IN CONVERSATION WITH
CARLO RATTI

Better Urban Planning with Science and Data

Carlo Ratti, Professor of Urban Technologies and Planning Director at the MIT Senseable City Lab, draws from his past projects to explain how data-driven methods can improve urban planning.

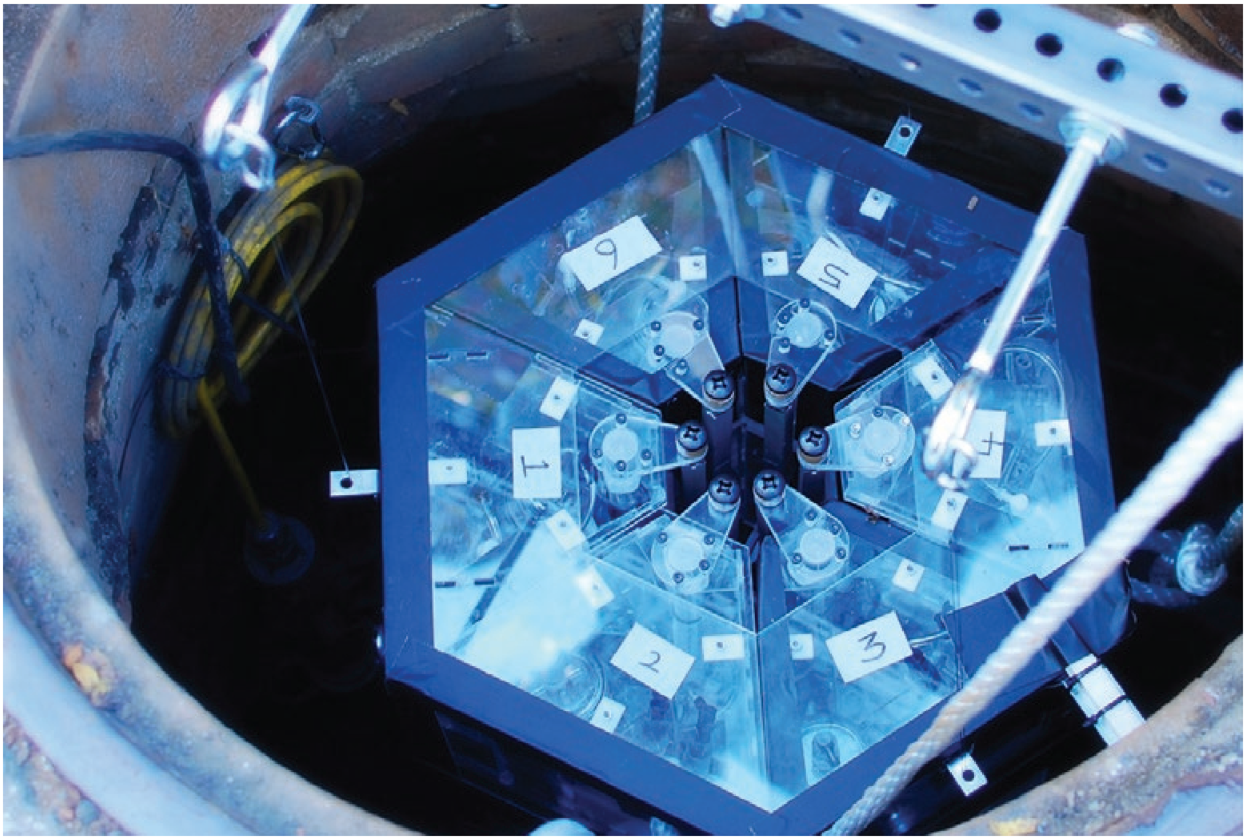
Image: Sara Magni

To what extent can understanding and examining the science of cities affect urban public policy? Do you have any examples in your recent/past works?

