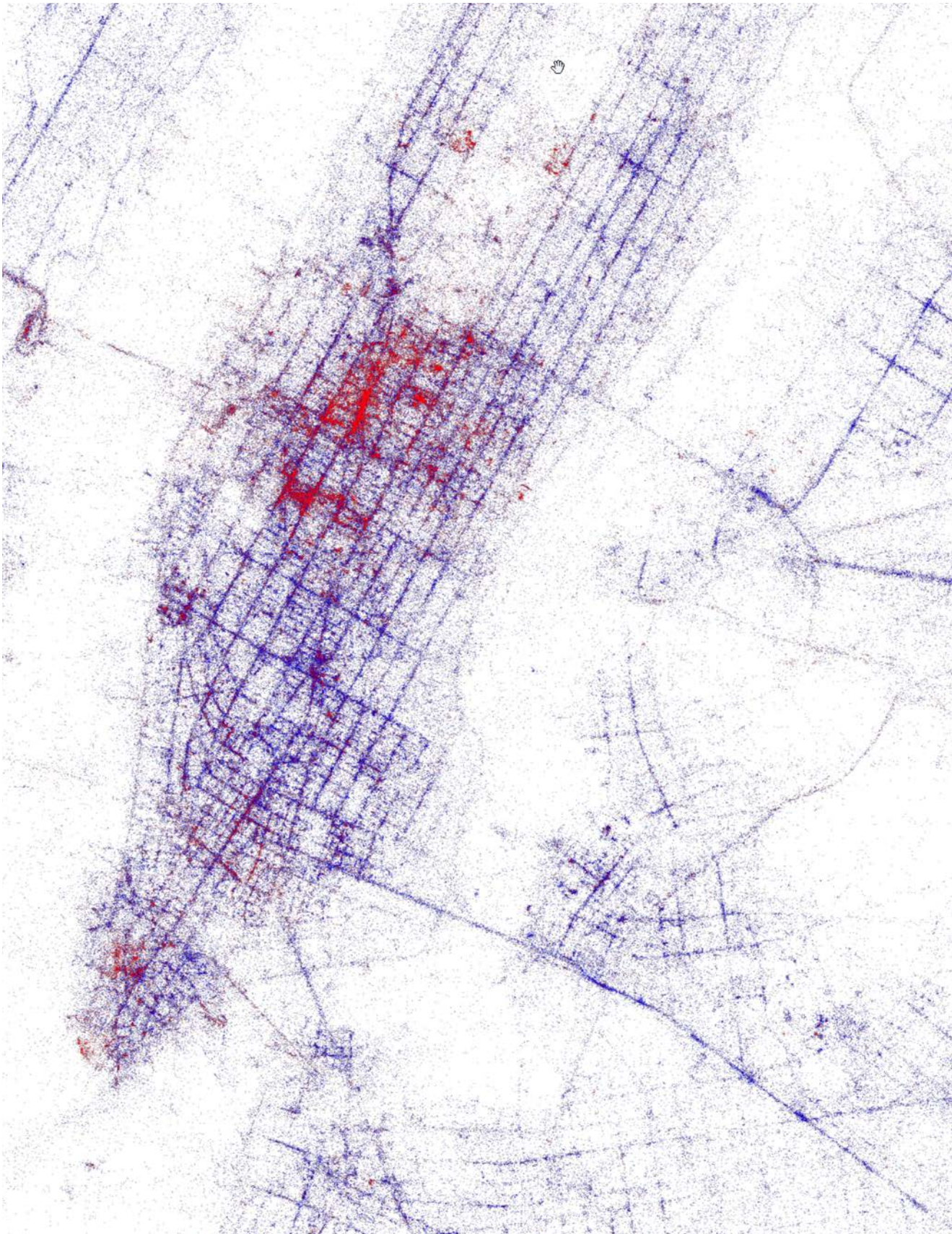
Data-Informed Design

Understanding how data-driven technologies can inform evidence-based decision making in architecture and urbanism.

Jordan Mathers

Byera Hadley
Travelling Scholarships
Journal Series
2019

NSW Architects Registration Board



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The Byera Hadley Travelling Scholarships Journal Series is a select library of research compiled by more than 160 architects, students and graduates since 1951, and made possible by the generous gift of Sydney Architect and educator, Byera Hadley.

Byera Hadley, born in 1872, was a distinguished architect responsible for the design and execution of a number of fine buildings in New South Wales.

He was dedicated to architectural education, both as a part-time teacher in architectural drawing at the Sydney Technical College, and culminating in his appointment in 1914 as Lecturer-in-Charge at the College's Department of Architecture. Under his guidance, the College became acknowledged as one of the finest schools of architecture in the British Empire.

Byera Hadley made provision in his will for a bequest to enable graduates of architecture from a university in NSW to travel in order to broaden their experience in architecture, with a view to advancing architecture upon their return to Australia.

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Jordan Mathers was awarded the Byera Hadley Travelling Scholarship in 2018
Cover image: New York - Locals and Tourists. Using Twitter data, data artist Eric Fisher made an interactive map where you can see if a location based tweet was from a local (blue) or tourist (red).

Locals and Tourists - New York. (2020). [image] Available at: https://labs.mapbox.com/labs/twitter-gnip/locals/# [Accessed 10 Jan. 2020].

Data-Informed Design:

Understanding how data-driven technologies can inform evidence-based decision making in architecture and urbanism

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Architects may no longer be the gatekeepers of design, so how do we innovate the field to advance the resilience, equity and flexibility of our cities?

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Introduction

"Technology is the Answer. But What Was the Question?"

It is important to reflect on the incisive remark by Cedric Price when discussing the implementation of new technologies in the design industry. This quote has increasingly become more relevant as the world transitions into a period where technology is reaching deeper into the essence of human experience and is in a state of constant innovation.

Yet, as we discuss it more, the architecture, engineering and construction (AEC) industry seems slow to take advantage of technological advancements. Architecture in particular is founded in more traditional methodologies of delivering architecture and urbanism. Few firms explore the full offering of advanced technologies and computational applications. Of course, Building Information Modelling (BIM) has rapidly overtaken traditional Computer Aided Design (CAD) tools. However, the prevalence of BIM software suites like Revit and Archicad means that for the most part they have only digitised the pencil. Dark Matter write;

> *"A lot of the ways new technology is being used, is solely focus on optimising and updating what we currently do, meaning we become easily distracted by the hype and promise of new tools or software — rooftop drone surveys, VR client meetings, BIM 4.0. This stops us engaging with the underlying issues we're trying to solve; creating more regenerative, circular and equitable cities in a rapidly urbanising and digital economy."*
>
> *(Medium - Dark Matter, 2019)*

Risks of Not Innovating

It's important to note that the AEC industry lags behind in almost all other industries in relation to digitisation. The graph below explains the need to consider innovation, showing that the construction industry falls behind most other industries in productivity growth due to a lack of digitisation. In the McKinsey report that published this graph they lay out the risks and rewards of innovation or lack thereof. Companies that lead the charge are winning market share and profit growth as well as an increasing wage growth that is twice the United States national average (McKinsey Global Institute, 2015).

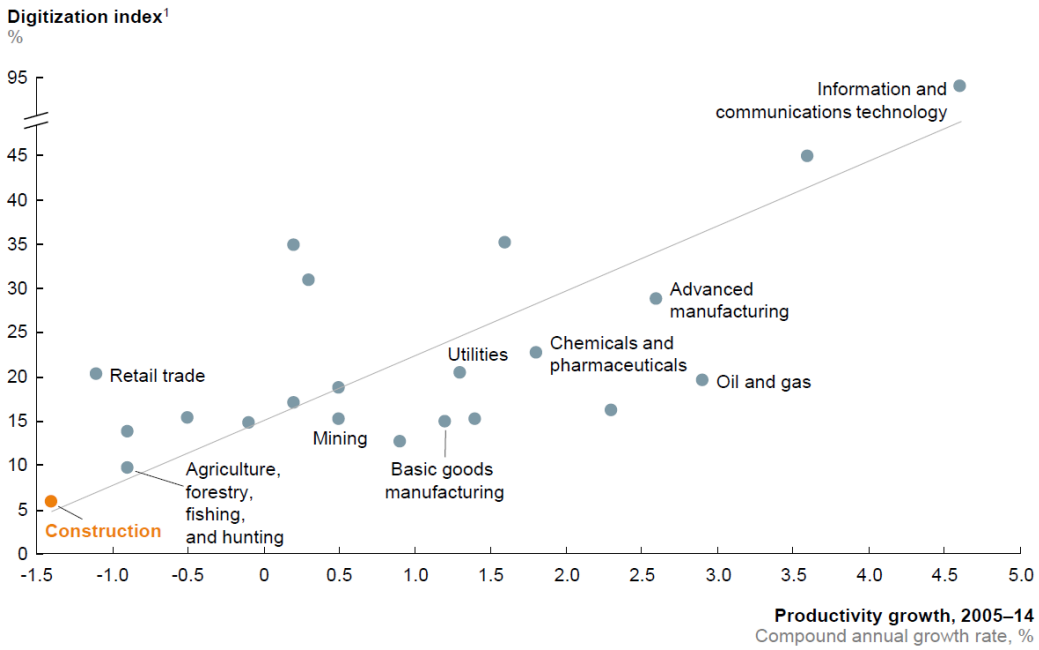
We have begun to see companies in the AEC industry facilitate this innovation and provide services that will unquestionably disrupt the way designers are engaged. Testfit, Hypar, Spacemaker and Archistar are all companies that provide services that are automating large parts of a designers job and eliminating the need to engage expert advice in earlier stages of projects. This is, as the McKinsey report suggests a, *"wake-up call - and an opportunity to reinvent every process with a fresh focus on the customer"* (McKinsey Global Institute, 2015, p. 4).

In a broader look at how digital technology is re-shaping industries, Richard and Daniel Susskind suggest that architects may no longer be the gatekeepers of design. Due to the rapid involvement of computational processes and the emergence of such platforms like those mentioned above, architects may no longer be necessary through every stage of a project. Instead the industry is expected to move towards providing bespoke services at different intervals throughout the project (Susskind and Susskind, 2015).

So how do traditional designers hope to compete with these new innovators in a field that has remained more a less the same for a long time? Technology is the answer. Or in this instance, data.

Lower digitisation in construction relative to other industries has contributed to productivity decline (Medium - Dark Matter, 2019).

Dark Matter (2019). Digitisation vs. Productivy Growth. [image] Available at: https://provocations.darkmatterlabs.org/what-is-designtech-41868f0bd45d [Accessed 10 Jan. 2020].



" While this topic might once have concerned only a few data geeks, big data is now relevant for leaders across every sector "

Big Data: The next frontier for innovation, competition, and productivity,
McKinsey Global Institute

The Value of Data

Data is not new to the industry, but as Randy Deutsch points out, there are a myriad of new ways that are available to designers to capture, analyse and apply data that we have never been seen before (Deutsch, 2015). Nicholas De-Monchaux opens his book by saying;

> *" Every two days - and at a rapidly increasing rate - we now collect and store more information than the total amount of information captured between the start of recorded history and the last decade. This information is increasingly spatial, and, more than ever, urban in its origins and character. "*
>
> (De Monchaux, 2016, p. 9)

Deutsch lays out why we, as designers, should be enabling the use of data to drive projects in architecture. Data is intrinsically scientific, if used correctly it can become a beacon of truth, providing the designer with absolute confidence that their recommendations are sound. It reduces risk, manages complexity and provides certainty to design decision (Deutsch, 2015).

This use of data in urbanism has been explored for some time. Urban science has been explored since 1995 by the Centre of Advanced Spatial Analysis at University College London. Since then, dozens of new research bodies have grown to explore how designers and cities can start to grasp the complexity that comes with big data and how it can be interpreted in a meaningful way. It is expected that by 2030, $2.5 Billion (USD) will be invested in urban science (Townsend, 2015).

With this massive investment in research and the advancement of technologies in big data, machine learning and artificial intelligence, it is understandable that it will begin to impact the AEC industry regardless of whether traditional methodology permits it or not. The power of data is no secret. It is the driving force behind some of the largest companies in the world. So why not explore how the future of data can impact the future of design.

This Report

This report is the culmination of my research into the myriad of ways that data can be used by designers in architecture and urbanism and how innovations in the field are being explored to advance the resilience, equity and flexibility of our cities.

This will be facilitated through the use of three sections. The first is two interviews with prominent researchers in the field of urban science. Charles Catlett is a researcher at the Urban Center for Computation and Data. This interview seeks to expand on the definition of urban science, placing it in context for architects and urban designers to understand how such research can impact on how we design buildings and places. The second is Fábio Duarte, principal research scientist at the MIT Senseable City Lab. The discussion provides an insight into how we can enable the use of data from common and sometimes unseen sources to reconsider our approach to designing cities.

The second section is introduced by an article discussing the implications urban data can have on how we understand human interactions with cities. With the growing discipline of 'place-making' in mind, this section considers how research and development of computational and digital technologies can be leveraged to understand more about how we define 'place'. Following this is an interview with Topos, a location intelligence company whom leverage the use of data to gain a deeper understanding of the nuances that define 'place'.

The final section acts as a survey of approaches towards the use of data that designers may consider using in practice to create more evidence-based decisions. This is followed by some resources, primarily relevant to New South Wales, that designers may find useful in their pursuit of data-informed decision making.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The Science of Cities

An Interview With Charles Catlett

Charles Catlett is the founding director of the Urban Centre for Computation and Data, a research centre that collaborates with scientists, artists, architects, technologists, and policy makers. Collectively, they use computation, data analytics and advanced technologies to understand the dynamics, design and operations of cities.

Previous page: An Array of Things sensor is attached to a light post in downtown Chicago. Photo by author.

What is Urban Science?

It's one of those terms like "smart cities" that seems to be in the eye of the beholder, but when I talk about or think about Urban Science, what I'm thinking about is using observation and data and theory to try to understand the dynamics of cities, not just urbanization or the growth of cities, but also just how they behave.

And when I say the dynamics of cities or how they behave, I also mean from a variety of different standpoints, one of which would be how cities impact regional climate, another would be how cities impact natural resources and fuel, use of energy. And another is just the way that cities interact with people and vice versa.

So to me, it's a fairly large multi-dimensional umbrella.

So how much do we actually know about how our cities work and how we can design and plan for maximum potential?

You know, when I interact with urban designers and planners, what I see is a lot of heuristics and sort of human experience, but not a lot of theory. Which is not a criticism but just an observation, partly because even theories about urban use of energy, much less about how people respond to different urban situations, even those are difficult to pin down.

So I think we know some things about cities. I think that there's pretty strong signals with respect to density and energy use. But I think that what we don't know is a lot more, orders of magnitude more than what we do know. Behavioral scientists will say that in general, people will respond to these conditions in certain ways.

Marc Berman at the University of Chicago is a behavioral scientist who studies how human cognition is impacted by urban versus natural environments. And so he'll give subjects a cognition test, like a memory test, and then he'll have some of them go on a walk through a natural wooded area, a park, and others will take a walk in a downtown area, and then he'll give them the same test at the end.

And so we find with work like that, in general people find natural settings as more restorative to human cognition than urban settings. And we think that's partly because in the natural setting, our full brain is able to relax, whereas in an urban setting, we still have a part of our brain that's watching out for, you know, buses or trucks or cars that might run us over, and watching the signal lights and other people, and things like that.

“ We seem to know a lot about slivers of the city, but not really how to put them all together. ”

So you combine multiple fields of inquiry in your research, from planning, design, computer science, governance, and more. Is this collaborative approach fundamental to your research and outcomes?

It is to mine. We do have a fairly well defined computer science research agenda, which has to do with reliable, resilient computing platforms that can live in outer space and wilderness and cities, and can survive for long periods of time without human intervention. And then there’s a companion thread in computer science that we support with that platform, which is to do machine learning, or what we call ‘at the edge’, or Edge Computing. So we do the machine learning inside the devices rather than sending all of the data back to some data center and analyzing it there.

So we have at the base of our work a set of computer science questions, but what I personally am more interested in is how those computer science activities can support questions that are difficult or maybe impossible to answer within a specific discipline. So if I go back to Marc Berman’s work, in order to really figure out, how do we apply Marc’s theories about human cognition to cities, and how do we take other work like the impact of PM 2.5 air pollutants on human decision making. How do we pull those together and learn lessons about how a given city works with respect to people and air quality and natural environments?

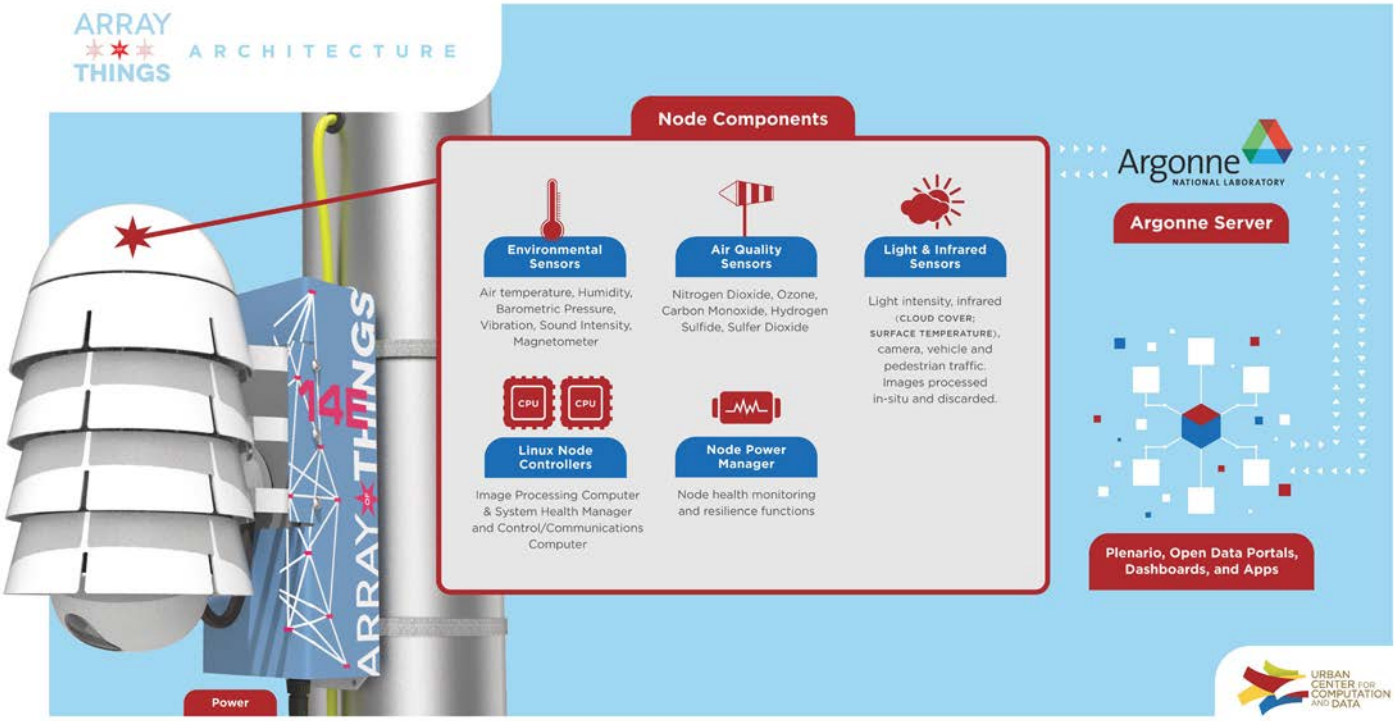
And then for folks from your discipline, how do you then not just design? First of all, how do you design the districts so that you improve people’s chances of making good decisions with respect to making sure there’s good air quality and there’s green spaces? But even longer term, how does a city set up the right building codes and ordinances so that over time, the city moves in a direction that reduces urban heat islands and improves and increases the access to green spaces? So these questions, to me, that require multiple disciplines are the most interesting ones, and that’s why our work tends to be multidisciplinary.

Is the development of new technology or the appropriation of existing technology a core component of your research?

You know, it is.

I would say we started with the Array of Things project. It didn’t really start out as a computer science project. It started out as a “providing data to other scientists” project, where we wanted to be able to provide a much higher spatial and temporal resolution set of measurements about the city to people who had questions about air quality of traffic safety or noise or other things. And then because we are computer scientists, we started to build this platform and realized that there were computer science challenges that we needed to tackle.

So these things are hand in hand. Early in the project, we said, “We’d love to be able to buy a device that does what we need, but nobody makes them, so we’re going to have to make them ourselves.” So it has become fundamental. I mean, as I said, we come from a computer science background, and I guess what we’ve discovered is that we play a role in this multidisciplinary science as well. So that work that we’re doing with resilient platforms and reliable platforms and with edge computing turned out to be integral to these other questions.



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The Array of Things sensor is equipped with multiple sensors that can quantify values from the general environment such as sound, vibration and temperature etc. and factors of air quality such as pollutants and various gas levels. It can also run software to measure pedestrian and vehicle counts.

Array of Things. (n.d.). [image] Available at: https://arrayofthings.github.io/ [Accessed 10 Jan. 2020].

That's interesting. Let's talk about the Array of Things. What data is collected through that program?

Well, you can think of Array of Things as gathering data in three different areas. One of them is the general environment, which includes meteorology data and includes sound and vibration and magnetic field and light at different frequencies. Temperature, humidity, barometric pressure, et cetera. So that's the general environment. And then the second area that we measure is air quality, and there we measure PM 2.5 and seven different gases. We measure all but one of the EPA criteria pollutants. What we don't yet measure, because there isn't a sensor that we can buy to measure it, is lead. At least not to measure it in the way that our devices work.

So that's two areas, environment and air quality. Then the third is what we would define as what we call software-defined sensors. And that means that what we're measuring is determined by the software that we're running at the edge, and there is where the need for software defined sensors comes in with many disciplines where the question that you're asking or the measurements that you need can't be measured with an electronic device.

So for example, if you want to know the flow of pedestrians or vehicles through a public space, that's not something you can buy. You can certainly instrument the intersection to collect data, but it's not something that's easily measurable with such sensors. And so we analyze images to get that, and so we program our devices.

Right now they're programmed so that every 30 seconds, they of course report all their environment and air quality data, but they also report measurements that we've taken with software, one of which is the number of pedestrians in the field of view of the camera, and another is the number of vehicles. And as we move forward, those software-defined measurements are going to get more and more sophisticated, in part because our algorithms are maturing, in part because we're upgrading the hardware that we're using.

So the Array of Things measures those three types of things. The environment, general environment and the air quality, and then the software defined sensors, largely about measuring the activity of the city. So if we want to know about traffic safety or the types of use of public spaces, that's where the software-defined sensors come in.

So all the data from your program is available online for free. Do you see open data as a necessity for cities to evolve?

That's a good question.

I think it is. I think it's necessary for cities to evolve, because I think that the way cities need to evolve, and the way that when we see progress in cities, however we define progress, often it's … Or maybe back up.

For cities to work, people have to cooperate. Whether that's parking attendants cooperating with drivers or accountants cooperating with the city, or architects cooperating with the planning department. Or just individuals cooperating as they get on and off of a train. And so if cities require cooperation to be operating optimally, then there needs to be some level of information that's shared about how the city is working, so that both people operate on responding to that data.

So I think open data is necessary for that sort of cooperation, not just because of the data itself, but because open data makes a statement about inclusivity and the decisions that are being made, and transparency about those decisions. So I think it would be difficult to have a city that works well where there's not sufficient transparency. I don't mean 100% transparency. We obviously don't want to put medical records online, or have a real-time display of where the police cars are. But I think open data is really a foundational piece.

With the Array of Things, when we have interacted with residents of Chicago through various public meetings that we've either participated in or held ourselves, people want to know, "How's the air quality in my neighborhood?" They don't want to get a report from the government that summarizes air quality in some way, although that would be nice. But they want to know on an hour by hour, day by day basis how things are going, and then they want to be able to present data to the city rather than just anecdotes.

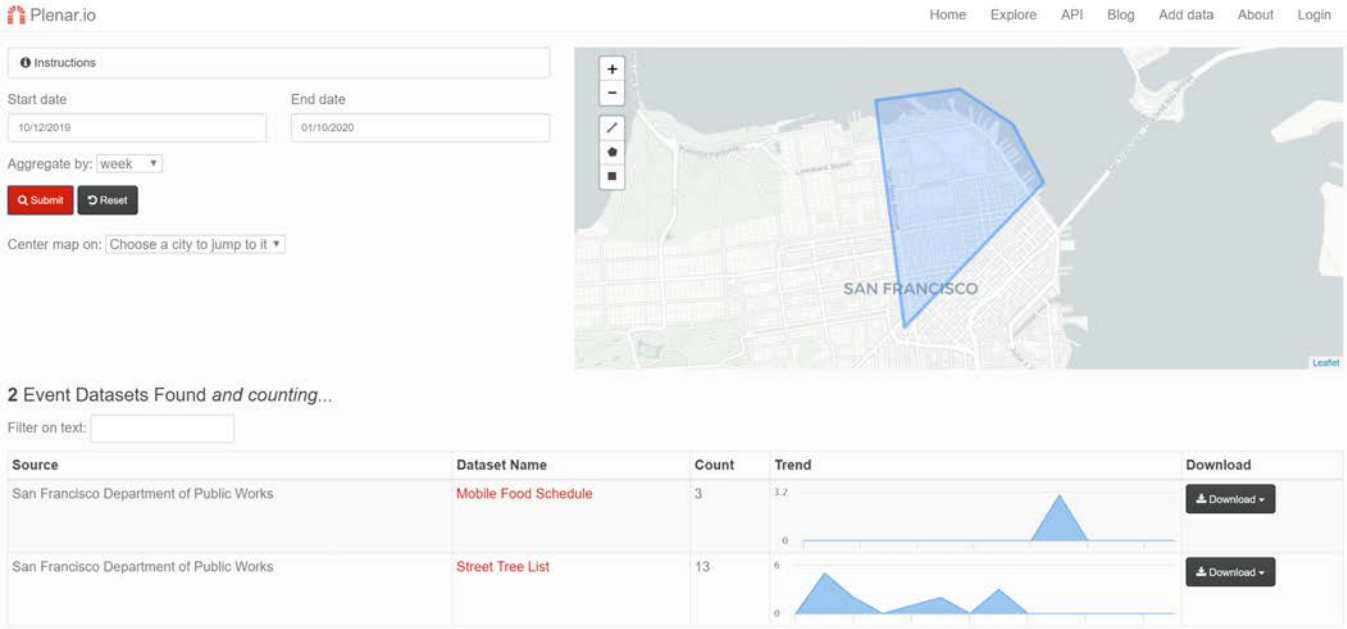
You're also part of a team that created Plenario. Can you give me a brief overview of that?

Sure. We built Plenario about six or seven years ago now. And the purpose of Plenario was that we saw that there were all these open data portals, including the one that the city of Chicago was operating, and we were also working with economists, behavioural scientists, sociologists, and others, and we found that the science community wasn't very aware of the data that was available to them in these open data portals. And so at the time, I likened it to the pre-web days of the Internet, where there were servers all around the Internet that you could download papers and other data, but there was no way to find them and know where they were.

So there were all these open data portals, different cities and counties and states, federal government's, but if you were a scientist and you wanted to, say, look at how crime impacts food safety in restaurants, just to pick two random data sets … Or maybe a better illustration was the work we were trying to do, which was to look at crime versus weather, and looking at weather changes over periods of dozens of hours or several days, and how that might impact crime. So we had to get data from at least two different sources just to study Chicago. One was the city of Chicago crime data and the other was the NOAA weather data. And for the average scientist that's trying to ask a question like that, they may not even know that the data is available.

