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Cultural Computation

Issue 0

Inquiry into public space, algorithmic design, data structures & urban complexity.

Cultural Computation
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cultural competition

Foreword

“Only art penetrates…the seeming realities of this world…There is another reality, the genuine one, which we lose sight of. This other reality is always sending us hints, which without art, we can’t receive.” – Saul Bellow

How does one understand a building? Is it the capturing of human spirit as interpreted by the architect? Or is it defined by the interaction of rents and capital that predicts its price? Is it the production & innovation that takes place within its walls? Is it the elegantly formulated algorithms that produce it as a scientific process? Or the creative destruction of the designer that gives birth to its form? Is it important to model the artist or scientist’s hand in its innovation or is the end result in the institutional investor’s portfolio noteworthy in itself? These questions and more formed the shared curiosity of the group of planners, artists, economists, architects and designers that came together to discuss and debate the interactions of culture, the built environment and the way we compute its shared experience – the city.

Cultural Computation started as a foray into advanced statistical methods, explorations of data, showcasing of computational techniques and questioning the meaning of results. However, over time and disciplines, Cultural Computation became a practice and a community. And importantly, the participant’s engaged in a space that enabled debate around the seemingly disparate ideologies and methods that form the basis of erecting the built environment. Traditionally the humanities and sciences are suspect of one another. However, it was often acknowledged by our community that they are symbiotic in understanding the human experience. In this way, the approach by all participants represented a rigor and creativity that could only accompany a passionate community trying to understand the dynamics of change in culture and computation.

Over the course of twenty sessions, the group discussed gentrification, asset pricing, urban form, architecture, spatial econometrics, even voxels – and questioned the very form and ethics of every model and data point proposed to the group. In this way, culture and computation is SA+P; and with the multidisciplinary interests, beliefs and work of its constituents a shared community was found. It is important to remember that it

Over the course of twenty sessions, the group discussed gentrification, asset pricing, urban form, architecture, spatial econometrics, even voxels – and questioned the very form and ethics of every model and data point proposed to the group. In this way, culture and computation is SA+P; and with the multidisciplinary interests, beliefs and work of its constituents a shared community was found. It is important to remember that it is often in these spaces that creativity and methodology is discussed and operationalized. Moreover, it is here that participants feel empowered to develop better models of our reality that reflect culture and computation.

What became clear over time in this space of intellectual diplomacy is that a thoughtful structure designed by an architect to capture and empower the human experience could not stand without the rents and capital of a building, nor the asset-pricing model that describes and predicts those prices generated by the economist. Moreover, both disciplines represent an art form and rigor that co-move to shape the building. Yet, neither discipline was very prepared for the penetrating reflections from those practicing art, culture and technology. What was often pointed out is that the built environment can be a reflection of humanity – its beauty and failings in representing all of societies participants race, color, sexual orientation, vulnerabilities and disabilities. Design and finance was sometimes for the creator and not the user(s). These distinctions in approach led to fundamentally shared aspect of their experience, but most of the members in the room had never really talked to one another's discipline at a deep level about the passion and care that they each took in creating the form before them.

In this way, Cultural Computation transformed into a practice space for intellectual leadership. The group led by Emily Royall – with strong contributions from DUSP planners, ACT artists, CRE economists, Architecture's designers – started with discovery around computation and moved towards a new intellectual space where the hunt for methods evolved quickly towards operationalizing data and then questioning the very foundations of the scientific process. Art, culture, computation, statistics, diversity, economics and gender intersected in weekly dialogues for a diverse group from MIT's School of Architecture and Planning. Most importantly the limitations and freedoms at the intersection of culture and computation, combined with a dialogue between individuals grappling to understand one another's discipline, led to the discovery of new frontiers in modeling the complexity of our urban habitat – cities. Organically, the empowerment of its members grew into an articulation of a body of work that reflects not only art, theory and criticism but a foray into empirical statistics, data and institutions.