Evidence-based policy, i.e., the idea that policy decisions should be informed by objective evidence, is gaining traction globally. In this sense, the understanding of cities through data—which many people refer to as the "new science of cities"—is vital. As an example, at Senseable City Lab under the Massachusetts Institute of Technology (MIT), we were involved in the Underworlds project, which employs robots to retrieve wastewater samples from the sewage system.

Taking wastewater samples as part of the Underworlds Project.
Image: MIT Senseable City Lab and Alm Lab

Underworlds started as an MIT-wide research initiative, with experiments conducted in the US city of Cambridge, Massachusetts; Seoul, South Korea; and Kuwait City, Kuwait. The small robots we placed into the sewage system act in two phases: the motion system positions the instrument centimetres above the wastewater using a bipolar stepper motor, nylon line and proximity sensors. After sampling, the motor reverses to wind the line and thereby lift the instrument back to street level.



Robots designed by MIT Senseable City Lab to collect wastewater samples from the sewers.
Image: MIT Senseable City Lab and Alm Lab

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The filtration system concentrates ingredients of wastewater, including bacteria, on a filter—which is later analysed in the lab with metagenomics, metatranscriptomics and metabolomics.

The initiative successfully detected the flow of bacteria and viruses in real time and resulted in a start-up called Biobot. It was founded by Mariana Matus and Newsha Ghaeli—researchers who were involved in the Underworlds project. The start-up is a combination of this experience and their expertise in biology and urban studies. Over the last few years, Biobot has been collaborating with different US cities to conduct tests and most recently, provide feedback on COVID-19 policies.

In your work Desirable Streets, the research findings highlighted several factors such as shop frontage and parks, rather than the shortest path, that encourage pedestrian activity. How do you think these scientific methods could shape the planning of streets in the future?

Long before I could run an experiment, I had a hunch. Twenty years ago, I was a student at the University of Cambridge, and I realised that the path I followed between my bedroom at Darwin College and my department on Chaucer Road was, in fact, two different paths. On the way to Chaucer, I would take one set of turns. On the way back home, I would take another.

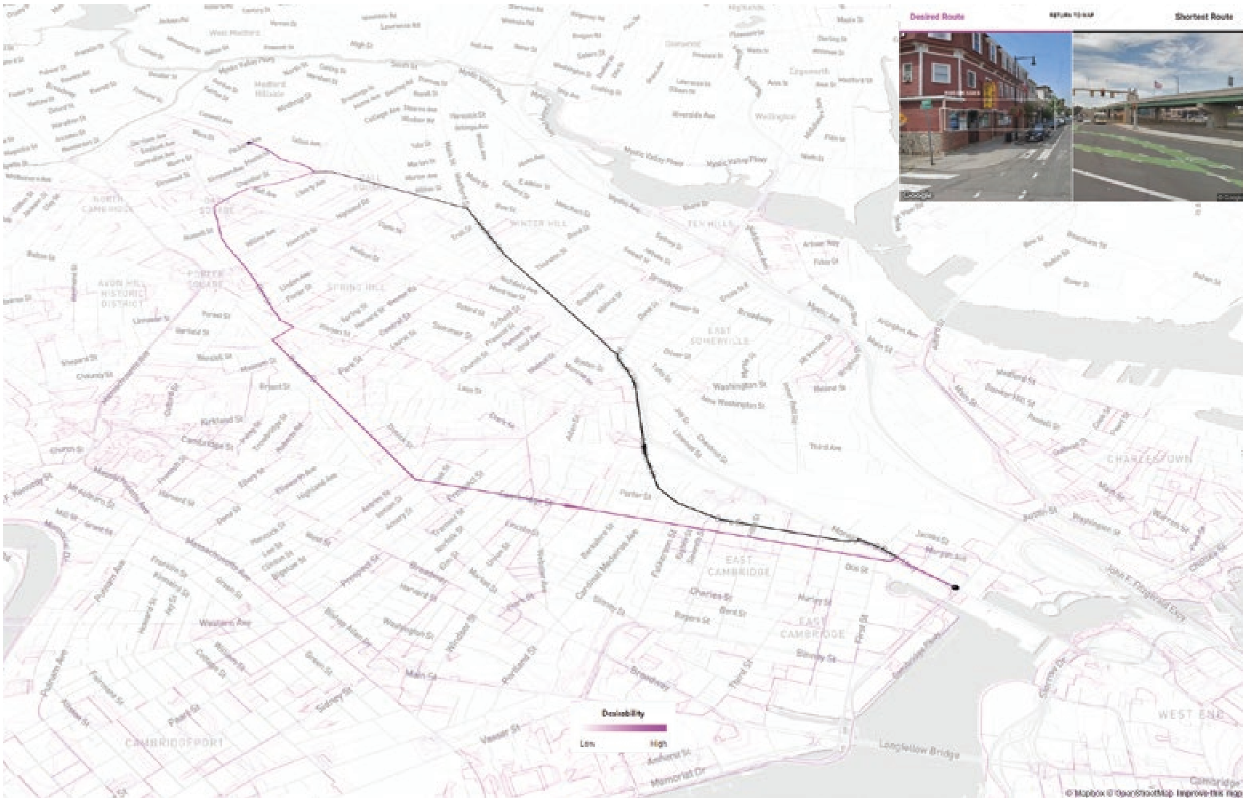
Surely one route was more efficient than the other, but I had drifted into adapting two, one for each direction. I was consistently inconsistent, a small but frustrating realisation for a student devoting his life to rational thinking. Was it just me or were my fellow classmates—and my fellow humans—doing the same?