So we built Plenario to do several functions, the first of which was to let people do a search, a spatial search, with a constrained period of time if they liked, such as, "I want to know about the south side of Chicago for the first six months of 2011." And so we built this search capability, and the response to that search was a list of data sets that were available from whatever source we could find for the south side of Chicago in that period of time. And then the second thing was to enable scientists to immediately use the data sets together. This meant that we had to take different data sets, with various temporal and spatial scales and units, and pre-align them. So we would go out in the different portals ourselves and pull data in. We pre-aligned all the data spatially and temporally, so that you could actually examine multiple data sets together to explore the spatial and/or temporal characteristics in order to determine if it might be worth studying for your question. This means every piece of data has a location, latitude and longitude, and it has a time and date.

And this was… You know, if I go back to the crime and weather, the first step there was finding the data, and then the next step was to align the data so that you could then study it. So we wanted the first two steps of alignment, finding and then aligning the data, to be point-and-click on the web, so that people could ask questions without having to do a bunch of work up-front, and therefore they'd be able to ask more questions. So that was the idea behind Plenario, and it was modelled after systems that our collaborators had built internally for their own purposes of situational awareness.



The Plenar.io platform allows users to identify public data sets using spatio-temporal selection. That means data can be selected from within a specific geographic region and within a specified time frame. As of early 2020 Plenario will be closed down in favor of the City of Chicago's new capabilities at it's open data portal, data.cityofchicago.org, and community resource portal, opengrid.io, which provide the discovery and exploration capabilities Plenario pioneered.

Plenar.io. (2020). [image] Available at: http://plenar.io/explore/discover [Accessed 10 Jan. 2020].

`Is the goal of these initiatives, like Plenario and Array of Things, to control decision making, or to inform?

Oh it's definitely to inform, not as a way to control. And definitely to inform and to do so in a transparent way. So for example, even the data from the Array of Things, there's a policy that keeps it open and free. And even though the City of Chicago is our partner, there's no governance authority for the city of Chicago to say, "Don't publish that data stream," or "Make a change to this data stream or that." Now, the city could say, "Take your devices down and don't measure anything," but they don't have any intervention on the data.

And we even had internal debates within our team where there was a question early on whether we should we publish the raw data from, let's say, the carbon monoxide sensors before we know that it's good quality data, or should we only publish that to scientists who understand this data, or should we not publish it at all and only publish our interpretation of those sensors? And the argument on the side of only publishing our interpretation was that it was a quality control argument. But the argument for open data was in some sense a different quality control, which is to say but if you publish all of the data, somebody out there might have a better way to get quality interpretation out of that data than we have.

So we decided the best thing to do would be to publish all of the data openly, the raw data and our interpretation of it, and the algorithm that we used to make that transformation. That way, if our goal is to inform rather than influence, then we're in the best position to inform in a sort of unbiased way.

Talking about bias, is there a necessary human bias to be had when talking about this stuff, or would you like to eradicate bias entirely?

Well, I think another term for bias would be intuition. Maybe bad intuition, but it's a sort of a human heuristic that's added to data that sometimes can actually be good, and sometimes it can be bad. So I don't think that we want to eliminate the human factor, but it would be good to know that it's there, to know what the biases are.

Absolutely. Is there an aspect of urban design or architecture that you see as changing over the next few years due to research into urban science?

I think there are many, but there's one that we are, or I'd say I am working on, along with colleagues outside of the Array of Things project. I have a project that's funded by the Department of Energy, and what we're doing is, we're taking the state of the art as it is today of looking at building energy demand as a function of weather, and we're trying to push so that we can model the urban weather at a resolution and fidelity that's a thousand times greater than what we can do today. So rather than just saying, "On this day, the temperature was this temperature at this hour, and the next hour it was this temperature for this building," we want to look at heat emissions from buildings and how they impact turbulence in cities, and we want to look at how not just shading, but airflow through and between buildings impacts their energy use.

And what we're trying to look at there is, you have a city like Chicago, and if you just look at the Chicago loop, you've got an order of a thousand buildings in the downtown area that are mostly fairly large buildings. And during a three day heat event like these super heat events that happened in Australia this summer, you want to know, of the thousand buildings in the downtown part of Chicago, which ones are going to have trouble meeting the cooling demands during one of those. And then you want to know what are the retrofits that you could put in place that would help those particular vulnerable buildings to perform during those events? And we assume that we will have more such events in the future.

So what we're trying to enable is the decision making over long periods of time, where ultimately, the city will say that we have to decrease the temperature in this part of the city by one degree during the heat events, and the way that we're going to do that is, over the next four years, we're going to set the following building codes in terms of setbacks and space between buildings, and even orientation and studies that you would do with turbulence to make sure that when you put this building in, it doesn't throw off the cooling and heating of the building that's downstream of it. So we're trying to use a computational modeling approach to help cities to do these long range plans.

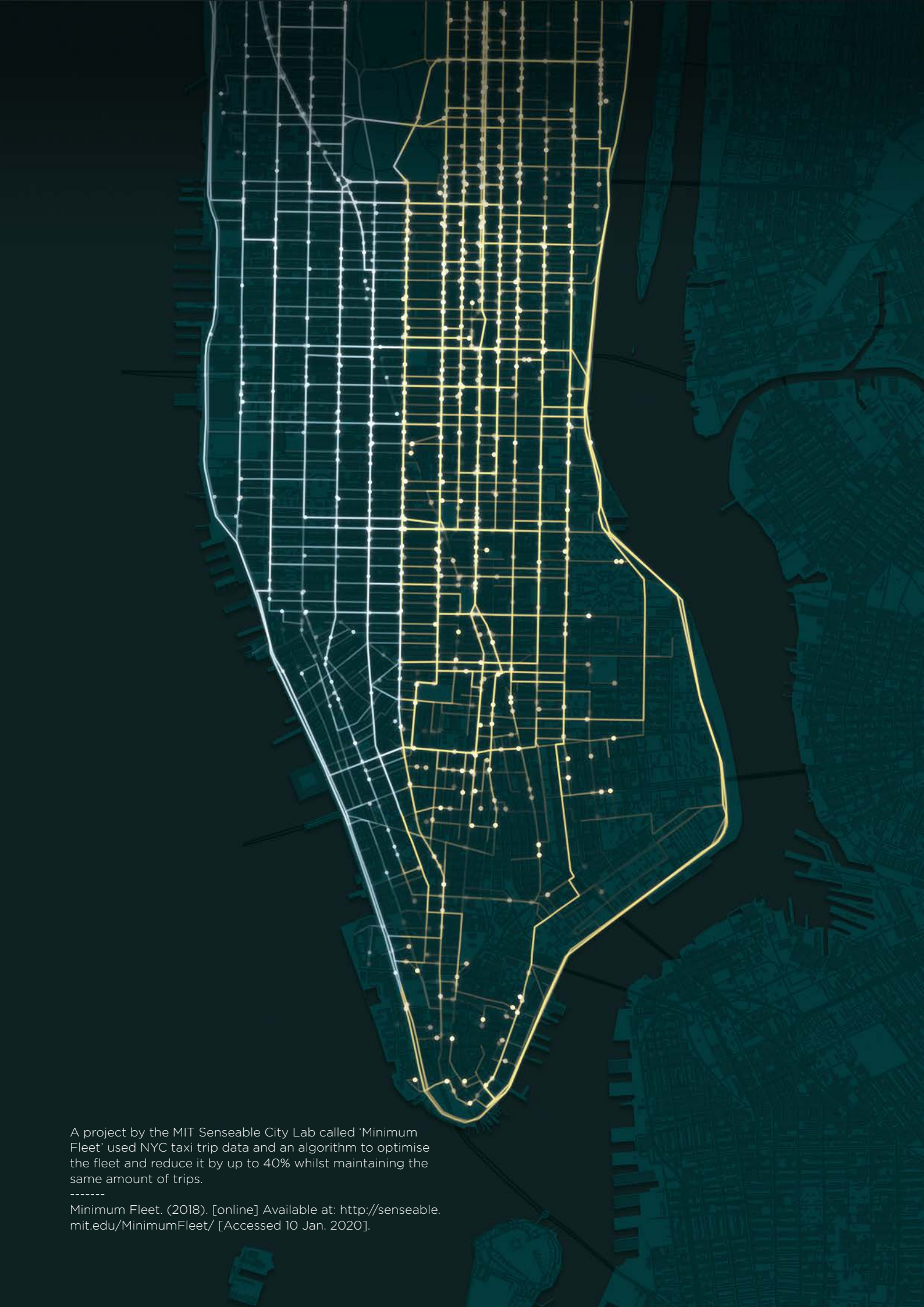
Is there a role that architects and urban designers can play in the development of that kind of future for our cities?

I think absolutely, and in fact, in the project that I was talking about, some of our partners are architects and urban designers, including from the city of Chicago. And if I look at a company like Skidmore, Owings & Merrill, let's say they're going to design a campus of 30 buildings in some city somewhere in the world. They already have the capability with some of their partners to look at the spacing and orientation of those buildings with respect to wind and heat islands and cooling and things like that. And then at the same time, they can put their building design into a wind tunnel and see how it will be impacted by forces from turbulence. But they don't really have the capability to get into an interactive or rapid evaluation of changes.

These changes are evaluated over a period of weeks, rather than minutes or hours. So they'll say, "Okay, well let's try this." "This" might be a taller building here, a shorter building there, a different orientation. Then they got to wait a week or two before the report comes out as to what that impact was. I actually started working with SOM on projects like this about seven years ago, and I'm still motivated by the notion that architects or urban designers can sit with their model, a virtual model of the space, and pull the buildings around it, change their shape, and then be given more or less … if not immediately, within an hour or two, a new assessment of what the energy profile will look like for that new district, or what the air flow is going to look like, or even what the forces on the buildings are going to be, so that I can decide whether I can get by with less steel and concrete in the structure with this particular form.

So yeah, so I think that community that you asked about is really the target community for what we're trying to do. And we're not just assuming we know what they need, we are definitely in a pretty tight collaboration with folks from that community.

" Open data makes a statement about inclusivity and the decisions that are being made, and transparency about those decisions "



A project by the MIT Senseable City Lab called 'Minimum Fleet' used NYC taxi trip data and an algorithm to optimise the fleet and reduce it by up to 40% whilst maintaining the same amount of trips.

Minimum Fleet. (2018). [online] Available at: http://senseable.mit.edu/MinimumFleet/ [Accessed 10 Jan. 2020].

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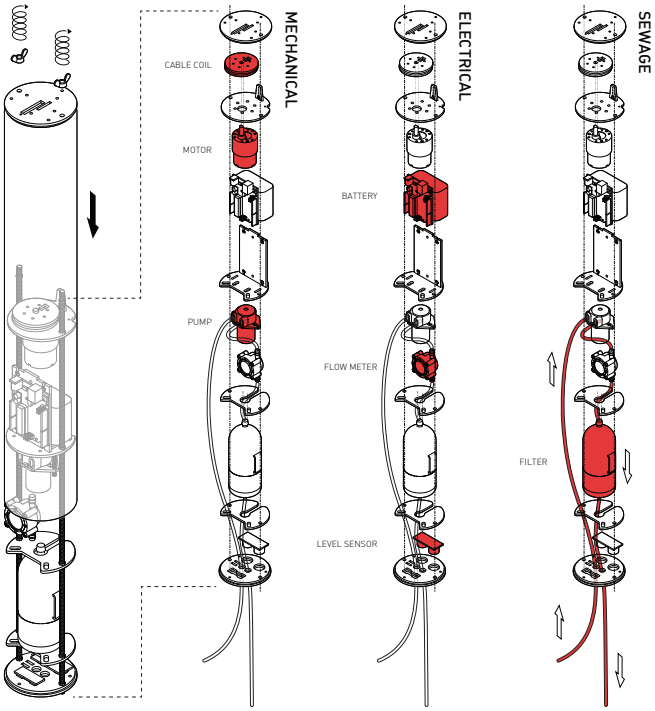
Making Sense of Discarded Data

An Interview With Fábio Duarte

Fábio Duarte is a principal research scientist at the MIT Senseable City Lab. He manages multiple projects that use data to gain insight into issues such as mobility, health and technology as well as managing their data visualisation team. He has a background in urban planning and has a PhD in communication and technology from the Universidade de São Paulo, Brazil. He has also served as a consultant in urban planning and mobility for the World Bank.



An axonometric of one of the sensors used in the 'Gangnam Poop: Underworlds in Seoul' research project that aimed to produce a bacterial map of Seoul using sewerage data.

Gangnam Poop: Underworlds in Seoul. (2017). [online] Available at: http://senseable.mit.edu/underworlds-seoul [Accessed 10 Jan. 2020].

So the city lab has a pretty eclectic mix of projects that cover mobility, sustainability, pollution, infrastructure, and more. Is there a driving principle behind all of these projects that unites them?

Yes, there is a driving principle and I think the driving principle is that we produce data all the time and most of the data we produce, we don't realize that we're producing this data and then we throw that away. I will give you two examples. One example is with cell phones. So for instance, with the accelerometer that we use in the cell phone for very basic tasks. The accelerometer measures the movements of the cell phone. What we found is that okay, what if we could use this data to measure infrastructure health in cities?

So we do have some people claiming that they could use the accelerometers to detect potholes in cities, but the problem of detecting potholes is that it's a small area and you need to rely on a bad driver to drive on the pothole. But if you think of bridges, we have in the United States alone, 55,000 bridges that have some infrastructural damage and we have hundreds of thousands of people drive with their cell phones across these bridges. So what we did, we said okay what if we take only the accelerometer data from the cell phones and we have the geolocation of the bridge. So if there is some sort of a higher vibration in this area, on this bridge, let's send technical staff to inspect. So, this is very useful, why? Because it's very expensive to send engineers to all these bridges. This is the data that we produce and we throw away because we're not using this data when we're driving.

And the other example is this data that we produce and we flush it off literally with the sewage system. Every time that you go to the toilet, you flush and we have so much biological data there. Then when the city samples this data, they only sample at the wastewater facilities plant, but by then all the sewage is mixed up so we don't know who is producing it, where it's produced and when it was produced. There are some companies producing what they call smart toilets, but it's quite invasive obviously if you have this. But if we put some small robots in the neighborhood level and collect the wastewater samples, we can have a biological map, bacteriological map I should say, from these areas almost in real time and we did that in Seoul, Boston and Kuwaiti City and we could find some different patterns related to specific diseases that we were measuring there.

So I think this is the underlying principle of the lab, what is the data that we produce and we usually don't use and how can we make sense of this data in other ways?

That's super interesting. Does the work solely revolve around technology and the data that you can attain from it or is there an augmentation with human inputs as well?

Depending on if it's directly human inputs it's hard to say, I will give two examples then you assess whether it is. For instance, one of the things that we do is we collect Google Street view images. So the same thing, data that's produced and we use for different things, but never perhaps to identify the basic similarities of different neighbourhoods in the city and this can be related to real estate prices for instance. What we did in a few projects is to measure for instance the mood of the country when Obama was elected only collecting, at the time, Flickr data. So it's a form of data inputs coming directly from people, but not that we're asking them as in a traditional survey.

It's another way of producing things that we simply don't care about and we simply put on Instagram or Flickr at the time.

Do you actually see these projects as having a direct influence on specific design right now, or is there an overview of what could be achieved with the right amount of information?

Yeah, so I think some of them they not only have a direct influence, but actually I'll give you two examples that actually change the design of something that we use in cities. A few years ago working with the city of Copenhagen we said okay, what if we could design a wheel that would get power every time that we brake and then make the bicycle electric only when we need it. So it's not simply a regular electric bike that you turn on and off, but the bicycle would know that I am riding the bicycle and the bicycle would know that every time that we have a three degree ramp, I need some boost. So the wheel would give me some extra energy to go to work and in your case you would be fine up to 10 degrees so the bicycle would save energy and only release this energy when you actually need because the bicycle would know who's riding it. It's simply triggered again by cell phone.

And the other one is a project we are doing in Amsterdam with autonomous boats with the same idea. So if we have these technologies changing the city, how can the lab take these ideas that we ourselves are advocating for and turn them into a design that will actually change, in this case of Amsterdam, how people move in the city using autonomous boats.

The 'Copenhagen Wheel' gathers data to learn how you pedal and ride and then automatically provides you with an extra boost when you need it.

Copenhagen Wheel. (n.d.). [image] Available at: https://www.superpedestrian.com/en/copenhagenwheel [Accessed 10 Jan. 2020].

You work with private industry as well as governments and other forms of research initiatives. Does this enable you more access to data that others might not have?

I think that the interesting thing for us is not to have access to data that others don't have, but to make use of data that everybody has but doesn't pay attention to. Just to stay with the two examples, sewage and accelerometers. Everybody can have access to accelerometer data, it's free, it's available on your cell phone, but nobody uses them and the sewage data the city does not even consider as data, but it's data.

Do you imagine that these projects are like pilot projects but then other people can take it further and explore it more?

Yeah, definitely. Some of them by chance, members of the lab themselves, turn into products, the bicycle is one example. We have another company using computer vision to grow plants indoors and so it was something that we're doing here with image recognition et cetera we said well, what if we do the same thing just to see if a plant is growing correct or not and then with this we tailor how much nutrients, different plants needed et cetera. This is a company now.

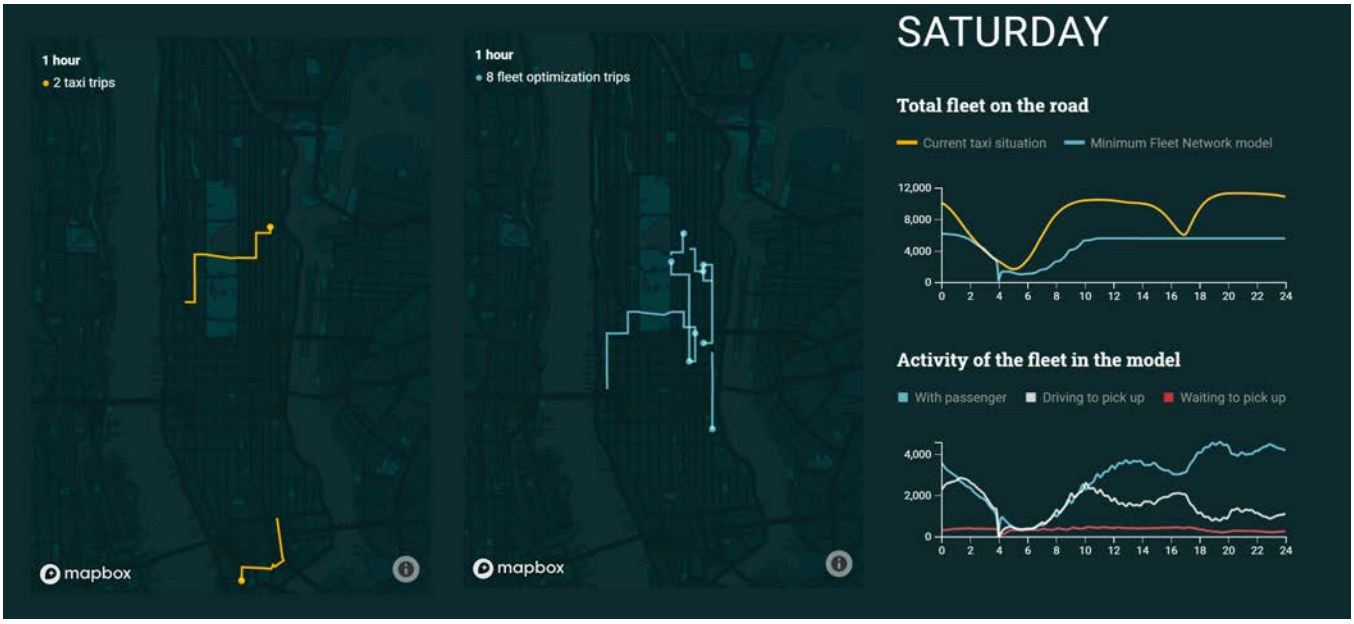
Is there a deeper understanding that comes from open data that would enable more empowerment to make better decisions?

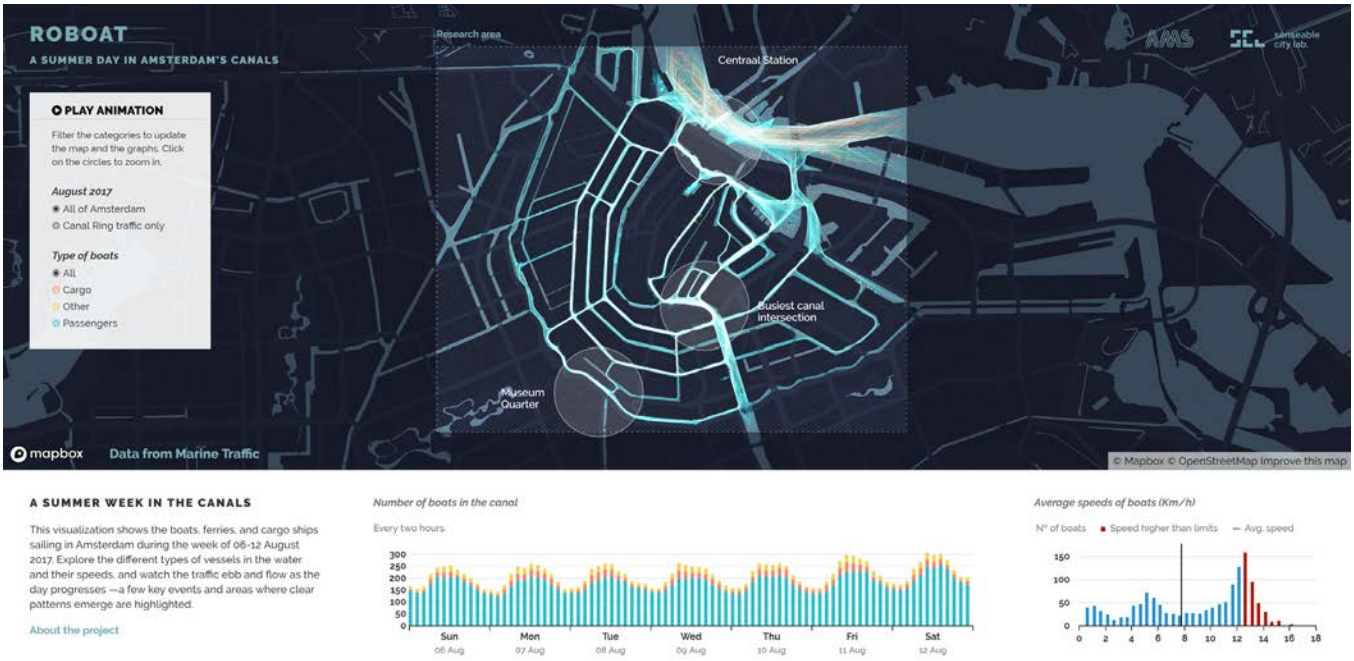
That's a political question you see and I think on the one hand for us here at MIT, it would be easier to secure. It's more on how you put intelligence into the data to make sense of them and then you get value of the data. Having open data does not bring any additional value to us. On the other hand, the problem is that if we go to developing countries, they don't have this information available as vastly as we have here. So, it might be unfair if we go to several parts of the word and say "Okay look, the solution is to have open data", and then they have open data but it's Europe and the United States who do the analysis of the data and use this data to create start-ups and different products to sell back to developing countries, what good are we doing to them? It's almost trading mirrors with Native Americans, "I give you a mirror and you give me your gold". So I think it seems to be politically correct to say let's have open data et cetera, but are you really sure that you are asking for open data with the data providers best interests?

" The interesting thing for us is not to have access to data that others don't have, but to make use of data that everybody has but doesn't pay attention to. "

Data from the 'Minimum Fleet' project shows how their process of optimisation has decreased the fleet size and increased the activity of the fleet whilst providing the same level of service and also reducing passenger wait times.

Minimum Fleet. (2018). [online] Available at: http://senseable.mit.edu/MinimumFleet/ [Accessed 10 Jan. 2020].





The Roboat project uses robotic boats to traverse the canals of Amsterdam to gather data about water quality etc. The above graphic is from 'A Summers Day in Amsterdams Canals' that used marine traffic information to visualise how boats are currently being used in the canals.

Roboat: A Summer Day in Amsterdams Canals. (2018). [online] Available at: http://senseable.mit.edu/roboat_summer_day/ [Accessed 10 Jan. 2020].

That's a really interesting point that I hadn't considered. Let's talk about the autonomous boat project you mentioned earlier, Roboat. Can you give me a brief overview of the project from your words?

So Roboat was a funny thing. We know that autonomous vehicles will transform how we move in cities and several governments and cities are investing in preparing the infrastructure for the autonomy that is coming and Amsterdam approached us through Delft University and Wageningen University in the Netherlands and asked us what do we think about that? What do we do with it? And we thought, okay but in the case of Amsterdam why use money on cars if you have 100 kilometres of canals? And said why don't we think of autonomous boats for the canal system and we started the project like this.

So we have two challenges on the one hand, a very technological challenge is that boats that navigate the ocean need a different technology than a boat navigating in a canal system. When navigating the ocean a GPS in enough, so if you are 50 centimetres far from your track, nobody cares. But in a canal system, 50 centimetres off your track you can hit another boat. So the technologies that we need to use are LiDAR and visual cameras and computer vision techniques that are quite different from simply using GPS for navigation. On the other side, the city of Amsterdam used to use the canals for transportation but slowly the canals became a tourist attraction. So how do we regain Amsterdam canals for the city again? So I think these are the main challenges, we tried the technological challenges on the one side and we tried the urban design challenges on the other side.

Do you imagine the data and the physical outcomes from that project informing how we design the public domain in the future?

In the case of Roboat itself, one thing that we're doing and we are going to have a deployment soon is if we have the boats circulating through the canals, we could sample water and have some basic analysis almost in real time and this could help the city make all the canals suitable again. At the moment they can't because they need to go there and test the waters often and that takes time. If we have these sensors in every boat then we can generate that data quicker and cheaper. It would not necessarily change the physical design of the canals, they would remain the same, but it will change how people can appropriate a physical space.

So obviously this and other projects look at mobility and the important steps in how we approach the future of autonomous vehicles in cities, is there something you've discovered in this research and through the use of data that you would consider more important than anything else?

I don't think there is something that is more important, but what I think we are seeing is that we will have autonomous cars in the future but what's in between then and now? So obviously we have several cars already with some sort of autonomy embedded, but we think that the city itself would be a sensing platform and eventually the city will also help to drive the car. What do we mean by that? So let's say that all the traffic lights are also intelligent and they're sensing that the flow is more intense in one direction than the other. So you can see it is not just one car communicating to the other where I am, but the traffic light can be also a data collector, sending information to other traffic lights and cars to synchronize traffic.

