensely with the DoT to refine their project. The City of Columbus, Ohio eventually won and will receive up to $40 million from DOT and up to $10 million from Paul G. Allen's Vulcan Inc. to supplement the $90 million that the city has already raised from other private partners.

"CITIES, WITH THEIR DENSITY, SCARCITY OF SPACE (ESPECIALLY PARKING) AND PLASTICITY (INCLUDING IN THE CONSUMPTION'S HABITS OF THEIR CITIZENS!), OFFER AN IDEAL ENVIRONMENT FOR THE RISE OF SELF-DRIVING CARS, FROM AN "ECONOMY OF SCALE" POINT OF VIEW."

N.M.: I was a bit shocked to see the failure of Bridj (a Boston based start-up specialized in micro-transiting solutions through an innovative public-private-partnership model) which simply folded its business without been bought out or recapitalized: given the buzz that had surrounded this innovative model, what signal does it send and what lessons should we learn from Bridj promise and ultimate failure? To succeed and scale does micro-transit requires AVs?

A.P.: Bridj tried to stay afloat and looked for possible acquisition from Toyota for instance I think. This failure has indeed shocked a lot of people in the industry because it was a very promising public-private-partnership model. So indeed it probably discouraged a lot of other promising ideas. It also goes back to how we do business in the U.S. If you are going to ask from people to give away their car and use transit instead, you need to provide an equivalent level of comfort and service. And as I understand, unfortunately Bridj failed to convince users on this and also lacked volume. And so it became quite difficult to run a profitable business on this basis. It's also a question of timing and relates to the low price of gasoline in the U.S. which surely played a part in this story.

N.M.: When you look at global mobility needs in the next 10-20 years, especially in emerging countries like India or the African continent, do you think that self-driving cars are the solution? Or to be precise... to which extent are they part of the solution?

A.P.: Well, there is a very simple reality that we cannot evade which is that there are inherent limits to road transportation efficiency potential versus rail for instance which can move thousands of people at one time and buses which can move hundreds. At the end of the day, betting heavily on self-driving cars will require putting more cars on the roads and building more roads which might not be the most efficient solution. So it's very important not to delude ourselves regarding the added value of self-driving cars vis à vis other modes such as mass transit systems like rail. When large volumes are required because of continuing demographic growth, mass transit offer a much higher potential in terms of consolidated cost and also carbon emission! If our 21st century is going to be a century of urban explosion, AVs are not going to be the "killer app" to address massive mobility requirements in emerging countries, such as in South Asia or Africa. To run effectively, AVs need top class road infrastructure, which is not often easy to find in emerging countries at the moment. And the cultural factor is important too. I mean we are struggling in the U.S. to shift the culture away from the 20th century model of individual cars to shared use and it's difficult! In many emerging countries, the shift is going the other way around (Win part driven by viewing car ownership as a status symbol) and that's not necessarily a good thing because bus, metro and tramways offer higher efficiency potential.

N.M.: We could even say that misrepresentation of the real potential of AVs could lead to cannibalization or delaying of other much needed large mass transit projects (e.g. new metro lines) which require large investment and almost systematically government subsidies and thus fiscal efforts... In other words, by inflating the potential of self-driving cars, aren't we running the risk of de-incentivizing public investment & fiscal effort?

A.P.: I totally agree with that! Hyping up the potential of AVs has a social cost and can be really counter-productive, especially in the long run. We really need governments around the world to invest much more on public transportation regardless of the potential of AVs. In short, an AV-based mobility ecosystem will be way more effective when it is paired with a robust public transportation offering, at least in the urban areas. Self-driving cars can act as good complement, for instance to cover the last mile or last few miles but they cannot be the back bone of mobility systems... at least in urban areas. Singapore is a great example of this. They are clearly seeing AVs as a complement. You cannot see Singapore without its public transportation systems. Same for Hong Kong or Paris. And the same should really apply to New Delhi, Dhaka, Lagos and the rising metropolis.

N.M.: And that's particularly important given the U.S. soft power and influence in the world, particularly in spreading the Artificial Intelligence & robotics revolution and its associated organizational models, business models and collective imaginaries. I mean the model of the "motorized middle class model" (with the associated urban & suburban sprawl) exported from America into many counties of Europe and now China, India and Africa is simply not sustainable, even with electric cars. We know it! So aren't we in a way simply rejuvenating it and trying to foil it again with new clothes, those of AI and robotics?