What follows is a body of work that reflects the authorship and curiosity of this unique community. It is important to remember the origins of these presentations. The authors are bringing novel ideas to a group that was quite dissimilar in training to themselves, and often had to work through a granular and fundamental distillation of their ideas to make them not only accessible, but engaging for participation. In this way, I am very enthusiastic about what Cultural Computation as a community can do for interdisciplinary work in creating the building blocks of cities. Such a practice and a community can work together to not only understand one another's perspective, but also (hopefully) create something new by reverberating between distinct approaches and incentives.

Dr. Andrea Chegut, PhD.
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Introduction

Cities are at the frontier of an emerging culture of computation. Urban environments are increasingly embedded in computational processes that shape urban design, perception and experience. Citizens, planners, architects, artists, corporations and governments all face challenges with the integration of emerging technologies into daily urban life. How to establish ethical norms and standards for the experience of technology in urban spaces has emerged as a point of critical discourse in 21st century design and planning.

The web of technological influence on urban life is only beginning to be tested and understood. Complex stakeholder relationships mediated by data streams, shape the contours of opportunity and constraints for the public. Data that citizens provide in exchange for participation in free digital civic services drives significant machine mediated decision-making on behalf of both public and private sector entities. The resulting planning, policy and business decisions can and do significantly alter the use and accessibility of urban environments. In addition to data collection, evolving software solutions mediate the process of design and development of the built environment. The constraints and experience of these applications and platforms depend on algorithmic design processes capable of propagating culturally inherited biases. Our daily use of these applications solidify these biases through our tangible engagements in public space---which may benefit or systematically disadvantage citizens economically, physically or psychologically. Likewise, new possibilities for the use of technology on personal, neighborhood and metropolitan scales promises to bridge gaps between cultures and communities. These new conditions created by digital-mediation across bodies and cities compel us to document, catalog and shape a language to describe and evaluate these experiences.

The newly formed, Cultural Computation group at MIT, aims to develop a culture that studies human interactions with technology in urban environments. Our growing relationship with computational systems has a produced a digitally mediated urbanism, where pervasive computing shapes our experience and understanding of the environment, each other and ourselves. By surveying the landscape of human engagement with technology in cities, Cultural Computation aims to shape a language whereby socially conscious practitioners can evaluate emerging technologies in digitally mediated environments.

In the past year, Cultural Computation established a platform for student work from disparate yet converging research agendas. By showcasing new and in process research, a forum emerged to discuss the edge-conditions of student body research. Membership of the group was dynamic and evolving, resulting in a new composition of attendees, depending on interest, at each session. Members at each meeting were asked to propose topics for the subsequent meeting based on occurrences of the current discussion. This resulted in a "random-walk" through student work and and an experimental approach to defining languages of latent concepts in design, ethics, planning and technology.

Several themes/troughs emerged as a consequence of this process: **Information Design, Spatial Dynamics, Systems Complexity, Human Cognition and Social Outcomes.** Information processing addressed the subjectivities embedded in data structures, algorithmic design and data governance models in smart cities. Spatial dynamics examined the use of data and modeling techniques to evaluate and map spatial conditions in cities. Systems complexity questioned how these mappings fit into a broader framework of systemic behavior, shaping an emerging condition of urbanism modeled after “informal” dynamics. Human cognition explored how human perception shaped opportunities and constraints for the use of technology in public space. Social outcomes cataloged the consequences of digital mediation on real-estate valuation, gentrification processes and economies in urban environments. Together these troughs built a lexicon for describing the landscape of human interaction with technology in urban environments.

This publication documents how this lexicon was developed through meetings, discussions, influences and content. Contributing authors are tagged with their various connections to each of the key troughs, so the reader may understand how the content of this work connects across themes and circumstances. The purpose of this publication is to establish a foundation for the development of an ethics of digital mediation in cities, as understood by a continuously evolving student body. Future issues will charter new domains and discussions of this progressing domain.