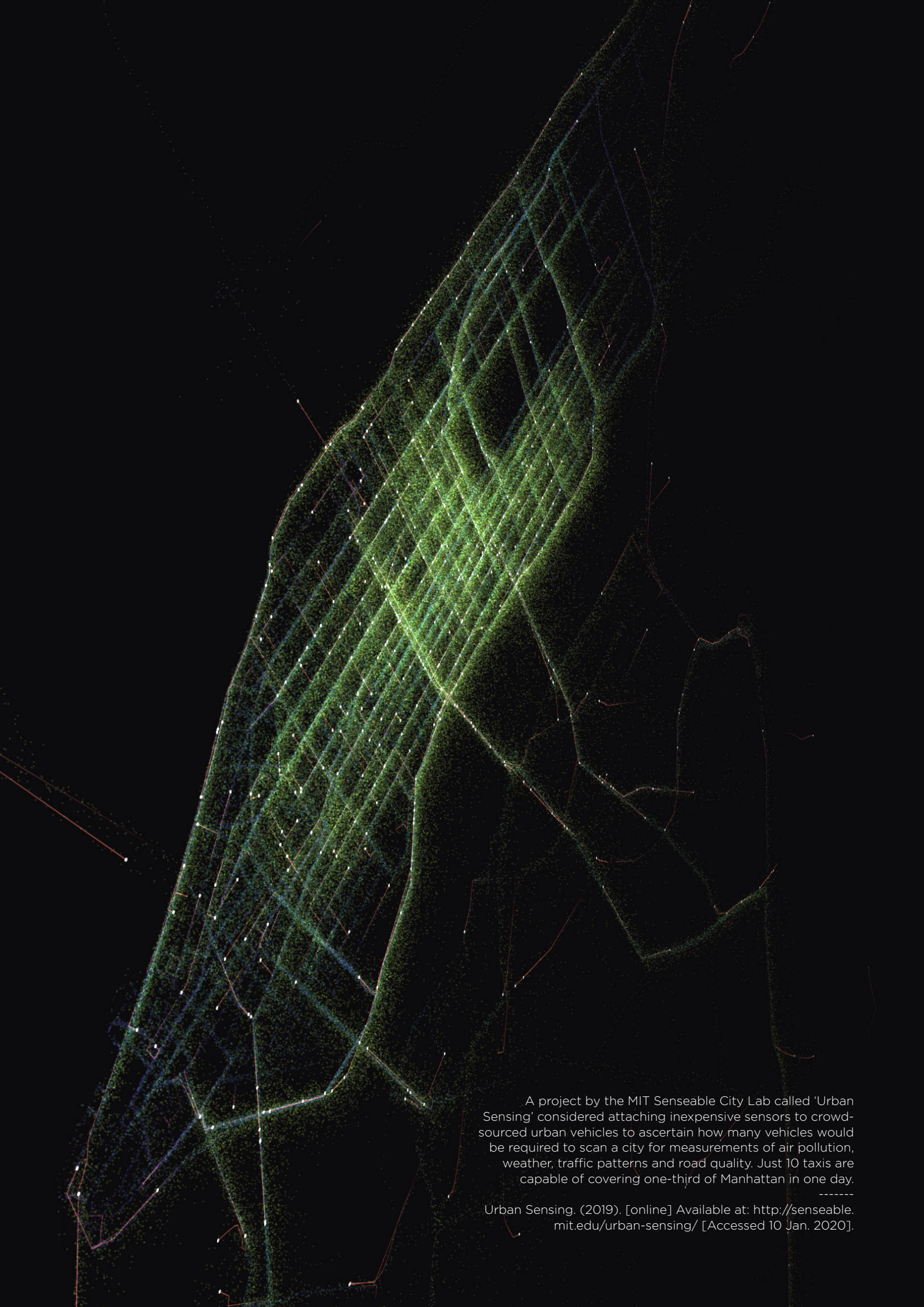
So what we found doing this research is that in the future we're going to have fully autonomous cars and now we don't, but in this process the city itself will gain some sort of autonomy and this is what we are working with in other projects, embedding this kind of sensing technology in urban infrastructures.

What is your vision of how we use data in the future of design and governance?

I think in the future, in regards to cell phones, we will have almost kind of a recruitment process. So let's say that you have your cell phone, a computer here, and we have a car over there. If we have this environment and you are driving on a highway, the highway system will recruit only the accelerometer data from the cell phone to perform some functions and after you leave the highway it dismisses you, it doesn't need your data anymore. So it would be a way of not only having the Internet of Things, but in a way that all these things communicate with each other when necessary.

Is there a particular form of technology that we need to make that happen or do you think it's technically possible?

I think it's coming naturally and it's more a way of designing the communication among different technologies than to attach a specific technology.



A project by the MIT Senseable City Lab called 'Urban Sensing' considered attaching inexpensive sensors to crowd-sourced urban vehicles to ascertain how many vehicles would be required to scan a city for measurements of air pollution, weather, traffic patterns and road quality. Just 10 taxis are capable of covering one-third of Manhattan in one day.

Urban Sensing. (2019). [online] Available at: http://senseable.mit.edu/urban-sensing/ [Accessed 10 Jan. 2020].

Understanding human experience through the use of advanced data analysis and computational methodology is an intriguing solution to how we consider designing our future built environments

4

Simplifying the Complexity

Using Data to Understand Urban

" Extremely large data sets that may be analysed computationally to reveal patterns, trends, and associations, especially relating to human behaviour and interactions "

Definition of 'Big Data'
Lexico Dictionaries. (n.d.). Big Data. [online]
Available at: https://www.lexico.com/definition/big_data [Accessed 10 Jan. 2020].

If we are to consider what data means in relation to our cities then this definition in itself is perhaps all we need. As an urban designer, one aspect of investigation is always the cultural and social implications a new development may have on a locale. You might measure this through any number of evaluation methods. Access to amenity, transport, community facilities and so on. But what about a core component of cities: human behaviour.

If we could measure human behavioural responses to places then surely we could deliver much more detailed, human centric cities and places than ever before. But how could we possibly begin to conceive of such a way to place a metric on things related to our emotional response and connection to place?

Luis Bettencourt writes that regardless of the amount of data that is available, computational urban planning is practically impossible (Bettencourt, 2014, p. 12). To him, cities are much more complex than can possibly be determined through a series of computational processes and cannot be fully understood by the most advanced technological methods.

> *" The exhaustive approach of evaluating each possible scenario in a city is impractical as it involves the consideration of impossibly large spaces of possibilities. "*
>
> (Bettencourt, 2014, p. 16)

This idea of the complex nature of cities was also well established by the prominent urbanist, Jane Jacobs. In her pivotal book, *The Death and Life of Great American Cities*, she famously paired urbanism with complexity theories and introduced the term 'organised complexity' to the planners vocabulary. The idea that problems in the city can be best described as, *" a sizeable number of factors which are interrelated into an organic whole "* (Jacobs, 1961, p. 432). To further explain this urban relation to Newtons third law (for every action, there is an equal and opposite reaction), Bettencourt created a theorem to represent the amount of interactions for a city of just a million people. The resulting number is larger than all the atoms in the universe (Bettencourt, 2014, p. 16).

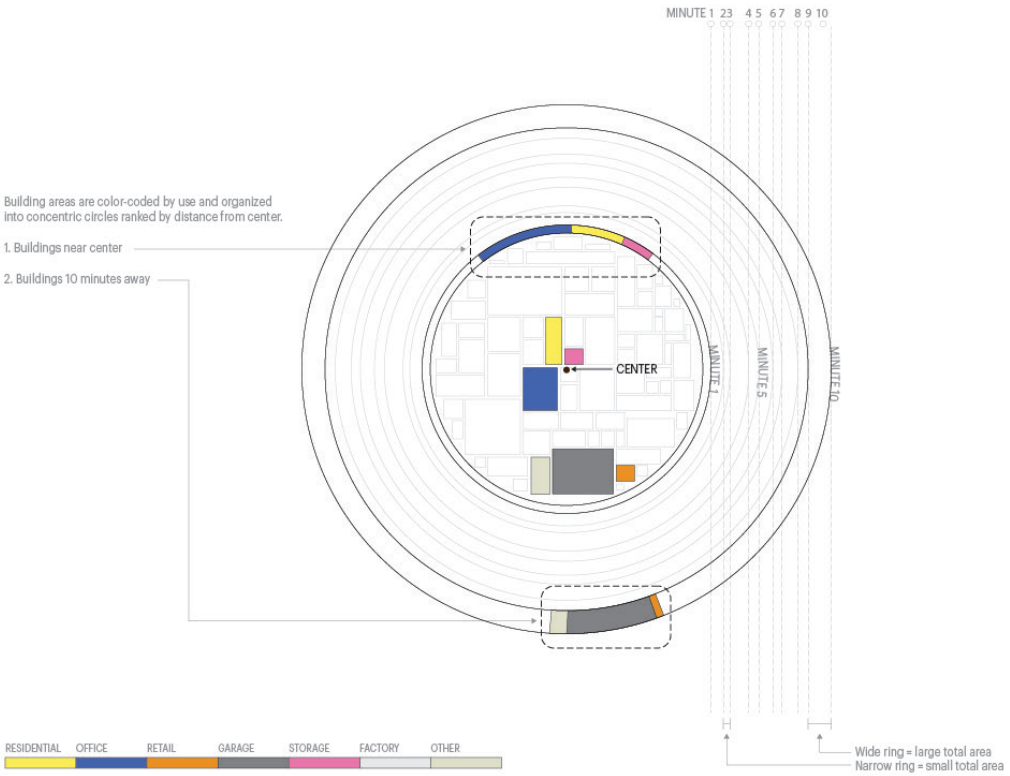
So if we are to believe that the city is too complex to be able to measure every human interaction, then how can data actually help to realise the character of a place?

It is perhaps not best to dwell on whether an architect, urban designer, or planner can solve every problem that our cities face, or could ever conceivably understand the vast magnitude of effects that a new urban development might have. Instead, it might be best to consider that data and computational methods of evaluating and using data in design are in their infancy. It is therefore more prudent to establish some ideas around what small and specific aspects of our cities we can begin to understand through the use of data analysis and exploration.

This was demonstrated in the interview with Fábio Duarte. The MIT Senseable City Lab sees value in the most unexpected of sources. Data that is commonly discarded and forgotten about becomes something that informs new approaches to understanding a city. What other ways are there to explain the obscurity of data and how can it be analysed to understand the human relationship to our spatial contexts?

An explanation of one of KPF UIs new methods of representing urban data. 'City Mile' is able to visualise land use diversity, structure sizes and density along with travel times. They use this to quantify the human experience with place that they call 'here' (Harvey, Wilson and Agarwal, 2019).

City Mile - Visualisation Explained. (2017). [image] Available at: https://ui.kpf.com/blog [Accessed 10 Jan. 2020].



KPF Urban Interface (KPF UI) have explored what aspects of the urban experience should form a baseline standard for how we evaluate zoning requirements. It is their argument that by establishing a series of quantitative metrics we can better design cities for people using goal oriented benchmarks, something they understand is a, *"difficult task given the complexity of urban systems."* (Wilson et al., 2018, p. 1).

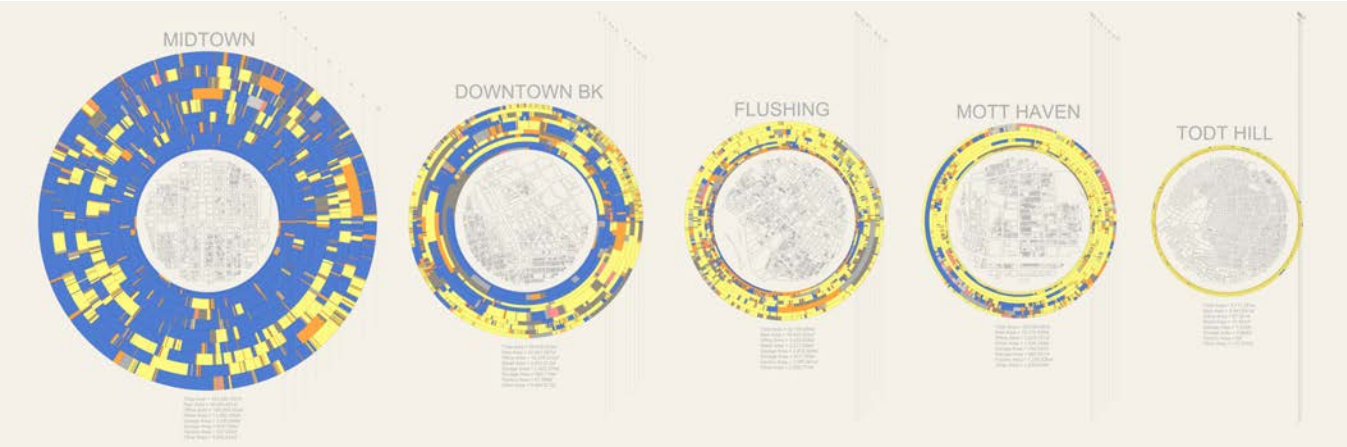
By creating a series of computational methods to procure and analyse a number of metrics such as comfort, mobility and activity, they can theoretically produce a baseline standard for how new zoning requirements, and then buildings, will impact human experience. This was strengthened by the creation of new methodologies for visualising and representing this data.

They posit that using these new methods of visualisation and computational analysis reduces the complexity of analysing detailed scenarios, therefore allowing for a more nuanced approach to how we design places.

> *" Both urban comfort and activity are time dependent. Therefore, it is suboptimal to prioritize sunlight in a park at a time that the park is sparsely used. Instead, times of direct sunlight can be coordinated with times of peak activity. Being more specific about when a park gets access to sunlight may make it possible to add significant amounts of density while also ensuring that sufficient sunlight reaches the park at the times of highest use. "*
>
> (Wilson et al., 2018, p. 7)

The 'City Mile' is used across the five boroughs of New York to ascertain the different experiences people may have within each different urban place (Harvey, Wilson and Agarwal, 2019).

City Mile - Five Boroughs. (2017). [image] Available at: https://ui.kpf.com/blog [Accessed 10 Jan. 2020].



Bettencourt actually suggests that methods of computational data analysis, such as those demonstrated by KPF UI, are where data is capable of being used to solve urban problems. Simple solutions can solve relatively difficult problems through the use of fast and precise measurements, delivered by the increasing speed and capabilities of modern computing and digital devices (Bettencourt, 2014, p. 14).

Another researcher exploring how modern technology and data can be used to understand more about how we engage with our cities is Professor Justin Hollander. Professor Hollander runs the Urban Attitudes Lab at Tufts University that explores how big data and psychology can play a role in urban planning and policy making. I spoke with Professor Hollander to understand the atypical ways that he is approaching human interactions with cities.

By initially researching sentiment to places through the use of Twitter data, surveys and ethnographic research, Professor Hollander became interested in not only the conscious reaction to different spatial contexts, but also subconscious

By using a number of technologies including eye-tracking, brain activity monitoring and visual attenuation software, his research aimed to uncover how a human subconsciously reacts to different places and architectural elements. He has found that buildings with face-like façades or well defined edges were more likely to attract visual attention (Hollander et al., 2018, p. 10) and that particular urban environments were more associated with positive reactions and a likelihood to spend more time there (Hollander et al., 2018, p. 1).

It is Professor Hollanders belief that this approach to urbanism provides an important insight into the human experience;

> *" It's our job to create places for them to look at and be moved and to think. But people are largely an unconscious creature. If that's all you're focused on, you're ignoring them as a complete creature. "*
> (Hollander, 2019)

This unique approach to understanding human

Eye-tracking technology is used to understand how people first look at and then focus their attention of a particular building, highlighting elements of a building that attract more visual attention.

Eye-tracking. (n.d.). [image] Available at: https://moresports.network/eye-tracking-in-der-architektur/ [Accessed 10 Jan. 2020].

'10 Minute Trip' is another new method of urban data visualisation that KPF UI use to understand how the city unfolds for a person travelling from 'here' to 'there'. It shows how far a person can get from an origin point in 10 minutes and the buildings or extent of urban fabric that is available to them using a combination of subway and walking travels. (Harvey, Wilson and Agarwal, 2019).

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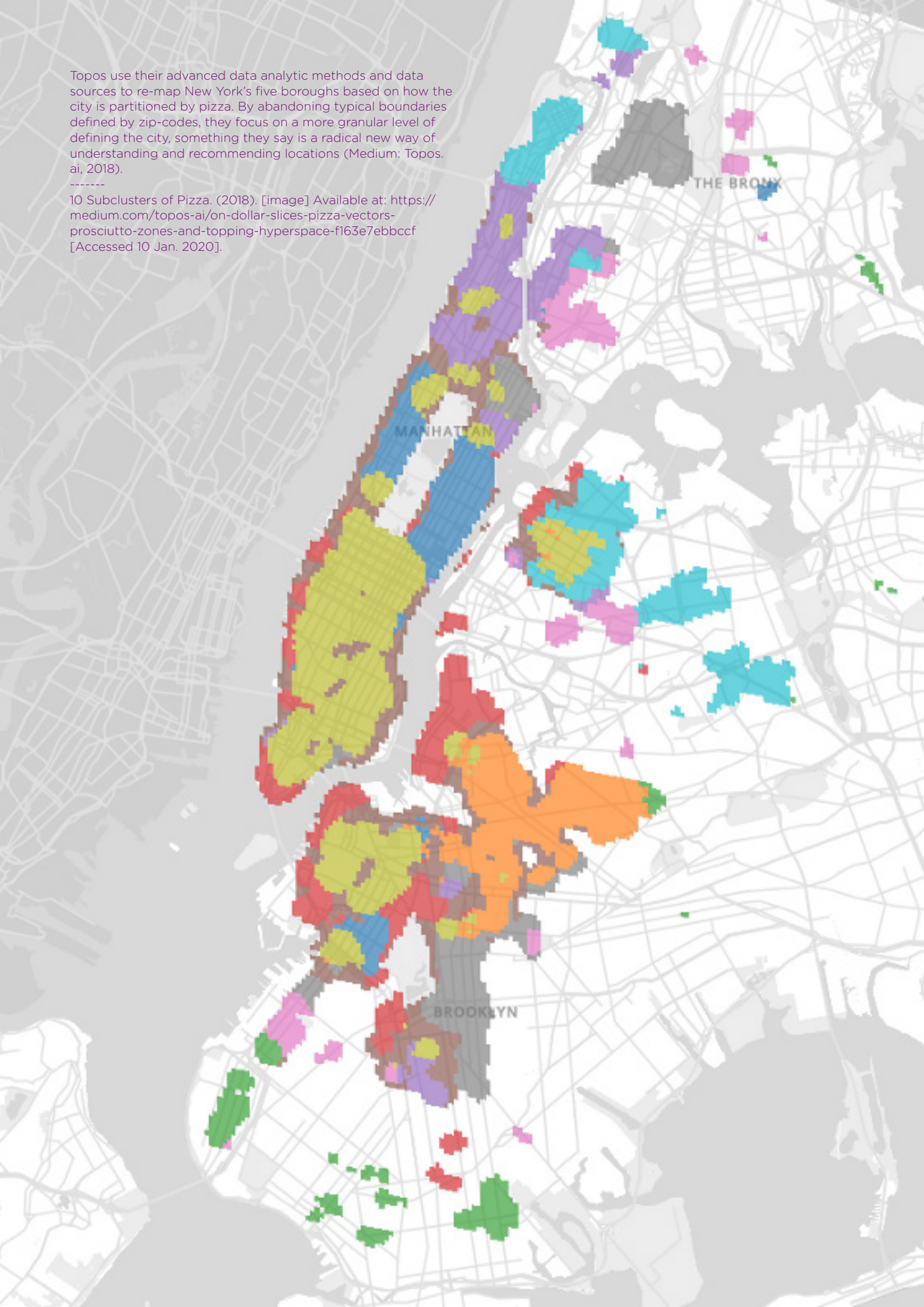
10 Minute Trip (2017). [image] Available at: https://ui.kpf.com/blog [Accessed 10 Jan. 2020].

experience through the use of advanced data analysis and computational methodology is an intriguing solution to how we consider designing our future built environments. Inarguably, Bettencourt and Jacobs are right that it is too complex to fully understand every nuance of human interaction that happens within a city. But we can use snippets of information, generated from the vast quantities of data that is being generated to gain at least some insight into how the city works.

Even though the city is complex, if we were to combine these snippets into a recognisable picture then we could potentially start to achieve a greater insight of our cities than ever before. Topos is one company that believes they are able to see that picture.



Topos use their advanced data analytic methods and data sources to re-map New York's five boroughs based on how the city is partitioned by pizza. By abandoning typical boundaries defined by zip-codes, they focus on a more granular level of defining the city, something they say is a radical new way of understanding and recommending locations (Medium: Topos. ai, 2018).

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10 Subclusters of Pizza. (2018). [image] Available at: https://medium.com/topos-ai/on-dollar-slices-pizza-vectors-prosciutto-zones-and-topping-hyperspace-f163e7ebbccf [Accessed 10 Jan. 2020].

5

Location Intelligence

An Interview With Topos

Topos is a location intelligence company that use artificial intelligence to, *"uncover the nuanced underpinnings of urban culture and the interaction between people and place"* (Topos.com, n.d.). Using hundreds of heterogeneous data sources they are able to produce a holistic understanding of location to build a granular view of cities and the culture that defines them.

One of your blog posts mentions you collect data from hundreds of heterogeneous data sources. Could you explain what some of those data sources are?

We collect all the ones we think everyone has like census data or some of the most prominent sources that would be obvious to anyone like POI (Point of Interest) data or some providers that sell mobility data such as things like traffic and public transport movement flow. Those are things we expect everyone would have and that we should have them too and they have value. We want all of our data to be up to date, so things like census data is infrequently updated. We will use it but we will want newer data even if it's redundant where possible to remedy that. We also want data that is as clean and consistent as possible across geographies. One of the things that we want to be able to examine among other things is similarities between place and so if we have inconsistent data between places then we are less able to create analysis between those places.

In regards to unique data, It would be things like unstructured data. So for example, text and imagery analysis using Natural Language Processing and Computer Vision where we start to find what are perhaps less accessible attributes of place. And again with this goal of combining as much data as possible to have a really comprehensive and therefore nuanced understanding of culture and place. So it's through, say, image analysis to give a more concrete example, that you can see things like presence of sky or presence of cityscape or presence of pedestrians, which when folded into other data sources starts to give a detailed view of data and also on a very granular level. You know, I think that's another thing that we're striving to create, is a granularity in the data we collect from an urban geographic perspective.

Meaning we want to go find our state in the zip code level, which as I'm sure you're familiar in The States is the politically, bureaucratically zoned classification of space. So we want to be able to look at places from any geographic unit, not just these kind of arbitrarily defined units. Not to say they don't have relevance, and in some cases are perfectly functional and the right way to view places. But in other cases they aren't. And so there is an idea of shifting that perspective. I think a lot of people are pre-programmed and think about place in the ways that place has always been defined. So they think about addresses and blocks and neighbourhoods and cities and counties and metropolitan statistical areas. But there are a lot of different ways to view place as well, that can be based on different forms of analysis, whether it's socioeconomic or geographic or all manner of kind of measures or ways of thinking about place.

Are your commercial targets purely real estate developability or is there a broader field of influence like city planning, architecture or urbanism?

Yeah, our ambition is to be in all of those spaces. I mean, location intelligence is the broad classification for the business category that we're in. Which is much bigger than one industry.. Real estate is a helpful starting place for us as a start-up. You know, you need to find a good product market fit and we're seeing that in real estate.

But for a lot of reasons we want to get into the other areas you mentioned and beyond. There's an opportunity to improve all of our products by being more diversified, applying learning to more than one space. And there are business benefits inherently, from a cultural perspective, from a staff attraction, retention perspective. I think there are many more technologists and designers and urban planners and thinkers who are less specifically interested in real estate than there are these broader applications.

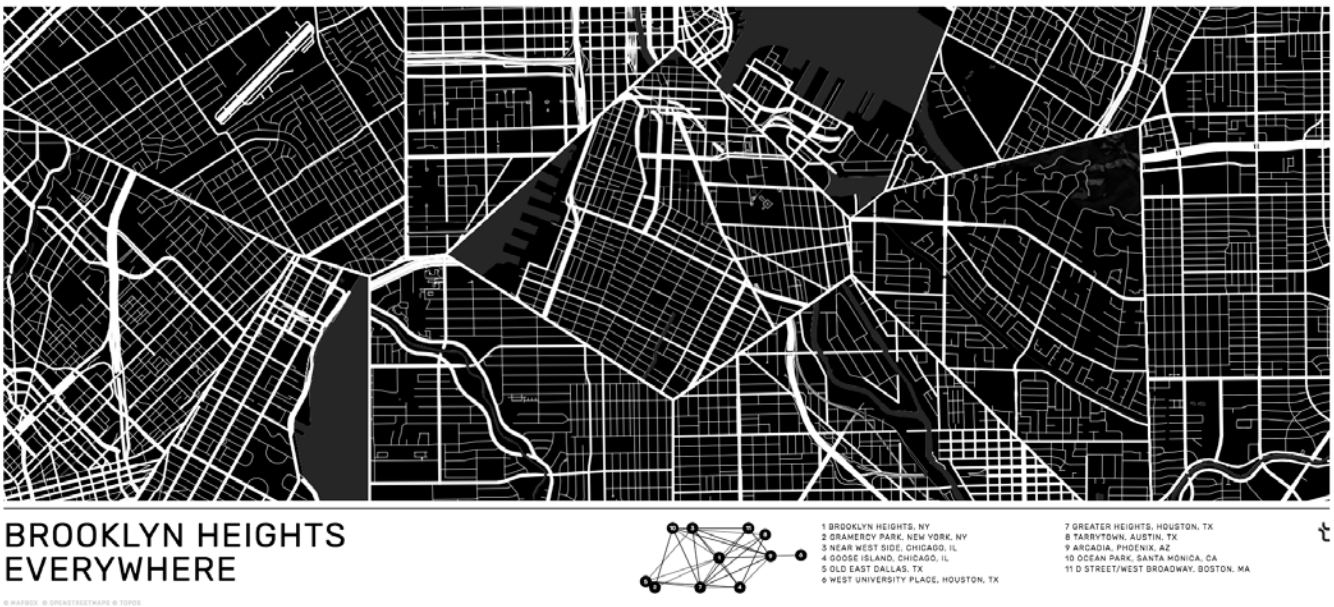
Can you tell me a bit about the Similarity Index?