Today with Big Data we have an answer to this question. We discovered that the most predictive model, representing the most common mode of city navigation, was not the quickest path. Instead, it is one that tries to minimise the angle between the direction a person is moving and the line from the person to their destination.

This finding appears to be consistent across different cities. We found evidence of walkers attempting to minimise this angle in both the famously convoluted streets of Boston and the orderly grid of San Francisco. Scientists have recorded similar behaviours in animals, which are described in the research literature as vector-based navigation. Perhaps the entire animal kingdom shares the idiosyncratic tendencies that confused me on my walk to work.

Desirable Streets used thousands of pedestrian trajectories obtained from GPS signals to construct a desirability index for streets in Boston. It was part of a broader investigation into human mobility we have been carrying out at Senseable City Lab.

An analysis of street desirability for streets in Boston.
Image: MIT Senseable City Lab



Calculating the most desirable route between two points.
Image: MIT Senseable City Lab

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We recently published another paper in the journal *Nature Computational Science* that finds people seldom take the shortest route to reach their destination. Rather, they follow the "pointiest path" that eschews angular displacements, even if travelling at small angles would actually be more efficient.

Such knowledge of human behaviour could be very useful in urban planning, in order to design better mobility networks in cities. Furthermore, we are no longer walking, or even thinking, alone. We are increasingly wedded to digital technologies, to the point that phones represent extensions of our bodies. Technological prostheses do not think like their creators. Computers are perfectly rational. They do exactly what the code tells them to do. Brains, on the other hand, achieve "good enoughs" and necessary compromises. As these two distinct entities become increasingly entangled and collide—on Google Maps, Facebook or a self-driving car—it is important to remember how they are different from each other. We need to make sure the technological devices can accommodate our irrationalities. AI should be an ally of organic intelligence.

Another one of your projects, Copenhagen Wheel, looked at how bicycle movement data could potentially improve planning for future bicycle routes in cycling-friendly cities. Could you elaborate on how data-driven methods like this impact our understanding of urban mobility in a holistic sense?

Copenhagen Wheel was a collaboration between Senseable City Lab and the city of Copenhagen in 2009. The initial idea was simple—an intelligent wheel that could be retrofitted on any bike and by doing so immediately turn it into an e-bike. Once installed and paired with a smartphone, the wheel would be able to sense the force of your pedalling and provide an appropriate level of assistance. It would track the speed, direction and distance travelled, as well as collect data.