Information Design

Spatial Dynamics

Systems Complexity

Human Cognition

Social Outcomes

1. Empathy In Digitally Mediated Public Space

how we connect across digital/physical borderlands

Contributors

Gizem Gumuskaya
Emily Royall

Silent Dome

Gizem Gumuskaya
Masters Design Computation '16

The Silent Dome is a public space architectural intervention that proposes to combat the problem of social segregation. This intervention harnesses the emergent dynamics of human social behavior with a bottom up approach that fosters a bio-cultural community identity of deafness. The Silent Dome confronts the marginalization of disabled people in general, the hard of hearing in particular, by providing a fresh perspective and creating a musical dialogue within deafness. This project enlarges the scope of sonic perception from the "ear" to the entire body. In this way it promotes empathy in public space by bringing together the hard-of-hearing and hearing individuals to collaboratively compose an improvisational piece through interactive architecture[1].

Harnessing Social Emergent Behavior

Vertical social segregation of society is one of the major issues long faced by civilization. The reasons for social segregation vary: arising bottom up, as in the case of an organic gentrification process,[2], or in a top-down manner, often through authoritarian regimes[3] that create an easy-to-manipulate society. No matter if the vertical social segregation is implicitly created or explicitly induced, it is always damaging for society overall, because it eliminates the essential human need for a strong democratic society, striving for equality.

Since in both cases segregation stems from, and manifests itself through, the built environment[4], architects and urban planners shaping society's public spaces must be aware of these dynamics-- and thus must design for the promotion of equity. This can be achieved by designers of the built environment *creating communities* through and around the design of public spaces, which forms a more horizontally integrated society, rather than a vertically segregated one.

With this aspiration, it must be acknowledged that a *community* is an organic entity; it forms autonomously and generates its own dynamics. Self-formation of a community is the result of a complex emergent process and therefore cannot be directed top down; it must arise bottom up. Precisely because of this emergent aspect of human sociality—the very subject of public space design— exploiting the self-generative and self-organizational ability of autonomous systems or *harnessing emergence,* is acutely relevant to the practice of architecture.

Design Methodology

The proposed design methodology for harnessing emergence, the Silent Dome, is driven by the fact that *harnessing emergence* poses an oxymoronic design challenge: the agency to be harnessed, the emergent dynamic, is not congenial to the idea of "being harnessed," which implies top down methods such as control, manipulation, domestication and utilitarianism. This autocratic approach contradicts the self-organizational essence of emergence that is unpredictable, autonomous and continuously introducing novelty. Emergent properties cannot be

controlled; they unfold only under the circumstances of self-control.

The way the proposed design methodology copes with this oxymoronic challenge is that it does not aspire to control the outcome of the emergent process, when in most design processes there is an end goal in mind. Here, the outcome remains open ended and unique to each circumstance; the methodology rather aims to actuate the emergent process itself via a three step framework: activation / incubation / cultivation.

1. Activation: interaction between individuals and space

Emergence arises from a network of interactions between individual agents. Yet, for this network of interactions to emerge, the agents must be excited in some way. Eliminating top down control does not necessarily mean reducing exterior stimuli to zero and just pave the cowpaths. In a chemical reaction, an activation energy input at the beginning is required for the remaining reaction to unfold spontaneously; in the same way, in public space, the curiosity and playfulness triggered by interactive architecture, inputs the required activation for coincidental individuals to become the agents of an emergent process. Under *incubatory conditions*, these agents can spontaneously engage in an emergent dialogue which leads to the formation of a community via communal creation.