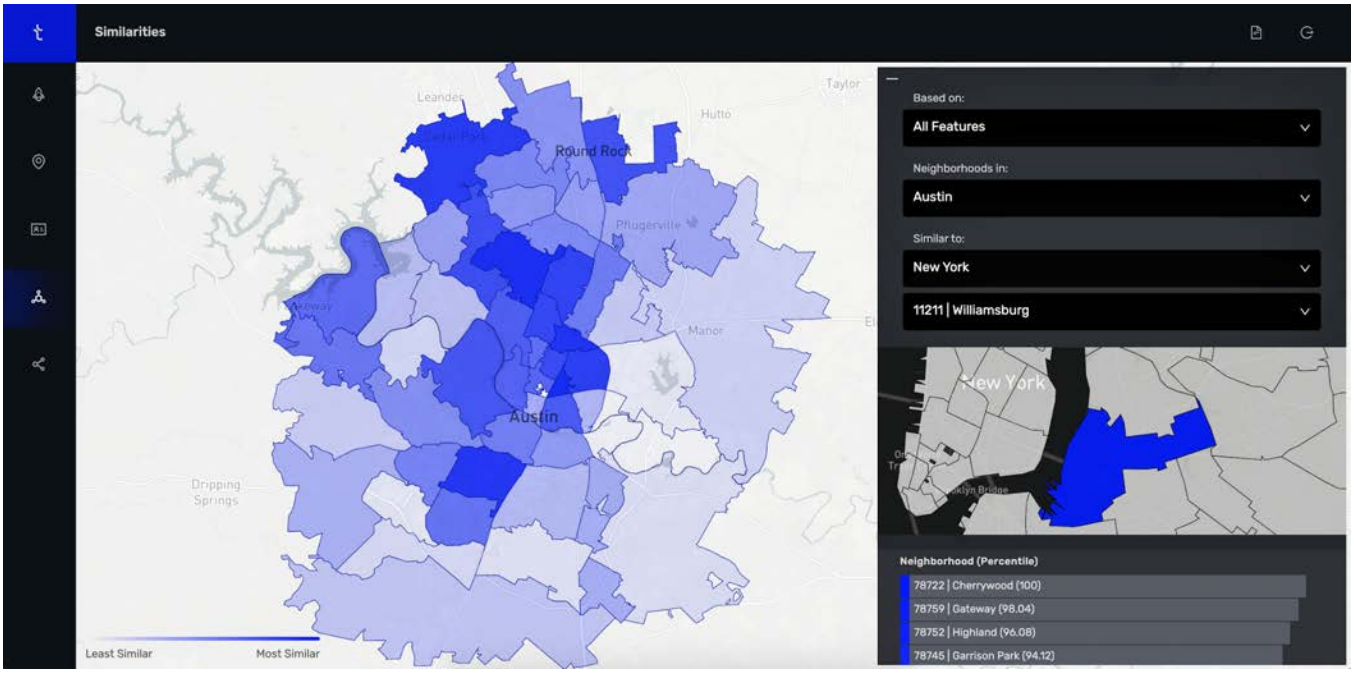
Yeah. The history of Topos is potentially helpful here. The two founders, Will and Mahir had worked together previously at a company called Seed Scientific that was acquired by Spotify, and they worked on the team that built the recommendation engine, which is now a pretty standard piece of functionality across a lot of similar software providers and media companies. From a technology perspective it is mimicked in something like Amazon product recommendations to, in this most direct case, Spotify where it's looking at meta-data and finding things with similar meta-data. So that is the gist of the similarity index, looking at the meta-data of place and what are other places with similar meta-data. And that's why we want to have the most comprehensive data available, because the more meta-data there is, the closer we can get to understanding what are the most accurate similarities possible.

Below, the Topos Similarity Index also has a public visual tool called '[x] Everywhere' to represent similarities between 1718 different neighbourhoods across the US. It was inspired by a number of projects including 'The Naked City' (1957) by Guy Debord, above (Medium: Topos.ai, 2017).

Above: Debord, G. (1957). The Naked City. [image] Available at: https://medium.com/topos-ai/introducing-the-topos-similarity-index-and-x-everywhere-82fcec1fb367 [Accessed 10 Jan. 2020].

Below: [x] Everywhere. (2020). [image] Available at: https://everywhere.topos.ai/11201 [Accessed 10 Jan. 2020].





Screenshot of the Topos Similarity Index comparing neighbourhoods in Austin, Texas that are similar to Williamsburg, New York. The darker the colour, the more similar that neighbourhood is. It shows that a neighbourhood called Cherrywood is a 100% match.

Courtesy of Topos

34 Your website kind of alludes to the idea that you can ask the similarity index questions, kind of like what is the Dumbo (suburb in Brooklyn) of San Francisco. Can you actually directly ask the software that? Or is it a bit more complex than that?

So generally, yes. [in demonstration] What I'm looking at is a map view. It's a split screen with two maps. So in this instance, on the one side, I have the city I want to research, and then on the other side I have the city I want to find similarities to. So I can say for Austin, show me how similar each of the neighbourhoods there are to Williamsburg, New York.

Is there one aspect of the similarity index that gets weighted more heavily than others? Or is it all a very broad approach to the data?

Oh yeah. That is what we're always experimenting with, is we're always adding data sources, and we're always allowing the machine learning algorithms to iterate to see what yields the most accurate result. In a fairly typical training type process, we have outcomes that we believe to be well understood and so we want to be able to achieve those as a means to refine the algorithm. And then based on that training, allow it to iterate, figure out its own weighting and what ultimately yields the most accurate result. There are definitely cases where, and I think they get interesting, where there is a lack of human insight that can be applied. And you can kind of intuit why an answer is suggested, but it's something that you wouldn't have arrived at yourself. Like a strange correlation between the density of dental offices to something wildly unrelated in our kind of human experience. Or the propensity for a discount shoe store to succeed. It's not entirely outside of the realm of what we will see sometimes.

You talked about this idea that relates to the complexity theory of cities. The kind of organic nature of a city being more complex than one source or understanding can determine. Do you take that kind of thing into account? How accurate do you feel that the tools you're developing are in understanding this complexity of a city? How accurate do you think it is to say, how is this neighbourhood the same as in New York?

I would say that we have a very strong scientific culture, by which I mean a culture of scepticism. I think that's the point of scientific exploration is it's more to prove yourself wrong than to prove yourself right. And that's something that we really hang on to. And then of course as a business we're trying to correct for that and always get better to the extent that we can confidently present an answer that we feel responsible in suggesting somebody should act on. So there are cases where we can very clearly test our accuracy. Say for example, looking at revenue predictions for a customer's business, we run tests to predict revenue based on existing locations, but have the actual revenue withheld for a few locations. This allows us to all see together how accurate the predictions are in a controlled approach.

And by training an algorithm against that and then revealing the answer, you can know exactly how accurate you are or aren't. And when doing that at a large enough scale, you can then build a confidence that it is in fact working, and that you can then start using it in a real application, which would mean predicting revenue for a not yet existing location, and that the system has been established, and now it's responsible to use it. I think there are certain places where at least as of yet, it would be harder to validate in that way. And I think that's just part of our ongoing process of building out our datasets, building upon our technology and growing that confidence that we have a clear understanding of place. And I think I spoke a little bit to this, it's hard to exactly frame the process in short, but sort of this interplay between machine logic and human logic. There are things the machine can reveal that are less intuitive, that is kind of going back to the example of a correlation between a dental office and a discount shoe store. But I think there are ways to continually be looking at that and examining whether or not it makes sense, and if not, trying to explore why. And if so then carrying on to the next problem.

Do you take into account this kind of human intuition approach to architecture or space? An emotional response to special conditions?

Yeah. For example, one of the team members that we recently hired [has experience in] a lot of predictive modelling on office spaces and the interactions between people's space and each other. And so that's very much about what you're speaking to, which is sort of the more emotional angle of what it is to exist in a place and to interact with animate and inanimate objects. And now his work with us is kind of expanding that view outward to the city scale. So I think that's an example of how we think about the issue that you're raising.

So is this kind of tool meant to be a be all, end all for your client? Or do you just expect it to inform their decision making? Or to be 100% accurate and say this is exactly how it would happen?

I think of course the ideal is that it becomes a be all, end all. That with increasing utility it becomes more of an optimal solution. The reality, as a start-up, we have to pick away at that challenge. So we start with specific industries, specific use cases and figure out how to serve those well, and then build from there.

Do you think you've discovered the true power of this approach to urban analysis yet? Or do you think it's still developing?

I think we feel confident that we're on a good trajectory. We turned two recently and we did a little off-site with the team. And one of the things that was interesting to examine, is that some of our early hypotheses were reasonably accurate and some of our ideas of where we might want to be today as of two years ago are in fact pretty close to where we are. So we're feeling pretty good that the technology makes sense, that some of our early theories are reasonably close to accurate and that we can just kind of keep following this path, and certainly there'll be some zigs and zags along the way. But the core principles of the company's founding, and specifically of what the technology can be, is working out pretty well.

" We believe constructing a granular view of culture has enormous potential to transform how we understand place. "

On dollar slices, pizza vectors, prosciutto zones and topping hyperspace
(Medium: Topos.ai, 2018)

To fully engage with and utilise data within practice, there should be a requirement for it to become a core component of the practice. Value should be placed on the continued development of skills and the exploration of new techniques

6

In Practice

A Survey of Data Use Methods

The following are examples of the ways in which designers can and are using data to inform or drive their designs. Not all of these would be applicable to every designer, project or locale, however these act as a brief overview of the capabilities that designers can aspire to, challenge and evolve should they be interested in exploring the use of data in practice.

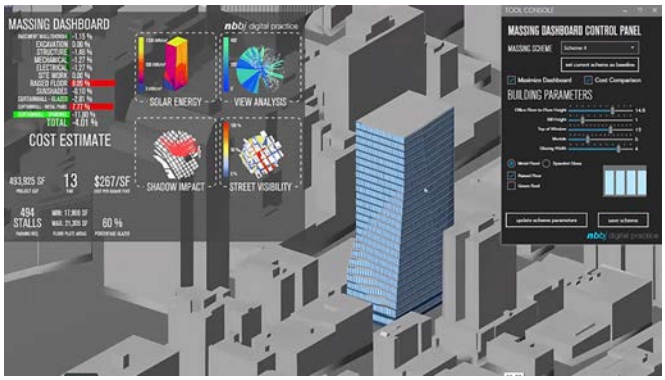
The majority of the examples and discussions here are aimed at providing a general overview for those interested in data and computational design. I have therefore avoided advanced and complex methods and negated from offering criticisms so as to not dissuade anyone from pursuing a particular avenue. Instead providing an initial insight to enable a designers pursuit into an ever evolving discipline within architecture and urban design.

Computational Design

The implementation of data-driven processes for most designers would generally evolve from a primary understanding of computational design. With the prevalence and growing interest in computational design methods using tools in Rhino, Grasshopper and programming, data-driven plug-ins are starting to surface. The majority of these methods are in their infancy if compared to methods used in the fields of data science and analytics, however they are becoming more abundantly available. Plug-ins like HumanUI allow designers to control their models from a dashboard and visualise data instantly whilst Ladybug allows for quick solar and view analysis. As these and others continue to evolve, so will the simplicity in which designers can start to engage in generating data from their own designs and models.

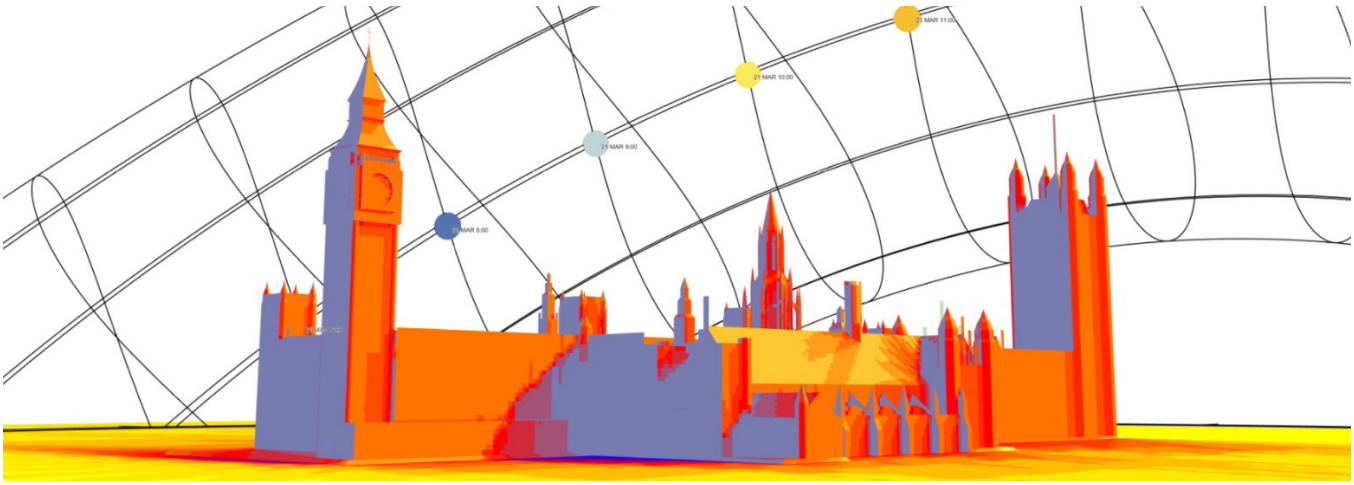
There is perhaps a misunderstanding that computational design is data-driven design. By simply using computational design tools like Grasshopper, you are not automatically generating designs from data, or even creating data from which results a design. For the most part computational design is simply the generation of complex or repetitive geometry that helps to reduce production time and increase accuracy. To consider computational design as data-driven then the model should either create data that can be analysed, or to be directly driven by data, that could create an optimal solution.

One method that is growing in popularity is the use of evolutionary algorithms to create optimal design solutions that fit singular or multiple criteria. There are several commercial applications that are starting to disrupt the industry using these tools. The exploration of these commercial applications helps to foreground why designers should consider advancing their skills and methodologies to compete with these solutions.



Human Ui is used to create a dashboard to quickly control and analyse building designs.

HumanUI. (n.d.). [image] Available at: https://www.performance.network/courses/build-user-interfaces-for-grasshopper3d-with-human-ui [Accessed 10 Jan. 2020].



Ladybug tools is used to visualise sunlight hours on a building.

Ladybug. (2018). [image] Available at: http://blog.rhino3d.com/2018/02/ladybug-tools-workshops-in-london-march.html [Accessed 10 Jan. 2020].

An urban scenario generated by Sidewalk Labs generative design tool.

Sidewalk Lab Generative Design Tool. (2019). [image] Available at: https://www.fastcompany.com/90443147/alphabets-sidewalk-labs-just-unveiled-a-software-that-designs-whole-neighborhoods [Accessed 10 Jan. 2020].

Archistar is used to identify potential new sites and create feasibility scenarios for assessment.

Archistar Demonstration. (2019). [image] Available at: https://www.therealestateconversation.com.au/news/2019/02/07/how-archistar-helping-property-professionals-find-residential-development-hot-spots [Accessed 10 Jan. 2020].

Generative Design

Machine learning is a method employing artificial intelligence models to create optimised solutions by learning from previous iterations. Evolutionary design employs machine learning at its core to determine the optimal design solution based on a series of objectives.

In the past couple of years, multiple commercial applications of generative and evolutionary design have emerged and started to shift how developers are considering site developments and feasibility scenarios. Testfit, Hypar, Spacemaker, and Archistar are all companies that use generative and evolutionary design to help create site solutions faster, more accurately and more efficiently than ever before. Sidewalk Labs, a company owned by the parent company of Google has also recently announced it's development of a generative design tool *"...which can help generate millions of planning scenarios - and identify options that best reflect local priorities" (Whitney and Ho, 2019).* They are not alone. Those mentioned above are established companies but there are new solutions popping up every other week that offer generative design solutions to traditional urban and architectural projects.

Though these tools are targeted at developers for feasibility and site acquisition stages of development, it does not limit designers from employing these tools to meet client expectations. If the existence of these platforms tells us anything, it is that they could essentially remove the need for an architect or urban designer from early stages of development all together. If that's true, then it should be a priority for designers to start implementing these methods within their client offerings. One way this could be done is by utilising the tools already available within Grasshopper to a level of detail and creativity that these solutions do not currently offer.

Evolutionary Design

Grasshopper has multiple evolutionary solvers available either natively or through plug-ins. Galapagos is Grasshopper's native evolutionary solver and has considerable documentation available to help designers to form a basic to advanced understanding of evolutionary design.

There are also several plug-ins available, one of which is Wallacei, a multi-objective optimisation engine. I spoke with Mohammed Makki, the founder and co-creator of Wallacei about the plug-in and how he thinks that this method of design generation is something worth considering when designing.

Mohammed was initially interested in a sub-field of biology called 'evolutionary development' and how he could introduce that within computation to investigate the impacts that can have on urban design. He began by investigating another Grasshopper evolutionary solver available at the time, but found that the results were slightly deceiving or didn't represent the complete picture. It would only reveal the most recent generations, only showing the user the most optimal solutions. He felt that this method didn't allow the user to fully interpret the data being generated by the solver and making their own informed decisions (Makki, 2019).

He developed Wallacei to combat this, to provide a full picture and allow the user to determine their own interpretations of the data whilst still being able to select every possible generation and to show the most optimal. By allowing this, Wallacei gives more control to the user and discounts a traditional argument that the computer is producing the wrong results, thereby negating the value of evolutionary solvers. If the user is in full control, then the computer can only be as wrong as the user.

Mohammed coordinated a post-graduate studio at the University of Technology Sydney's Faculty of Design, Architecture and Building for the Master of Architecture course in 2019.

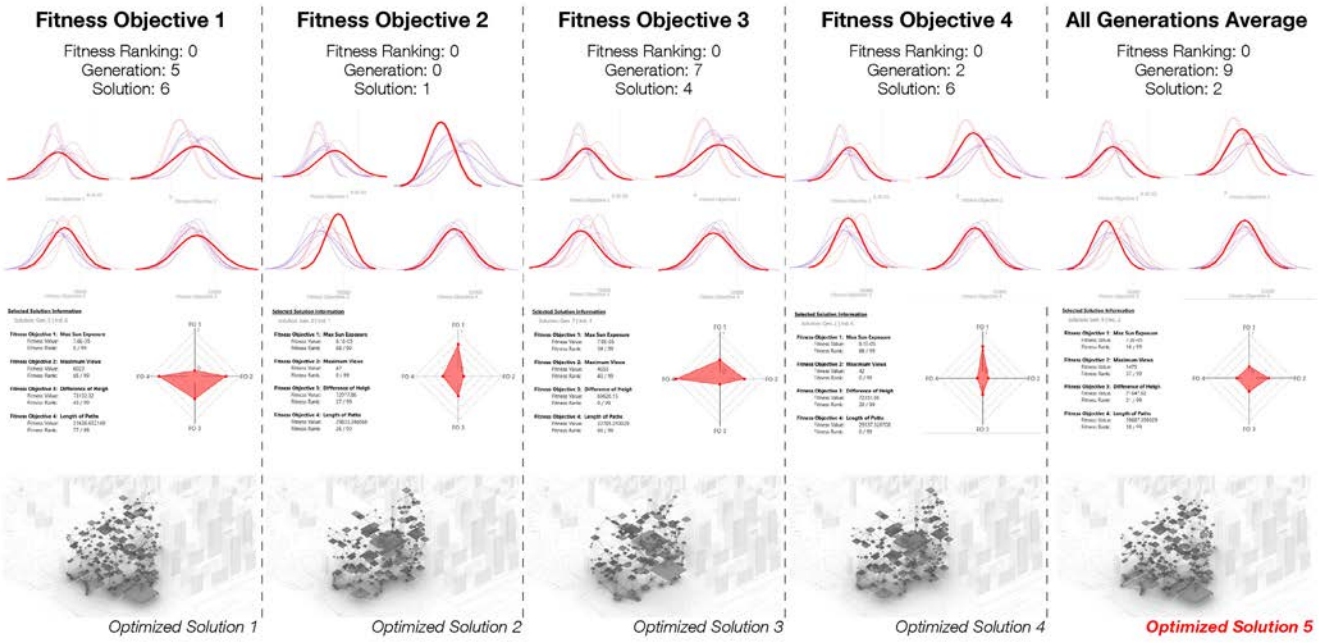
This course, 'The Populationist vs. The Topologist', explored the use of evolutionary processes in the design of urban scenarios. Throughout the semester students were tasked with selecting an existing urban area from anywhere in the world, analysing it and then using Wallacei and evolutionary design principles to design a better solution for that urban area that still maintains the character of the existing development.

I had the opportunity to be present throughout the semester for presentations and critiques and was able to witness the growth of these projects. The majority of students had little experience in using Grasshopper and even less experience in evolutionary design, however in the end the result of all groups was an outstanding level of creativity, detail, analysis and foremost, a considerable understanding of evolutionary design that could compete with some of the best computational designers. This studio was proof that what could be seen as a particularly complex method of design at first glance, can be applied from zero knowledge to full effect in a short period of time. In the hands of an experienced designer with an understanding of the aesthetic, social, cultural and creative aspects of developments these tools can offer more than their commercial counterparts.

I connected with one of the groups after their final presentation and asked them some questions about their experiences with the studio and about their project.

Wallacei is used to find optimal solutions that fit multiple objectives.

Wallacei. (n.d.). [image] Available at: https://www.food4rhino.com/app/wallacei-0 [Accessed 10 Jan. 2020].



Wallacei Studio

An Interview With Students

Jason Choi and Chi Thanh Phat Nguyen chose a superblock in Kyoto as their foundation urban scenario. During the semester they developed an understanding of evolutionary solving using Wallacei and how to implement it with various other Grasshopper plug-ins such as the environmental analysis tool, Ladybug, and a network analysis tool, DeCodingSpaces Toolbox.

The result was a rather intriguing solution that uncovered the depths that evolutionary solving can reach and highlighted that the solutions are not purely based on geometric considerations, but on social and cultural relationships.

Give me a brief overview of your project. What were you trying to achieve and do you feel it was successful?

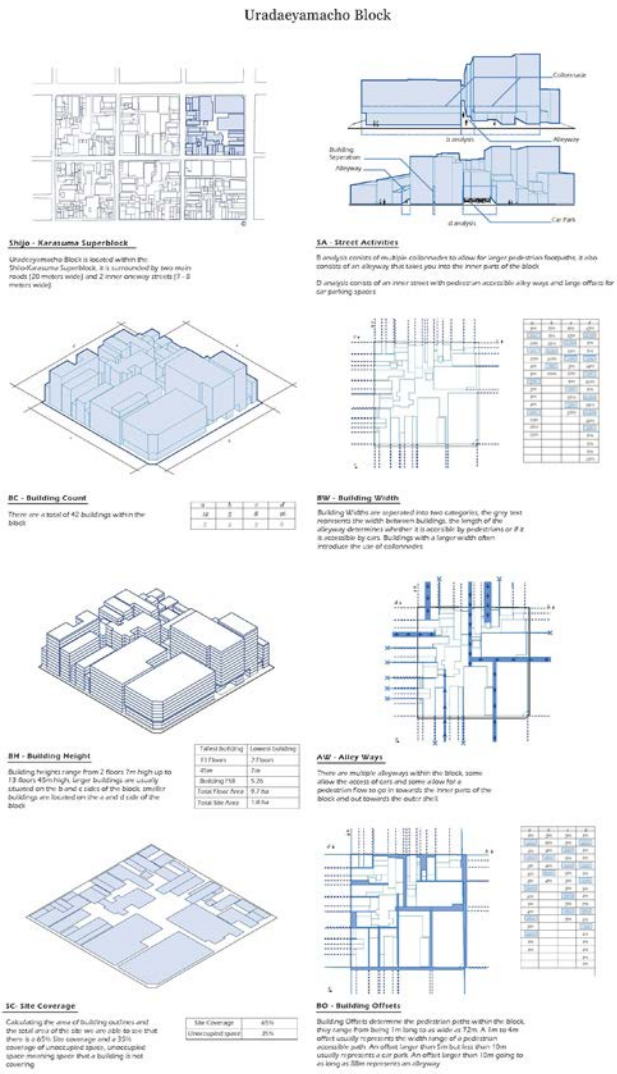
Our project focuses on how urban planning approaches can use alternative methods that utilise social and cultural aspects as a foundation to tackle the underlying complexities of an urban tissue. Culture is able to be often maintained through generations and thus serves as a primary contributor to deal with aspects of growth. The importance of quantifying social and cultural aspects of an urban model begin to create an understanding behind the characteristics of what makes each physical aspect unique to the city; in measuring the quality of these aspects, the data can be further extrapolated to implement, improve or regenerate aspects of the urban tissue.

A superblock located in Kyoto is our primary research target, experiments were conducted on its unique alleyway network, breaking down its physical morphological characteristics to understand its quantitative properties and its relationship to user experiences to identify the already existing social and cultural traits. Through the use of the evolutionary process within the design field, these traits are computationally translated for further implementation to algorithmic solvers to help regenerate a series of individuals that are significant improvements from the original superblock.

How much of Grasshopper did you know before the studio and did you have any prior experience in evolutionary design?

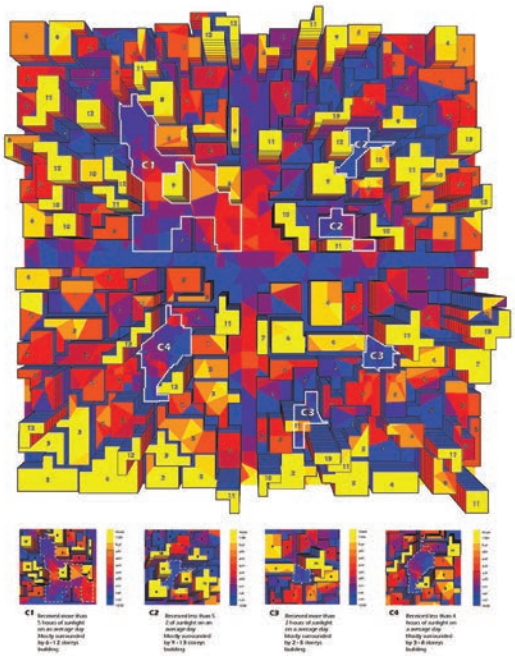
Jason:
I had very little experience in grasshopper, my knowledge went as far as trying to understand the placement of components within an online tutorial. Following the design studio I was able to understand that very careful cognition played a large role in a successful script, that most design ideas could be broken down into data sets and the use of mathematical tools would keep everything precise and measurable.

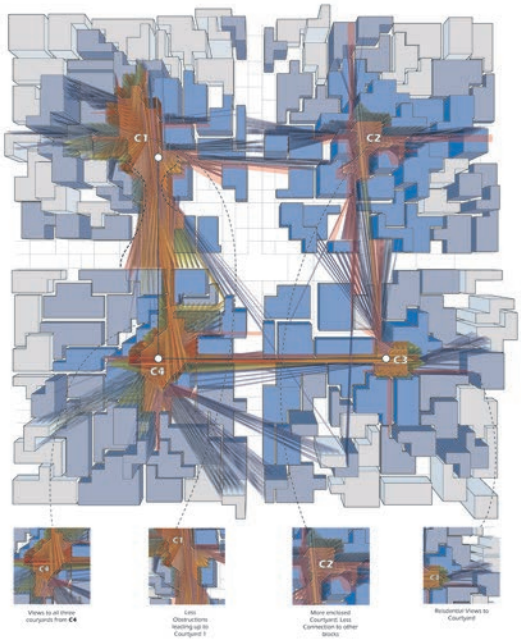
Phat:
I had multiple encounters with Grasshopper during my undergrad degree. However, most often I wasn't able to fully grasp the fundamental ideas/ processes of the tool. As far as my knowledge went, I was able to write up basic scripts with the help of tutors or online tutorials. However, during the course of this semester, I was able to learn the foundation of Grasshopper and realised that logic and critical thinking are fundamental to a successful script and the quantification process of tangible and intangible data would help the design process stay objective and measurable.

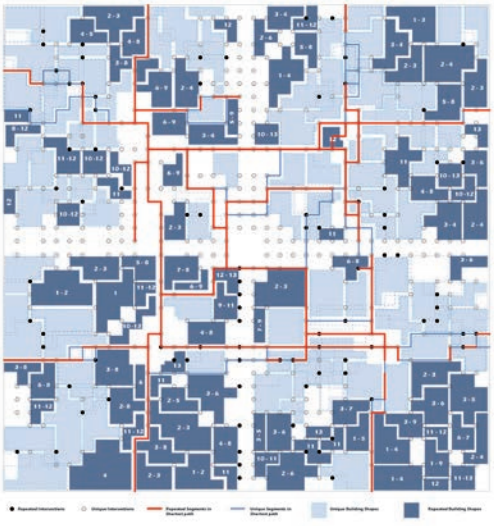


An analysis of superblocks in Kyoto provides the framework and data for how to characterise the existing situation and then how to approach creating an optimised version of it.

Courtesy of Jason Choi and Chi Thanh Phat Nguyen







What are your thoughts on the pros and cons of using evolutionary design in urbanism?

