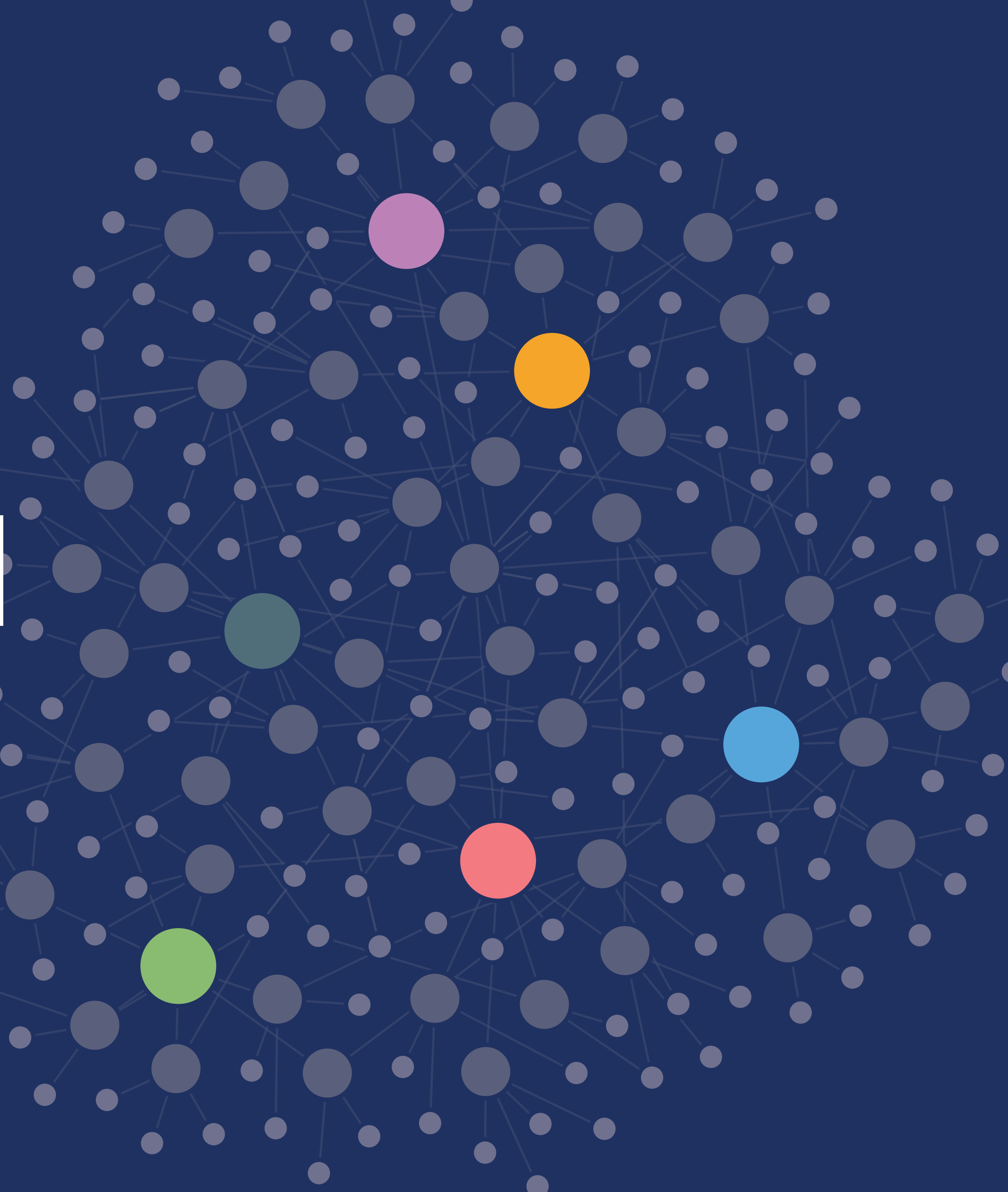
The Future of Urban AI

Global Dialogues on Urban Artificial Intelligence



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URBAN AI

CORNELL TECH | HOME OF THE JACOBS TECHNION-CORNELL INSTITUTE

Contents

Acknowledgments

This summary was authored by Anthony Townsend, Sarah Popelka, and Hubert Beroche.

We would like to show our gratitude to the experts for sharing their pearls of wisdom with us during this webinar series: Ron Brachman, Kris Vanherle, Sara Berry, Ariel Noyman, Arthur Getman, Julia Zimmermann, Paul Healy, Ana Chubinidze and Nadina Galle.

Also, many thanks to Michael Batty who accepted our invitation to contribute to this Notebook and to Ben Oldenburg who designed and illustrated this project.

Foreword

Towards a General Artificial Intelligence

Michael Batty, Emeritus Professor of Planning, Centre for Advanced Spatial Analysis, University College London

AI has rapidly become the contemporary face of computing although computers have been used to augment our intelligence from their earliest days since their invention in the middle years of the last century. In fact, it was Alan Turing (1950) himself who impressed on science in his paper 'Computing Machinery and Intelligence' that computers might even be used to simulate our own intelligence through a kind of 'strong AI' where we were able to program computers to replicate our own human decision processes. The first wave of what John McCarthy called AI in 1956 was very much focused on how we might get computers to not only simulate our own thought processes but in doing so, to improve human thinking by exploiting the speed, memories, and logics of the first digital computers. AI gathered pace along these lines until it became apparent in the 1970s that it had hit a barrier – no amount of clever computers pitting their wits in games like chess could ever replicate our own decision processes and consequently the field entered what some have called its first "winter" (Wooldridge, 2020).

However, running in parallel to the concern for strong AI was the notion that a much 'weaker' form might be developed which built on the rapidly increasing power of computers to massage 'big data', largely by fashioning models that could search for patterns using intricate multivariate statistical models that could replicate data sets whose causal structures were simply too complex to unravel. Models based on successive reweighting of the data used to train them to generate good outcomes began to emerge based on neural net like connectivities between elements of their data. These models were said to 'learn' the best way of predicting patterns in data, constituting the emerging field of machine learning but as computers got ever faster, layer upon layer of neurons associated with elements in the data emerged and the focus evolved to deal with what has been called 'deep' learning. There is now even a sense in which the field is standing at a threshold where a much stronger AI might emerge which from these diverse developments.

Yet the age-old problem of getting computers to think and to think like ourselves is far from resolved philosophically. There is a move in the field to consider that a 'general AI' might be at last emerging but no matter how deep we might go in terms of building learning models, the basic constraints that our own human knowledge is so diverse that we will never get a machine to replicate it, still presents a major barrier (Batty, 2022). This problem is best seen in the problem of self-driving cars. In the contributions that follow this introduction, Ron Brachman demonstrates extremely clearly the dilemmas posed by accruing enough data so that the processes of driving are completely automated. There are always very obvious behaviours that a self-driving car will never be able to anticipate and this is not because the car has not been trained on the basic data, it is more because the data needed can never be anticipated. We ourselves often invent the data as we go along and no amount of past data can anticipate this. This is a good reason why we may not see self-driving cars, at least in the wild, any time soon. Although we may not be able to predict the future, we can indeed invent it and thereby lies another dilemma.

The papers that follow all hint at these dilemmas facing AI which I noted in my preamble. The partnership between Cornell Tech and Urban AI that is cemented by the various contributions range quite widely across contemporary computing. Cornell Tech's horizon scanning survey of the field and published in their report edited by Anthony Townsend on ***The Future of Urban Tech*** (https://futureofurbantech.org) presents a series of scenarios about the near future that are bundled together as straws in the wind for the future of AI. These are categorised first as the transformation of "hard" urban systems based on Supercharged Infrastructure, Wild + Well cities evolving on advanced biotechnologies, and Resilient Corridors amplifying efforts to halt climate change. These are then contrasted against "soft" urban systems. Dark Plans – software designed to shape cities in strange new ways, a New Screen Deal involving the risks and rewards of urban tech, and Urban Innovation in its wider economic focus. The report sets the context for the various presentations that are included below that broaden out AI into the form of contemporary computing and the digital transformation.

Brachman's paper sets the scene and questions the limits to AI whereas the other papers such as that by Anne Chubinidze tell of geopolitical issues, markets, innovation, surveillance and privacy in diverse ways from Paul Healey, all setting a very wide context for AI. In this sense,

"Although we may not be able to predict the future, we can indeed invent it and thereby lies another dilemma."

general AI is about today's computing but various papers point the direction to how biotechnologies and climate change are affected by AI as contained in papers by Julia Zimmerman and Sara Berry on vegetation in cities. Participation of various kinds from the use of tools such as those developed by Ariel Noyman in Kent Larsen's City Lab at MIT, to Kris Vanherle's sensing and measuring the environment using low cost devices that can be arrayed extensively to catch what is happening in both natural and built environments, are discussed. Traditional tools for 3D cities from Larsen's Lab and transportation from Art Getman complete the picture painted of the next ten years in AI. The cooperation between Cornell Tech and Urban AI which this set of papers initiates, points the direction as to how a more general AI might evolve. There is much room for thought here in the pages that follow and the YouTube (2023) videos that support these papers provide a gentle and effective complement to these ideas.

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Introduction

Urban AI Exits the “Trough of Disillusionment”

Anthony Townsend, Urbanist in Residence,
Jacobs Urban Tech Hub

Future historians will look back on 2022 as the year deep learning broke out of the box. It had only been a decade since the technology burst onto the scene, when the AlexNet convolutional neural network smashed records in the 2012 ImageNet Large Scale Visual Recognition Challenge (ILSVRC), computer vision’s Grand Prix. But despite a rapid spread into every domain of science and industry, deep learning remained behind the scenes, buried deep in the cloud or stashed under the hood of self-driving cars.

The twin bombshells of DALL-E 2 and ChatGPT, released by San Francisco-based startup OpenAI in November, changed all that. Suddenly deep learning was right in our faces. Anyone with a smartphone could order up synthetically generated images and prose, tapping a simulated intelligence with the vast archives of the web at its disposal. With delight, we started to play with these new handheld deepfake factories. But the deep meaning of deep learning could no longer be ignored. It wasn’t simply for targeting ads or driving machines down interstate highways. It was for making the culture, in a turbocharged burst of creativity powered by our own natural language.

It didn’t take long for urban technologists to see the possibilities. At Cornell Tech, we’re exploring how to use DALL-E to empower community groups to produce photorealistic illustrations of proposed developments, to support campaigns for better design. One of our master’s students is building a DALL-E-esque tool for generating 3-D models of buildings and even entire districts from natural language requests. “Hey Siri! Draw me a dense block of low-rise multi-family dwellings with common gardens and bike parking.” Urban designers of the future will simply dictate straight to a digital twin, it seems.

But the excitement over large language models, the AI approach behind DALL-E and ChatGPT, glosses over lingering barriers to deep learning’s usefulness in the urban realm.

The first obstacle is deep learning’s voracious appetite for data. The power of convolutional networks, the underlying algorithm behind most deep learning today, comes from their ability to identify intricate patterns in the gargantuan corpus of texts and images available on

An imagined cityscape generated by DALL-E 2 in response to the prompt "A futuristic city mashing up New York and Paris and controlled by artificial intelligence." (Anthony Townsend)

the public web. But urban AI operates in relative data scarcity. And this isn't just a lack of instrumentation. Deploying more sensors won't close the gap. Even the most abundant urban data on hand today, like mobile phone "bread crumb" trails don't come close in magnitude or dimensionality to the training data ChatGPT wields to crack a joke or write a piece of code.

There are also institutional obstacles to amassing sufficient training data for deep urban AI. Data generated in urban settings is often closely held. Businesses guard trails scraped from apps to extract commercial value. Branches of city government secure data streams under increasingly strict administrative guidelines, and routinely keep them from each other. Such "silos" of secret data are the norm, and the barriers between them are growing stronger rather than weaker, and justifiably so, as our concerns about data privacy and security swell.

This data scarcity may make city streets a safer place than the open web when it comes to tracking individual activity, but it hamstrings urban analysts. This is a longstanding challenge. Data scarcity has afflicted urban modeling efforts from the very beginning, and was one of the "seven sins of large scale models" identified by the scholar Douglass Lee in a seminal 1973 paper.[1] Deep learning's payoff for urban AI may be much further in the future than we think, if it ever arrives at all.

The second obstacle to deep learning in the urban world has to do with the narrow nature of its perception and prediction, and why they are so data-hungry to begin with. As AI scholars Gary Marcus and Ernest Davis put it, most deep learning systems behave like "idiot savants". They exhibit superhuman ability within a limited domain of recognition tasks, but fail suddenly when confronted with novel examples not present in the training data. This brittle form of recognition is an outgrowth of how deep learning actually "learns". Deep learning tools don't actually understand what it is you are asking, the texts they are scanning, or their own responses in any formal

1 Lee, Douglass B. "Requiem for large-scale urban models", Journal of the American Institute of Planners, May 1973, Vol. 39, No. 3. Available at https://dl.acm.org/doi/pdf/10.1145/1102945.1102950.

> “Understanding our cities presents perhaps the greatest challenge to true AI.”

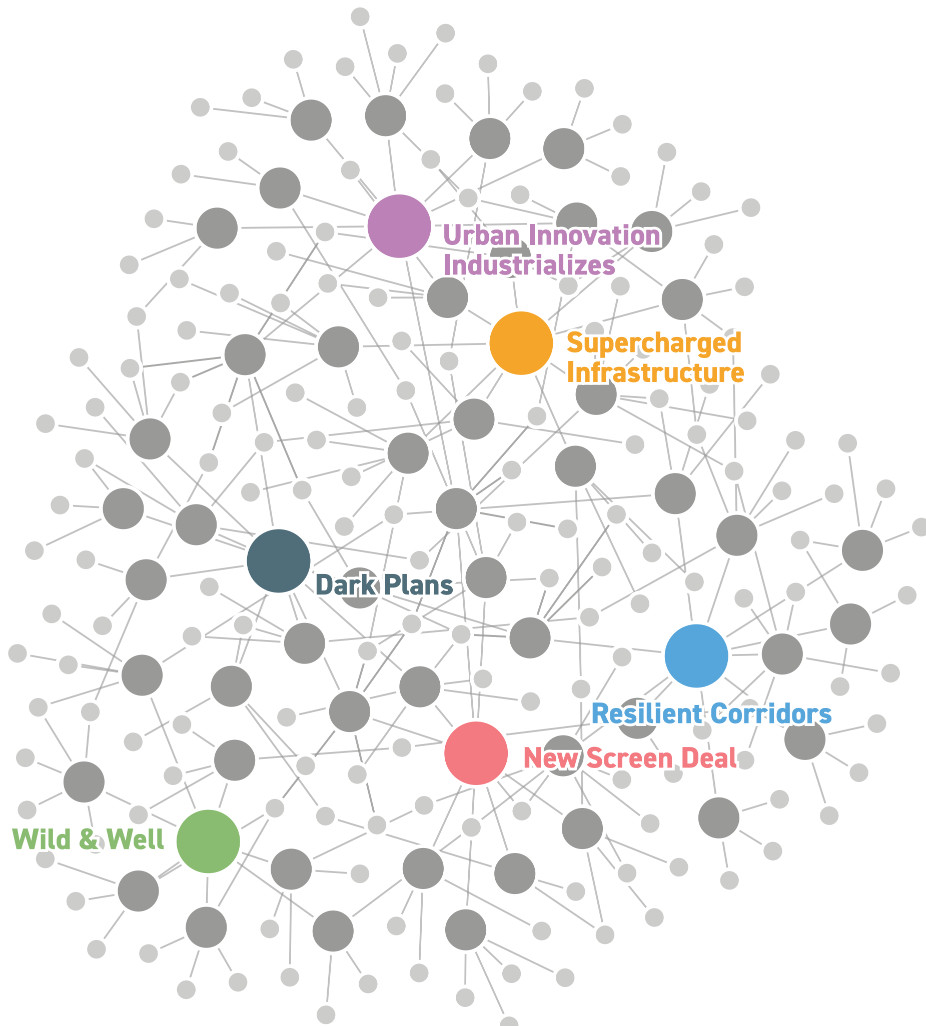
logical sense. They are mostly just superhuman summarizers, able to predict with uncanny speed and precision the next word or pixel that fits best, based on everything that has ever been written or drawn or photographed before.