A.P.: Well... that's sometime the impression that I have looking at a company like Tesla and the socio-technical imaginary it's putting across so brilliantly. They have become iconic of the shift from combustion to electric engine but their model is still deeply ingrained in the individual car model which is not sustainable for the reasons we discussed before. Public education around the real challenges and possibilities of these technologies really matter. We need more public policies on that too to make public transportation become a way of life and diminish the status symbol that cars represent. This shift has already happened in a number of cities like in Paris for instance. Engineering that shift is not easy and it takes time. It can result from a combination of public education, tax and market incentives delivered on the long run.

UBERIZATION OF THE CITY

Interview of Roland Ries,
Mayor of Strasbourg
By Nicolas Miailhe

Roland Ries is a specialist in questions of transportation and urban mobility. He was the driving force behind the reintroduction of the tramway in Strasbourg tramway in the early 1990s.

Elected Mayor of Strasbourg first in 2008 and re-elected for a second consecutive in 2014, Roland Ries' agenda focuses on boosting and diversifying transportation solutions, and finding alternative to individual cars. On the longer term, his vision is of a more compact, socially diversified city with enhanced connections with the German town of Kehl.

Roland Ries is also 1st Vice-chair of the Strasbourg Eurometropolis with responsibility for transportation and mobility and also for GART, the umbrella authority for the metropolis's different transportation authorities.

He was a French senator from 2004 to 2014 and is considered one of Europe's best specialists in urban mobility. He is also chair of Cités-Unies France, a federation of French local and regional governments involved in international relations.

KEYWORDS

- UBERIZATION
- SHARING ECONOMY
- DIGITAL REVOLUTION
- SHARING

Mayors need to find strategies to manage the uberization of their cities.

INTRODUCTION

In this interview, Roland Ries, Mayor of Strasbourg shares his perspective about the challenges and opportunities triggered by the rise of large digital platforms and marketplaces which are powered by matching algorithms. He advocates for a measured approach whereby municipal decision-makers need to embrace change wisely to maximize the upsides and minimize the downsides of the rise of these new actors and services.

Nicolas Miailhe: Do you feel that uberization is a poison pill for major municipalities?

Roland Ries: I am, of course, fully aware of the threat that uberization and the gig economy pose to the job market and the deregulatory risks to whole sections of the market economy. But these fears, real as they may be, must not lead us to condemn these changes out of hand by viewing them simply as destroying jobs. These shifting patterns of consumption, which seem so threatening, reflect inescapable changes sweeping our societies. Let's be quite clear: trying to stop this process is a lost cause. The trick is to accept change calmly, which makes it easier to stay in control of what's going on and, most importantly, to make the most of these changes because they reflect what people want. One thing I'm sure of is that the service specialization mindset is no longer the way forward.

N.M.: What do you mean by that?

R.R.: Take mobility in the city as an example. We always, too often at any rate, assume that traditional transportation offerings such as buses, trams and metro systems can be rolled out everywhere. This assumption involves building complex, costly and space-hungry infrastructure that takes a long time to deliver, whereas we could imagine far more flexible networks able to meet a far more diversified range of demands. We need to understand that, with a little imagination, we can unlock a vast reservoir of untapped services. A private car is used for only 8% of its lifespan, precisely because it's private. More shared use would be far better in terms of meeting the planet's sustainability goals. But this would of course involve achieving a balance with manufacturers to avoid provoking an unwelcome industrial collapse.

"LET'S BE QUITE CLEAR: TRYING TO STOP THIS PROCESS IS A LOST CAUSE. THE TRICK IS TO ACCEPT CHANGE CALMLY, WHICH MAKES IT EASIER TO STAY IN CONTROL OF WHAT'S GOING ON AND, MOST IMPORTANTLY, TO MAKE THE MOST OF THESE CHANGES BECAUSE THEY REFLECT WHAT PEOPLE WANT. ONE THING I'M SURE OF IS THAT THE SERVICE SPECIALIZATION MINDSET IS NO LONGER THE WAY FORWARD."

N.M.: Are the collaborative economy's virtues sufficient to justify the absence of political will to regulate the activities of platforms?