Jason:
The use of evolutionary design is very beneficial to methods of urban planning as it is able to be used to reveal patterns of growth within an urban tissue as well as ensure the tissue is capable and flexible to change. It's selection process is also unique and in comparison to a traditional design iterative process, it can be more meticulous and provides a more objective solution. The only con lies in the time it takes to generate evolutionary design through computational tools but this is a con that I believe will soon relieve itself as technology begins to improve in the near future.

Phat:
The pros of using evolutionary design in urbanism lay in the process of allowing designers to set the overall environmental conditions with quantifiable objectives then later ensure that the urban model could evolve and adapt to change. And through growth, the process could then adapt and optimise to certain environmental changes at the time. The cons that lay in evolutionary design is that it is still relatively new within architectural schools and heavily computationally based, which not many students are open to and thus it is aimed towards a niche group with advanced computational skills to be able to comprehensively utilise it.

Do you think you will use it again in future studies or practice?

Jason:
Due to the success we found within the process and the result of this project, I do see myself using evolutionary principles within future practices. As it is a principle I very much understand and a process that displays a tremendous amount of rigour within the design process, I can see myself applying it to urban planning projects but am yet unsure about the application to building designs. This is an area of evolutionary design that I have not very much immersed myself with but nevertheless I do see how it could be beneficial.

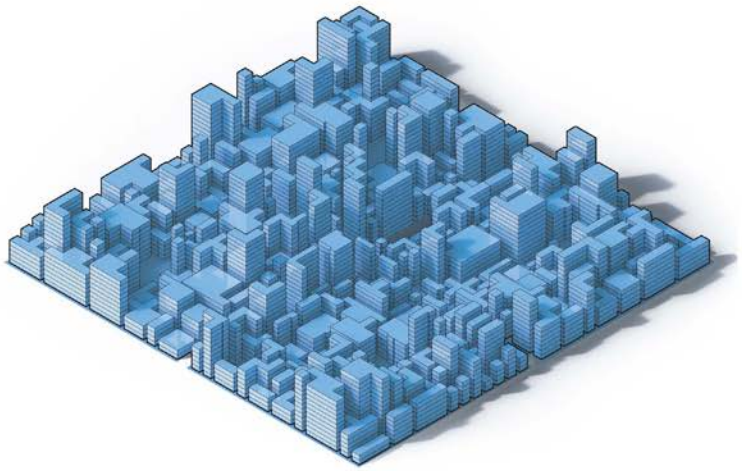
Phat:
I do believe that evolutionary design is very beneficial for urban planning projects. Rather than using evolutionary design through a computational tool, I'd like to apply its design principles and processes to my future studies/ practices.

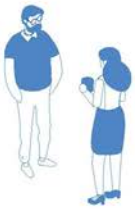
A number of analysis methods utilising Wallacei and common Grasshopper plug-ins are used to determine the most optimal solution.

Courtesy of Jason Choi and Chi Thanh Phat Nguyen

The chosen site in Kyoto, Japan and their objectives that covered factors such as human interaction, solar access, connectivity and density.

Courtesy of Jason Choi and Chi Thanh Phat Nguyen





Objective 1.

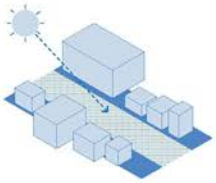
Increasing People Interaction

To increase the intensity of pedestrian interactivity through the use of close proximity street network

Objective 2.

Greater Inner Alleway Connectivity

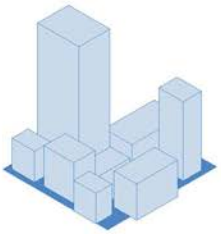
Creating multiple connections and interruptions of navigational paths from multiple users



Objective 3.

Increasing quality of solar distribution on open areas

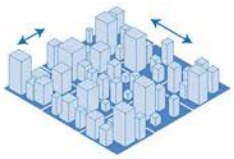
Allowing for an adequate amount of sunlight amongst highly active areas within each block



Objective 4.

Maintain Urban Density

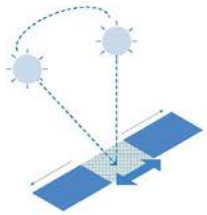
It is important for the city of kyoto that all programs maintain their current density



Objective 5.

Maximise the integration valuefrom block to block

Widen and create the shortest navigational paths between blocks

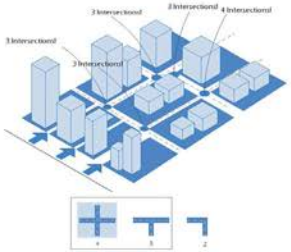


Criteria 1.

Maximise Desirable Sun time on Ground level

To allow all spaces to have prime afternoon sunlight in order to encourage users to occupy these spaces during this time

To include: G1. G5. G3. G4.

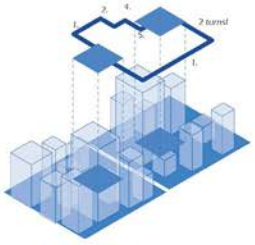


Criteria 2.

Maximise Alleway Intersections and Alleyway Entries

Allowing for the most possible amount of entries within each block's intricate alley way network as well as the highest possible amount of pedestrian intersection

To include: G2. G7. G5. G6.



Criteria 3.

Minimise The Amount of Turns on Shortest Paths

Allow for more visual recognition between pedestrian squares

To include: G1. G6. G2. G7. G5.

Criteria 4.

Minimise variation in total floor space area of different height categories

Height categories 1 - 4, 5 - 9 and 10 - 13 must begin to achieve a total floor space area ratio of 1/3 between themselves

To include: G1. G2. G3.

In Practice

A Survey of Data Use Methods Continued

The Public Life Data Protocol

The Public Life Data Protocol (PLDP) is a suite of metrics used to gain an understanding of public life in urban spaces. It was developed by the Gehl Institute, in collaboration with Gehl (the practice), the Municipality of Copenhagen and, the City of San Francisco with support and input from Seattle Department of Transportation. Its aim is to provide a scalable and comparable standard format for data collection that describes activity and use in cities and spaces anywhere in the world (Gehl Institute, 2017).

It can be used to determine various metrics of people, use and space such as gender, age, mode of travel, posture, activity, spatial characteristics and more. These can be collected through analogue observational studies or by using automated digital technologies (Public Life Data Protocol, 2017, p. 5).

The goal is to provide a common language across various governmental departments or for private curation that can then be used to evaluate and analyse with ease. This would allow, as Gehl suggest, to design 'Cities for People'. For this reason, they have created the PLDP as an open source project that anyone can use.

It is available at *https://github.com/gehl-institute/pldp* along with sample data and documentation about how to best use it.

Smart Sensors

Anyone even slightly familiar with urbanism would have heard the term 'smart cities' at some point in their career. As Charles Catlett pointed out, the definition of such a thing is in the eye of the beholder (Catlett, 2019). Smart cities are an attempt to consider how technology will impact the future of our living and working lives in cities across the world. Sidewalk Toronto is one approach that has gained interest in the past couple of years through it's intended development of a city district that uses technology at it's core.

Although some of their methodology and implementation methods have been criticised, there are aspects that have evolved from such ventures that are interesting to consider when looking at data for design insight. One of these things are smart sensors supported by a digital overlay. This technology was not founded in smart cities but is a core component of it.

Smart sensors use a number of different digital and physical technologies to create data about any kind of space and are typically connected to a robust network of other devices. This kind of technology is commonly referred to as the Internet of Things (IoT).

The Array of Things project, as described in the interview with Charles Catlett, is one such sensor that measures environmental conditions in urban areas such as air pollution, temperature and climate. The aim of this is to gain an insight into different environmental conditions that could be impacted by different urban scenarios and to then suggest an alternative that would improve of those conditions (Catlett, 2019).

Another sensor has been developed by Numina to monitor street-level activity and to produce data that they say can save lives and money (Numina, 2020). I spoke with Paul De Konkoly Thege, Numina's operations manager, to get an understanding of how their and other smart city technology can impact decisions by designers.

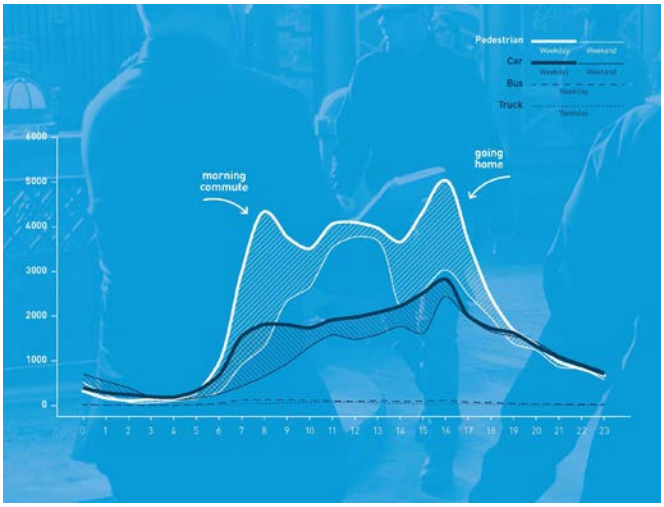
> *" Our mission is to make cities more responsive so they can be more equitable, more accessible, more prosperous places. "*
>
> (De Konkoly Thege, 2019)

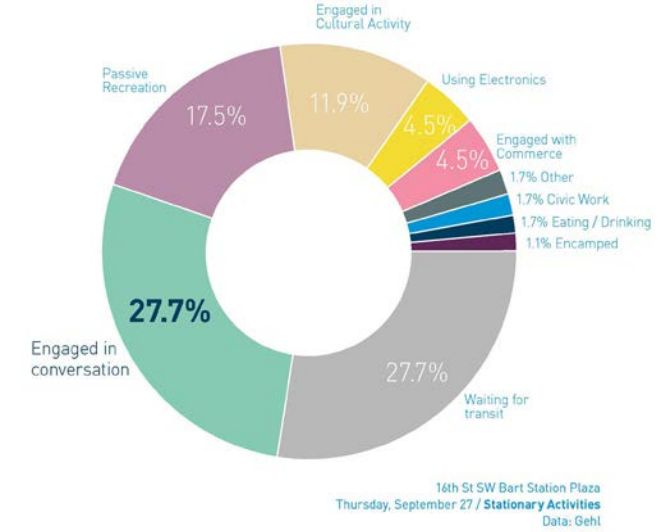
Their device measures the where, when and how of movement in the public domain by the use of image analysis called semantic segmentation that is able to identify different elements automatically. The device takes an image multiple times per second, analyses it on-board, uploads the data then discards the image. Occasionally an image is saved for quality control purposes but this method helps to maintain privacy.

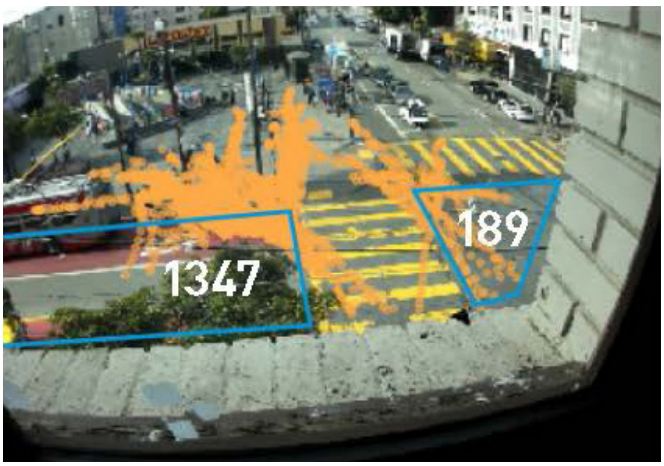
At the time of our conversation they were able to identify five classifiers: cyclists, pedestrians, a single passenger vehicle, buses and trucks. Since then, they have also developed their systems to recognise trash within the public domain. By determining an understanding of how people move and act within the public domain can help inform how the public domain can be designed and/or maintained (De Konkoly Thege, 2019).

A Numina device attached to a light pole.

Numina Device. (2019). [image] Available at: https://republic.co/citiesense-starling-childs-citiesense-partner-numina-launches-their-api-for [Accessed 10 Jan. 2020].







Numina have worked with Gehl on multiple projects to assist them with data collection for projects along with supporting the PLDP. One project is the 16th Street Mission Station Plaza.

The plaza, in the mission district of San Fransisco, is a highly used BART (underground) station entrance however has seen issues with a lack of maintenance and an increase in crime, drug use and homlessness (Gehl, 2019). Despite this, the community surrounding this is supported by a strong advocacy group of local business owners who wish to see the plaza transformed to be safer and more welcoming without displacing the current demographic.

I was present during Gehls recommendations to local stakeholders at Stamen Designs office on the corner of the plaza intersection. By using a combination of their own analogue data collections with the PLDP and data from a Numina sensor mounted in the Stamen Design office they were able to analyse the typical usage of the plazas and then create an informed design outcome with several suggestions for how to approach any future development of the plaza. This methodology of obtaining data from multiple sources, along with testimony from key local representatives allowed Gehl to make confident evidence-based decisions that took into account pedestrian accessibility, movement, safety, social and cultural aspects.

Data from Numina sensors and anaologue collection using the PLDP provided an insight into how people use the 16th Street BART plaza. Pedestrian and vehicle counts, pedestrian activity, jay walking events and pedestrian walking directions all provide greater insight, quicker and more robustly than can be typically gathered by other means.

Gehl (2019). Public Space + Public Life in 16th Street BART Plaza: Preliminary Findings. [online] San Francisco: Gehl. Available at: https://issuu.com/gehlarchitects/docs/public_life_of_16th_street_bart [Accessed 10 Jan. 2020].

Producing Data

When discussing the use of these smart sensors like the Array of Things and Numina, it should be noted that these are solutions that come after something has already been designed. The Array of Things sensors are mounted on light-poles in Chicago to measure existing environmental conditions. The Numina sensors are similarly mounted in whatever way they can in various locations to measure existing street-level activity.

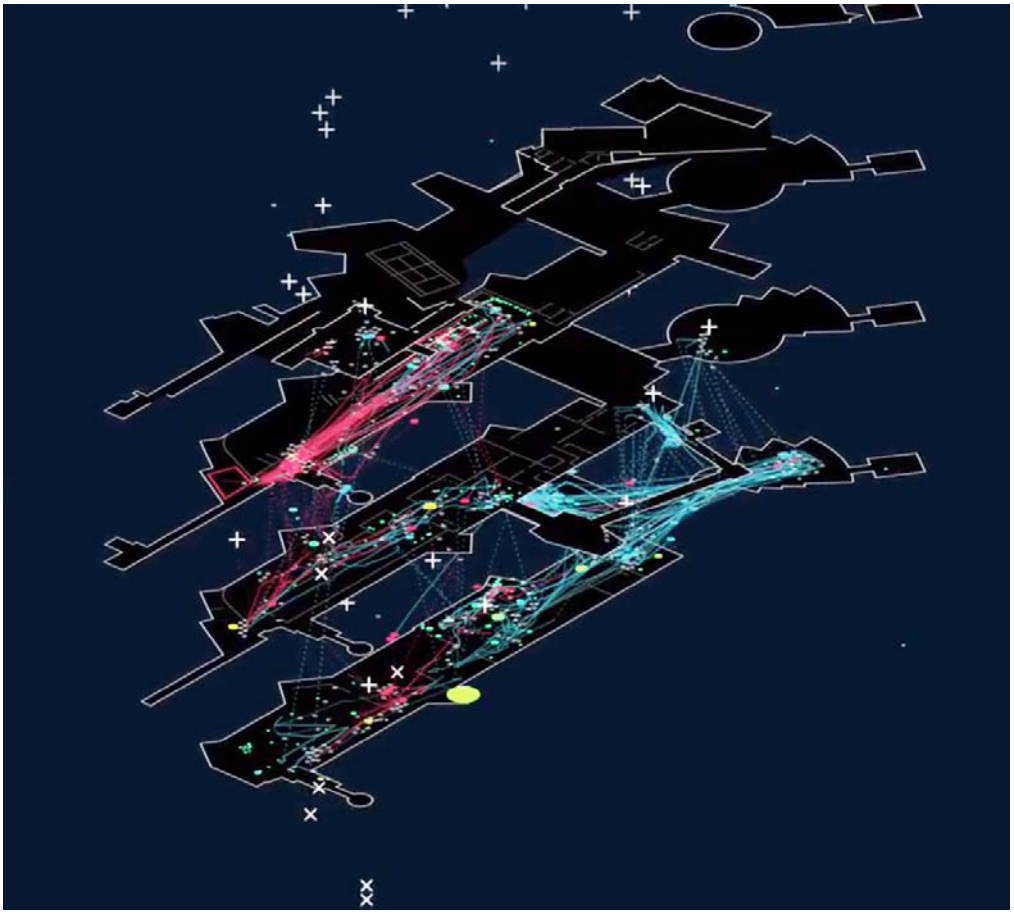
A true smart city project should not just be influenced by data but would also generate data and is then capable of adapting based on that data. To do this, designers should consider designing with sensors embedded in their spaces and to design flexible and adaptable buildings and public spaces that can change as the users do.

To understand what this means I spoke with Scott Brewer, co-founder of Art Processors, an experiential design consultancy that delivers digital engagement solutions for museums. One of their earliest works was developed for the Museum of Old and New Art (MONA) in Hobart. 'The O' is a mobile device that is given to all guests of the museum that replaces traditional wall-mounted interpretive texts (Art Processors, 2013). Not only this, it is also capable of placing guests in a virtual queue for popular exhibitions so that they no longer need to wait in line to enter exhibitions but are instead notified by the device when it is their turn to return.

Scott mentions that the kind of services that Art Processors provide are ad-hoc solutions in existing facilities, but has always had an interest in implementing these technologies from the get go

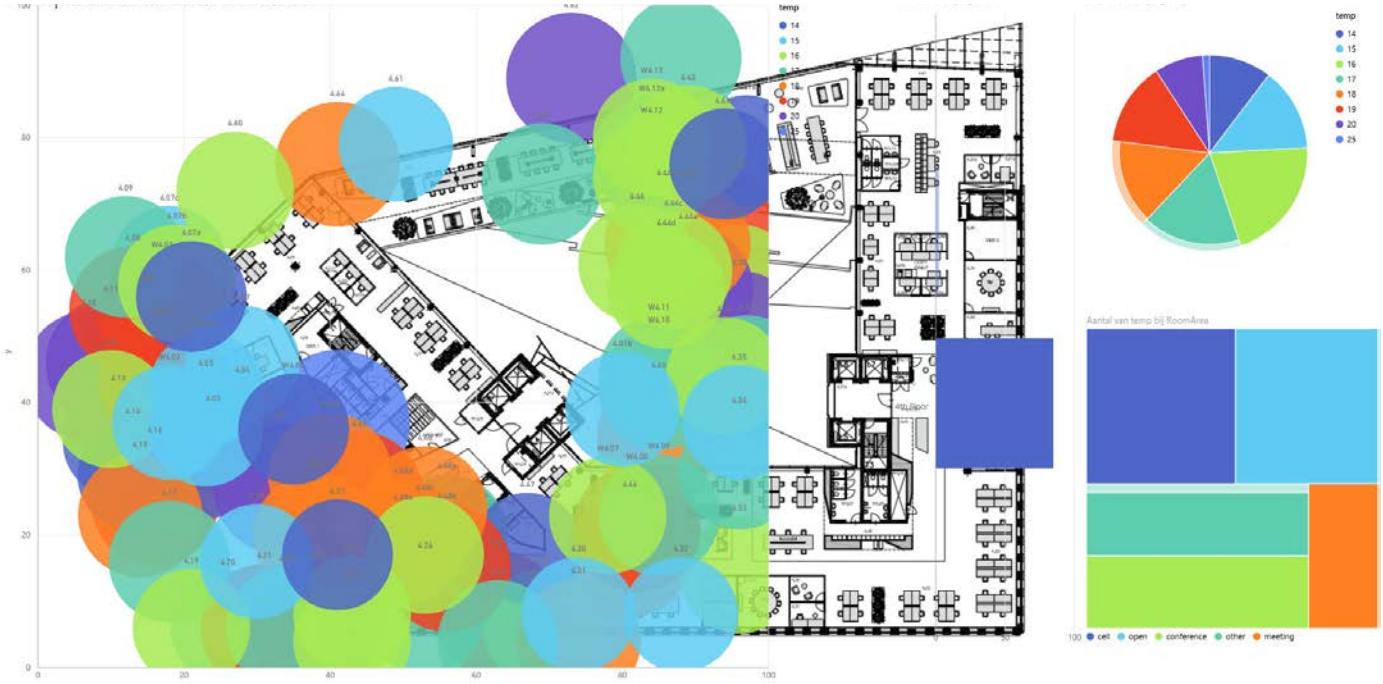
> *" I actually believe they are a lot more valuable if they're thought about earlier on in the design process, and I guess all of that really comes to the work we did with MONA. "*
>
> *(Brewer, 2019)*

When appropriately developed as a key component of the design, like 'The O', the digital technology can not only influence the user experience but also start to provide insight into how that building or space can be used more efficiently or pragmatically. 'The O' could provide that insight by anonymously tracking movement via check-ins to different locations through the museum. This data was then visualised by Stamen Design to show that while people are queuing to see a particular exhibition, they are also able to be anywhere else in the museum, viewing other artworks and having a more joyful experience that couldn't be achieved by waiting in line (Brewer, 2019).



A visualisation developed by Stamen Design using data from 'The O' at MONA shows people interacting with artwork around the museum whilst they wait in a virtual queue.

The O - Virtual Queue. (n.d.). [image] Available at: https://www.artprocessors.net/what-does-a-virtual-queue-look-like/ [Accessed 10 Jan. 2020].



The dashboard contains information about the entire building, including localised floor temperatures as shown here.

The Edge - Dashboard. (2015). [image] Available at: https://www.bloomberg.com/features/2015-the-edge-the-worlds-greenest-building/ [Accessed 10 Jan. 2020].

Low power ceiling panels are equipped with sensors and equipment to monitor temperatures and lighting and adapt based on user requirements.

The Edge - Ceiling Panel. (2015). [image] Available at: https://www.bloomberg.com/features/2015-the-edge-the-worlds-greenest-building/ [Accessed 10 Jan. 2020].

Another example of making digital technology a core component of design is the Edge in Amsterdam. Designed by PLP Architecture for consulting firm Deloitte, it is one of the smartest and greenest buildings in the world. Beyond its exemplary qualifications at achieving a 98.4 BREEAM rating (a sustainability assessment), it hosts over 28,000 smart sensors and digital technologies across its 40,000sqm of office space (Randall, 2015).

Embedded within every ceiling panel is a series of sensors and instruments that are capable of connecting multiple devices and controlling the lighting and temperature of small workspaces. Every employee has a preference for their desired working temperature and light conditions and get automatically directed to a part of the building that has those exact specifications already set up for them.

This method of hot-desking provides 1,000 desks for 2,500 employees seamlessly by connecting with their schedules, knowing when and how many people will be in the office. The building is then capable of shutting down areas or even entire floors to optimise energy usage when it knows there are less employees present. All this information is synced to a dash board that controls multiple other functions of the building such as it's environmental status, robotic vacuums and patrols, even addressing when towel dispensers in bathrooms need replenishing (Randall, 2015).

Online Platforms

The PLDP is inherently a manual process of collecting data, requiring at least one person to be on the ground with a clipboard, unless using digital technologies like the Numina sensor. However, another method of manual data collection is through the use of interactive web maps that allow users to add to a collection of resources and provide their own input into what could be a very large project.

This method of civic and public data collection is becoming more popular with cities around the world adopting various methods of public engagement using web maps. The value being that they can collect more data for cheaper and with relative ease for an indefinite period of time. Similarly, the value to users is that they can have a direct impact on decisions that are made in relation to their cities.

One such interface was the 'Free to Be' movement, a crowd-mapping solution to female safety in public places. Developed by Plan International with XYX Lab - Monash Space Gender Communication Lab. XYX Lab explore various issues around creating and supporting gender-sensitive design practices for cities (XYX Lab, n.d.). The 'Free to Be' website allowed young women in Sydney, Delhi, Kampala, Lima, Madrid and Melbourne to drop a pin on a map and suggest if they felt safe there and provide comments about why (Plan International, 2018).

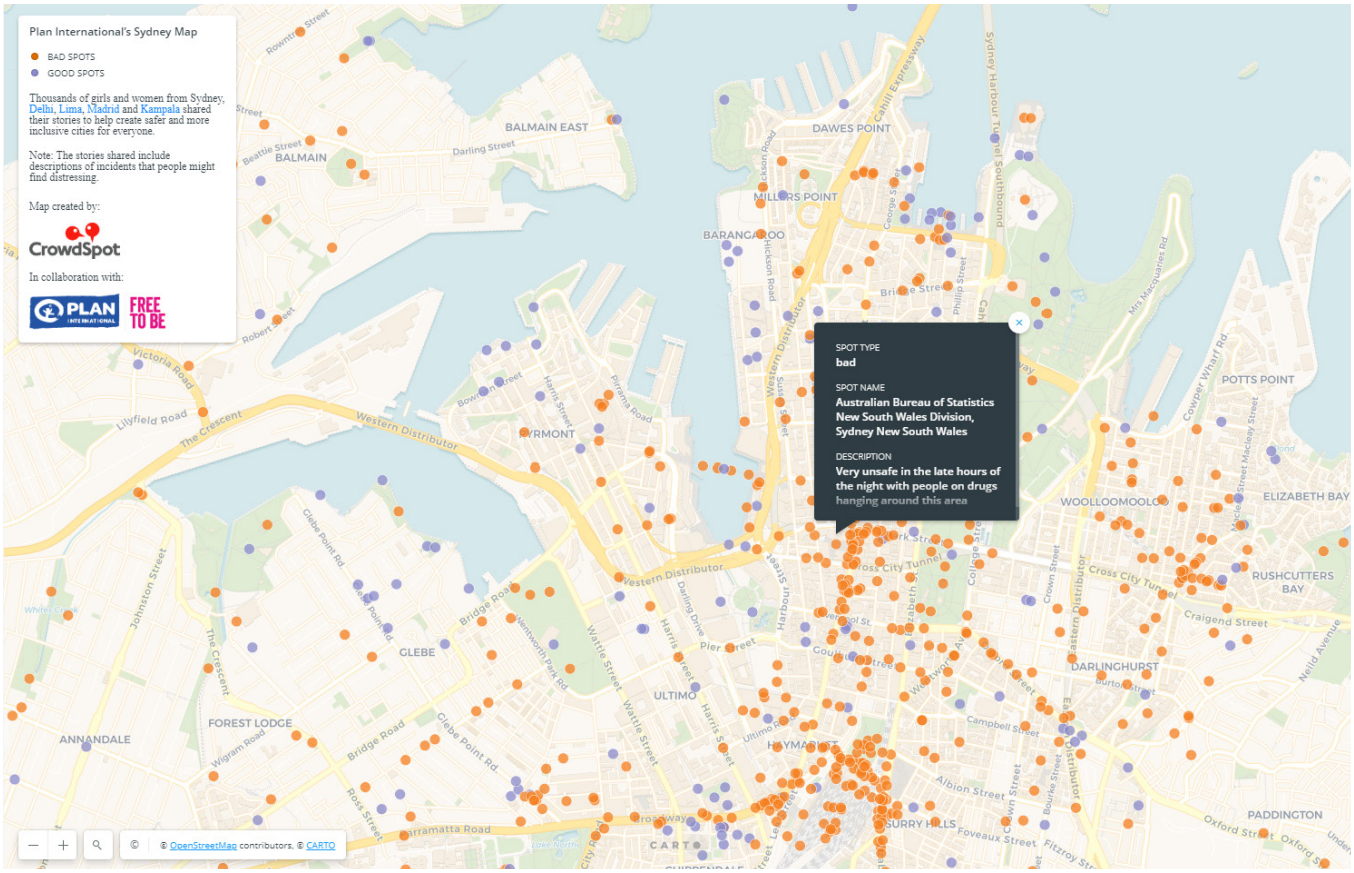
The results could then be analysed to provide a general understanding of where women felt more or less safe in public places and why they felt that way. Arup, in collaboration with XYX Lab developed a research project based on the data from the interactive map to determine an understanding of how different lighting scenarios lead to perceptions of safety (McAllister, 2019).