This has big implications on the streets of New York, Shanghai, or Istanbul. Cities like these constantly surprise us with new situations, combinations, and events. It isn’t a flaw. It is a feature. Deep learning’s extreme specialization requires great care in engineering and design to fit into such complex settings. But more troublesome is deep learning’s brittleness when dealing with “edge cases”, as computer scientists call them. It also turns out to be rather difficult to predict when a deep learning system will fail at its assigned task, making it far more risky to deploy them in high stakes use cases in complicated cities. Step outside the record of the past on which a deep learning model is trained, and you step off the map. Coupled with the “black box” inscrutability of deep neural nets (a property scholars call “interpretability”) that makes it hard to explain why a model produces the predictions it does, what makes deep learning so dangerous in these sorts of settings is its propensity to fail catastrophically but without revealing much about how to avoid such mistakes in the future.

Deep learning’s difficulties in adapting to city life are formidable obstacles. These missteps will likely slow the pace of adoption, yet also drive new innovations that carry the whole field forward. This is clearly the case in applications such as automated driving, which has both failed to deliver on its original timetable, yet spurred massive investments and breakthroughs that will have far-reaching impacts. The quest for self-driving vehicles, as quixotic as it seems at times, is really our generation’s “space race”—a massive technological push with big, unforeseeable impacts. But it is also an opportunity to reconsider other, older ideas about how to create artificial intelligence. Solving the most mundane everyday problems city dwellers face requires drawing on enormous and contextual bodies of knowledge that deep learning algorithms rarely tap—what we think of as “common sense”. Classical AI, with its reliance on symbolic reasoning and structured representations of knowledge, can tap the vast network of ontologies being developed around smart cities, buildings, and infrastructure to fill the holistic gaps in deep learning’s worldview. Understanding our cities presents perhaps the greatest challenge to true AI. But the tools are falling into place, and with luck we will soon enough assemble and harness these capabilities to the great benefit of all humanity.

It is, however, still early days. Today, the starting point for an exploration of the future of urban AI begins in what technology forecasters call “the trough of disillusionment”, the period after initial hype for a new technology has worn off, and the hard work of putting it to ethical, productive use begins. After a decade of hype about self-driving cars and the growing literature on implicit bias embedded within production AI in the public sector, we are wary. But now we have a much clearer idea about which tools we might develop or use, and where to apply them.

Methodology



View The Future of Urban Tech

To deepen our understanding of how deep learning and other AI technologies are being used to address pressing urban challenges, UrbanAI and the Jacobs Urban Tech Hub at Cornell Tech partnered in autumn 2022 to produce a program of webinars.

Road Map: The Future of Urban Tech Horizon Scan

Our road map for this journey was The Future of Urban Tech, a ten-year horizon scan anticipating big scientific breakthroughs and engineering innovations in the field. Drawing on thousands of published sources—journals, news sites, and blogs—this study synthesized this raw data into 217 unique perspectives charting anticipated discoveries and inventions in urban tech over the decade ahead.

This complex set of possibilities is summarized in the horizon scan's six topline forecasts. Think of these as the front page stories you might read on a news site in 2032. They describe the big directions of change that will shape the journey ahead for everyone.

Three forecasts describe the transformation of "hard" urban systems. **Supercharged Infrastructure** will rewire the city into a deep, actionable web. **Wild + Well** cities will tap advanced biotechnologies to take livability to new heights. And **Resilient Corridors** will amplify our efforts to halt climate change and prepare communities for the inevitable shocks to come.

Three more forecasts unpack deep conflicts in "soft" urban systems. **Dark Plans** designed and enforced by software will shape cities in strange new ways. This will trigger a backlash, giving rise to a **New Screen Deal** that redistributes the risks and rewards of urban tech. Meanwhile, a planetary scale supply chain for city-making technologies will take shape as **Urban Innovation Industrializes**.

Ambassadors from the Future

AI is at work throughout each of these forecasts, creating new capabilities and raising new risks. To explore these in detail, we convened eight sessions where thinkers and practitioners working at the forefront of urban AI could share their knowledge, insights, open questions and concerns about the future. Offering a tour through the horizon scan, these "ambassadors from the future" provided a sneak peek at the opportunities and challenges we will all face in the coming years.

The Supercharged Infrastructure forecast, for instance, imagines a world where everything is connected, but the real breakthroughs are in how we navigate those new webs with the power of AI. AI pioneer and Cornell professor Ron Brachman explained in our first session, an entire new generation of computational tools and data structures that can model what we call "common sense" are needed if we're to expect smart buildings, vehicles, and devices to survive in the urban wilderness.

The second forecast, Wild & Well, deals with tapping the power of wild things to improve life in cities. As urban ecologist Nadina Galle explained, this is an idea that moved from fringe to foreground during the pandemic, as animals flocked into depopulated cities and we spent more time in the well-ventilated outdoors.The low-hanging fruit here, literally, are trees. Julia Zimmerman explained how Berlin is mobilizing crowdsourced analytics and care for street trees. In one of the rare but compelling appearances of deep learning in this series, Sara Beery showed how Google researchers harnessed the supernatural sensing power of computer vision to derive valuable insights about street trees across entire cities.

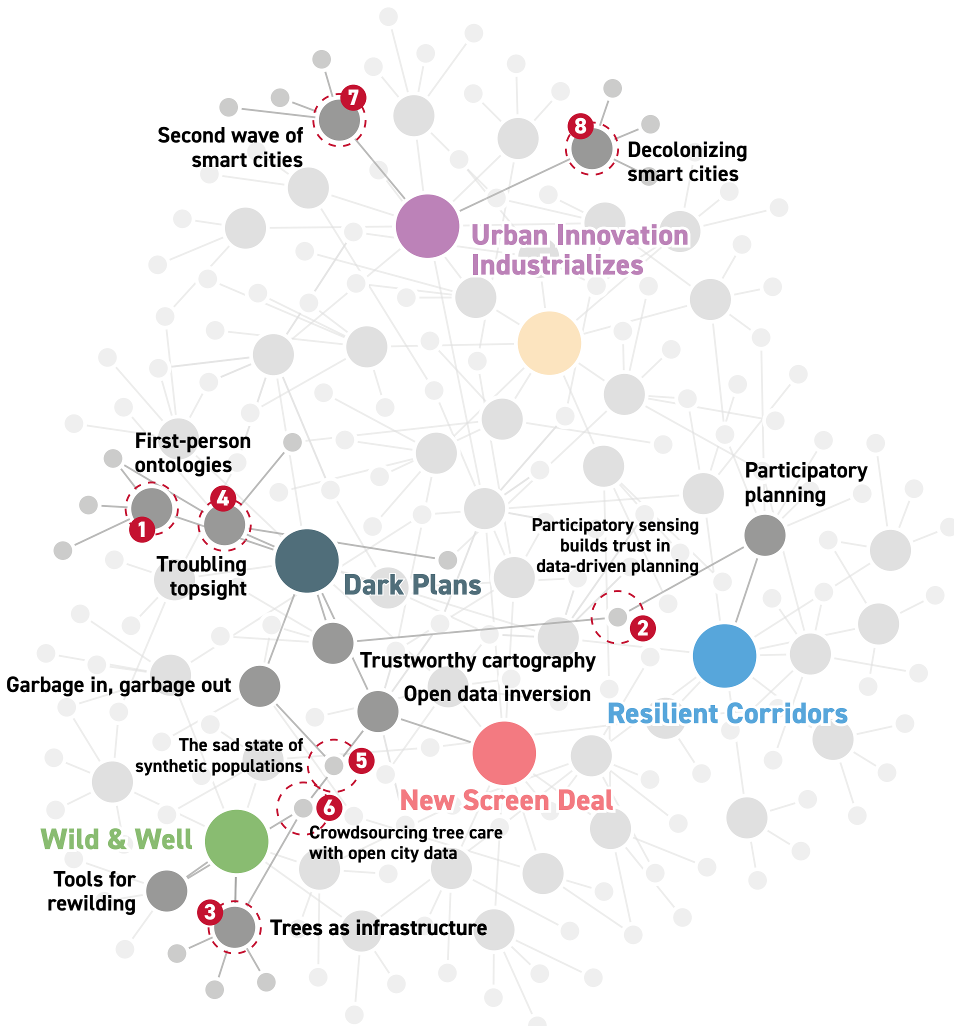
Three sessions featured speakers working across the intersection of two more forecasts—Dark Plans, which looks at the often hidden tensions between optimization and serendipity; and Resilient Corridors, which focuses attention on how climate mitigation and adaptation is being constructed at a regional scale. Kris Vanherle showcased Telraam, a participatory traffic sensing collective that has spread across Belgium and beyond, and is creating a new ground truth for transportation policy. Arthur Getman explained how startup Replica uses synthetic populations to power detailed "activity-based" models that help cities model the actual trips people make across different transportation systems. Finally, MIT's Ariel Noyman showcased CityScope, a platform for interactive urban design that layers data and simulation in ways that multiply the value of each individual element. Each of these efforts tap deep learning to solve small pieces of the problems they face—but they are also working to fill the gaps of data scarcity that limit deep learning's prospects to solve urban problems in the first place.

Two more sessions helped us zoom out and survey the landscape of urban AI futures from a global perspective. Building on the Urban Innovation Industrializes forecast, venture capitalist Paul Healy of Commonweal Ventures explained the innovation opportunities investors see as cities take on challenges related to climate change and growing service demands. Ana Chubinidze of Adalan AI mapped out the geopolitical tensions within the smart cities movement. This is the new terrain on which the social and political terms of a New Screen Deal might be worked out over the coming generation.

This notebook contains detailed summaries of each of these eight conversations. As the work of these brilliant scholars and practitioners highlights, we must be humble forecasters. For every hypothesis we might formulate, countercurrents aren't hard to find. Different futures can coexist in different world regions, and even within the same city. Our urban (AI) future is not a straight line but a branching network, a living thing that generates many ideas and inventions. Most we'll find curious. But there will also be extremes—remarkable innovations that fascinate us, and horrifying failures that shock us.

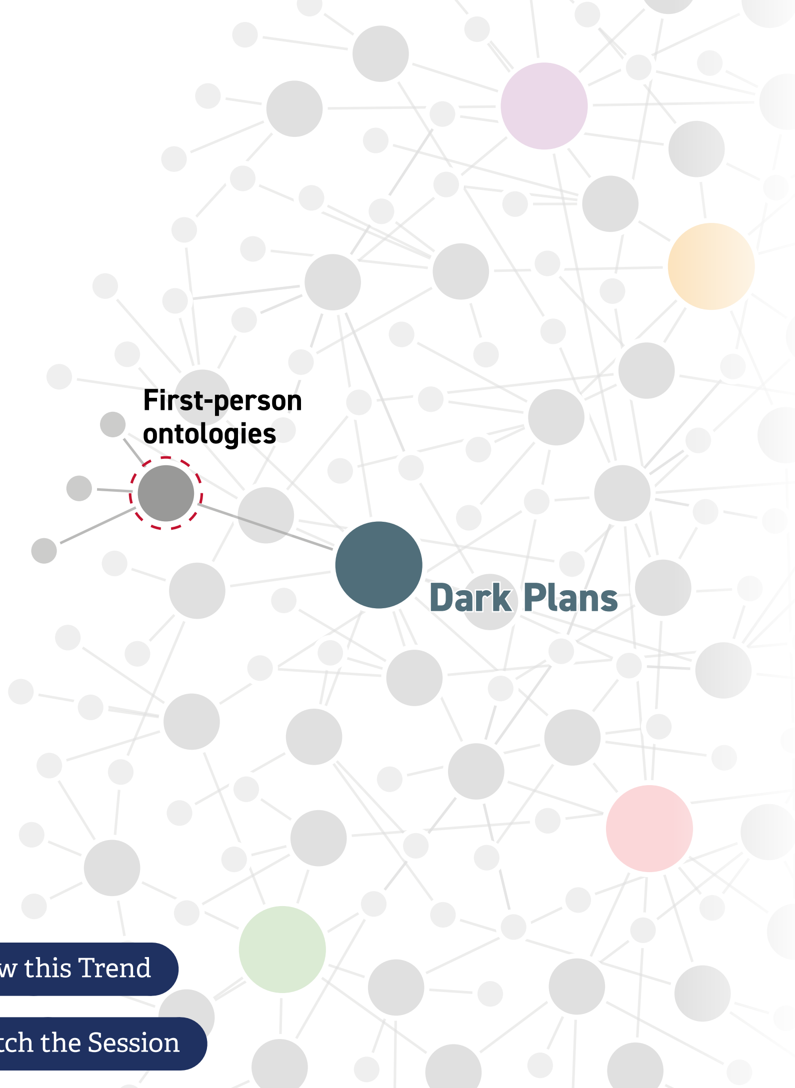
For cities, the challenge will be anticipating the extreme opportunities and risks of AI and putting structures in place to manage them. A handful, such as Amsterdam, Helsinki, New York, and Singapore have begun that process of studying and setting guidelines for the arrival of urban AI. But there is much more work to be done. UrbanAI and Cornell Tech are delighted to be your guides as we continue the conversation in the years to come.