2. Incubation: interaction between individuals

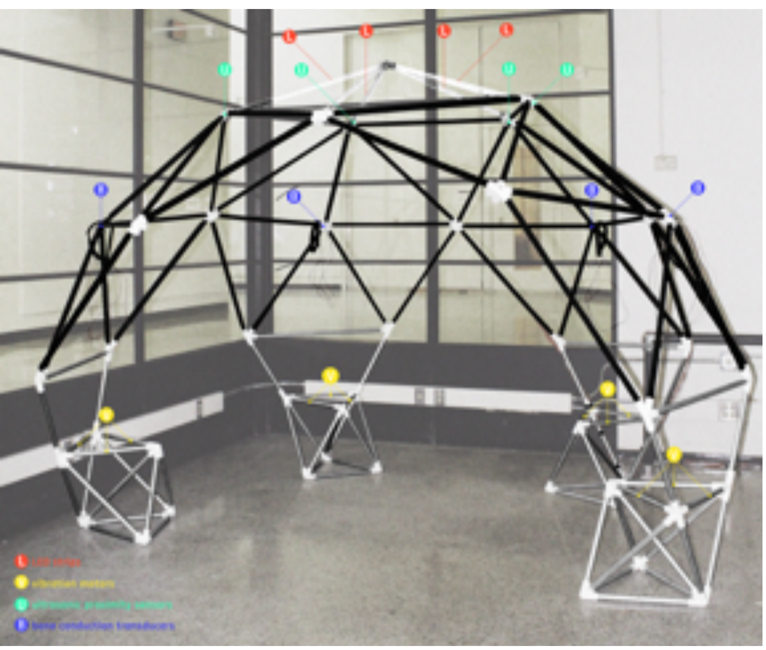
However, in most architectural interactive interfaces due to the predictability of interactions, which is in fact a required feature for rigorous responsiveness, there is a high possibility that this "activation energy" will be absorbed quickly and the excitement of the first encounter is quickly consumed. Once novel, excitatory conditions are normalized due to the adaptive nature of humans. For interactions of agents in the space to mutate into interactions between agents themselves, there has to be a dialog starter beyond the amazement of the interaction itself, such as the context specific considerations of architectural intervention. Asking the question "what problem does architecture address in this particular location or with this particular

audience?" shapes conditions for emergent behavior.

3. Cultivation: becoming non-distinct parts of a unique whole

When harnessing emergence, the outcome is open ended; emergent results cannot be pre-viewed, they can only be observed in retrospect and are unique to each group. This empirical communal creation, which is the result of an exchange of reciprocal efforts, is at the core of the formation of a common ground between strangers in public space. The emergent properties will not only be observed in the interactions between the players, but are also present within the communal creation itself.

The User Experiments section includes observations on the above three steps in the context of The Silent Dome project.



The Silent Dome

The Silent Dome is a spatial music pavilion where the music is created by four players at a time, via their gestural interactions with the architectural space as well as with one another. Within the social norms, especially in a musical context, hearing loss is either ignored, suppressed or faced with the imposition of a fixture or aid. The Silent Dome accentuates the possibility of exploring musical interactions within the constraints of deafness as well as within the opportunities of other heightened senses (touch, seeing, etc.).

A series of ultrasonic sensors[5], vibration motors[6], LED strips[7] and bone conduction transducers[8] are deployed within the folded, tubular elements of the structure. The collaborative improvisational composition being output[9] in real time, not only through haptic and visual channels that are alternative to the classic auditory canal in musical perception; but also the auditory canal itself is "hacked", since it is assumably faulty in deaf people, via exploiting the sound transmission capacity of human skull bones.

Form

The co-evolution of architectural form and mechatronics of the project, from a circle to a dome and then to a geodesic dome, are induced by both conceptual and technical requirements as described below:

<u>Circle</u>: Using bodily engagement as a means for sonic creation is well-known

to the hard of hearing and is also a valuable empathy practice for hearing participants. Because the main interface for controlling the music is one's gestures, the pavilion has a circular spatial arrangement to allow clear sight lines so that everyone can participate in the visual conversation.

Dome: Due to the need for accommodating the interactive interface required for gestural control, as well as the appropriate visual and haptic output channels, the circle evolves to a dome in order to occupy the space in its full dimensions.

Geodesic Dome: To enable the visual permeability between the interior and the exterior of the pavilion, the dome was stripped down to its bones and was deployed as a geodesic dome. This visual link is designed to invert the roles between deaf and hearing people to promote empathy: spectators surrounding the dome will only be able to see the physical manifestation of the sound in human interaction (output channels are holistically perceived only by the players themselves) and will not be able to actually hear the sound itself--which is exactly what hard of hearing people experience in their daily lives.