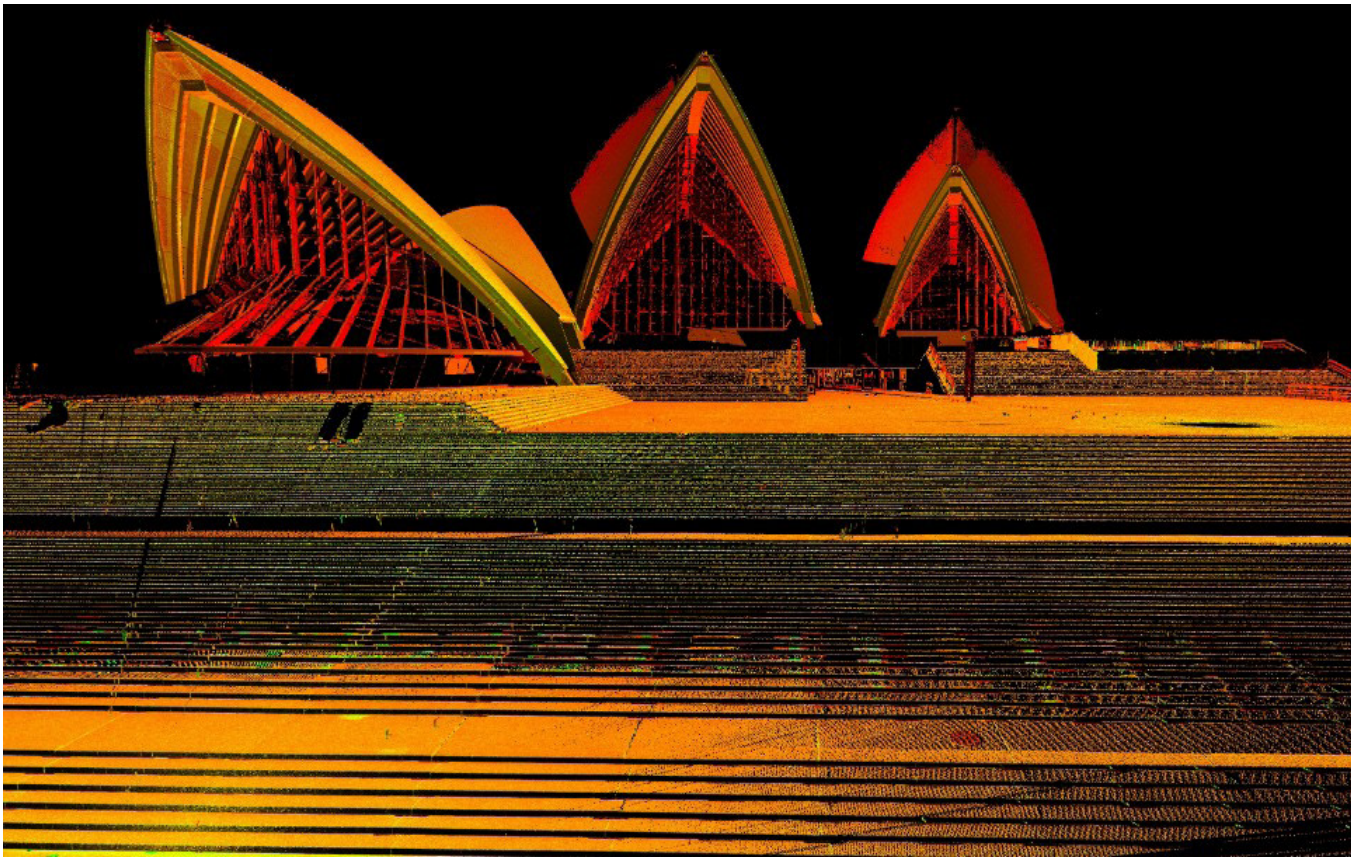
The results of this research allowed them to determine that design standards for lighting compliance in those locations doesn't take into account the multiple ways in which people experience light and that the quality of light, not the quantity, is the most important factor in the perception of safety in spaces (McAllister, 2019).

The research suggests that we should design holistically for 24 hours and that inviting participant engagement in early stages provides the capacity to design a more inclusive environment (McAllister, 2019).

The Sydney 'Free to Be' map shows locations that women have tagged as good or bad and provided comments as to why.

Free To Be - Sydney. (2020). [image] Available at: https://crowdspot.carto.com/builder/5b579455-6e9c-4df1-a79e-a8e4c375a77b/embed [Accessed 10 Jan. 2020].





CyArk use LiDAR to scan historical world heritage sites such as the Sydney Opera House for preservation purposes.

CyArk - Sydney Opera House. (2016). [image] Available at: https://edition.cnn.com/2015/04/09/tech/cyark-laser-cultural-heritage-mci/index.html [Accessed 10 Jan. 2020].

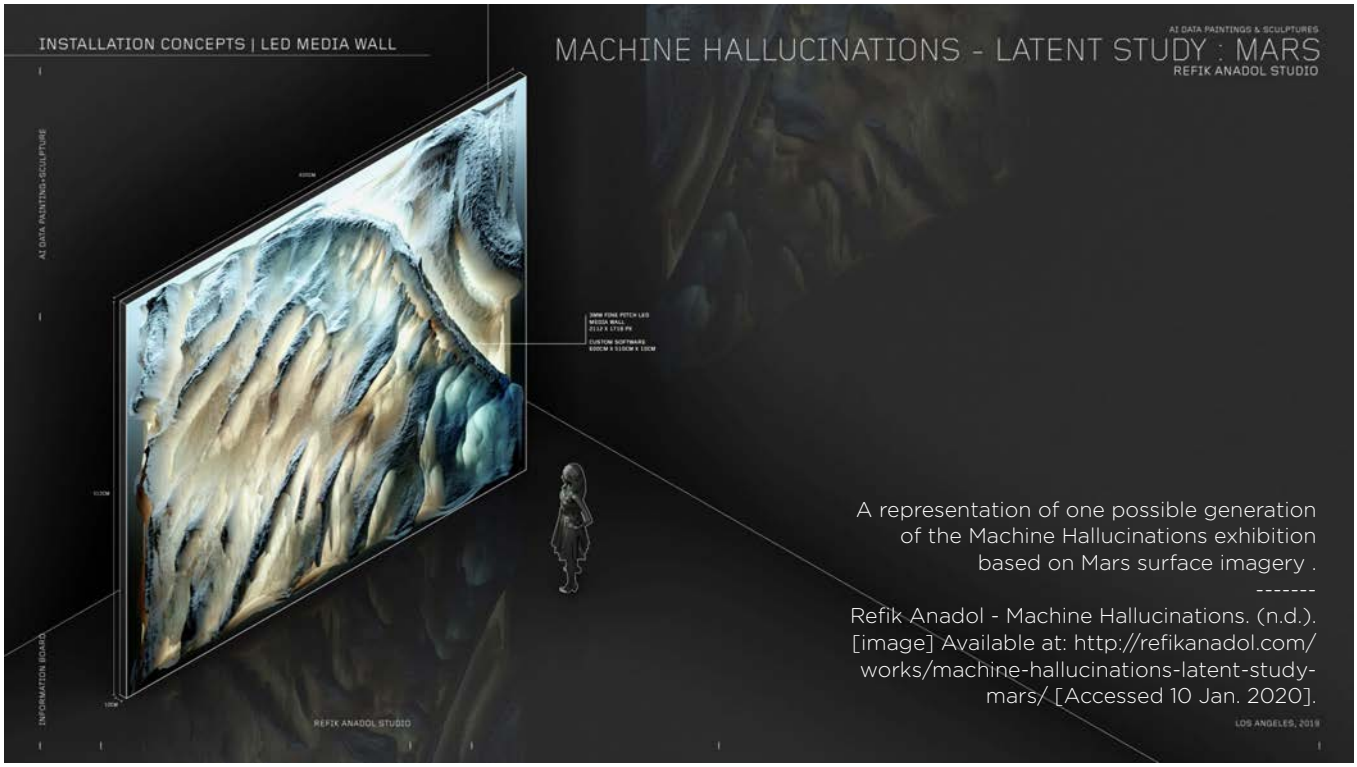
Digital Copies

Another method of using smart technology is the use of LiDAR mapping to generate detailed point cloud information that can then be used to create an accurate 3D model or digital copy of the built environment complete with minute levels of spatial detail, texture and colour. With the foundation of the point cloud feeding into the start of a project, designers could be more confident that their designs will change less due to further site developments at later stages.

LiDAR has recently been evolving to become a quicker and more detailed way of surveying existing buildings and sites of any scale. Several services are offered to designers that use ground-based survey methods or drone mounted sensor systems.

WeWork have been using LiDAR scanning in the early stages of their projects to get a better and more detailed understanding of their new locations prior to design and construction (Sullivan, 2019).

CYARK is a non-profit organisation that specialises in the conservation of historical sites around the world. By using detailed 3D documentation from LiDAR scanning to preserve minute details and aspects of some of the most important buildings and spaces in the world, CYARK is able to create a digital picture of a building that can be used by conservationists, historians and others to inform where work is needed and in what capacity to uphold the integrity of ageing structures. It also creates a digital archive of important buildings and places which may then be restored should they be damaged or destroyed (CyArk, n.d.).



A representation of one possible generation of the Machine Hallucinations exhibition based on Mars surface imagery .

Refik Anadol - Machine Hallucinations. (n.d.). [image] Available at: http://refikanadol.com/works/machine-hallucinations-latent-study-mars/ [Accessed 10 Jan. 2020].

Aesthetics

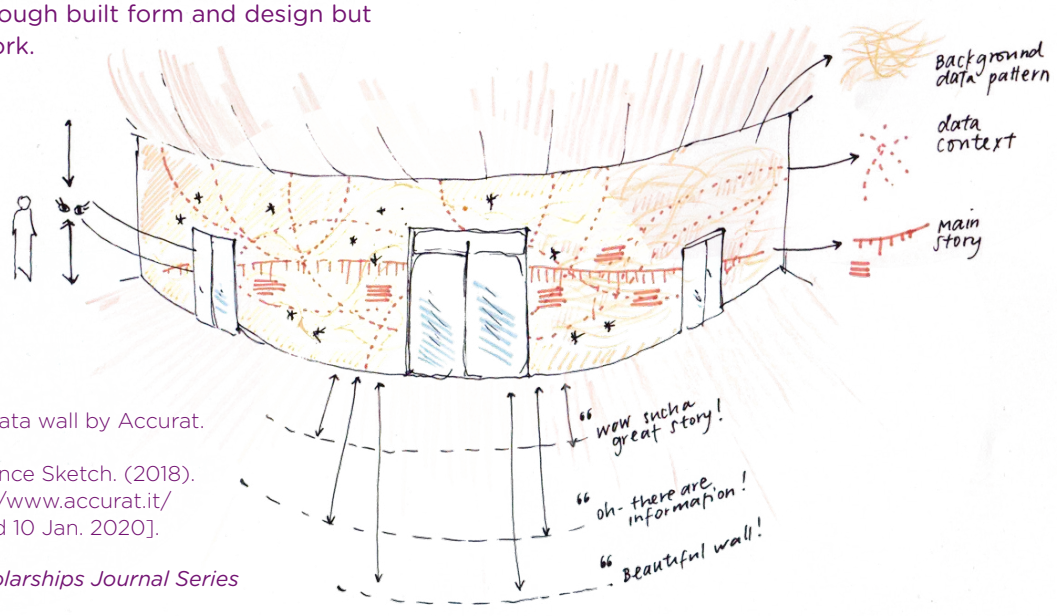
There are also examples of using data purely for aesthetic reasons either by using data for art installations that create interest in a place or by embedding stories from data visualisations within physical designs.

Refik Anadol Studio uses data paired with AI systems to create digital artworks that project light and sculptures onto surfaces. In 'Machine Hallucinations' the studio used 1.5 million archival photos from the HiRISE telescope of MRO Mars. Using a method of AI called Generative Adversarial Networks, Refik Anadol trained a model using the images and was able to produce artwork that he says has *"Come to represent collective memory, hidden layers of history, and then consciousness of a planet that, otherwise, might remain unseen"* (Refikanadol.com, n.d.).

The majority of these artworks are an interesting take on data and show that they can impact our relationship with places not only through built form and design but through evocative artwork.

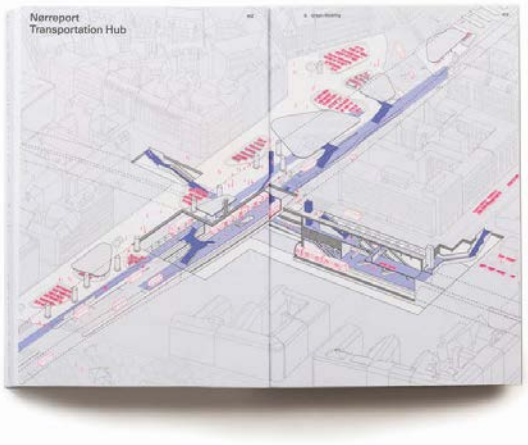
In mixing this approach to data using artwork and architecture, designers can deliver experiences that intrigue and provide multiple levels of interaction.

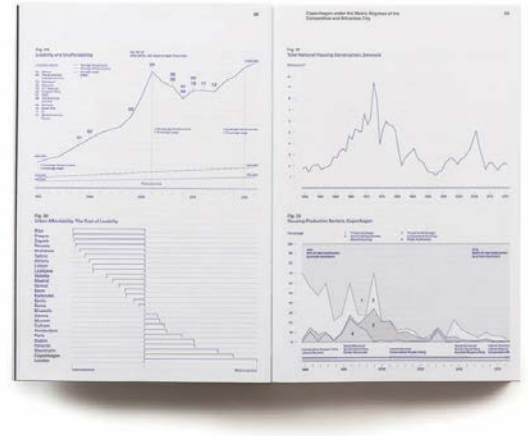
Accurat, a design and data visualisation consultancy firm, designed an interactive wall for a Starbucks in Milan. The wall explores the story of Starbucks history and its coffee with a visual interpretation but also through an augmented reality experience. The augmented reality app acts as a "magic lens" to help discover 3D animations and additional stories that you couldn't experience otherwise. This unique combination of physical, digital and the exploration of data impacting on design transforms typical elements like a wall into a "living artwork" (Accurat, 2018).

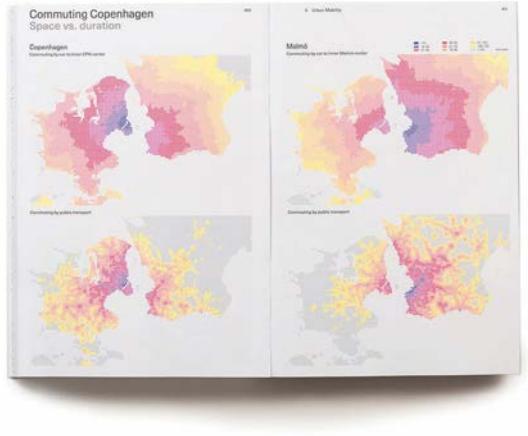


A sketch of the Starbucks data wall by Accurat.

Accurat - Data Wall Experience Sketch. (2018). [image] Available at: https://www.accurat.it/works/starbucks/ [Accessed 10 Jan. 2020].







Geographic Information Systems (GIS) and Mapping

Perhaps the easiest and most direct way that designers can start to use data within practice is to explore the multitude of offerings within GIS.

Having existed for some time, GIS is the digital version of cartography. Detailed and meaningful maps can be developed relatively easily using geo-spatial data available from many sources. Many government, public and private institutions and companies offer mapping layers that deliver information in regards to transport, topography, demographics, environment and more.

In recent years, the application and use of GIS has exploded due to the prevalence of cloud based systems, wide spread availability of data sources and online visualisation platforms. Mapbox and Here provide the ability to quickly visualise geo-spatial data online and share it with anyone, anywhere. More detailed maps and interfaces can also be developed with a knowledge of the respective Application Programming Interfaces (APIs) and coding experience.

The ride-sharing service, Uber, have been releasing swathes of their geo-spatial data online to their public data platform, Uber Movement. Information about travel times, speeds and mobility device use is available for various cities around the world and can be downloaded to be analysed in more depth.

It's not uncommon, and increasingly becoming standardised, for government agencies to upload geo-spatial information for public use across varying sectors. In New South Wales, you can access thousands of data sources on their environmental data portal, SEED. And the Australian Bureau of Statistics publish geo-spatial information to visualise census and demographic statistical information frequently.

Mapping is not only a great way of visualising information, it an excellent way of telling a story. As a method of visualisation, maps can not only reveal information previously unknown to a viewer, but do so with as much creativity and flair as any architect can present a building. The Atlas of The Copenhagens, written and presented by several architects and graphic designers, uses GIS and maps to explore the urban territories of Copenhagen. The book, *"offers a visually seductive, yet informative and comprehensive, understanding of the city of Copenhagen"* (Ruby-press.com, n.d.).

Pages from 'Atlas of The Copenhagens' shows information about commuting, liveability, housing, energy use and transportation.

Atlas of the Copenhagens. (2019). [image] Available at: https://archinect.com/features/article/150142142/atlas-of-the-copenhagens-book-review [Accessed 10 Jan. 2020].

Research and Development

Many of the examples shown before are easily explored by an individual interested in computational design, data analysis and visualisation. However, to fully engage with and utilise data within practice, firms may consider greater investment to make it a core component of the practice, placing value on the continued development of skills and the exploration of new techniques. This investment may currently be out of reach for most small and medium sized firms, however as this technology becomes more ubiquitous, if these skills and techniques are not adopted, then the cost could be far greater than the investment of a few skilled employees.

There are some firms globally that have realised this and have developed considerable research and development teams that span through computational design, program and software development and spatial data analytics.

Superspace is an office embedded within Woods Bagot. They explore the relationships between digital technology, people, and place. Superspace utilises an atypical skill set to deliver clients solutions beyond what most firms are capable of offering. Through the use of spatial data analytics, software development, process automation and design computation, they deliver research and projects primarily within urban design.

Developed to assist strategic planning for government, developers and real-estate consultation, as well as using it within direct project work, Superspace developed a tool called CIVITAS. This tool utilises an automatic data harvesting and generation system to collect, collate and present massive amounts of data around many metrics of evaluation for urban sites across multiple cities. CIVITAS is used to scout cities for locations that match the users interests (Superspace.agency, n.d.). The details behind CIVITAS are considerably complex, but it serves as a good example of empowering research in practice towards data science and computational design.

The global design, engineering and construction company, HDR, have also invested in the value of a research and development team. Perhaps nothing could also be more relevant than the work they do, and the name they are under, the HDR Data-Driven-Design (D3) team span internationally and develop and produce tools, programs and methodologies for all their staff to employ in the design and development of projects. To provide a deeper insight into their work and the potential benefits that having a computational and data-driven team are, I spoke to their computational design lead for Australia, Jeremy Graham.

Civitas can identify sites based a number of criteria.

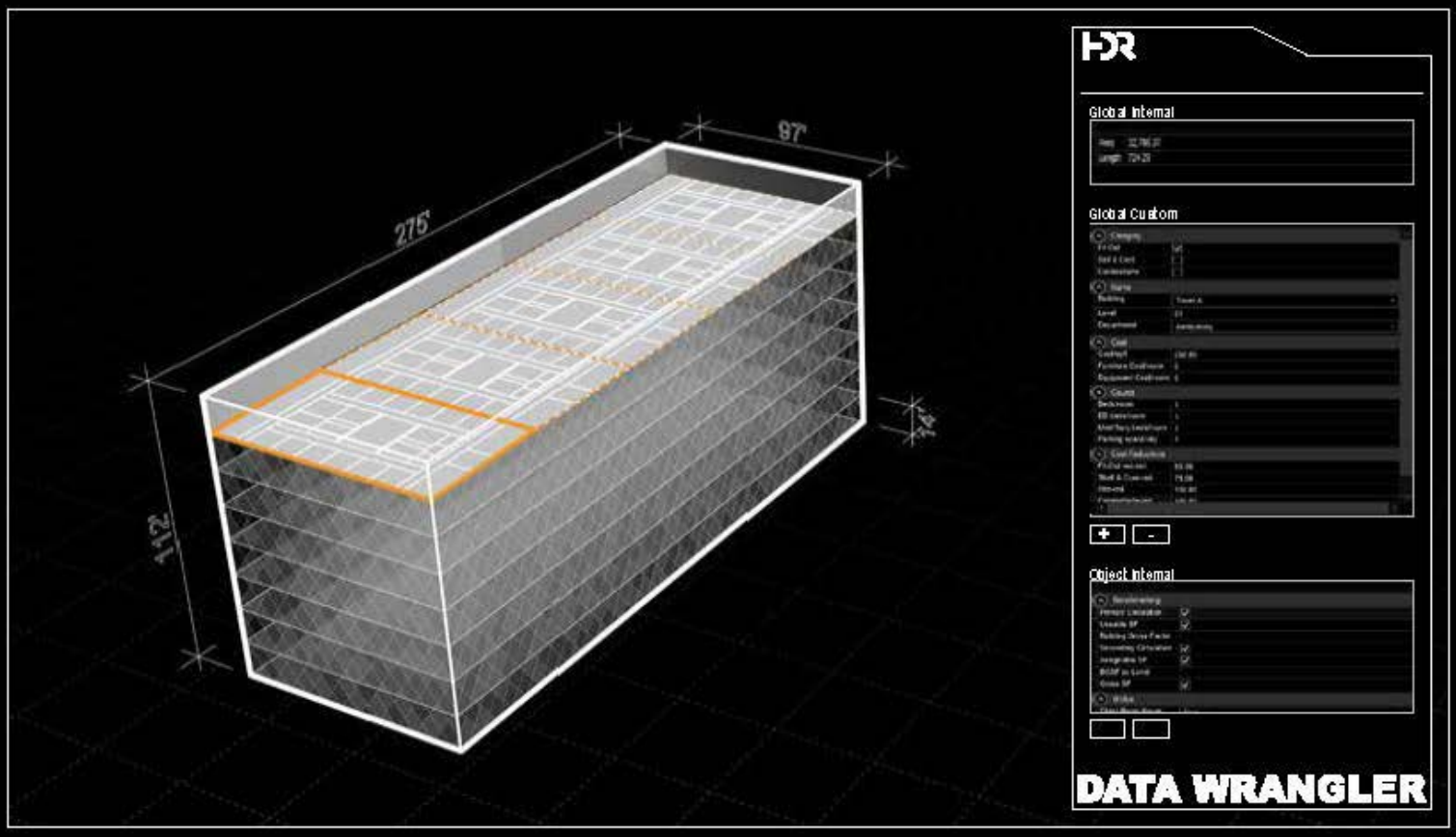
Superspace - CIVITAS. (n.d.). [image] Available at: https://superspace.agency/projects/civitas/ [Accessed 10 Jan. 2020].

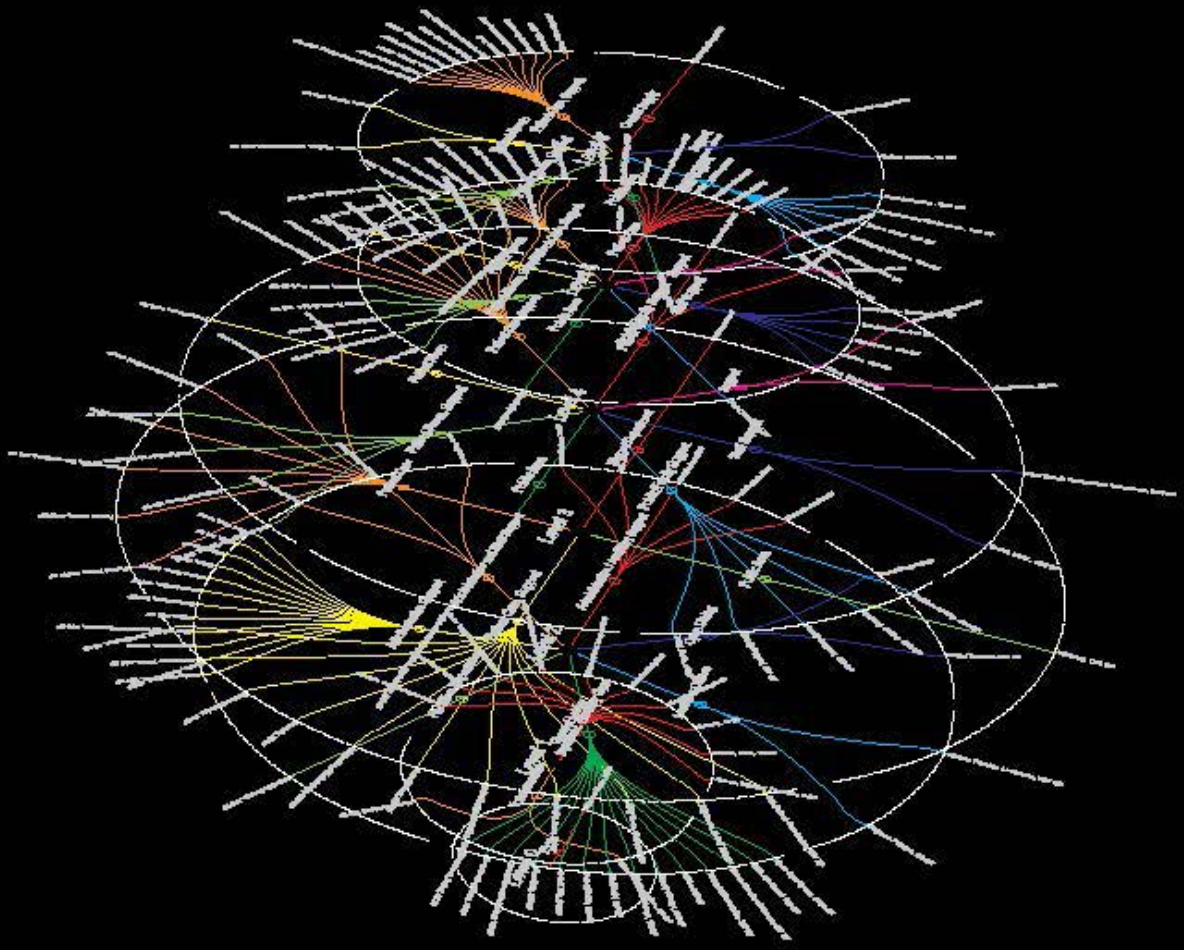
Machine Hallucinations by Refik Anadol.

Refik Anadol - Machine Hallucinations. (n.d.). [image] Available at: http://refikanadol.com/works/machine-hallucinations-latent-study-mars/ [Accessed 10 Jan. 2020].

An in-house tool called 'Data Wrangler' is used on a masterplan project to leverage more information from their models.