The Future of Urban AI Series



1 AI, Urban Systems and Common Sense

Synthesis of the episode with
Ron Brachman, Director of
The Jacobs Technion-Cornell Institute



View this Trend

Watch the Session

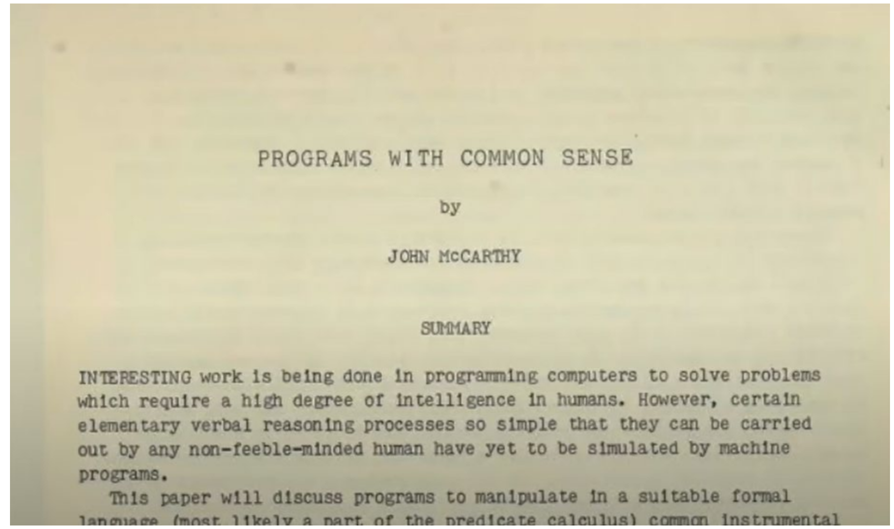
At present, AI systems have limitations that prevent them from operating autonomously in urban environments, by virtue of the fact that they are trained on limited sets of historical data. According to Brachman, the future of urban artificial intelligence lies in the ability of AI systems to take into account realities beyond those programmed knowledge bases, exercising what he terms "common sense." Currently, the most successful AI systems operate within a contained, domain-specific proficiency, but lack the ability to meaningfully extrapolate to situations for which they lack expertise. If a given scenario does not exactly resemble what the AI has been trained to recognize, it will perform poorly. This limitation does not pose an issue in "closed worlds," where edge cases (rare and/or unexpected circumstances) rarely arise, if at all. In a game of chess, for example, where the rules always remain the same and players can be expected to follow those rules to a tee, a bot can be programmed to interpret and respond to any move an opponent plays against it. However, the real world is an "open world:" dynamic and unpredictable. This lack of predictability has already led to a number of high profile artificial intelligence blunders — Alexa challenging a child to electrocute herself, GPT-3 giving destructive mental health advice, and self-driving cars stopping for stop signs in billboards. The issue of open worlds is particularly acute in the case of artificial intelligence that operates in urban contexts.

Cities are inherently complex. While sets of rules do govern collective behaviors, those rules only go so far in determining the individual actions of the multiplicity of independent agents that exist in urban spaces. As Brachman explains, cities follow a long-tail distribution of the probability of events. This means that no one rare event is particularly likely to occur, but there does exist a high likelihood that any number of rare events will occur. This presents quite a challenge when it comes to programming artificial intelligence to operate in urban settings, particularly if the training data is composed of past events that have already occurred (a set which contains some scenarios unlikely to repeat and omits many others that might still happen). It would be impossible for programmers to include every potential scenario in an AI's training set. So if the future of urban artificial intelligence is to bypass this limitation by designing systems

> “The issue of open worlds is particularly acute in the case of artificial intelligence that operates in urban contexts.”

that can make productive decisions beyond the training data that they have at their disposal, what might that process look like from a design perspective?

In Brachman’s eyes, it comes down to building common sense and intelligibility into the architecture of AI systems. Beyond the current standard of basic background knowledge, domain-specific expertise, and the ability to respond to common scenarios with default actions, all of which only prepares AI systems to deal with routine situations, the technology will need to develop such that artificial intelligence can perceive and make sense of external data, in order to diagnose an unforeseen circumstance and shift its approach accordingly. As part of shifting its approach, a well-designed artificial intelligence should have high-level functioning to determine whether the intended goal still applies in the context of the new situation (Brachman gives the example of a self-driving car on its way to a grocery store: if a parade, an unexpected scenario, obstructs its route, the car might need to make the decision to find a different grocery store or even to just give up and return home). This kind of autonomous reasoning falls under Level 5 autonomy (ISO 22989:2022), in which artificial intelligence has the capability to make decisions without human oversight or input. Many AI scholars caution that the removal of human oversight at that level of autonomy can pose a risk to human health and safety; article 22 of the GDPR explicitly bans a lack of human oversight in decisions with legal effects. In light of these concerns, Brachman calls for interpretable, rational intentionality to be built into AI systems. That is, if a decision made by a Level 5 artificially intelligent system comes into question, programmers should be able to back out a clear logical progression toward the decision made, following the formula: Agent X performed Action A because it believed Premise P and it wanted to achieve Goal G. If decision making follows such understandable lines, programmers can utilize the resulting causal chains to pinpoint faulty logic and improve the common sense knowledgebase of the AI system. As such, programmers can maintain some insight, if not oversight, and provide correction as needed.


PROGRAMS WITH COMMON SENSE

by

JOHN McCARTHY

SUMMARY

INTERESTING work is being done in programming computers to solve problems which require a high degree of intelligence in humans. However, certain elementary verbal reasoning processes so simple that they can be carried out by any non-feeble-minded human have yet to be simulated by machine programs.

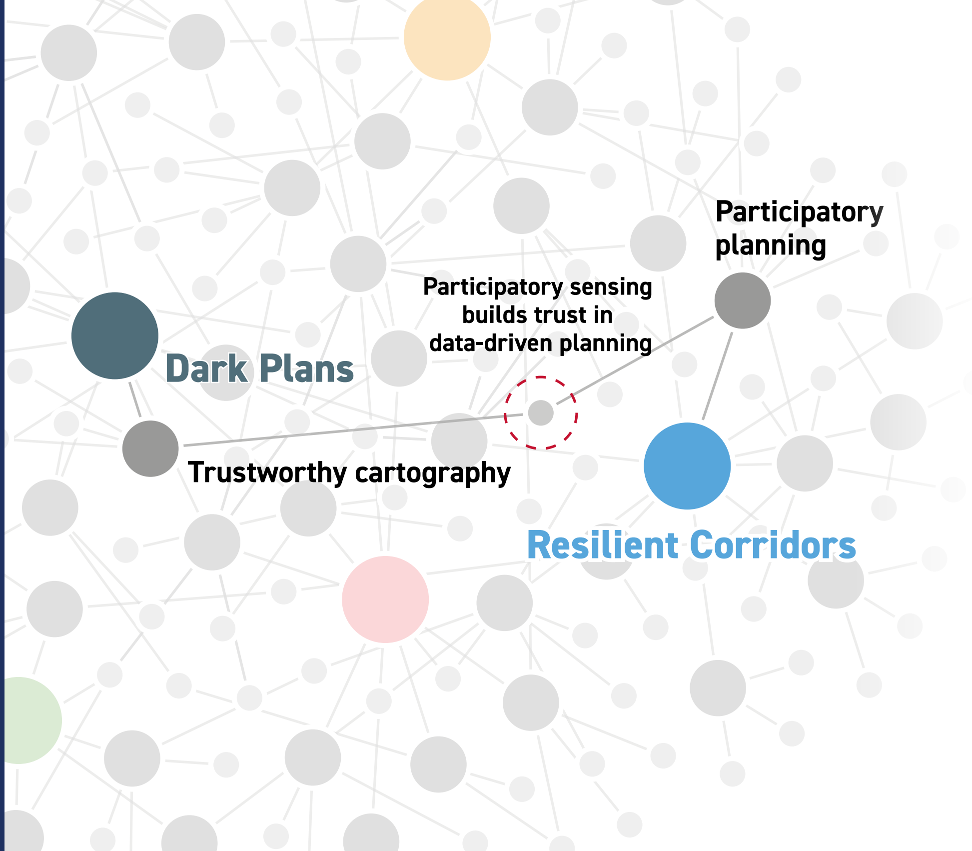
This paper will discuss programs to manipulate in a suitable formal language (most likely a part of the predicate calculus) common instrumental

Programs with Common Sense — John McCarthy

Common sense-based artificial intelligence, as implemented in the manner that Brachman describes, will not be stuck simply reacting to the present based on limited data about the past. Rather, those systems will nimbly interact with dynamic, continuously shifting urban environments, prepared to cope with any unforeseen events, well into the future.

2 Towards Participatory Sensing

Synthesis of the episode with
Kris Vanherle, Co-Founder at Telraam



View this Signal

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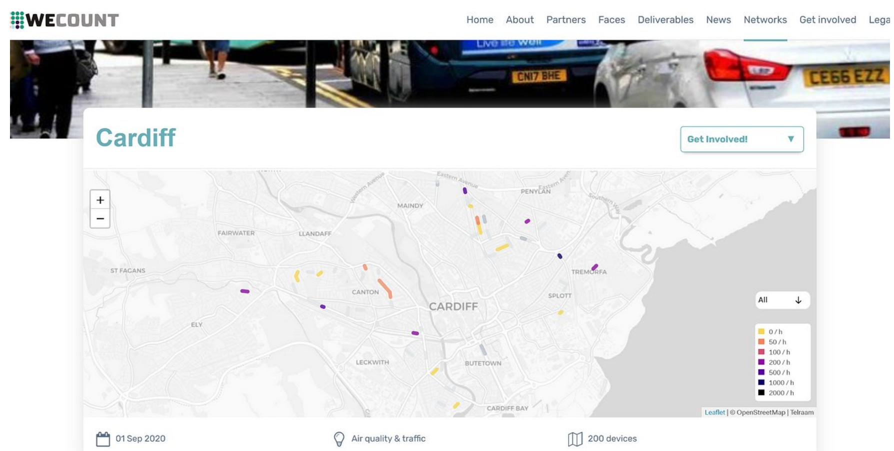
The concept of digital transformation in urban environments has usually gone hand-in-hand with the implementation of smart city infrastructure and "Internet-of-Things" (IoT) technologies. Both strategies require the installation of networks of sensors, which can capture the messiness of urban life and turn those complexities into intelligible graphs and charts, from which decisionmakers can identify patterns, plan for interventions, and measure the impacts of their efforts. This classical approach follows a top-down model. Due to the cost and technical overhead traditionally associated with installing sensors and managing the large amounts of data that they capture, the ability to fund and carry out urban sensing projects has rested in the hands of local governments. Kris Vanherle, co-founder at Telraam, is shifting this paradigm with his new project, "Wecount," which envisions a more participatory future for urban sensing. He shares his successes and lessons learned in the second episode of "the Future of Urban AI,"



Source: WeCount Project

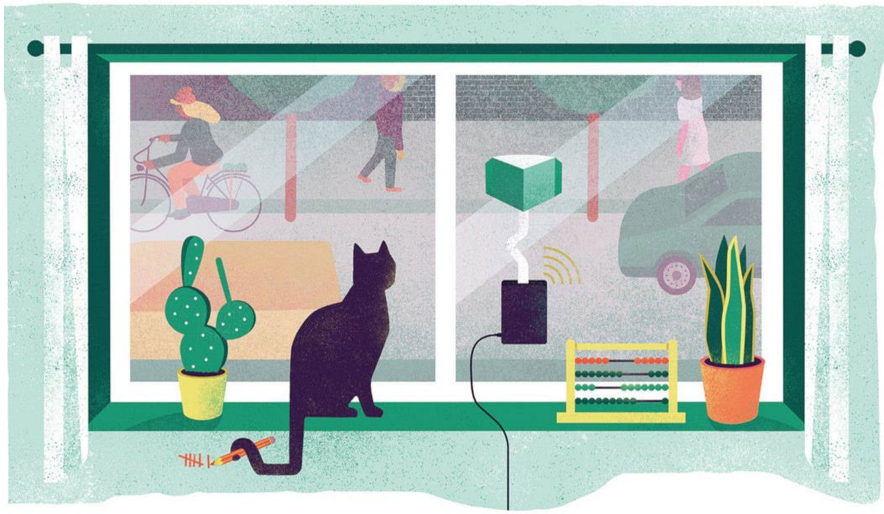
Contrary to the "smart city" approach, Wecount utilizes a bottom-up, collaboration-driven model for monitoring and analyzing urban mobility. The Wecount approach follows two basic premises. First: citizens have concerns related to the flow of traffic in their neighborhoods but lack the data to sufficiently advocate for their needs to local governments. At the same time, local governments have a desire to improve services, but might lack resources to collect sufficient data to inform and prioritize their efforts, especially in the face of a costly "smart city" technology implementation. Wecount's solution forms a triangle of sorts between citizens, governments, and Telraam. At the apex, citizens volunteer to perform the installation and maintenance of the sensors, having a key role in decisions about sensor placement. Citizens also contribute heavily to data analysis and interpretation. Municipalities provide the funds for the sensor devices themselves, and in turn get to benefit from the resulting data and analyses. Telraam acts as a coordinating entity, facilitating the equipment purchases and data access. By incorporating low-cost, flexible sensor technology and citizen volunteerism, Wecount allows municipalities to distribute the responsibility of sensor installation and better engage community members. The limited financial and administrative oversight associated with this model also better supports long-term assessment efforts, as the participatory structures reduce overhead and allow the sensor program to outlast discrete pools of project- or time-specific funding.

Source: WeCount Project

In order to ensure a fruitful implementation and assure continued success throughout the program, Wecount has developed a collaborative project implementation method with 5 phases. In the first phase, scoping & community building, Vanherle stresses the importance

> "Following its philosophy of fostering an inclusive citizen science ecosystem, Telraam provides participants with the tools to access the data, perform their own analysis and gain insights."

of setting the geographic scale of the implementation and bringing relevant community stakeholders to the table. In the next phase, co-design, community members share the traffic-related problems that they have identified in their neighborhood and strategize about the placement and mounting of the sensors. Co-design processes can require more time and effort, but in the end Vanherle has noticed that participants feel a greater sense of ownership of the project and maintain higher levels of engagement. In the data collection phase, Telraam trains and supports citizens in the sensor installation. All data processing, from object detection to object tracking to object classification is mediated by open-source artificial intelligence packages and takes place within the sensor devices themselves, following a "privacy by design standard." Following its philosophy of fostering an inclusive citizen science ecosystem, Telraam provides participants with the tools to access the data, perform their own analysis and gain insights. In the final phase, citizens and municipalities work together to reflect on the insights gained, design a policy to improve the situation, and collaboratively monitor the impacts of that their efforts.

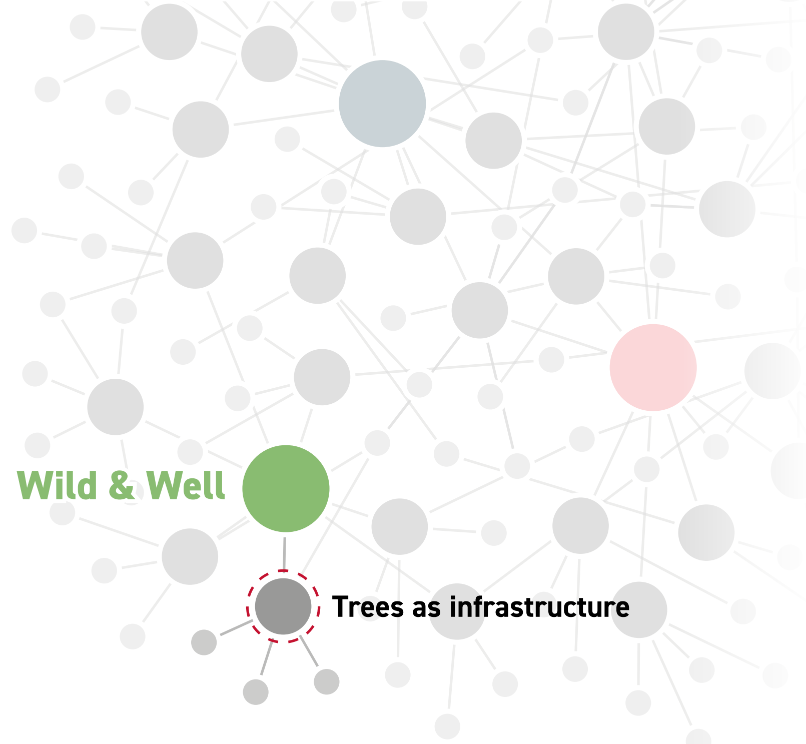


Source: WeCount Project

Telraam has already begun implementing the Wecount model in several Belgian cities. Successful projects have included: identifying transportation mode shifts following COVID-19 lockdowns and associated public health messaging, proving speed limit non-compliance and advocating for/ measuring the efficacy of various traffic calming interventions, and assessing the impacts of construction projects on route selection. Based on his experience coordinating these projects, Vanherle shares some key takeaways to ensure a bright future for participatory urban sensing, First, the technology design needs to be simple and easy to understand. If the sensors are too complicated to install or interact with, then participants will be less likely to engage. Second, involving citizens in material ways makes them more likely to take ownership of a project and want to see it through. Similarly, citizen science does not equate to passive data collection; citizens should be trusted to analyze and interpret the data as well. Finally, for a participatory sensing project to be successful and sustainable in the long term, municipalities should demonstrate that the data collected will actually lead to change. With multi-stakeholder collaboration, citizen centered data collection and analysis efforts, and flexible, low cost technology, participatory urban sensing seems a promising future for broad scale, sustainable data collection, analysis, and monitoring in urban settings.