Structure

The context specificity of the structure does not arise from *place,* but from *audience*: The Silent Dome was not planned for a specific location but for a particular yet ubiquitous audience. In order to encode this universality into the structure itself, the struts of the dome were designed in a way to prioritize easy transportation, convenient assembly and disassembly; in fact almost the entire structure is made of thick[10] paper. Planar board sheets were cut and scored on certain axes to be folded into a tube whose two facing edges were connected via press fit joints. This method of strut fabrication is not only lightweight but also provides full control over the embedded electronics throughout the dome's lifecycle: the structure sustains its form even if the press fit joints are released on multiple struts.

User Experiments

The way players interacted with the pavilion during user experiments provided invaluable evidence towards the validation of the three step methodology for harnessing (social) emergence. At the beginning, all four players were very excited, even engrossed, by the unusual experience of having their daily gestures, such as moving limbs or torso on the sonic y-axis; people rarely get a chance to explore musical reciprocities in their bodily engagements *(Commencement of the 1st phase: Activation)*. This kick-off enthusiasm was sustained as the players explored the proficiency of their novel augmented bodies and unaccustomed ways of perceiving sound such as hearing through the skull bones and perceiving rhythm via haptic and visual channels. In the first five to ten minutes, each player individually probed for the allowances and the constraints of this new mode of engagement. Shortly after these initial moments of discovery, players started to listen to one another and to explore what they can do *together* as a group *(Transitioning to the 2nd phase: Incubation)*.

In this one higher level, a novel mode of interaction, a less individualistic one started to emerge. Similar to the beginning where unexpected experiences were provoking individual engagement, in this second phase, it was the communal dialogue being provoked by novelties experienced by the group; such as being one of the multiple players of a musical instrument, creating music with hard of hearing individuals (applicable to the hearing players) and creating music with hearing individuals (applicable to hard of hearing players). These emerging novel experiences in the second level generated novelty at each higher step along the incubatory phase. For interactive architecture to trigger emergent dynamics, there must arise novel implications when individuals interacted with it as a group and as individuals; these implications must be relevant to the individual as well as to the group as a whole.

Finally *(Observing the 3rd phase: Cultivation,)* the overall composition consisted of four interlocking layers, all of which evolved in response to one another. Emergence was not only apparent in the fact that there arose a meaningful musical composition, but because it was also detectable within the musical structure of the composition itself. This situation demonstrates a fractal nature common to emergent systems. Individuals who participated in a musical dialogue through The Silent Dome collaboratively created a musical composition unique to their group. This communal creation itself, as well as the experience of it, is the heart of social emergence.

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(1) A physical space that employs responsiveness to its surroundings

(2) Organic gentrification is a process where the migration of artists, who are in quest of low rents and vast spaces, into deserted urban areas, such as an abandoned industrial zone, attracts higher income groups which cause dramatic increase in land value as well as a change in sociocultural fabric and eventually force artists to move out.

(3) In the form of systematic extermination of the public space in order to prevent interaction between people which due to social interactions' emergent nature, may trigger autonomous, hence hard to control, movement (an extreme case can be seen in Orwell's 1984). All the successful revolutions happen bottom up and the ones being directed top-down fail: authority dislikes autonomy.

(4) ...which is not surprising considering the huge effect that the built environment has on human behavior and sociality as implied in Churchill's "We shape our buildings, afterwards they shape us!"

(5) Four ultrasonic proximity sensors are embedded into four different strut joints in a way that each sensor covers the gestural activity zone of the participant sitting beneath it. The acquired proximity data for each participant is transmitted in real time into an Arduino serial object an instantly mapped into a specific frequency range on a particular MIDI channel (in an audio synthesizer software Max MSP). The sound control pathway is the same for all participants each of which operate on a different channel; the overall composition is the juxtaposition of these four channels.