From HDR Data-Driven Design Report (HDR, 2017)





7

Practice Based Research

An Interview With Jeremy Graham

Jeremy Graham is the computational design lead in Australia for HDR's Data-Driven Design team. He is an architect, holding a masters degree in architecture from the University of Western Australia, however he also works across disciplines of engineering, data analytics and software development. At HDR D3 he develops computational models and tools to assist designers and clients in utilising big data for real-time decision making.

Tell me about HDR D3, what it is that you do and why you choose to do that?

HDR are quite a large architectural engineering firm with about 10,000 to 12,000 employees globally. There's about 8,000 to 10,000 engineers and 2,000 architects, and I work across a variety of different sectors from health, technology and education to engineering specific projects.

I do this within a group called the Data Driven Design group, otherwise known as D3. Our goal is to analyse different ways that we can use data to help inform design decision making.

We work with different data sources such as creating our own data using things like drones and sensors, to collecting public data or even through the purchasing of big data sets. We have quite a lot of data stored in-house which our team uses in various ways.

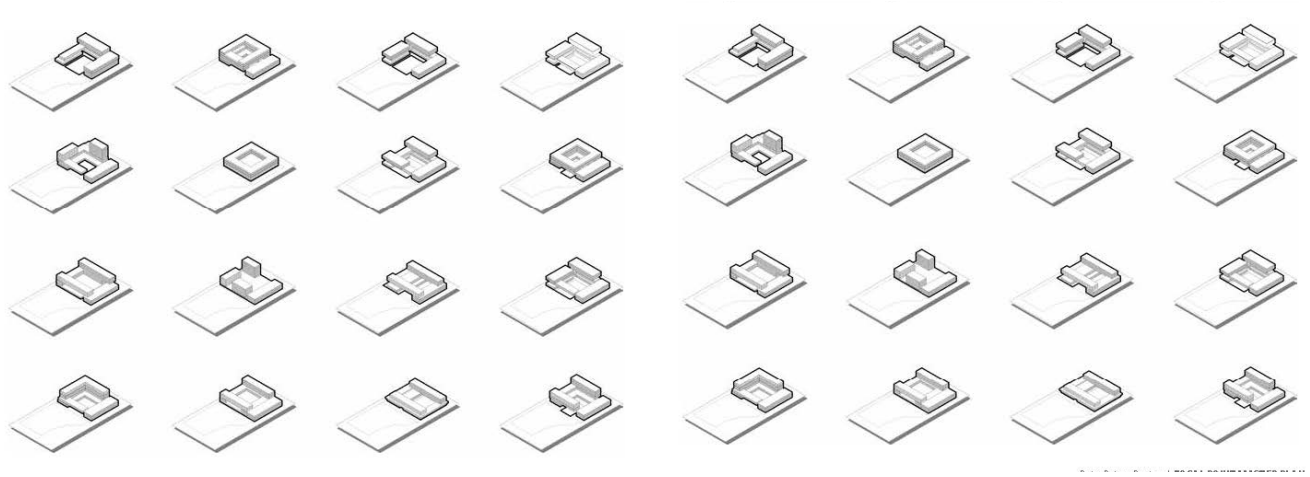
We're made up of three streams. We have the predictive analytics group, which is mainly data scientists and data engineers. These guys are tasked with mining, cleaning and analysing data using data analytics techniques.

We then have the operations design stream which is mostly industrial engineers and simulation experts. They look at how they can simulate the operation of buildings to see if we can improve it. For example, the emergency room in a hospital, they analyse the way that it operates and see if they can improve the plan or the layout of the room, to operate better.

And lastly, we have the computational design group which I lead here in Australia. We develop the tools, work-flows and models that facilitate the analysis and the optimization of data.

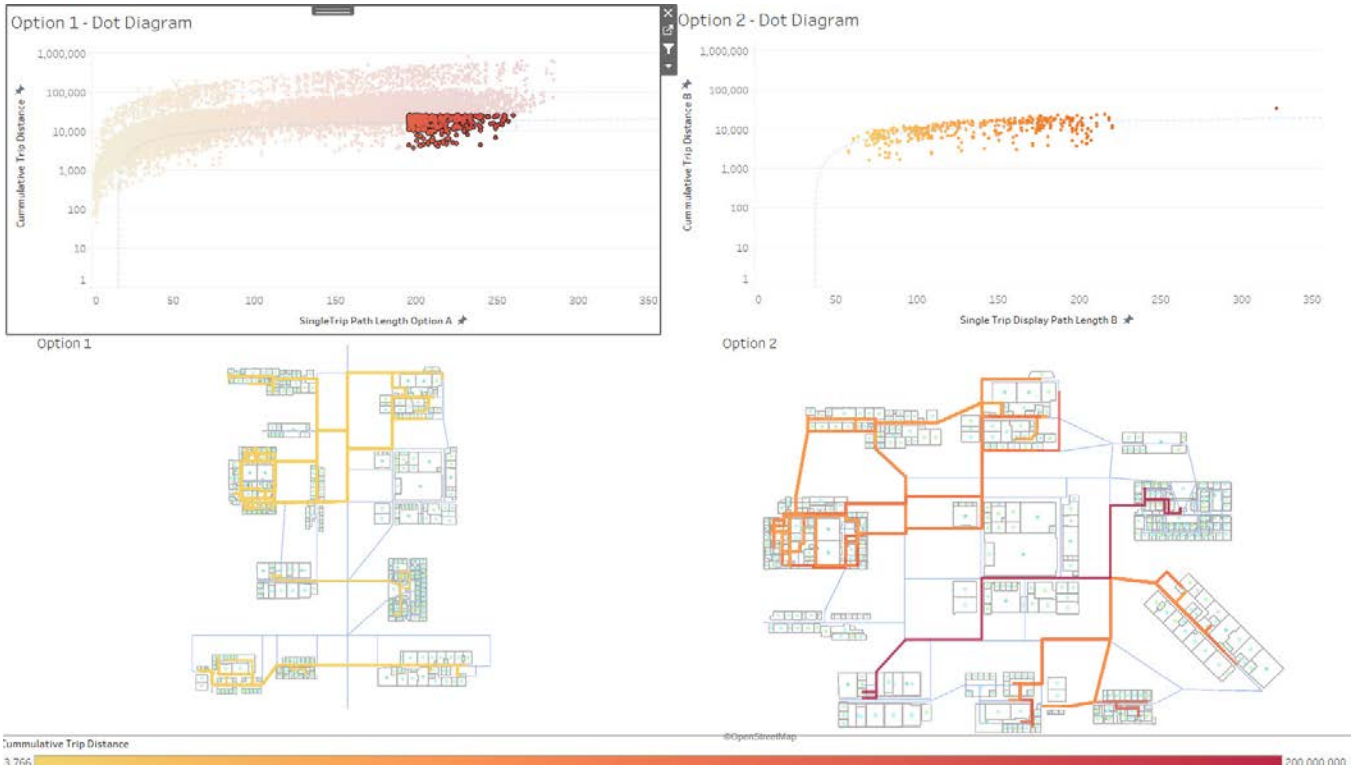
At the end of the day we all work together as one group tackling various projects and assisting sectors with how they might use data to help their designs.

A lot of the time this occurs at the front end of projects. For instance in health we might help a client analyze public data around health records and demographics to see how it might impact the location of a hospital.



" Design is an iterative process, requiring constant exploration, replication and refinement. The automated nature of computational design increases the speed and efficacy of this process, which is otherwise time- and effort-intensive. "

From HDR Data-Driven Design Report (HDR, 2017)



Movement throughout a campus is analysed using client data and then informs a computational model that can also test new designs to find the best solution.

Courtesy of HDR Data-Driven Design

What do you see as the biggest value in using data to inform design processes?

For us it's all about objective decision making. Instead of traditional architectural techniques where architects might make certain design decisions based on experience or traditional methods, we try to use data to objectively make design decisions.

That's a real advantage for us, being able to sit down with a client and actually show them why one design might be better or worse than another based on what the data is telling us about those designs.

To give you an example, we're working with a company at the moment that have a lot of buildings on a large campus, and they have brought us in to analyse how their buildings are used by their employees because they're finding their current designs quite inefficient as their facilities were built so quickly and sporadically. So we've taken all their data around how their employees are moving around their campus. The data in this case is how their employees use swipe cards to move in and out of rooms, all of which is recorded.

By using that data, we could then build a computational model, which allowed us to quickly analyse those different movement patterns and then mock up some future plans and run that same analysis.

The benefit of doing this was that we could show the client which plans might be better or worse based on that analysis. In this case, the client had their own idea of what they thought the best design was. The idea being that if you put the admin area in the centre and all the functional spaces fanning off from the centre, then it should be the perfect design.

And so by using these data-driven techniques, we were able to identify that was actually a very poor design based on historical data because people weren't moving through the admin to get between the different spaces, which made the design very inefficient.

Being able to demonstrate that to the client allows us to provide additional merit to our designs rather than trusting traditional notions of design.

In regards to objective decision making as you mentioned, are there concerns that using data to inform a design processes could possibly erode the value of traditional methods, such as design intellect or human intuition?

Possibly certain aspects, but it depends on what the design problem is and who's curating the use of these tools, so the use of the data.

I think the key thing with all of these methods we're using is that they're tools or methods, they're not the single and only solution. It's just a set of tools within our many ways of designing that can we can use and apply it to different problems.

The way that we've approached that problem is that when we develop these different tools they're not just used by some of the computational designers at the back of the office, we develop these methods to abstract away a lot of the complexity, so that more people can actually use the tools and do the analysis.

We don't give all this data to a data scientists and they tell us the best solution to our problem. We allow planners, designers and even stakeholders to use these tools and look at the data. It's really just used as a way to help arrive at a decision, but it doesn't give us the ultimate answer. And so in that sense, a planner still has control over whether they take purely an objective approach or they combine the data with traditional methods.

HDR D3 have developed a tool called Data Wrangler. Could you tell me more about that?

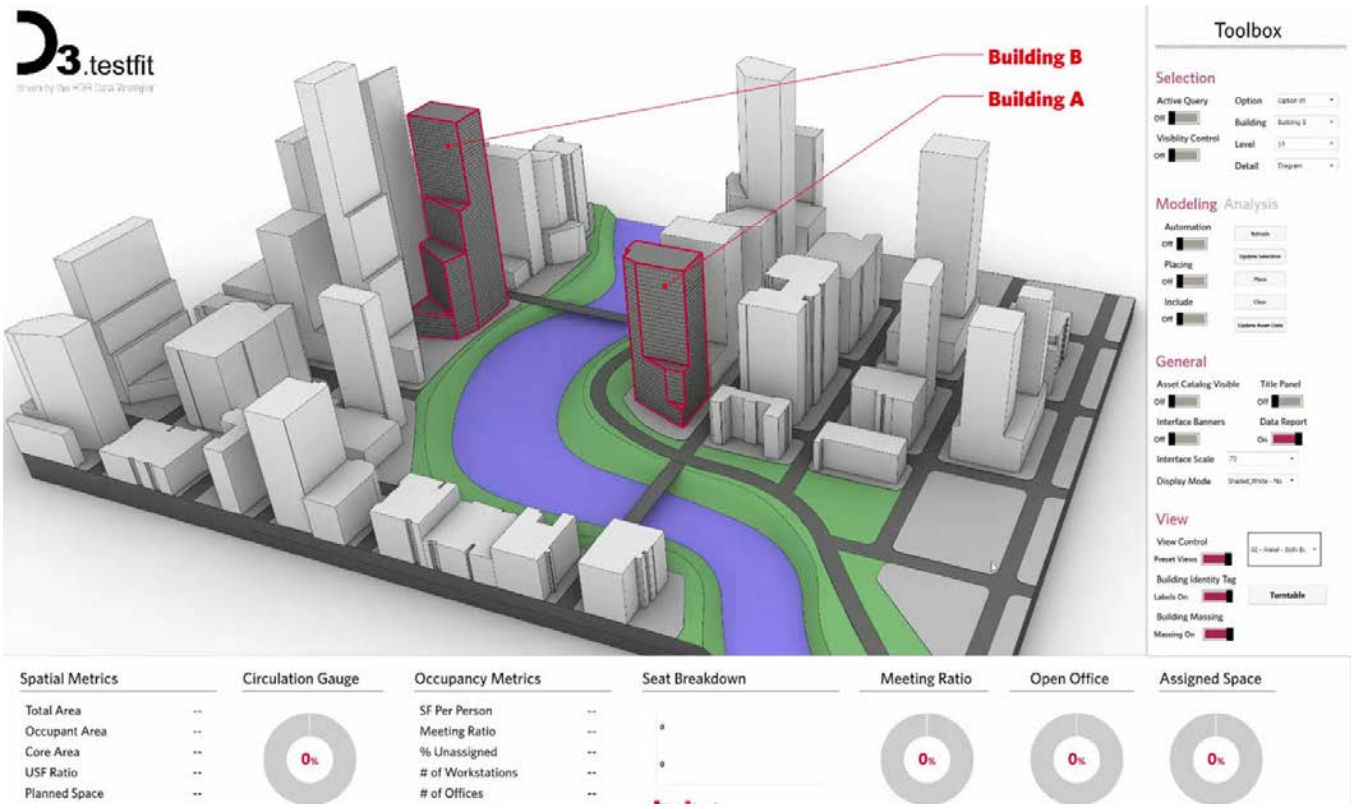
Data Wrangler is a tool that we've developed in conjunction with an external consultant. What it allows planners and designers to do is attach parameters, or information, to different pieces of geometry in Rhino.

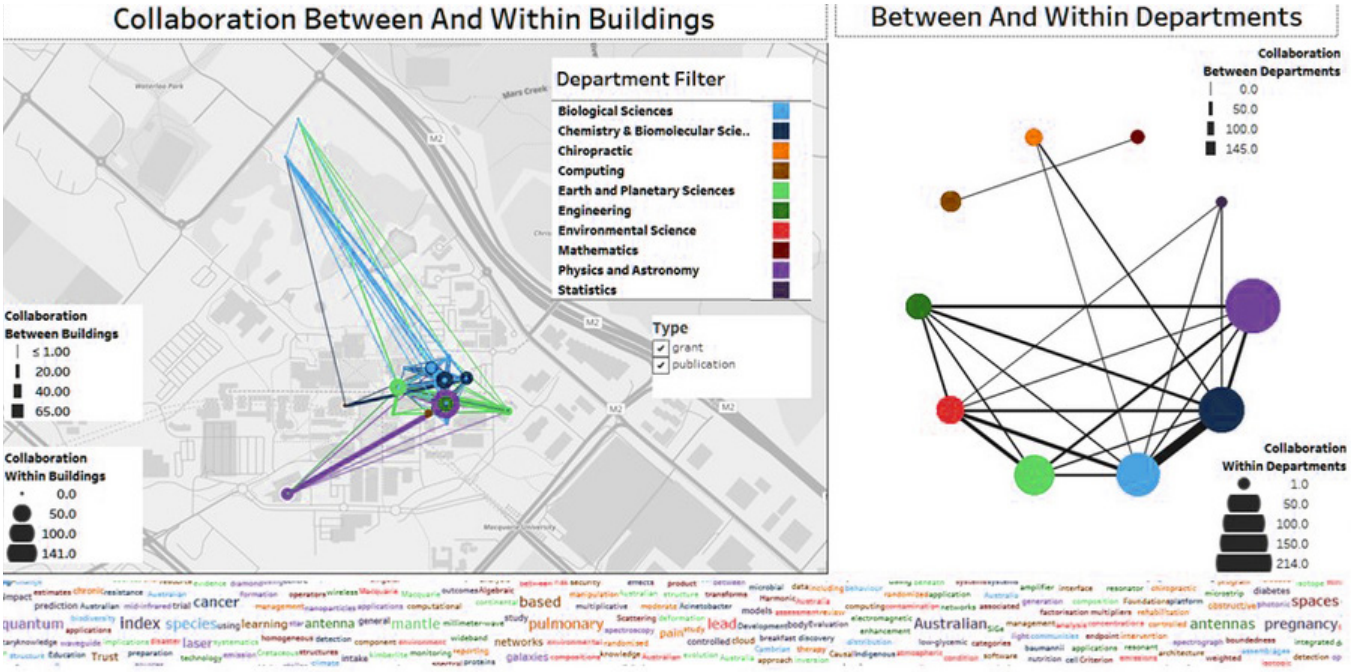
You can do this natively with object attributes in Rhino. What Data Wrangler does is provide a very easy interface to do so. As I mentioned earlier, by abstracting away a lot of the complexity, it provides a very simple interface for people to start using data or parameters very early on in the design.

We can then pull that data out of the geometry and start utilising it in different ways using Grasshopper or other plug-ins we have developed. We might use it to generate geometry or we might use it as a filterable tool to analyse different scenarios. There's a lot of different ways that we can use it.

Data Wrangler can be used to place and extract data from typical models in Rhino with greater ease so that designers can gain better insights into their designs in a more meaningful way.

Courtesy of HDR Data-Driven Design





Data Wrangler is an example of designers creating or procuring data from their models. How would you relate the use of big data and public data sets to architecture?

When we're talking about data in architectural projects, there's a few different sources you might get it from. It could be generated within the project, you might get it from clients directly or you could get it from public sources.

A lot of the time we're seeing value in the feasibility stage of a project from the public sources of data.

To give you an example, we're working with a university in Sydney and they're looking at locating a new building on campus. As an architect we might use traditional master planning methods to define different ways of where we might position that building across the campus, but we wanted to supplement that with public data sources that we had access to.

One of the ways we did that was we looked at all the public information around where medical publications were occurring from the website PubMed. We pulled all of the different publications so we could map where those publications were occurring or what groups were making publications across the campus.

By doing that, we could then map where all the collaborations were occurring across the campus. This gives us an indication of where we might locate a building as a central point to where all those collaborations are occurring, rather than people moving large distances across the campus.

That's just one example of how an architect getting access to that public data source has impacted where we've located a new building as opposed to design with traditional methods.

I understand that's an example of network analysis which is most commonly used in data science. Do these methods from other fields impact on the way you work as an architect or designer and do you think you would be doing the same work if you didn't have that kind of collaborative approach between disciplines?

Yes. A field like data science is having an impact on the way we're working. It's not often that an architecture firm has data science specialists sitting around the office. By collaborating with data scientists, we're using tools and methods that we probably wouldn't have done so otherwise. That's probably where our group has found the most strength, is the fact that we're merging different sectors together.

I don't see why we wouldn't be doing the same work without this though. Anything can be learned. But we wouldn't be exposed to some of the techniques from these other disciplines. One of our data scientists has a PhD in deep learning. He provides a large amount of information and guidance and I don't think we would be doing the same things if he wasn't a resource in the group.

Above: A university campus in Sydney is analysed using data from medical publications to find out which departments work with each other more to then locate a new building that is most central to those connections.

HDR D3 - University Collaborations. (2019). [image] Available at: https://www.tradelineinc.com/reports/2019-4/using-data-driven-design-produce-research-supported-customized-client-solutions? [Accessed 10 Jan. 2020].

Are there methods of using data to inform design processes that any designer could start using now without a considerable learning curve?

Yes, there certainly are. We talked about attributes in Rhino. There are ways to store data in these models and then analyse project data. So you might be on a project team and a QS has project data around different rates or different area rates of a building. You can use that as a way to populate all those figures within a project model and then start working with that data.

One accessible way that we do that is by using tools like Power BI which is a simple data visualization tool. Visualizing your data it in different ways using these accessible platforms is a simple thing anyone can use.

Talking about projects generating data, computational design has been around for a long time, but we're starting to see a lot more people use it more openly. With that we're getting more access to different ways to generate project data and to analyse it.

A lot of people are using computational design but it's mostly form finding and facade manipulation. But you may think about how you can we use these tools not just for form finding or design but about what data is being generated when we change the form?

That was the turning point for the D3 group. They switched from using it for design to using it as a data generation technique.

Have there been ethical concerns when dealing with some of the data sets you handle and do you think that the ethical handling of data within the design profession is something that would need to be resolved as the impact of data driven design expands?

Certainly when working with client data. We apply rigorous data security protocols to ensure any data we work with is secure. This however isn't such a big deal when working with data generated in computational models or public data sources, which the majority of designers would do. As data driven design grows, architects will need to be diligent in how they handle data provided by the client and in most cases, the client will require their data to be stored and used in a secure way. If architects intend to use this data, they will have to apply those data security protocols.

Next page: Computational design and analysis is used to design an ice-skating arena that maximised glazing but minimised sunlight impact

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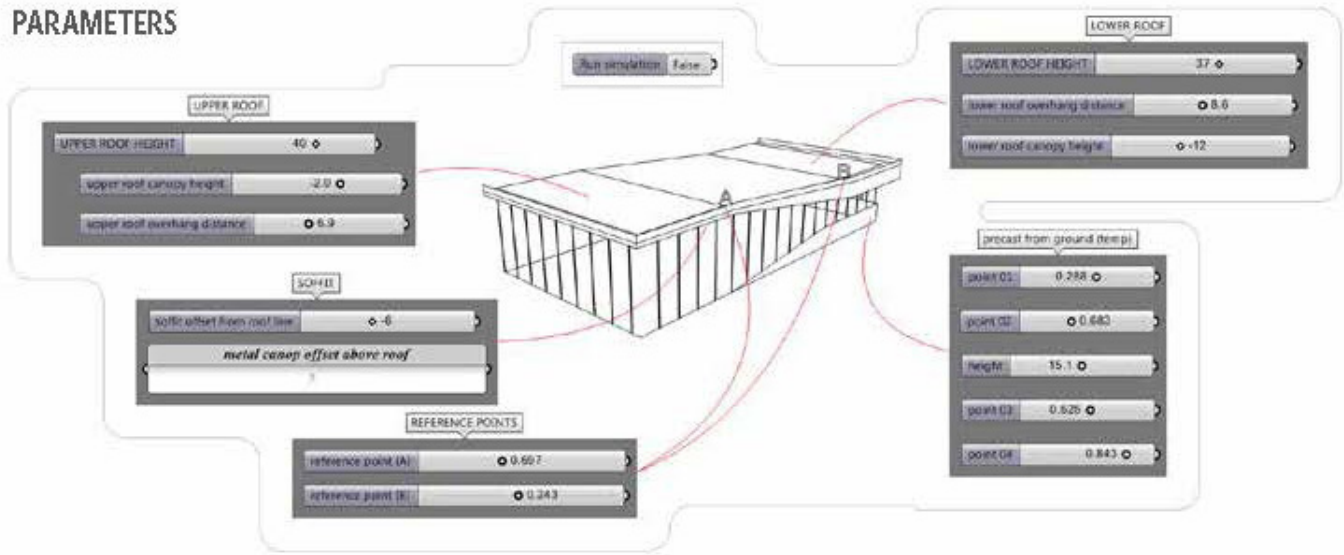
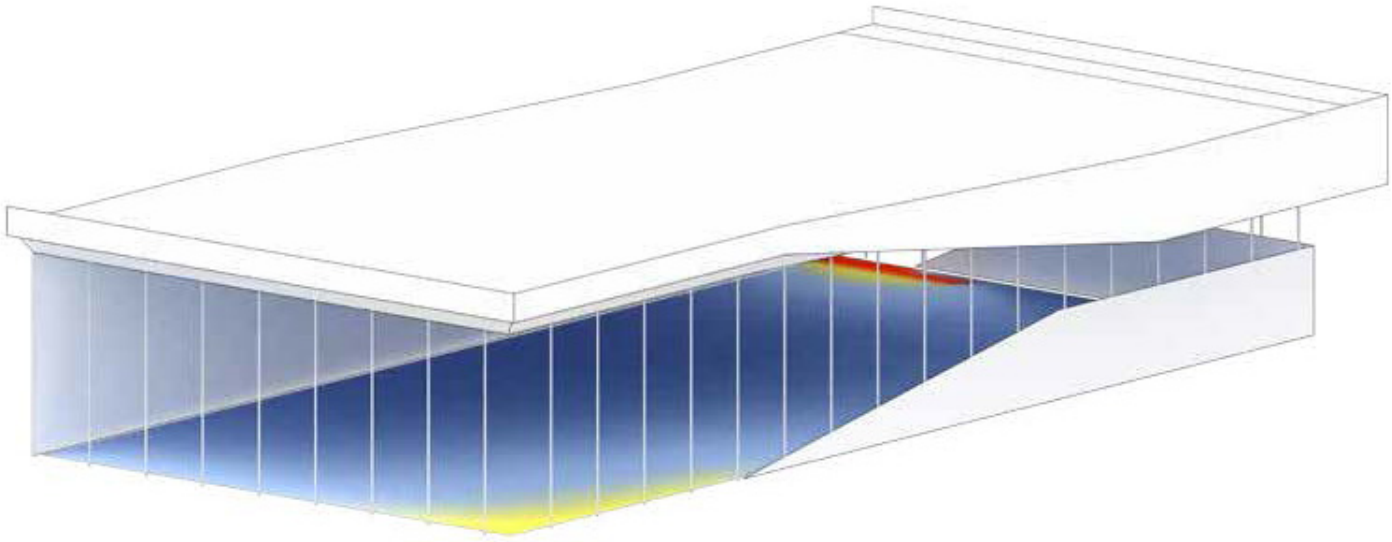
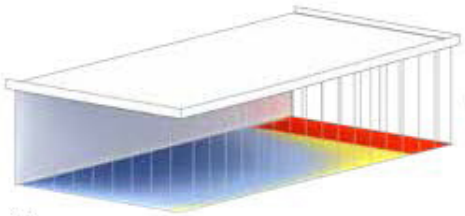
From HDR Data-Driven Design Report (HDR, 2017)

PARAMETERS







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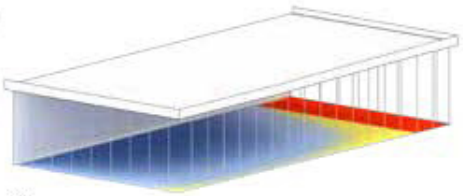

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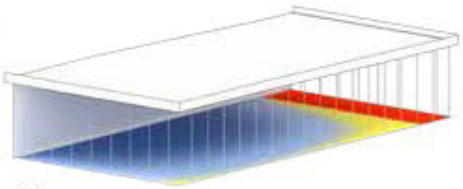

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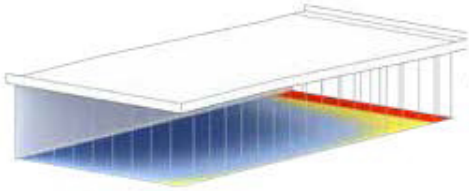

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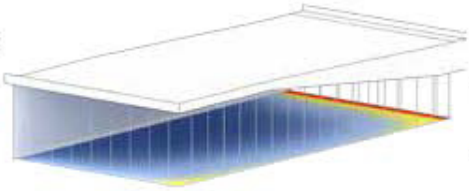

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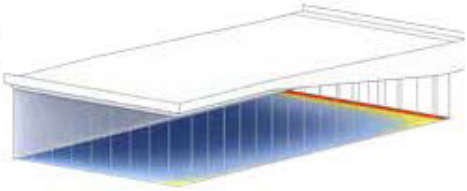

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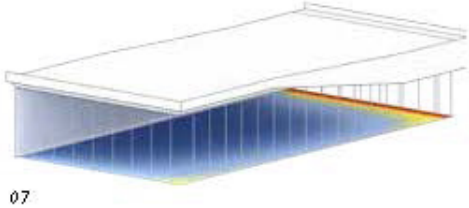