3 The Quantified Canopy

Synthesis of the episode with
Sara Beery, Assistant Professor at MIT
and Visiting Faculty Researcher at Google



View this Trend

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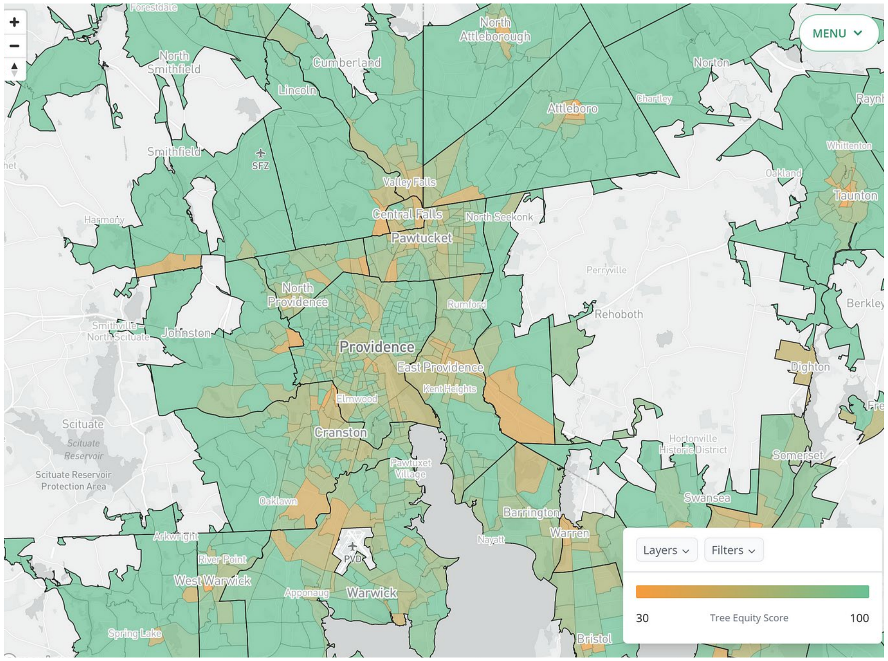
When people think about urban assets and infrastructure, certain elements particularly stand out in their minds. Utility networks supply the intake and expulsion mechanisms that are necessary for urban metabolism and functioning. Roads and other transportation systems convey people and goods throughout our cities and beyond. Streetlights illuminate our public spaces. ICT infrastructure keeps us connected. But what about trees?

It's easy to overlook the leafy branches that look over us. And yet, tree canopies provide numerous positive effects on urban life. According to Sara Beery, an ecology/conservation-focused computer science researcher and incoming professor at MIT, these include promoting urban biodiversity, reducing air pollution, providing carbon sequestration, reducing energy use by providing shade/ natural cooling, mitigating extreme heat islands, and promoting physical and mental health. In light of these benefits, many cities invest considerable amounts of money in purchasing, planting, and maintaining the health of their trees. However, access to urban greenspace is not universal, and Beery pointed to studies exploring both socioeconomic and racial bias in urban forest distribution across cities. Advocacy groups, such as Tree Equity Score, use automated tree canopy maps generated from aerial remote sensing data to identify neighborhoods that are underserved in terms of the benefits provided by urban forests and advocate for more inclusive access to trees. Tree canopy coverage only goes so far: to optimize tree planting to reduce inequity, mitigate urban heat islands, and build resilient natural infrastructure that can adapt to future climate change cities need to know the location and species of individual trees. Within the realm of urban forestry planning alone, municipal governments will sometimes spend millions of dollars on tree inventories and censuses. These data collection efforts provide critical information on the existing state of urban forests and guide the planning for their future. However, the cost of traditional tree inventories prohibits many cities from being able to conduct them. The cities that can afford to conduct them usually confine their surveys to a limited geographic area and sample with low frequency. Additionally, the lengthy time frames associated with the current survey methods lead to results that quickly fall out of date.



[Map of Rhode Island](#) *covered by the Tree Equity Score. Source: Tree Equity Score*

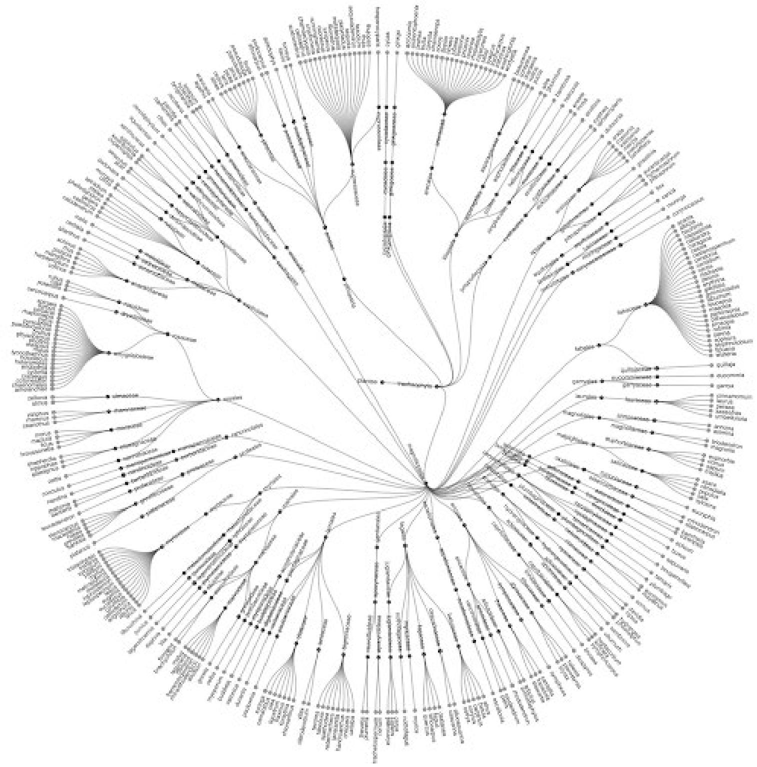
Source: Tree Equity Score

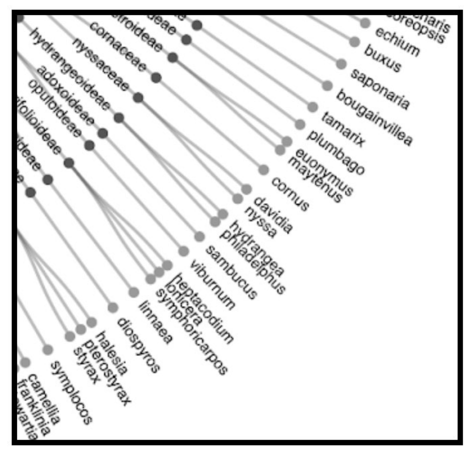
Beery, in collaboration with Google and other researchers, is utilizing artificial intelligence to investigate automating urban canopy extraction and tree species identification as a lower-cost and more comprehensive alternative to the manual counting methods. She and her team trained deep learning models to identify and classify trees using a combination of aerial imagery and Google Street View imagery (with non-tree, non-sky, non-road pixels blurred for privacy). They tested the scalability of different approaches and identified some important trade offs related to the input data source and the geographic specificity of the training dataset. In terms of input data, they found that aerial data was much more widely available and often more current than Google Street View data, but that Google Street View provided important supplemental visual information that was crucial for species differentiation: models trained on Street View data were 2–3x more accurate at identifying trees than models trained on aerial data alone. Making use of both input data sources proved beneficial. In terms of the geographic specificity of training data, they found that models trained on cities with a broader distribution of different tree species generalized to other locations better than models trained on cities with a higher concentration of a specific type of tree, even in cases where cities had less training data overall. However, the models trained on a combined training dataset (i.e. not trained on a specific city or region) performed better than the more context-based models in most cities.

Recent strides in this work have culminated in Beery and her team releasing the Auto Arborist Dataset, an impressive output that provides 2.6 million tree records accounting for 344 genera across 23 North American cities. She and her collaborators are continuing to work on improving and expanding the dataset by striving to better understand, quantify, and limit uncertainty within their models. Some techniques they are exploring include incorporating Lidar data, accounting for geographic and temporal context (as the same species of tree can have a very different appearance depending on the season and the characteristics of its localized environment), incorporating self-supervision into the models, accounting for "multilabel loss" (i.e.

“Once cities can obtain detailed data for all the trees within their boundaries, without having to conduct costly surveys or censuses, they can better focus their resources on increasing equity and ensuring the resilience of their urban forests well into the future.”

identifying and labeling background trees that appear in the training images, so as not to confuse the model with unclassified data), and bolstering citizen science participation to provide more ground-truth data. Beery’s efforts seek to contribute to the future of urban AI by expanding the geospatial scale of accessible, inexpensive access to urban forest information via automated tree species identification and allowing for improved results across a broader and more diverse geographic scope. Once cities can obtain detailed data for all the trees within their boundaries, without having to conduct costly surveys or censuses, they can better focus their resources on increasing equity and ensuring the resilience of their urban forests well into the future.

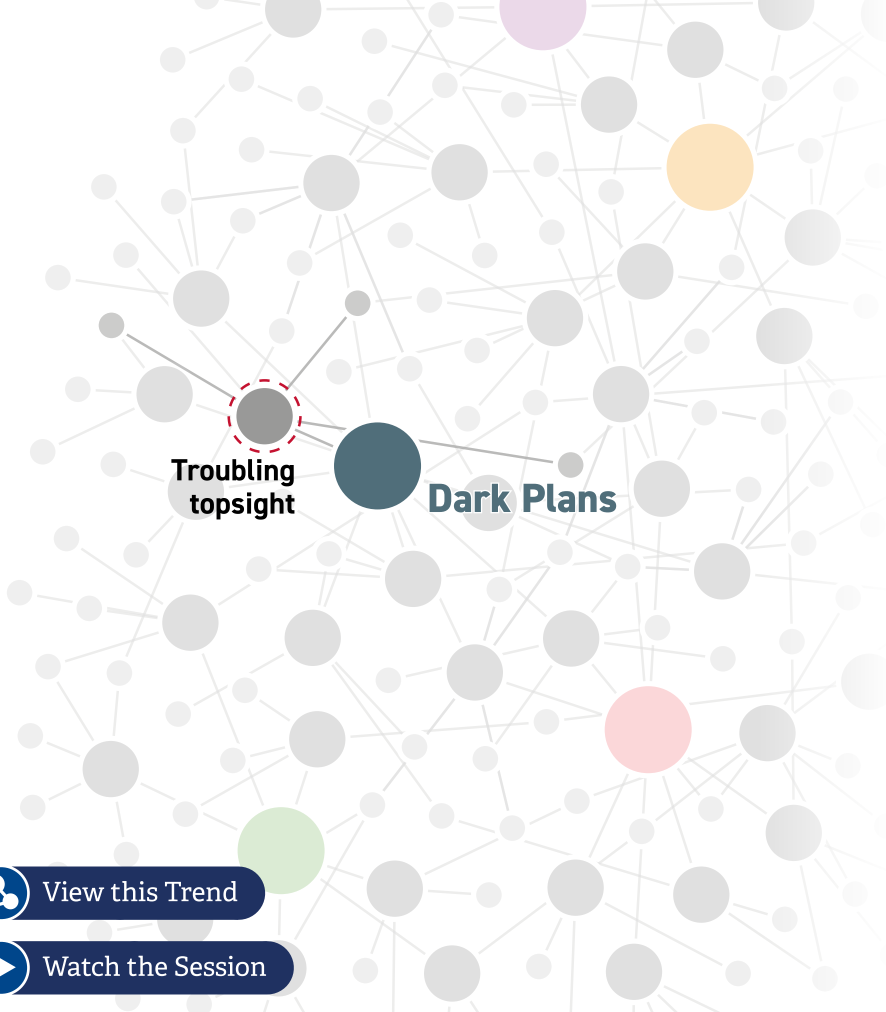




“This dendrogram shows the taxonomic structure of the genera in Auto Arborist. The dataset is taxonomically diverse, with >300 different genera represented.” Source: The Auto Arborist Dataset

4 CityScope: From Smart Cities to Street Knowledge

Synthesis of the episode with
Ariel Noyman, Research Scientist at the MIT Media Lab



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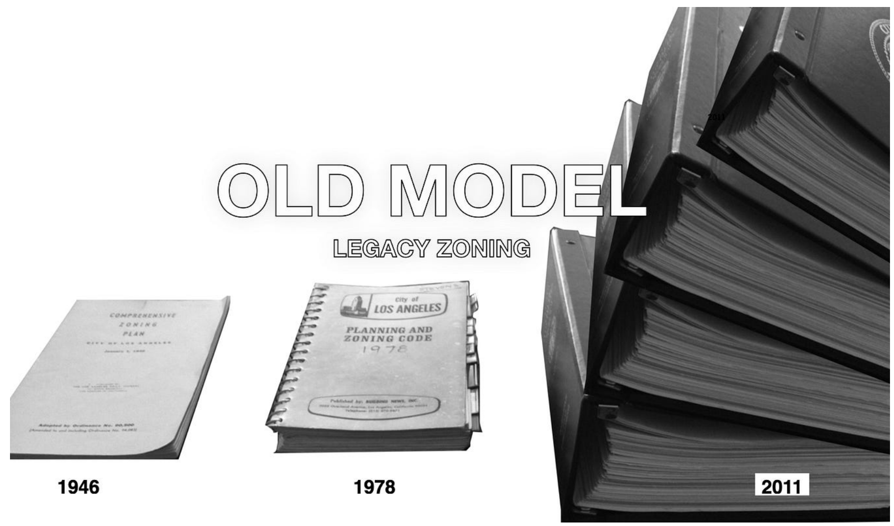
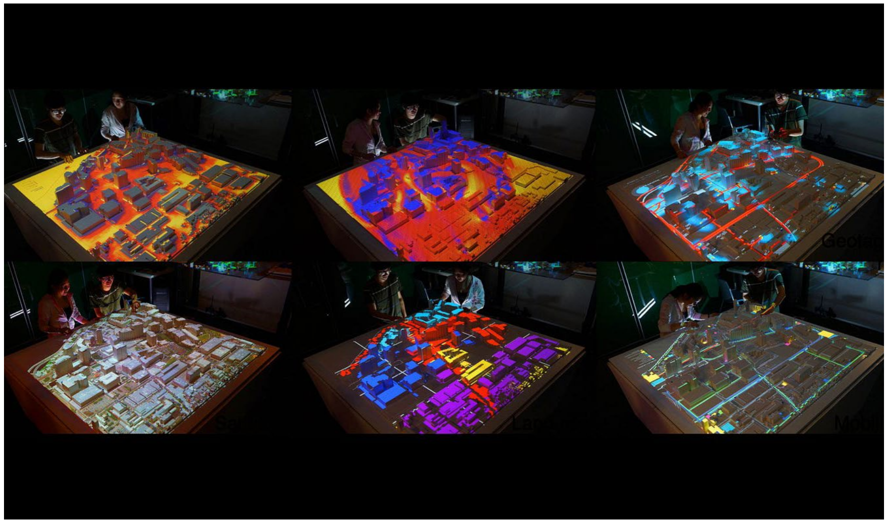
Ariel Noyman, a researcher at MIT, opened the 4th "Future of Urban AI" lecture with a very poignant graphic: a juxtaposition of the Los Angeles building code legislation from three different years: in 1946, a thin booklet; in 1968, a thin binder- slightly thicker than in 1946; in 2011, a stack of multiple thick volumes. As architecture and urban planning requirements become more complex, designing for urban spaces becomes more and more top-down, slow, and bureaucratic. However, Noyman and his CityScope team at MIT envision a future where evidence-based, data-driven, AI-enabled modeling drives a new urban planning process. In this vision, truly participatory urban planning allows for meaningful co-designing with citizens. Within the past 10 years, they have developed and iterated on the CityScope platform to accomplish four primary competencies: insight, transformation, prediction, and consensus.