R.R.: The difficulty lies in a confusion between, on the one hand, a new economy where goods and services are exchanged and shared—something that has a truly positive impact on traffic congestion and air pollution, two of the banes of almost every city—and a platform economy that offers professional services based on the principles of economic liberalism and unfettered competition. The reality is that we have to find a path between two extremes: overbearing regulation that prevents any loosening of the current system, and a deregulated free-for-all that produces a jungle for workers where only the fittest survive. But I'm convinced we can identify solutions that avoid price distortions which open the door to unfair competition. I continue to believe in the importance of the regulatory role played by authorities.

N.M.: French legislators seem very reluctant to intervene, as if they would prefer not to get involved.

R.R.: The Mayor of London withdrew the operating license from Uber, even though it operates in over 300 major cities worldwide. No government authority in France has these powers. Here, it's only prefects who can take measures like that. And they can't act arbitrarily, they have to do what the law tells them, which at the moment is no more than to keep the peace between taxi drivers and private hire drivers. The European Commission does have the power to harmonize measures at the EU level, but it remains deliberately reserved. We could, quite justifiably, hope for a more ambitious and proactive attitude. In the meantime, government authorities can play a real role fostering a full-fledged social and solidarity economy.

N.M.: What incentives could be put in place to encourage virtuous loops between the platforms and actors in this sharing economy?

R.R.: In a number of publications, including *In the Swarm* (MIT Press, 2017), the German philosopher Byung-Chul Han offers a highly convincing argument: behind the possibilities of unmediated digital interconnections lie new forms of alienation, meaning that "exploitation is possible without domination." In this scenario, uberization will only increase instability in the world as well as individual loneliness. I'm not so sure that this is inevitable. We have the power to act, especially at the city and regional levels. Our duty as elected local officials is to reflect on new patterns and work with our constituents to invent a genuinely green and collaborative social economy, one that will forge social ties and stimulate our collective intelligence, placing the concepts of social justice and humanity front and center. A key stage in this process lies in grasping the importance of this problem and the enormity of the issues involved. It's not about simply looking at the symptoms. And again it's up to

Tram pont Kehl - ©Jérôme Dorkel / Strasbourg Eurométropole

us, mayors and local councilors, to put in place the conditions for this new civic awareness to take hold. What's at stake is no more nor less than the democratic structure of our lives in society as a whole and our ability to exercise our free will.

You have to start by stating a fact: actors from the social and solidarity economy want to keep their distance from platforms such as Uber or Deliveroo, which they feel to be structurally incapable of virtue. Let's be clear: what we're talking about here are conflicting philosophies that embody opposing and mutually antagonistic social models. This isn't something that wishful thinking is going to change. Partnerships with conventional businesses, on the other hand, exist already and generally work well. For our part, as a certified fair trade territory we try very hard to make sure that our public procurement policies are beyond reproach in order to encourage actors from the social and solidarity economy to compete for contracts. We systematically encourage collaborative cross-fertilization, in particular through our support for Fab Labs and Maker Fairs. And we also work to educate the public so that residents can identify the different types of economies.

N.M.: In the short term, how can we manage the destabilizing effect Airbnb is having on French cities?

R.R.: You have to be vigilant without clamping down too hard. I was impressed by a statistic about Airbnb's exponential success that I heard during the Paris climate conference. During the three years from 2012 to 2015, it was offering two or three times more space in existing buildings than the hotel industry had built in the previous three or four decades. This observation alone highlights an environmental aspect that is often underestimated: the sharing era now offers a real alternative to the kneejerk drive to keep on expanding. The downside is the accelerating professionalization of Airbnb, which is driving up rents and property values, particularly in city centers, some of which end up losing their permanent residents because they're priced out of the city. The problem we have is a lack of aggregated data that would let municipalities adopt targeted policies to make sure that we have the attractive accommodation that our visitors deserve while also protecting the peace and harmony of our city centers. To be effective, I think a necessary first step would be setting up an observatory.

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“Improvements and convergences in machine learning and neurosciences combined with the availability of massive data-sets and the ubiquity of high-performance scalable computing on the cloud are propelling us into a new age of artificial intelligence and robotics. With the wave of extreme urbanization the world is going through, cities stand to play a key role in realizing the potential of these technologies. The promise these developments hold to do more with less, and to enhance quality of life for all is immense; so too are the risks and challenges, including in terms of control, privacy and security.”

Nicolas MIAILHE
Co-founder and President,
The Future Society

Published by VEOLIA INSTITUTE
30, rue Madeleine Vionnet - 93300 Aubervilliers - France
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