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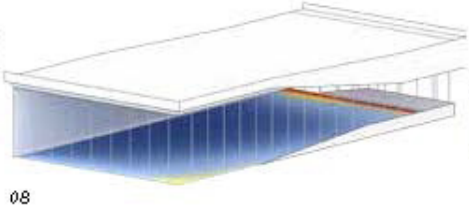

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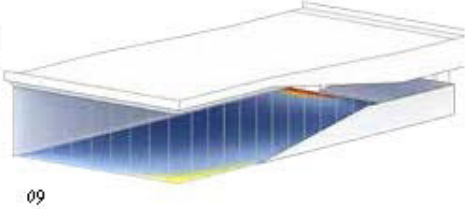

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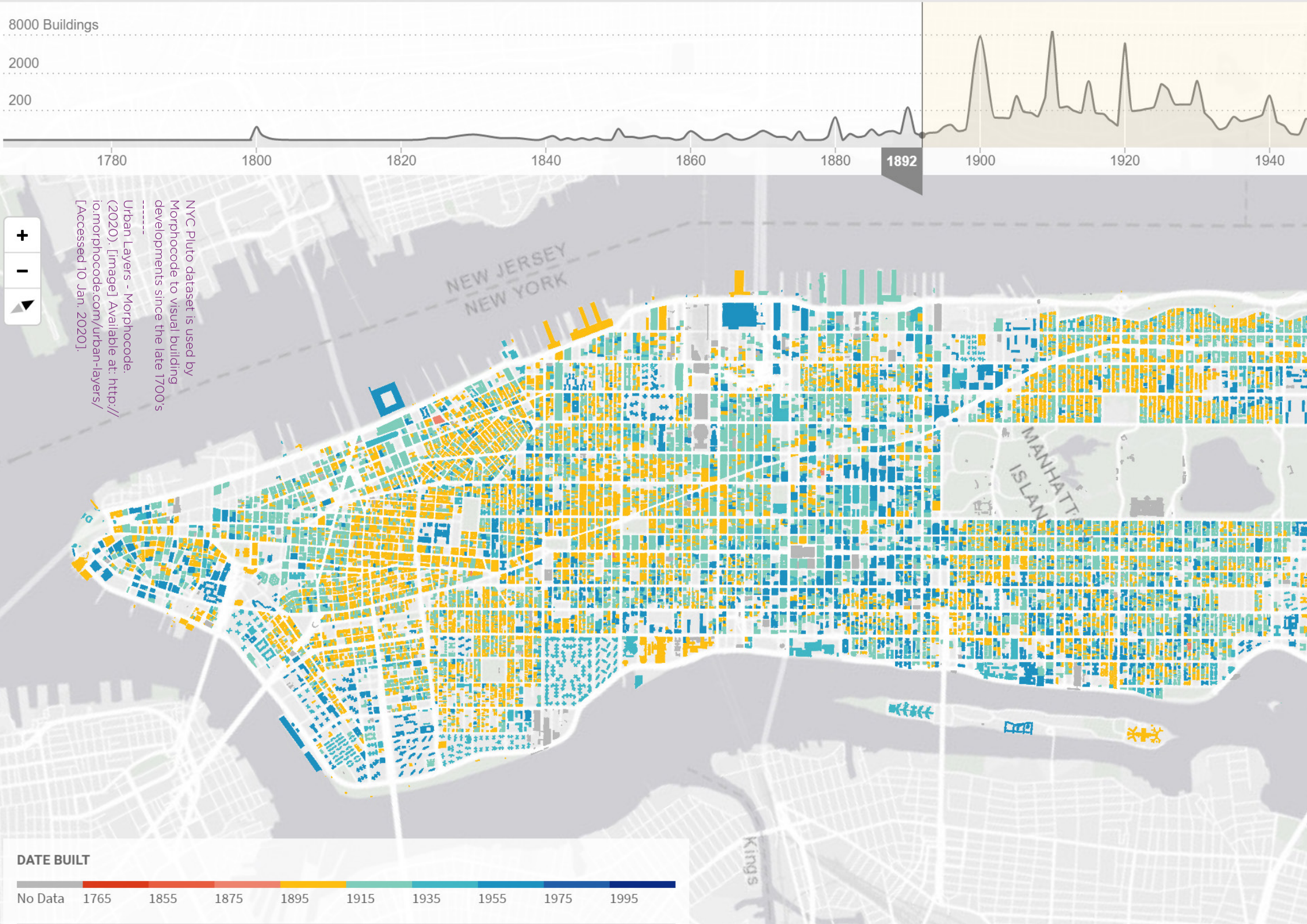
8000 Buildings
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NYC Pluto dataset is used by Morphocode to visual building developments since the late 1700's
Urban Layers - Morphocode. (2020). [image] Available at: http://io.morphocode.com/urban-layers/ [Accessed 10 Jan. 2020].
DATE BUILT
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8

Getting Started

Some Select Data Sources

This section presents a number of learning resources and data sources for those inexperienced, but interested designers who wish to start engaging with data-informed design. The majority of these resources have been explored and experimented with over the past year as I have begun my own pursuit of advanced computational design and exploratory data analysis.

These resources are primarily targeted at designers in New South Wales, however they would hopefully provide an insight for those designers in other states and countries as to where to look for similar information.

I offer advice about particular resources based on my experiences with them. I do not have any affiliation with or financial incentive to recommend these products to you.

Learning Resources

To start with, it is prudent to understand that designers are not the typical audience for the following resources. Our skill set has therefore not evolved around the particular ways in which they are used and so it would be best to learn some new skills to be able to confidently handle these new tools. This is not to say that you require new skills, by all means, experiment as you see fit. However, to appropriately use these resources, a basic understanding of how to use them correctly, and probably more importantly, how not to use them.

Having ventured down this path over the past year, I am also aware at how daunting picking up new skills can potentially be. Particularly when approaching programming, it is difficult to first understand where to start, and then to apply it to design specific tasks. The information following hopes to alleviate some of that stress by providing what I have discovered to be the best learning resources.

Python

Python is a fundamental tool in data analysis and also has great benefits in design. It can run independently but it is able to be used directly in Rhino and Grasshopper to build useful scripts and plug-ins.

- Codecademy[1] is a useful interactive web tool for learning Python, and other programming languages. You can learn Python 2 (no longer supported) for free however I would recommended the small price to learn Python 3 and have access to specific learning streams and more advanced tutorials.
- Corey Schafer's Youtube channel[2] is useful for understanding particular elements of programming when you get a little stuck on a topic.
- Automate the Boring Stuff[3] is entirely free online, but you can also support the author by purchasing the book. This course is great to learn the power of Python in assisting simple, everyday tasks.
- Archistar Academy[4] have architectural design specific tutorials for Python and other methods using Rhino, Grasshopper and Revit.
- The official Python documentation[5] is also a great resource to learn specifics about standard Python functions.

1. https://www.codecademy.com/
2. https://www.youtube.com/channel/UCCezIgC97PvUuR4_gbFUs5g
3. https://automatetheboringstuff.com/
4. https://academy.archistar.ai/
5. https://docs.python.org/3/
6. https://github.com/gboeing/osmnx
7. http://geopandas.org/
8. https://numpy.org/
9. https://pandas.pydata.org/
10. https://matplotlib.org/
11. https://seaborn.pydata.org/
12. https://python-visualization.github.io/folium/
13. https://stackoverflow.com/questions/tagged/python
14. https://www.qgis.org/en/site/

Once you have an understanding of Python basics you can explore some useful packages (plug-ins) in relation data and geo-spatial analysis. The following are some interesting packages.

- OSMNX[6] is a useful tool to download Open Street Maps information and visualise it directly in Python. It can download roads as network graphs, a powerful data analysis method typically used in social media to ascertain connections across a network.
- Geopandas[7] allows to run computational tasks on geo-spatial information such as demographic information attached to polygons of district boundaries
- Numpy[8] and Pandas[9] are essential to data analysis in Python and you will most likely come across these during your learning period.
- Matplotlib[10] and Seaborn[11] are both visualisation tools used to represent data. Matplotlib is most widely used but is rather complex to understand at times. Seaborn is a simple wrapper around Matplotlib to simplify a lot of the basic commands.
- Folium[12] can create interactive web-maps to visualise geo-spatial information relatively easily.

As is usual with learning new things, Google is your friend, and if it's in relation to programming, you'll probably end up on the Q&A platform, Stack Exchange[13]. You'll find out pretty quick that even the most experienced programmers ask questions so don't be ashamed if you're finding it difficult to learn a specific task. There's always an answer and plenty of people are willing to help you find it.

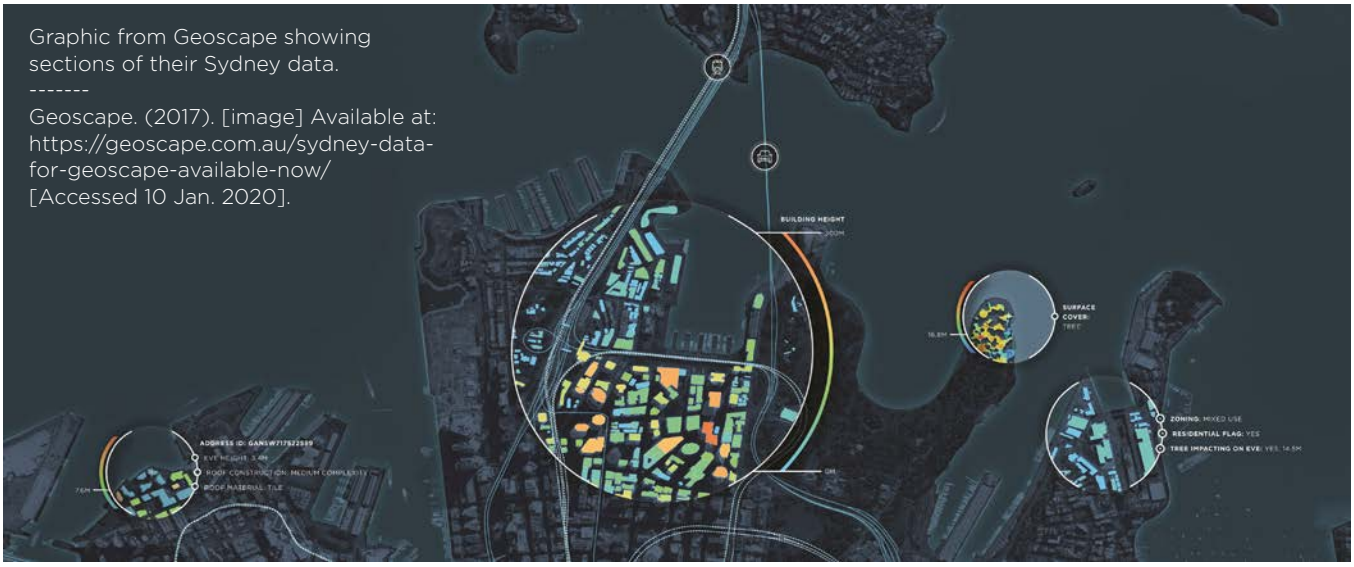
GIS

I have explored new skills in GIS less than Python and programming, however it is still relatively easy to pick up new skills and learn simple tasks to solve solutions.

To get started, QGIS[14] is a popular open source program that is completely free to use and comes with considerable documentation to assist in learning. QGIS also has integration with Python to be able to run more advanced tasks if necessary.

The common format for GIS files are geo-packages and shapefiles. These files contain geo-spatial information such as polygons, lines and shapes that define any number of geographic boundaries or places. For instance, these could be suburbs, train lines or bus stops. Data is attached to each object to convey information about that element, this could be the area, name, most population counts for a suburb.

GIS software such as QGIS can be used to visualise many of the following data sources as they are primarily geo-spatial in nature. It is recommended to explore these sources to determine the file types available and the best software to use them with.



Graphic from Geoscape showing sections of their Sydney data.

Geoscape. (2017). [image] Available at: https://geoscape.com.au/sydney-data-for-geoscape-available-now/ [Accessed 10 Jan. 2020].

Demographics and Census

The following are a list of useful data sources that represent demographic and census information that can be used to visualise and analyse things such as population, density, age and gender.

- The ABS Census[1] site is where you can start to find information gathered from all previous census' including the most recent, 2016 at the time of writing.
- You can download Datapackages[2] from the same site. These include geo-spatial data in the format of geo-packages with which you can visualise demographic information from hundreds of different sub-categories.
- Australia wide mesh blocks[3] can be downloaded that cover the smallest geographic boundaries of information that ABS publish information with.
- Mesh block counts[4] contain information about the population within each mesh block boundary. These can be merged with the geo-spatial mesh blocks using QGIS.
- The commute to work[5] dataset contains information about distance to work or place of usual residence. This also includes a count of jobs within each area, allowing to make a job density map.

Topographic and Cadastral

An extremely useful resource for designers, even if not for data exploration, is topographic/cadastral information such as contours and lot boundaries. Using GIS to obtain these layers can save designers considerable time in drawing and context modelling.

- Sixmaps ClipnShip[6] is the NSW governments mapping portal that allows users to download GIS layers entirely free (but limited per day). You can select a boundary and download massive extents of data in a couple of easy steps. I would suggest to select shapefile as the data format and MGA 56 as the projection for Sydney. You will have to request topographic and cadastral separately.

Built Form

Building footprint information is also useful information and can reduce modelling times drastically given the accurate information. Unfortunately, many consistent building sources are paid and there is no free city model like that offered in other cities like Adelaide[7], Melbourne[8] or NYC[9].

- Geoscape[10] can be used to obtain building footprints, elevation, heights roof types and more. It can be slightly outdated depending on when they updated the region of interest, however it covers every building over 9sqm in Australia.
- Open Street Maps[11] can also provide building footprint information, if available for the specified area, however is mostly void of useful information. It can also be queried here[12] and here[13] and the Python package OSMNX, as mentioned before, can download OSM information.
- The aerial imagery platform, Nearmap[14], also has a 3d textured model available and at their conferences around the country in 2019, they showed a WIP of their semantic segmentation develops to automatically highlight buildings and over attributes using machine learning and AI. Not yet available but something to keep an eye on.
- Not relevant locally, however NYC has a great building footprint information using their Pluto[15] data set you can ascertain detailed and time specific land use information.

1. https://www.abs.gov.au/census
2. https://datapacks.censusdata.abs.gov.au/geopackages/
3. https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/1270.0.55.001July%202016?OpenDocument
4. https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/2074.02016?OpenDocument
5. https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/2071.0.55.0012016?OpenDocument
6. https://maps.six.nsw.gov.au/clipnship.html
7. https://data.sa.gov.au/data/dataset/3d-model
8. https://data.melbourne.vic.gov.au/Property/City-of-Melbourne-Simple-3D-Model/bhar-6zhw
9. https://www1.nyc.gov/site/planning/data-maps/open-data/dwn-nyc-3d-model-download.page
10. https://geoscape.com.au
11. https://www.openstreetmap.org/export
12. https://www.geofabrik.de/data/download.html
13. https://overpass-turbo.eu/
14. https://www.nearmap.com
15. https://www1.nyc.gov/site/planning/data-maps/open-data/dwn-pluto-mappluto.page

Environment and Planning

The national public data platform[1] aggregates data from multiple sources across Australia including the NSW environment[2] data portal and the NSW state[3] data portal.

- Vegetation cover[4] shows the percentage and area of different vegetation types on modified mesh block areas.
- Urban Heat Island[5] shows areas affected by urban heat island. It's best to refer to their documentation as to how to interpret this.
- Heat Vulnerability Index[6] provides information about an areas capacity to adapt to heat change based on a number of factors. Again, best to refer to their documentation to understand this better.
- The 2017 NSW Land Use[7] map covers most of NSW except the Greater Sydney region. That can be found in the 2013 Land Use[8].
- NSW Local Environment Plan[9] (LEP) layers can be downloaded by contacting the environment data broker. It's a massive dataset so can't be easily hosted online. You can find their email by following the link above.
- Melbourne Urban Forest[10] maps the cities public trees. A similar data set is available for every tree in NYC[11] which includes data about the ecological benefits of each tree.

Transport

The NSW Transport[12] open data portal is a useful resource for data pertaining to public transport use, opal trips and route information. The City of Sydney[13]data portal also contains useful information in regards to pedestrian counts.

- Opal trip[14] data sorted by month, operator, line and card type can be downloaded as a spreadsheet.
- Population[15], Employment[16] and Workforce[17] projections contain projected figures to ascertain future demand.
- GTFS bundles[18] can be obtained and used to ascertain trip routes, stops and headways (times). This requires a more advanced knowledge of the GTFS specification and how to extract information using QGIS or Python.
- Train station entry[19] information can be mapped using QGIS.
- Walking counts[20] can be obtained from the City of Sydney to understand pedestrian activity. Similar data can be obtained for the City of Melbourne[21].

1. https://data.gov.au/
2. https://www.seed.nsw.gov.au/edphome/home.aspx
3. https://data.nsw.gov.au/
4. https://data.gov.au/dataset/ds-nsw-96d5f9a6-af2c-45f9-8966-3741dfc34f02/details?q=vegetation%20cover
5. https://data.gov.au/dataset/ds-nsw-35ac40ba-197a-40ab-bd18-7ed7e41a4ac6/details?q=heat%20island
6. https://data.gov.au/dataset/ds-nsw-4cefc3e4-3faf-4e7e-a34b-7335f264c67d/details?q=heat%20vulnerability
7. https://data.gov.au/dataset/ds-nsw-de27e381-9595-4562-9347-b00e71d4c3bd/details?q=
8. https://datasets.seed.nsw.gov.au/dataset/nsw-landuse-2013
9. https://datasets.seed.nsw.gov.au/dataset/environment-planning-instrument-local-environmental-plan-land-zoning
10. http://melbourneurbanforestvisual.com.au/
11. https://tree-map.nycgovparks.org/
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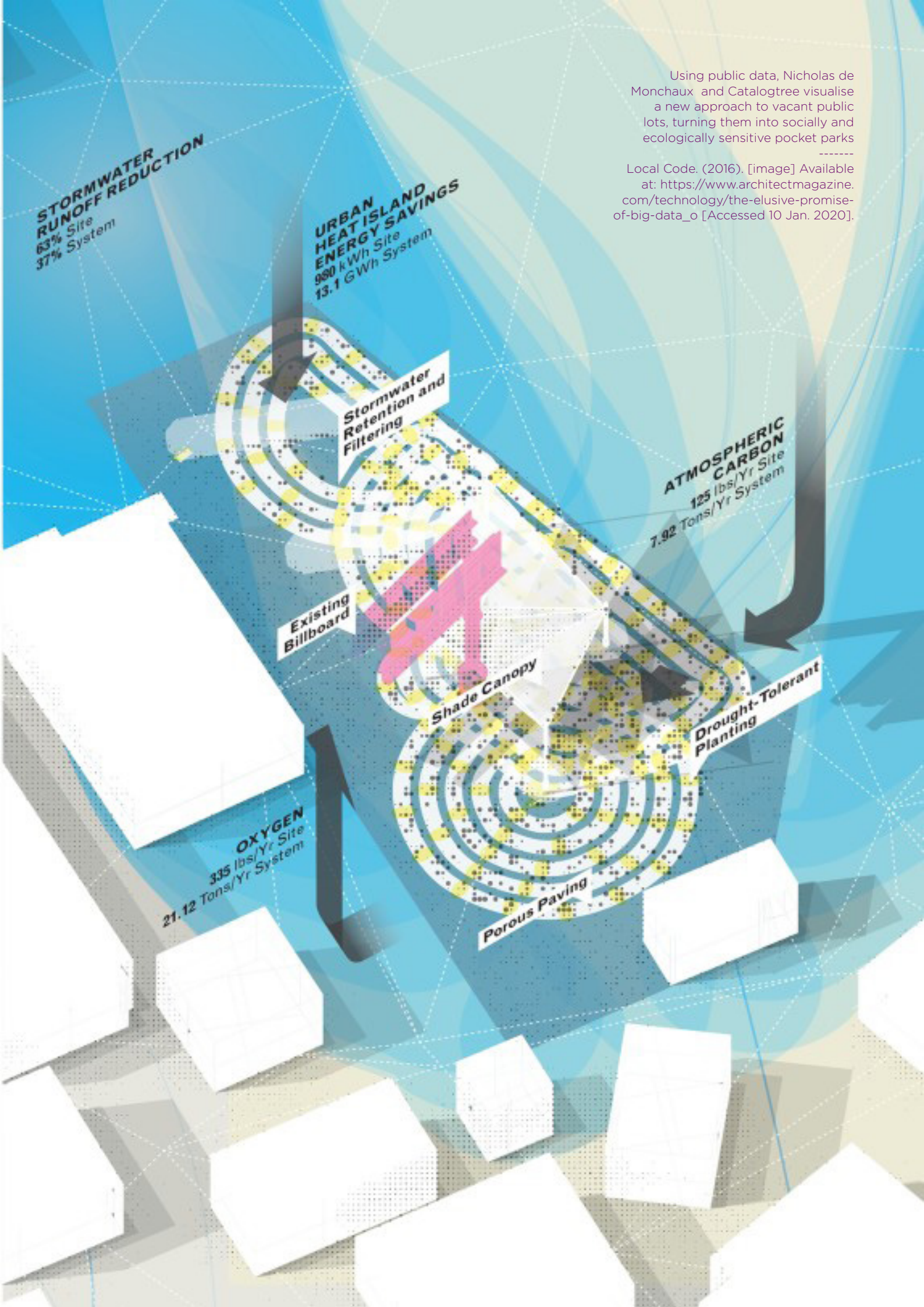
18. https://opendata.transport.nsw.gov.au/dataset/timetables-complete-gtfs
19. https://opendata.transport.nsw.gov.au/dataset/train-station-entrance-locations
20. https://www.cityofsydney.nsw.gov.au/vision/sustainable-sydney-2030/transport-and-access/liveable-green-network/walking-counts
21. http://www.pedestrian.melbourne.vic.gov.au/

City of Melbourne Urban Forest Tree Map.

Melbourne Urban Forest. (2020). [image] Available at: http://melbourneurbanforestvisual.com.au/ [Accessed 10 Jan. 2020].



Using public data, Nicholas de Monchaux and Catalogtree visualise a new approach to vacant public lots, turning them into socially and ecologically sensitive pocket parks

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Local Code. (2016). [image] Available at: https://www.architectmagazine.com/technology/the-elusive-promise-of-big-data_o [Accessed 10 Jan. 2020].

9

Closing Remarks

The role of the designer is changing as our industry evolves and innovates. To be more resilient in the face of change, to compete with industry disruptions, and to make sure that our considerable intellect and creativity is not lost to more efficient and cost-effective solutions, designers should be engaging with new technologies that place us as competitors in the market.

This report has looked into the broad implications of how data can start to act as a source of innovation and aid in forming evidence-based decisions in architecture and urbanism.

Through interviews with Charles Catlett and Fábio Duarte, an introduction to urban science and the ubiquity of urban data was presented, highlighting the value that data can play in the future of our cities. They also demonstrated the impact digital technology and technical advancements are having and how we can enable better urban design and understanding with data.

Thoughts on the implications of data in relation between human interactions and 'place' were supported with an interview with location intelligence company, Topos. This demonstrated how data can play a big role in expanding our understanding of how humans interact with the built environment and can influence decisions around design, allowing more detail, and flexibility to adapt to our rapidly evolving urbanisation.

Finally, this report explored how data is currently being used in practice to inform and drive decisions was uncovered. Data can be used in a multitude of ways to influence designs, whether directly or indirectly, it can play a large role in the advancement of designs across multiple scales and typologies.

It is the intention that this report will inspire architects and urban designers to engage with data to inform and drive decisions. Not only on an individual basis, but for entire offices to consider and build a strategy for how they negotiate technological innovation to drive design.

Most importantly, we should be able to confidently adapt cities to our continually evolving relationship with buildings and place. Advancing and supporting good urban design and architecture should be at the forefront of any design studio's ethos, and data is a significant way we can make that change.

10

Acknowledgements

This project is the culmination of over a year of investigations, reading, talking, interviewing and obsessing. I owe a massive degree of gratitude to those that have helped me pursue this research project.

I would like to thank the NSW Architects Registration Board for their support in selecting my proposal and giving me the opportunity to travel to North America and meet some like-minded people. Without their commitment and investment in me, I would not have ventured on this journey.

To the individuals and companies that have met with me throughout this research and their time in allowing me to interview them and gather their insights to inform my own - Professor Justin Hollander, Fábio Duarte, Scott Brewer, Egbert Stolk, Mohammed Makki and his students, Paul De Konkoly Thege of Numina, Damian Boyd-Boffa of Topos, Daniel Davis, Andrew Heumann, Eric Rodenbeck and team at Stamen Design, Anna Meussig and the Gehl San Francisco team, Nicholas de Monchaux, Jeremy Graham of HDR, Anthony Townsend and Charles Catlett - thank you.

I would also like to thank my colleagues at TERROIR for their continued support throughout the past year. The ability to present and engage in discussions has helped me focus and reach this point. I would like to place a particular focus on the directors of TERROIR, Gerard Reinmuth, Scott Balmforth, Chris Rogers and Tamara Donnellan for their mentorship and encouragement in pursing this research.

Finally, I would not be where I am without the generous support of my family, friends and partner throughout my life. Your constant encouragement, assistance and patience has been nothing short of inspiring.

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About the Author

Jordan Mathers is a graduate of architecture with experience across a range of building and urban design projects within Australia and overseas. He has a Bachelors of Architectural Design from University of Adelaide (2013) and a Master of Architecture from University of Technology Sydney (2017).

As a student, Jordan developed considerable practice experience, influencing his approach to design, through the aid of an international internship at Copenhagen based studio, Adept Architects, Melbourne studio, Denton Corker Marshall and, Sydney studio, Bennett and Trimble.

He is currently working at TERROIR Architects in Sydney, New South Wales where he works across a diverse portfolio of projects including health, education, civic, cultural projects and varying scale urban design masterplans. Jordan also applies these skills to teaching, having tutored at the University of Technology Sydney and often taking part in studio critiques.

12

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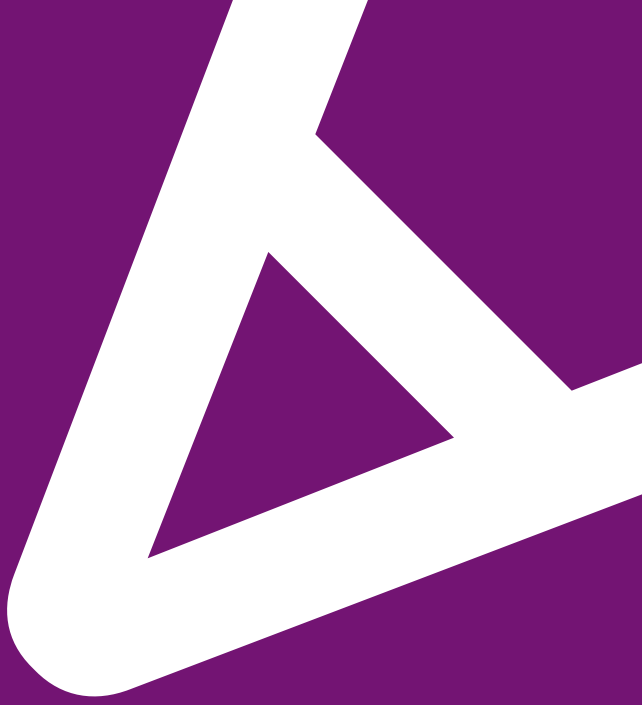

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