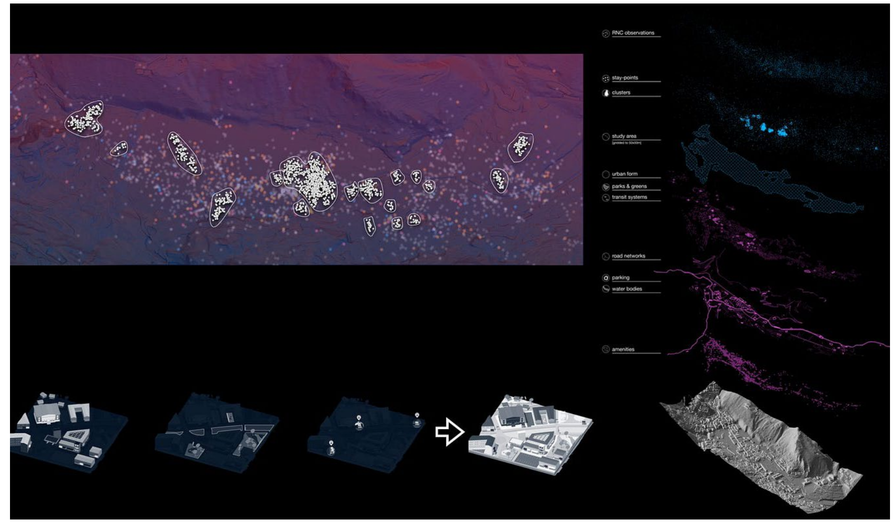
"A juxtaposition of the Los Angeles building code legislation from three different years: in 1946, a thin booklet; in 1968, a thin binder- slightly thicker than in 1946; in 2011, a stack of multiple thick volumes". Source: Ariel Noyman's Presentation

In order to provide insight, CityScope functions as an urban observatory. The team overlays layers of data on a 3D model (often constructed from LEGOs). In doing so, they begin to understand dynamics of urban movement and human behavior, based on existing data. During COVID-19, this approach proved particularly useful in identifying which forms of urban congregation bore a greater risk than others. They could overlay information on COVID-19 cases, individual location data, and information about urban activities and amenities to decipher which activities contributed the most to rising case counts. By obtaining this level of granular insight, cities could tailor their confinement strategies and identify key public spaces in which to intervene, in order to limit human-to-human contact and ensure safer public health practices without reverting to a full metropolitan lockdown.



Source: Ariel Noyman's Presentation

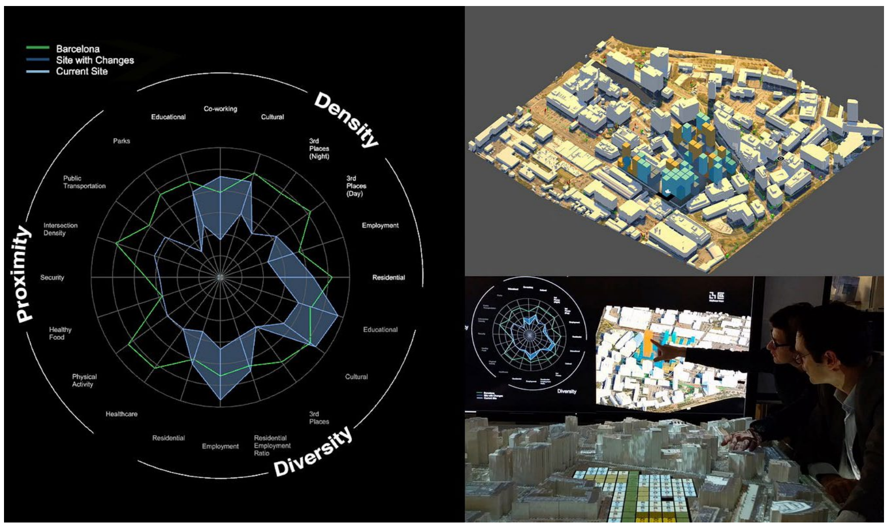
In addition to providing insight, CityScope allows for quantification and experimentation around urban transformation. By "codifying the building code," the City Scope team were able to turn complex building regulations into computational units of analysis, against which they could benchmark proposed urban designs. Through CityScope, they are able to test the coherence of designs with current building laws, as well as estimate the impacts of the new developments on a number of key performance indicators (e.g. density, diversity, and proximity). This proved useful in Hamburg, Germany in 2018, when the city requested assistance evaluating proposals for an urban redevelopment related to its bid to host the 2024 Olympic games. By utilizing CityScope, the team was able to evaluate proposals in a more data-driven way.



Source: Ariel Noyman's Presentation

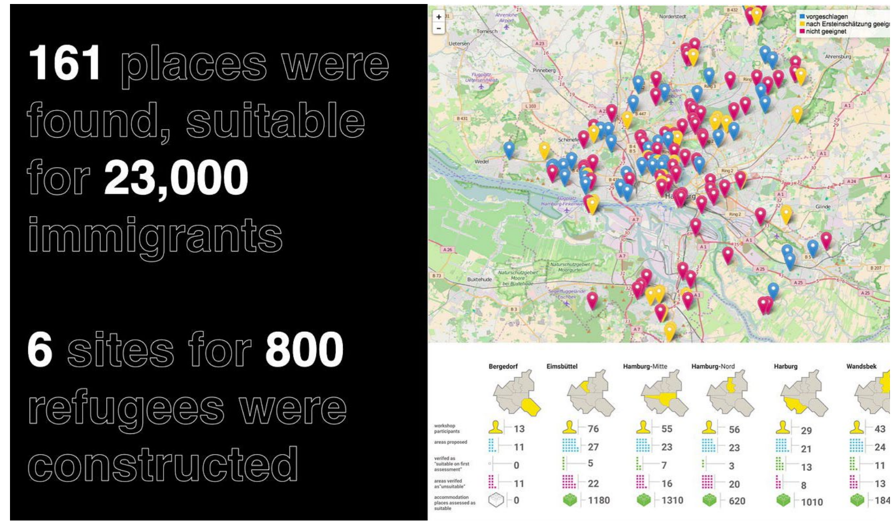
The prediction capabilities of CityScope allow cities to test urban designs and evaluate their utility. To serve this purpose, CityScope employs agent-based modeling to simulate human interactions with and derive use patterns for proposed designs. With traditional urban design practices, prototyping often cannot occur until the proposed development is built. However with CityScope, the team can assess the potential impacts of the designs in question and essentially prototype the urban interventions prior to implementation. The CityScope prediction components were used in high profile urban redevelopment projects, including optimizing certain aspects of transportation planning in Hamburg (by modeling how new transport hubs affect the ways that agents move about the city), and estimating how the Champs-Elysee revitalization plans in Paris, France would affect the manner in which people use the space.

> “By presenting users with a tangible, intuitive interface composed of familiar materials (like LEGOs), CityScope invites citizens with little to no technical or design experience to interact with proposed projects and co-produce viable solutions.”



Source: Ariel Noyman's Presentation

In Noyman's eyes, however, the real power of CityScope lies in the platform's consensus-building capabilities. By presenting users with a tangible, intuitive interface composed of familiar materials (like LEGOs), CityScope invites citizens with little to no technical or design experience to interact with proposed projects and co-produce viable solutions. The very medium of CityScope allows urban planning conversations to switch from top-down, technical, and design-focused to bottom-up, accessible, and action-oriented. In the FindingPlaces project, which was commissioned by Hamburg, CityScope was able to engage the public to select 161 viable sites for integrated refugee housing within the city. The prospect of housing refugees in the city might have previously faced strong NIMBY-ism but was instead met with a “yes we can” attitude, mediated by CityScope.



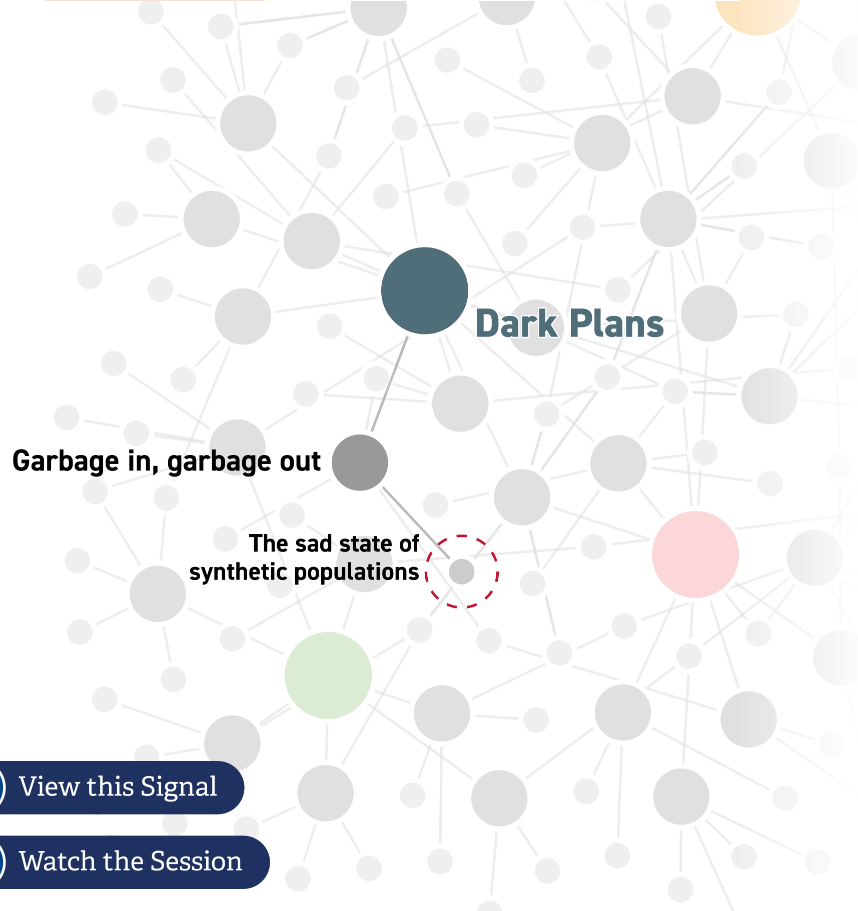
Source: Ariel Noyman's Presentation

Looking to the future, Noyman envisions the AI components of CityScope as augmenting human capabilities, rather than replacing human capabilities. To improve the adoption and quality of CityScope results, he recommends clearly communicating the models used to citizen participants (so as to avoid pushback due to a lack of understanding how the models work), maintaining long term partnerships with cities (through the creation of a CityLab, which ensures that the city can make the most of the setup overhead associated with implementing CityScope in a new city and to allows the platform and objectives to grow with the needs of the city), and encouraging participating cities to provide robust and easy-to-connect-to data pipelines. These shifts would allow for greater portability of the CityScope platform and provide a larger proliferation of truly participatory and citizen-centered urban design.

5

Synthetic Populations and The Future of Transport Modeling

Synthesis of the episode with
Artuhur Getman, Senior Solution Engineer at Replica



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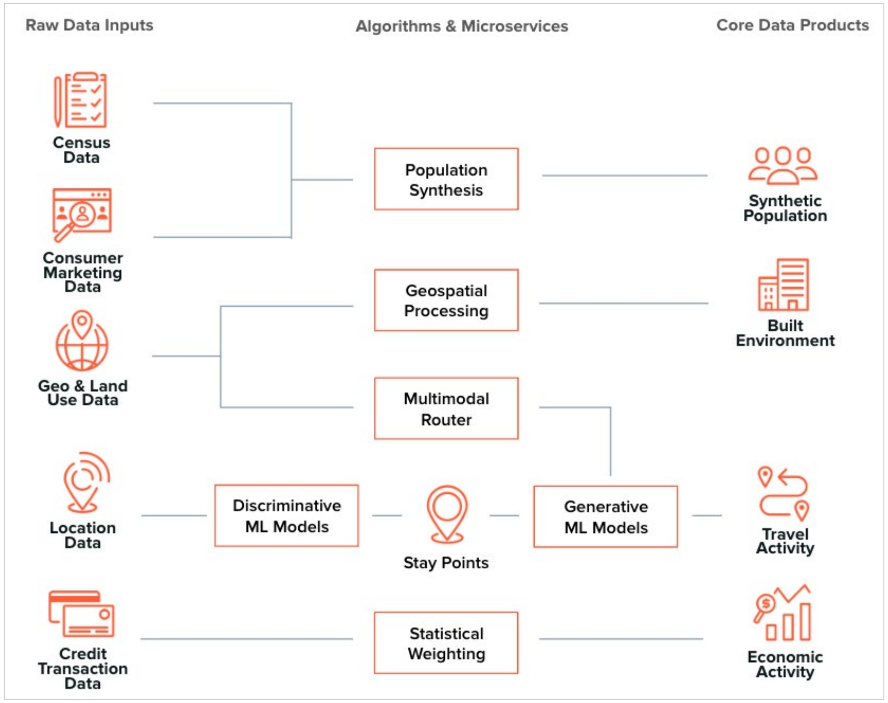
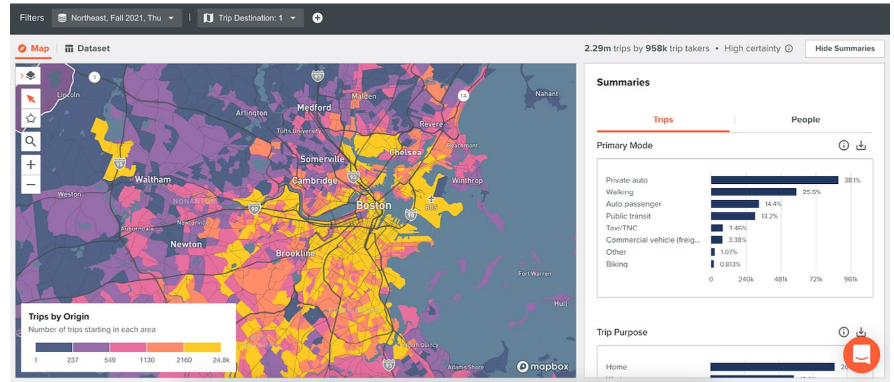
As with most urban systems, transportation networks can be elaborate and vast. Despite this complexity, urban planners strive to ensure that transport and mobility systems serve people efficiently by continuously making modifications as needed. Thus, they have sought ways of boiling down the multifaceted nature of transportation systems, to better understand the complex underlying processes and dynamics. Various techniques of transportation modeling (i.e. abstracting the particularities of transportation systems to estimate and build representations of the key components of transportation systems) help serve this purpose. Using such tools allows planners to answer questions related to how, where, and why people travel, in order to better understand the existing system and plan for future changes. Due to certain restrictions associated with traditional transportation modeling techniques (specifically a subset of models called “trip-based models”) and associated input datasets, they often produce results that can be out of date, and which provide a fairly generalized view of mobility dynamics. However, an increase in the availability, volume, and coverage of novel urban data sources has allowed a new form of transportation modeling to arise: the “activity-based model” (ABM).