As a smart system laden with sensors, it would monitor air quality but also track the speed, direction and distance travelled by the bike on which it is installed.

The Copenhagen Wheel "smart wheel" retrofitted onto a bicycle (*left and right*).
Images: Max Tomasinelli

The project was met with great success. It gave birth to mobility start-up Superpedestrian, which has since invented more sensor-driven mobility devices like e-scooter LINK, with the capabilities of remote diagnostics and even remote maintenance.

Understanding people's biking habits—and that of other types of micro-mobility—is important for envisioning a city's transportation system as a whole. With a well-thought-out set of lanes, more people would consider commuting by bicycle. Such changes could reduce congestion and pollution, and data collection is the first step to achieving it.

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You also talked about the concept of designing streets to have multiple functions, such that unused space is minimised in order to achieve a higher-density yet sociable environment. What do you think is the role of government and policymakers when it comes to these land-use policies on mixed-use plots, road sharing, etc?

I think governments have an important role to play in terms of incentives—which in turn can promote some of the changes we are discussing. During the COVID-19 pandemic, such transformations on our streets emerged naturally as soon as local governments allowed businesses to expand outdoors. In the future, we could imagine a kind of platform that would allow people to bid and propose uses for such real estate, and as a result allow a dynamic occupation of space.

What do you think is the biggest challenge and limitation that architects and urban designers face in the practice of urban planning and design these days, in terms of keeping up and applying digital technology and data-driven approaches?

One of the main challenges faced by urban design professionals is the increasing complexity of the issues they have to tackle. From a once-in-centuries pandemic to drastic climate change, their scope exceeds the capabilities of one single profession. Architects need to join forces with experts from different disciplines to develop comprehensive design

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solutions. I refer to this new role as "choral architect" in our book *Open Source Architecture*. This future architect or urban designer is someone who is informed about different fields and capable of mobilising various communities to tackle the most urgent problems nowadays. Keeping up with digital technology is crucial in this kind of collaboration because it allows all the parties involved to work together efficiently.

In terms of the choral quality of design, I would like to mention the project CURA. It is an open-source design based on converting shipping containers into mobile Intensive Care Unit (ICU) pods in response to the shortage of hospital beds during the first wave of the COVID-19 pandemic. From design to fabrication, it took us only weeks to complete the prototype, and this was made possible through collaboration among doctors, engineers, medical equipment producers and many more experts from different areas—under the coordination of our designers and architects. It was not easy to get all the parties coordinated, especially at a time when physical meetings were not feasible, and it was up to the team to develop a design solution that bridges the multiple perspectives and most adequately addresses the issue at hand. We published all the plans of the mobile ICU pod on a website, and as a result, companies in the UK, Greece, the UAE and other countries were able to replicate the design and help their local communities.

Mobile ICU pods created from converted shipping containers as part of the CURA project (*left and right*).
Images: Max Tomasinelli

How can data-driven design approaches include more participatory design in which local communities are activated, and heard?

Sharing data—either as raw numbers or as data visualisation—can be a powerful tool to engage communities. There are many interesting examples related to open-data initiatives, such as new citizen-developed apps to better interface with public transportation. Also, digital networks allow new forms of participation, creating feedback loops among designers, city officials and citizens. What I mean by this latter point is that digital platforms enable input and sharing of knowledge in real time—and hence new forms of participation akin to what happens to open-source communities. In this sense, they facilitate a large group of individuals/organisations in being the co-creators of a project.

What is your vision for the role of science-backed, data-driven approaches for cities in the next 20 years?

I expect sensors, Big Data and artificial intelligence to play an ever-increasing role in future cities. Hopefully, this would also be accompanied by widespread data literacy and transparency—so that we can all monitor and be part of such transformations.