As he describes in this episode, Arthur Getman, a Senior Solutions Engineer at Replica, is using big data and artificial intelligence to drive the future of transportation modeling in the United States. Replica seeks to improve the field in two primary ways: by enhancing analyses by using more current data and by allowing planners to disaggregate data and follow the journeys of specific groups of people. American transportation models have typically made heavy use of US Census Bureau data and related derived products, as well as commuter surveys, all of which have very infrequent update rates. Replica, on the other hand, uses proprietary data sources covering mobile phone location data, connected vehicle data, point of interest data, consumer and resident data, economic activity data, and traffic count data, most of which can be obtained in near real time. Replica cleans and combines these data sources with publicly available data, such as OpenStreetMaps data and GTFS feeds to round out information about the built environment. In using these sources, Replica has the ability to perform highly granular and up-to-date analyses.



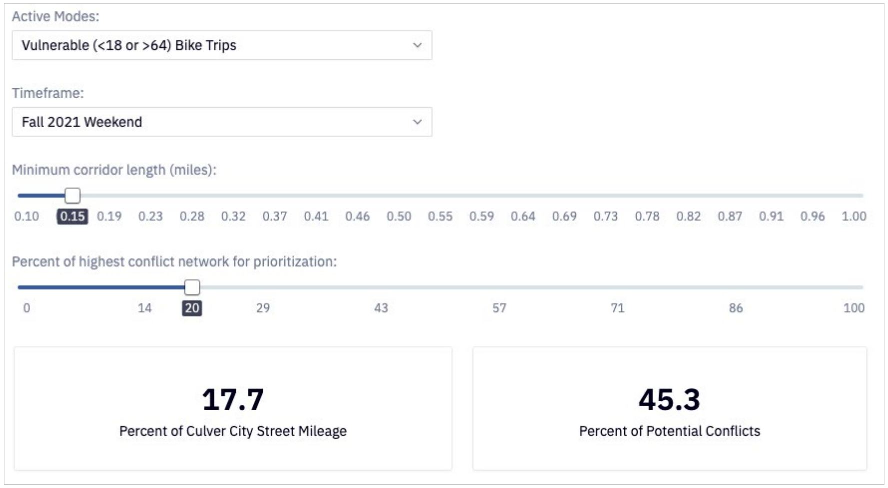
Source: Replica

Replica has designed a number of artificial intelligence algorithms, in order to improve the utility of the data they obtain. First, they synthesize populations from demographic data, using techniques such as generative models to estimate household relationships and persona trainers to define typical work, home, and school locations for each household. To simulate the built environment, Replica uses OSM data to inform a multimodal routing engine. Having generated modeled population and environmental data as inputs to the ABM, Replica uses three types of machine learning models to predict the synthetic population's travel through the constructed space: an activity sequence model to simulate an agent's choice of activity, a location choice model to simulate which places each agent might travel to for each activity, and a mode choice model to represent which transportation mode they might select for their journey. By contrast to this high level of specificity, traditional models usually do not have sufficient data to estimate trip information beyond rough zonal origin-destination linkages, as well as generalized demographic information. The kind of specificity that Replica's approach provides has led to a number of use cases in the United States, particularly with regard to incorporating an equity lens in transportation planning.



Source: Replica

Getman and his team have utilized this sophisticated activity-based modeling approach to achieve a number of positive outcomes. In Culver City, California, the city wanted to embark on a Vision Zero program to reduce traffic fatalities but had limited data and staff resources. Typically cities utilize data on traffic crashes to come up with High Injury Networks. In smaller cities this data is more difficult to come by. With a lack of abundant crash data, Replica performed an analysis finding the highest concentrations of vulnerable road users, including pedestrian and bicyclists of specific ages. This data was paired with another data set — driver behavior data from devices inside of vehicles. Corridors with a high concentration of driver behavior events and vulnerable mode activity on a per mile basis were identified as the city's High Conflict Network. Culver City managers can now use this tool to identify the highest concentrations of potential conflicts to prioritize implementing interventions on and messaging their urgency to the communities that stand to benefit from them.



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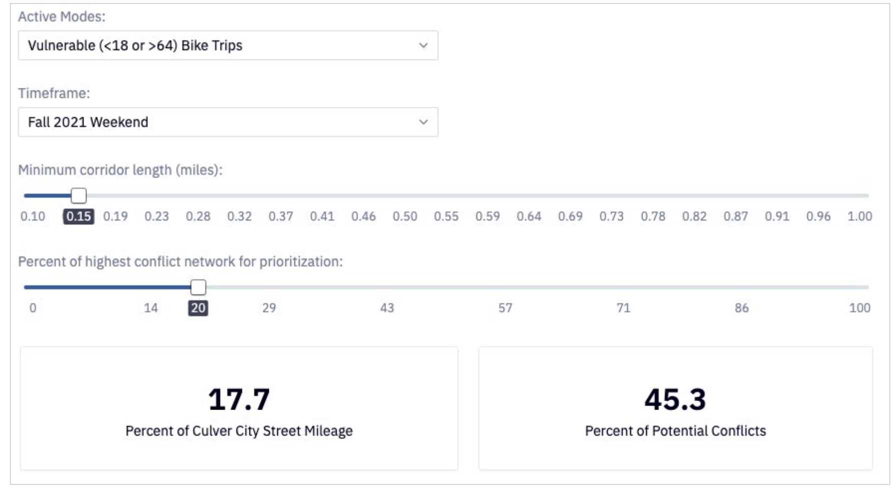

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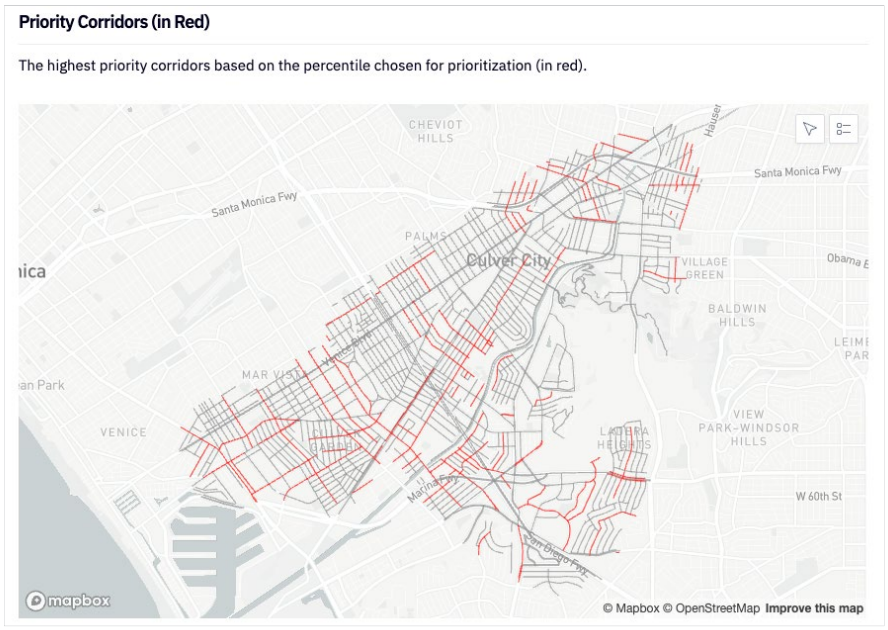
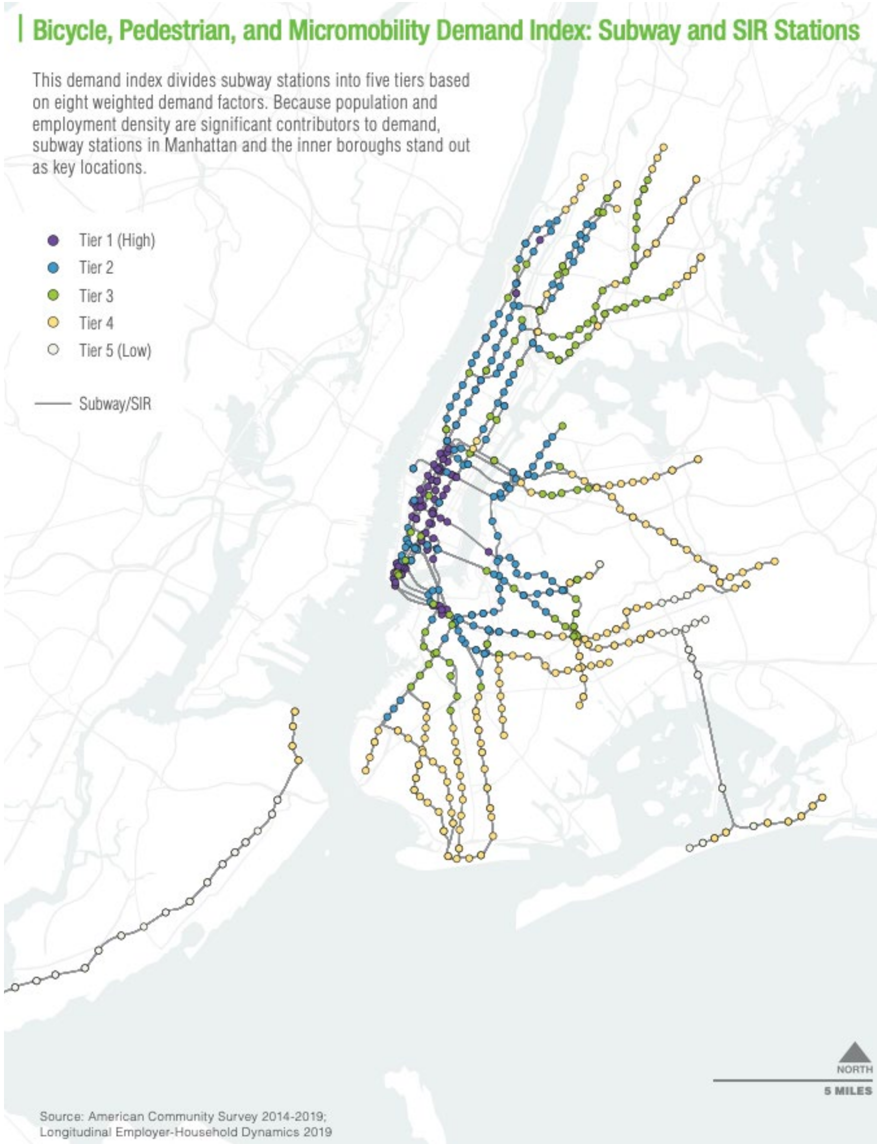


Source: Replica

Replica is also helping transit agencies adopt much faster to a rapidly changing ridership landscape after the onset of the COVID-19 pandemic. In New York City, the MTA used Replica data to understand and prioritize the most important trips; those of essential workers. The agency planned when service would close for cleaning of train cars during the peak of COVID in such a way that would not impact work commutes of essential workers, in an effort to avoid impacting these most important trips. The agency continues to use Replica data, most recently in its Extending Transit's Reach report, an action plan to promote active mode and micromobility connections to transit facilities. The report relies on Replica data for pairing the demand for bicycle facilities around train stations along with the priority of investment at those facilities based on an equity index. The granular level of mode-specific trips that Replica data provides illuminates where residents and tourists are most dependent on, and in need of, facilities like bicycle lanes and bicycle parking in conjunction with their train trips. It can also be used to see where those in need of facilities have also been historically disenfranchised.



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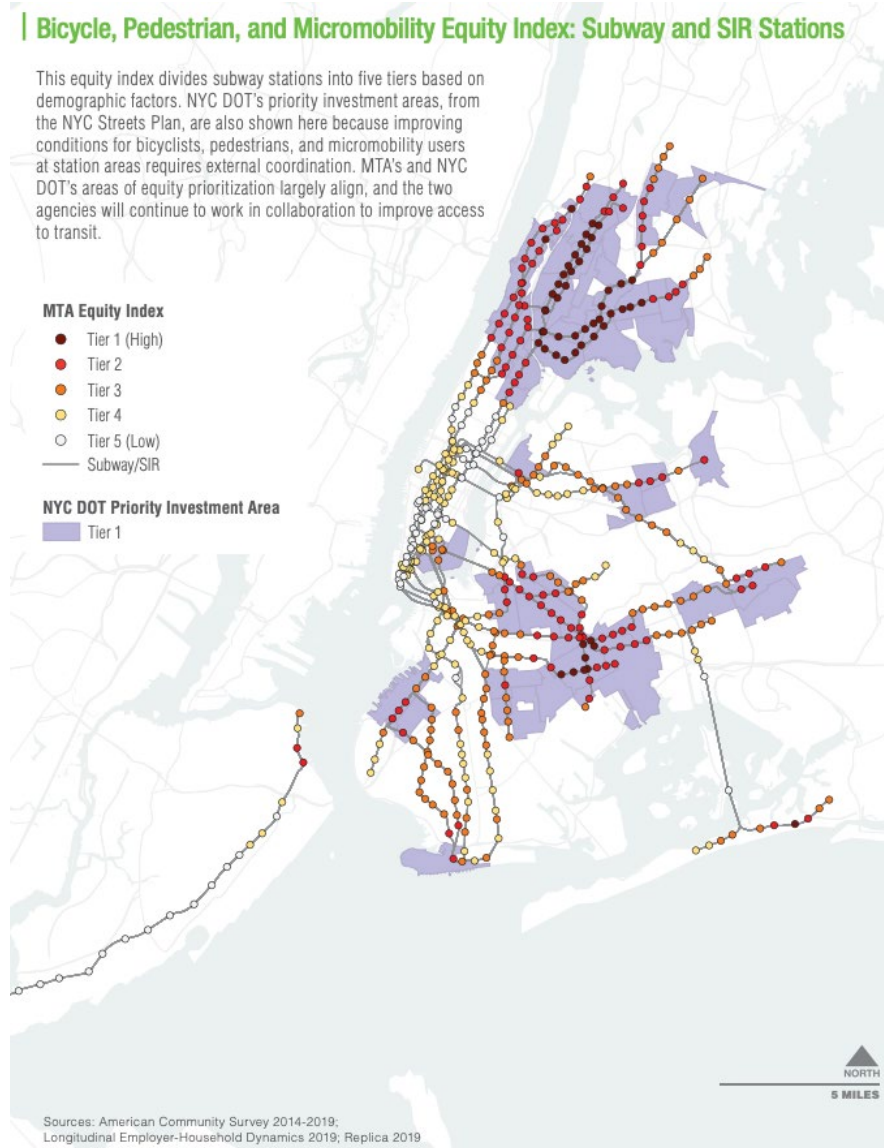


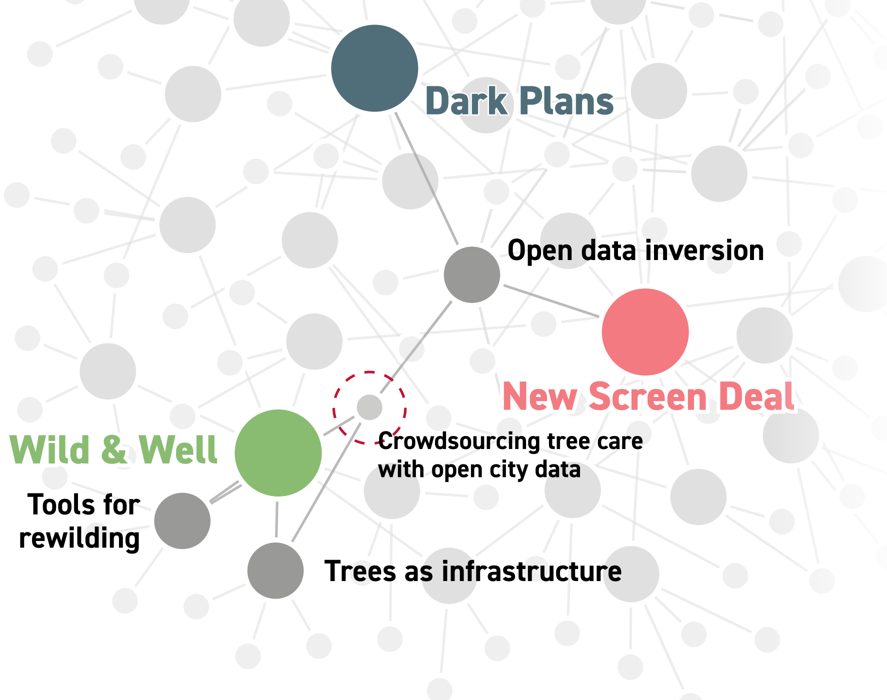
Source: Replica

With the novelty introduced by urban big data sources, activity-based modeling represents a future of urban artificial intelligence not only in its innovative approach, but also in its augmented capabilities. Since the models simulate population characteristics and preferences, as well as environmental features, one can modify any of those input values to predict corresponding outcomes. As such, ABM lends itself to scenario modeling applications, such as estimating citywide transportation behavior shifts that might arise as a result of demographic change or altered employment dynamics. ABM can also allow planners to test modifications to policies or the built environment, giving them a decent impression of how those changes might affect traffic patterns within the city. ABM can thus help shape the on-the-ground future of transportation, in addition to itself representing a technological future. Getman does emphasize, however, the utility of combining traditional data collection methods with synthesized data, as sources of ground-truth information. Given the relatively high fidelity and precision of commuter surveys, they represent a source of accuracy that can be used to calibrate modeled data. However, AI methods, like those that Getman presents, have great utility in filling any gaps in sampled data, and have indeed led to more tailored transportation system interventions.

"With the novelty introduced by urban big data sources, activity-based modeling represents a future of urban artificial intelligence not only in its innovative approach, but also in its augmented capabilities."

6 Crowdsourcing Tree Care with Open Data

Synthesis of the episode with
Julia Zimmermann, Research Associate at CityLab Berlin



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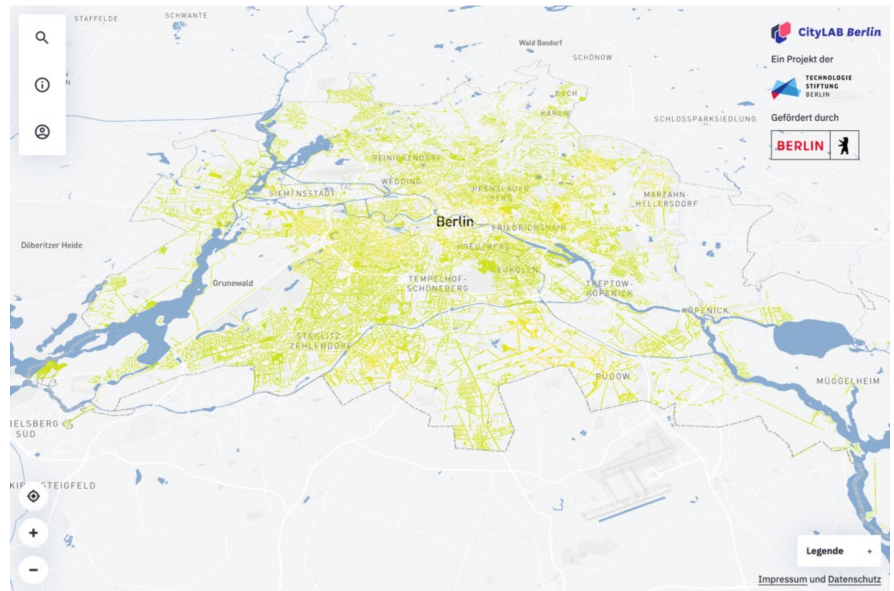
City Trees offer numerous benefits to urban residents. For this reason, cities have a stake in knowing about and caring for their urban forests. As Sarah Beery showed in the 4th episode of the Future of Urban AI, how artificial intelligence is shaping a future in which costly and time-consuming tree censuses can be automated, allowing cities to more easily obtain a broad and comprehensive view of the geographic and species distributions of trees within cities. But what can cities do to ensure the health of their canopies once they have access to comprehensive tree inventory data? Julia Zimmermann and the team at the Technology Foundation Berlin and the CityLAB Berlin have developed two applications that enable citizens and municipalities alike to make use of open arborist data to ensure the health of urban forests. In doing so, they utilize artificial intelligence technologies to redesign tree care and watering prioritization to support a greener urban future.

Source: Julia Zimmermann's presentation

Although trees improve the quality of life for urban citizens and provide many positive benefits, humans place unintentional stress and wear on urban forests. As Zimmermann shares, a number of directly human-induced challenges make it harder for trees to grow in cities. These challenges include: small tree pits that prevent sufficient rainwater from seeping into the soil; human misuse of tree pits (e.g. by parking cars or storing household goods on them), which can damage the trees and roots; soil compaction, as from building and development around the tree, which can affect oxygen levels in the soil; dog urine and road salting which can change the chemical composition of the soil; and sun ray reflection off of glass windows and skyscrapers, which intensifies the sun's heat in a localized area, essentially burning nearby trees. Additionally to those urban challenges, climate change effects, namely rising temperatures and heat waves and as well as changing precipitation patterns and droughts serve as additional forces that put a strain on trees' vitality. With all of these factors making life harder for urban trees, they need a little extra help to remain healthy and continue to provide the leafy canopies that benefit urban residents.

In order to support urban tree care efforts, Zimmermann and the team at the Technology Foundation Berlin and the CityLAB Berlin developed two open-source applications: Gieß den Kiez and QTrees Baumblick. Both applications have the common goal of tracking and facilitating urban tree care, but each takes a slightly different approach. Gieß den Kiez capitalizes on community members' existing relationships with the trees in their neighborhoods to coordinate watering efforts. For years, Berlin residents have taken it upon themselves to provide additional irrigation, especially when trees seemed affected by periods of drought. However, they did so in a very ad-hoc manner. Now, with Gieß den Kiez, over 800.000 city trees of Berlin are visualised on an interactive map. By clicking on every single tree, citizens can not just explore the tree population of Berlin and get information about each tree's species, its age, and water needs, they furthermore can take care and water their favorite trees within the app.

> "Residents can ensure that they avoid over- or under-watering trees, and a community forms around ensuring the continued health of the urban forest."



Source: CityLab Berlin

Thus, neighbors are providing transparency into tree care efforts. In this way, residents can ensure that they avoid over- or under-watering trees, and a community forms around ensuring the continued health of the urban forest. The CityLAB Berlin additionally created an open Slack workspace to facilitate communication and coordination between community waterers. But there is one hurdle: the platform — so far — just estimates the amount of water that a tree should receive based on its age.

Source: CityLab Berlin

This is where Quantified Trees (QTrees) enters the room. QTrees is a research project funded by the Federal Ministry for Environment, coordinated by the Technology Foundation Berlin and executed with the Birds on Mars GmbH and the Greenry Department of Berlin Mitte. It aims to mitigate the climate change effects on urban trees, by providing an AI-based forecasting model for when exactly to water a city tree. Using machine learning-based forecasting algorithms, QTrees takes into account a number of tree health indicators, including the trees species and age, watering data, weather data, shadow index data, crowdsourced reports of tree damages, and soil tension sensor data, in order to predict which trees will be most at risk and will require additional care to remain healthy. All the information around one single tree is ultimately shown within the app "Baumblick". With the predictions returned by the models, public administrators and civil society groups can target their interventions to the trees that need them most. The incorporation of AI into urban forestry management represents a transformation of the field, improving upon previous methods of prioritizing tree care. According to Zimmermann, standard methods such as following standardized rules can result in prioritizing waterings of less endangered trees, while other approaches like evapotranspiration models contain too many assumptions and lack context specificity. A more contemporary proliferation of IoT sensors provides useful real-time data but is not easily scalable due to the cost and spatial/environmental impacts of the sensors and network technologies. However, the QTrees approach allows urban forest managers to make decisions using the positive elements of each of the past methods while employing artificial intelligence to overcome some of the drawbacks.

Gieß den Gieß is looking back at three very dry and thus active summers, whereas the QTrees app will be officially launched at the beginning of 2023. Zimmermann is focusing her efforts on expanding their reach and acceptance within the municipalities. The whole team made a point of providing open-source code on GitHub for their applications and utilizing open data of the municipalities, in the hopes that cities beyond Berlin will create adapted versions of these applications to support their own tree care efforts.

7 How AI is Reshaping the Urban Environment: A VC's Perspective

Synthesis of the episode with
Paul Healy, Principal at Commonweal Ventures

View this Trend

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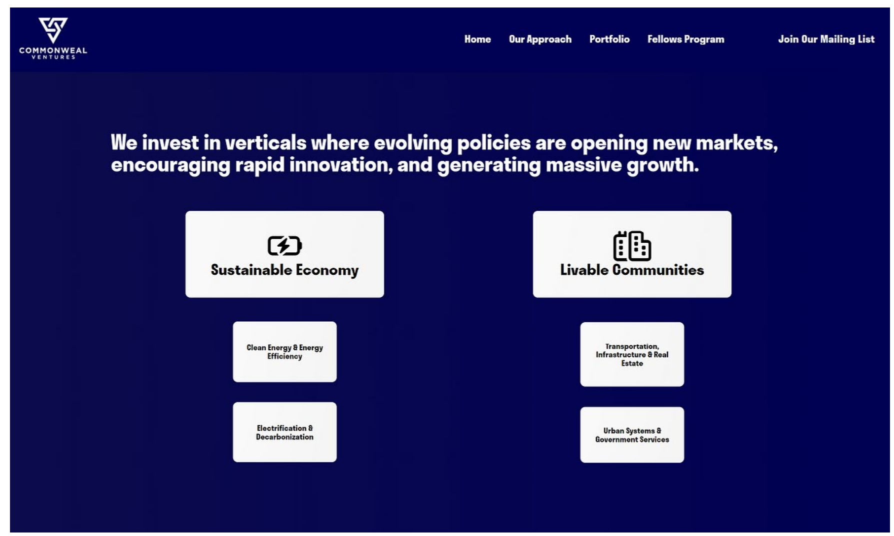
Artificial Intelligence has come to permeate many sectors, fundamentally changing the way that we make decisions, do business, and behave. However, despite the momentum with which other industries have adopted AI technologies in their operations, urban-oriented projects and use cases have been much slower on the uptake. Paul Healy attributes this disparity to differences in the financialization capacity of AI technologies in the urban sector compared to the commercial sector. With his firm, Commonweal Ventures, he seeks to invest in opportunities that promote the use of artificial intelligence to encourage rapid innovation in the realms of a sustainable economy (including clean energy and decarbonization) and livable communities (including transportation, infrastructure, real estate, urban services, and governance). In this episode, Healy discusses how funding and political prioritization can align to drive AI implementation and urban innovation, literally shaping the future of our built-up places.



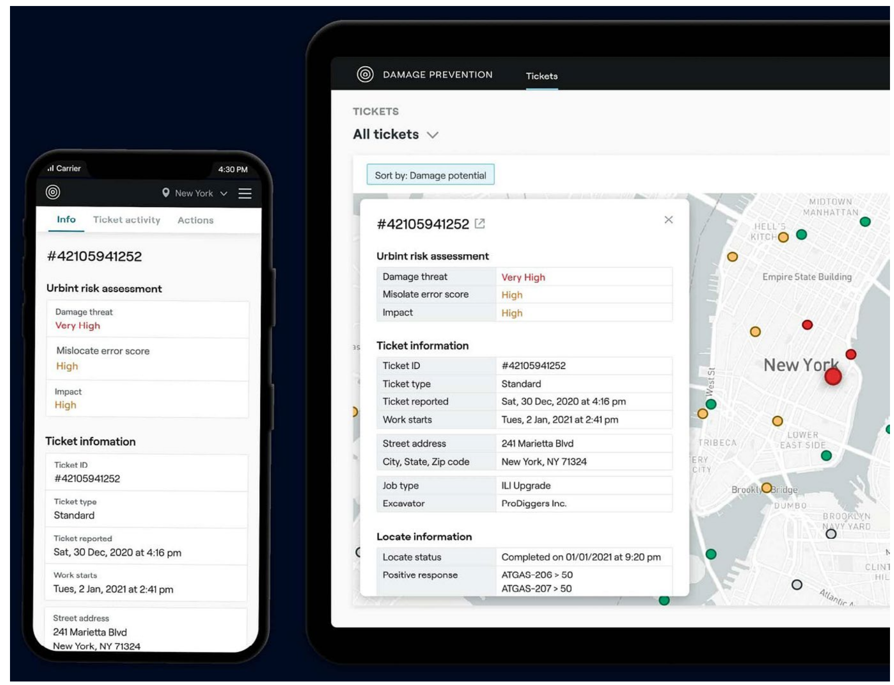
Source: Commonweal Ventures Website

In general, tech companies find it less profitable to develop urban-oriented artificial intelligence solutions, due to the capital intensiveness, long time frames, and limited returns associated with such projects. Healy attributes this trend to physical infrastructure

“Despite the momentum with which other industries have adopted AI technologies in their operations, urban-oriented projects and use cases have been much slower on the uptake.”

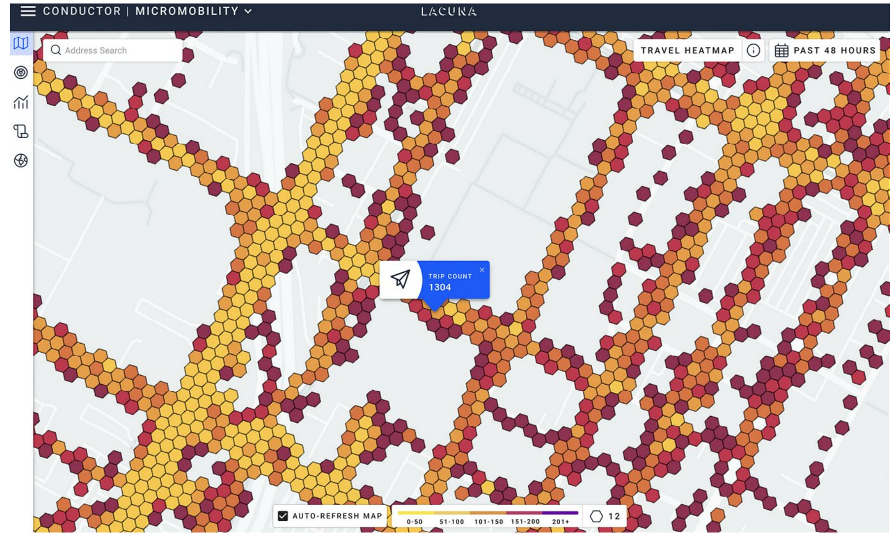
needs typically associated with urban AI applications: whereas other algorithmic use cases only require technical overhead, urban-oriented use cases often require investment in sensor arrays and other physical assets that interact with the built environment. Installing such devices requires capital investment, as well as time and savvy in terms of navigating the permitting procedures and multiple stakeholders that govern the urban built environment. Additionally, since urban AI technologies interact with humans in a much more present and material way (e.g. facial recognition software and AI-enabled vehicles), the public tends to vocalize concerns and hold companies and governments to a higher degree of accountability. Public engagement of this nature is positive in terms of shaping technologies that align with human interest, but it can lead to a slower implementation. However, Healy and his team have identified a number of complementary factors that will serve to accelerate rapid innovation within the urban artificial intelligence market in the near future.

As governments concentrate their focus on increasing sustainability, cities arise as primary arenas for legislation and grant funding. Various legislative mandates have generated new markets for AI-driven technologies. For example, in New York City and other places that have implemented building energy use caps, building owners have a new need to effectively monitor and reduce their energy consumption. This kind of demand opens the doors for tech companies to develop and improve upon platforms that can utilize artificial intelligence to perform monitoring and optimization at scale. Additionally, related legislative efforts have led to the allocation of large pools of funding for green energy, decarbonization, and infrastructure rehabilitation and improvement efforts. Developers and governments accessing those funds represent the second source of demand for innovative artificial intelligence technologies that can improve the performance of the systems and structures they build. Finally, recent labor market shortages have necessitated the use of technologies that can augment the capabilities and efficiency of existing workforces. With these external factors supporting a market for urban innovation, a handful of tech companies have already seized the opportunity to apply artificial intelligence to urban governance and infrastructure problems, in a unique and innovative way.



“Urbint Lens for Damage Prevention identifies high-risk excavations and powers interventions to stop incidents that damage assets, threaten reliability, and endanger the safety of workers and your community.”. Source: Urbint

Healy shares examples of urban AI innovations in the built environment, mobility, and government services sectors. In response to concerns about aging infrastructure, Urbint has developed a highly effective artificial intelligence model that consumes various urban data to predict infrastructure failures before they occur. With the widespread use of such technologies, the future of the urban environment will be much safer for urban residents and less costly for infrastructure owners. In response to the tense and contentious regulatory landscape surrounding shared micromobility offerings, Lacuna has developed an urban digital twin specifically designed for e-scooter policy modeling and planning. With the ability to assess the impacts of policies and regulations prior to implementation, the future of urban mobility will lead to a much more harmonious relationship between mobility providers, governments, and citizens. In response to the negative impacts of short-term apartment rental apps on the urban housing market, Deckard (which Commonweal Ventures backs) has developed an algorithm to pull residential listings from a number of sites, comparing those data to public records, in order to identify properties that may have been renovated without permits or listed for short-term rental without following the appropriate procedures. With the ability to automate flagging potentially problematic properties, the future of local policy enforcement can be much more efficient and less biased. In all of these cases, shifting regulatory and funding landscapes have spurned new technologies to improve urban life.



"Hot Wheels: Why Heatmaps Are A Policymaker's Dream : One of the most powerful tools at a policymaker's disposal is the historical data that illustrates which areas were most used by micromobility vehicles, and we're proud to introduce three new heatmaps that do just that." (Source: Lacuna)

While the interplay of current external factors has spawned new markets that promise to shape an exciting future of urban artificial intelligence and innovation, Healy cautions that governments and urban innovators must remain attentive to a couple of risks. First, since data scientists utilize historical data when they train their models, they run the risk of designing algorithms that perpetuate past biases. To get around this challenge, data scientists and governments must be aware of the limitations of their models and correct for them. New York City has taken a legislative approach to this issue, requiring companies that use hiring algorithms to disclose to applicants what factors the algorithms consider, as well as to subject their algorithms to periodic external audits to ensure a lack of bias. Second, since urban AI implementations often consume sensitive personal data, like biometrics, governments and developers must take strict measures to ensure the privacy and security of those data. With these risks in mind and accounted for, the market is rife for artificial intelligence-led urban innovation, leading to a more efficient, sustainable, and livable urban future.

8 Geopolitics of Smart Cities

Synthesis of the episode with
Ana Chubinidze, CEO of AdalanAI

View this Trend

Watch the Session

Over the past decade, the implementation of smart cities — urban centers augmented by the installation of Internet of Things (IoT) sensors and artificial intelligence technologies — has emerged as a global urban development trend. Certain nation-states and cities have emerged as key players in terms of shaping the character of the smart city and influencing other countries in their own implementations. In this episode of The Future of Urban AI, Ana Chubinidze of Adalan AI shares how strategic narratives elaborated by international stakeholders can shape the development of Urban Artificial Intelligence.

As Chubinidze points out, and as technology theorists have often described, technology is not neutral. Technology contains values, which serve to frame the reality in which the technology operates (Welchel 1986). By the same token, artificial intelligence, as a form of technology that interacts directly with society, carries its own underlying values and geopolitical orientations by extension. On top of this, Chubinidze observes that international stakeholders are more and more transforming urban technologies into strategic assets, as well as instruments of influence and power. In a future mostly urban where cities are having a growing importance, understanding the forces that drive the spread of urban artificial intelligence technologies and associated technologies becomes crucial. To this end, Chubinidze, in collaboration with researchers at Urban AI, analyzed the strategic narratives driving the development and implementation of urban technologies in three contexts: the United States, the European Union, and China.

In the United States context, Chubinidze has identified a trend of utilizing smart city technologies and artificial intelligence to promote "service-oriented cities." In this bottom-up model, citizens serve as both customers and co-producers, having influence on the systems that are built to serve their needs. Local governments in the United States envision the city as a service platform, existing to meet the needs of residents. The governance is highly inspired from the urban entrepreneurialism concept, coined by David Harvey. As such, a majority of the projects utilize the private sector or public-private partnerships to facilitate their implementation. This Smart City

Illustration of the American narrative. Source: Geopolitics of Smart Cities: Expression of Soft Power and New Order (Hubert Beroche et al.)

Illustration of the European narrative. Source: Geopolitics of Smart Cities: Expression of Soft Power and New Order (Hubert Beroche et al.)

narrative highlights the United States' democratic positioning of residents in decisions around technology, as well as the market-influenced emphasis on the "service" element of public services, in which residents have the expectation that cities should exist to efficiently and effectively serve them.

In the European Union context, Chubinidze describes the emergence of a strategic narrative elaborated around ecology and privacy. Whereas the United States focuses on optimizing urban activities to improve the quality of life of residents while reducing operating costs, the EU prioritizes utilizing technologies to decarbonize cities as well as protecting urban biodversity and privacy . In this narrative, artificial intelligence optimizes for resource conservation, for monitoring and modulating energy and water consumption, and for improving collective transportation efficiency to discourage the use of single-occupancy vehicles. Citizen participation and data privacy also factor into the EU context, which takes a very human-centric approach to technology implementation. Thus the EU focus also lies on ensuring agency rathen than viewing citizens as customers to be served. This narrative reflects Europe's desire to improve existing elements of the built environment to support a greener, more livable future.

Lastly, Chubinidze characterizes the chinese strategic narrative through the terminology that China itself uses: "Safe Cities,". In this paradigm, sensors and AI technologies are oriented toward surveilling human behavior and promoting urban security and societal harmony. In contrast to the United States and EU implementations, China utilizes a very top-down approach to UrbanTech governance. The

Illustration of the Chinese narrative. Source: Geopolitics of Smart Cities: Expression of Soft Power and New Order (Hubert Beroche et al.)

> "By understanding the different ways in which cultural ideologies and strategic narratives influence technological implementations at the local level, as well as the relationships between cities in different world regions in terms of technology and knowledge transfer, researchers and artificial intelligence developers can get a better sense of how various AI markets might evolve and shape urban life."

national government manages the safe city programs, which include more than 100 cities, and it opts for algorithms that centralize and automate elements of local governance. To this end, China espouses a highly techno-centric approach, developing, piloting, and exporting innovative domestic technologies. In addition to producing new technologies, China also seeks to produce institutional knowledge, instructing cities in other countries on how to implement their own "safe cities," using Chinese devices and following China's approach.

By understanding the different ways in which cultural ideologies and strategic narratives influence technological implementations at the local level, as well as the relationships between cities in different world regions in terms of technology and knowledge transfer, researchers and artificial intelligence developers can get a better sense of how various AI markets might evolve and shape urban life. Additionally, understanding the narrative behind the regional developments of urban technologies can shed light on the ways that they interact with urban residents and vice versa. With that level of understanding, it is possible to assess the risks and externalities associated with urban artificial intelligence projects, to ensure smoother, safer, and more ethical implementations. This kind of analysis will become increasingly critical, as 21st-century cities take on more autonomy with regard to technology implementation, governance, and diplomacy.

Conclusion

Embracing Urban Complexity

Hubert Beroche, Founder of Urban AI

What can we learn from this exploration of the future of urban Artificial Intelligence? Can we see patterns of development or common trends across countries and disciplines? Do we identify shared concerns or enthusiasms among urban stakeholders?

The first observation, which has been highlighted by Ron Brachman as well as Michael Batty and Anthony Tonwsend in their introductions, is the intrinsic complexity of cities. At the systemic level, complexity means that cities are shaped by the behaviors of interconnected but still autonomous agents. This freedom at the individual level doesn't mean that cities are chaotic spaces, but rather that urban order is achieved through a bottom-up dynamic; it is constantly evolving and renewed by the continuous flow of people interacting together and with the urban environment.

This urban complexity could be seen as a frontier for urban AI. At the computational level, it emphasizes the need to have AIs able to comprehend shifting situations and to adapt to unpredictable events. Humans convey subtle meanings: a glance might signal that a pedestrian wishes to cross the street. Humans also act in unexpected ways: a tree moving on the sidewalk might be a child in costume for Halloween and not an actual moving tree. Those urban scenes require "common sense" to be well understood and processed. While quite obvious for human beings, this ability is far from being self-evident for AIs. Actually, some researchers believe that "common sense" might be acquired only by Artificial General Intelligences - AIs that can perform any task that a human can perform. Concretely, it would mean that urban AIs might need a computational (r)evolution to be fully implemented and reliable (Episode 1).

Other frontiers related to the intrinsic complexity of cities have been raised and studied during this webinar series, including the diversity of agents that make up urban systems. Cities are composed of numerous stakeholders with different - sometimes opposing - interests and temporalities. While private organizations and startups mainly plan their strategies based on accounting years (12 months), public institutions and local governments have usually longer timeframes (between 5 and 7 years). This misaligned temporality to which is added the capital intensiveness needed to deploy products or services in cities make urban innovation more complicated and risky to be funded (Episode 7). Put in perspective with Brochmans' insights, it means that urban AIs need to do more with less.

> "Urban AIs need to do more with less."

The last frontier analysed during this exploration is the political dimension of urban AIs. Urban AIs are political both as technologies subject to regulations and as instruments of power (Episode 8). Urban AIs' architectures, components or interfaces might radically change from one city to another, depending on their own local norms and regulation. For example, urban drones can be seen in the skies of Chinese cities, but not in many European cities. Conversely, urban AI can (re)shape local behaviors and influence urban governance, as the now famous case of Waze has shown. Those political elements question the scalability, and spatiality, of urban technologies. Can, and should, all cities use the same navigation apps or carpooling services? In terms of local sovereignty as well as urbanity, should Paris, New York or Bogota really be engineered and framed by the same technological systems? Those issues of scalability and spatiality bring a fundamental urban truth back to the forefront: cities are localized structures. As such, urban AIs to be situated technologies.

The multidimensional frontiers presented here have often been seen as obstacles that need to be removed. In the past, innovators tried to simplify cities or to strengthen technologies to make them work in urban environments. However, the experts who provided insights for the "Future of Urban AI" series have proposed another approach. Instead of proposing to simplify cities, they highlighted strategies to enrich urban complexity through information technologies. Instead of strengthening technological systems, they showed how to empower agents.

We see those approaches play out in the projects presented by Replica (Episode 5) and CityScope (Episode 4). In both cases, urban AI is used to better understand urban dynamics and behavioural patterns. Rather than shying away from complexity, those technologies leverage it to deliver actionable insights for multiple stakeholders. Similarly, the Telraam project in Belgium (Episode 2) and the QTrees initiative in Berlin (Episode 6) embrace human autonomy- using urban AI to empower citizens. The first case demonstrates equipping citizens with low-cost sensors, empowering the community to crowdsource and analyze mobility data, thus contributing to bottom-up decision-making processes. The second case showcases collaborative governance of urban resources through the provision of providing environmental information that allows people to collectively monitor and care for urban trees.

The presenters in the series not only unveil the future of urban AI, they also tell us *what is* urban AI. They show how to to leverage spatiality to develop situated technologies. They strive to take advantage of limited capacities to invent frugal computational systems. They imagine meaningful technologies which empower people. By doing so, they pave the way for a new manner of innovating, in which urban complexity is seen not as an obstacle to be removed, but rather as a welcome challenge. By presenting those futures, the practitioners in the series show what it means to urbanize Artificial Intelligence.

> "The experts who provided insights for the "Future of Urban AI" series have proposed another approach. Instead of proposing to simplify cities, they highlighted strategies to enrich urban complexity through information technologies. Instead of strengthening technological systems, they showed how to empower agents."

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Urban AI

UrbanAI is a Paris-based think tank dedicated to the emerging field of Urban Artificial Intelligence. Given the highly complex and human-centered nature of urban systems, scholarship and practical implementation of artificial intelligence technologies in cities requires a uniquely multidisciplinary lens. Urban AI seeks to generate a holistic body of knowledge on urban artificial intelligence by federating and collaborating with a growing, global community of researchers, public servants, start-ups, and urban subject matter experts, who work at the intersection of cities and technology. Together, they carry out multidisciplinary projects to better understand and assess the impacts of artificial intelligence on urban life and vice versa.

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Urban Tech Hub

The Jacobs Urban Tech Hub at Cornell Tech is a new academic center in New York City that generates applied research, fosters an expanding tech ecosystem, and cultivates a new generation of urban technology leaders. We bring a human-centered approach to research and education with the aim of building a better world through increased access and opportunity within the technology sector.

Based at the Jacobs Technion-Cornell Institute at Cornell Tech, the Urban Tech Hub leverages the resources of Cornell University and brings together researchers, engineers, scientists, urban tech companies, government agencies, and community organizations to address the challenges facing cities today.

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