(6) via vibration motors embedded into the seat: The seats are made of aluminum to ensure effective vibration transmission. The bases sustain the tubular structural character of the geodesic dome and they are designed in a way that when a participant sits on a base, two tubes at the upper surface gets anchored to the sit bones (Ischial Tuberosity) of the participant for the haptic experience to influence the entire body.

(7) LED lights embedded into the top most pentagon made of clear polycarbonate struts

(8) Bone conduction transducers: A bone conduction transducer is in fact a simple oscillator that creates a magnetic field between two cones around which a string is wind. As the string crosses from one cone to the another, change in the magnetic field vibrates the string. This vibration is then amplified via a small metal piece connecting the string and into a large canopy covering the cones. This metal canopy vibrates as the string does. When one presses this vibrating surface against their skull, bones constituting the skull start vibrating; so do cochlea as an extension of these bones.

(9) Output Devices: Since both frequency and amplitude data of the overall composition is aimed to be transmitted through participants' skull bones into their cochlea, hence by-passing their assumably faulty auditory canal, the output of Max MSP is directly fed into the bone conduction transducers without further processing. However since the aim of the vibration motors and LED lights was to amplify rhythmic aspect of the overall composition (hard of hearing peoples are believed to be more sensitive for haptic input), the output of Max MSP is further processed in Processing to select the amplitude information and output this precise layer of information, via an Arduino hooked up into Processing, to vibration motors and LED lights.

(10) Thickness: 0.8mm/1/32"

Skúmaskot

Emily Royall
Masters City Planning '15

We are not "for" each other in digitally mediated public space. Instead, we participate simultaneously in hidden worlds, that we as individuals are uniquely aware of—or not.

In this project, I examined the borderland territory between physical and digital public space. In an era were our experiences of each other and ourselves are increasingly mediated by digital devices, understanding the opportunities and constraints of this medium is acutely important. Though smart phones and wi-fi networks permeate our digital public spaces, I chose to focus on an especially controversial form of technology affecting our use of the public sphere: surveillance.

Surveillance technology is ubiquitous, pervasive and nearly omniscient. Widespread use of the technology by both private and public institutions blurs the boundaries between traditional notions of public and private spaces. Ultimately, "is someone watching" has become a less relevant question in the day to day than the more pertinent "who's watching?" Indeed, America's widespread adoption of surveillance technology is intended to quell our fears and put to bed any notion of dispute in the event of a crime. However, as we've seen over the past several years with police use adoption of body cameras, our own subjectivities are highlighted when stakeholders debate personal interpretations of the precisely the same footage.

Perhaps a less researched topic is that of consumer-grade surveillance. Today, personal surveillance cameras line our homes, fences, yards and cars. The promise of bringing surveillance home feels empowering, and contributes to a sense of control over daily life. However, a majority of consumers are not aware that surveillance footage streams live online, and unless password protected is legally fair game for the viewing pleasure of anyone who knows how to use a computer.

The disturbing mesh of unprotected personal and public surveillance devices is a medium. The website http://www.insecam.org maintains a live feed of un-protected security cameras all over the world. Because these cameras are not password protected, and like most surveillance cameras, run off the internet— their live footage is retrievable via simple commands typed into your web browser. Free. Legal. Not only that, but you can also target their geolocation.

Over a week long period I sat and had dinner with a woman in San Francisco and her cat in front of her TV---streaming live from my computer. I watched over people's living rooms while they were at work, and enjoyed the peaceful humming of their serene aquatic fish tanks (for some reason, substantially large number of Americans film their aquariums).

While trolling vulnerable cameras in public spaces in Boston, I came across one in a space I was able to geolocate and walk to, which I did while remotely streaming and recording its footage. By the act, the public space around me transformed into a stage. I experienced the same environment in a way that was obviously deviant from other people, but for very private reasons. I was using the space for a hidden use that was simultaneously very visible to passers by through my own behavioral deviation. People stopped and wondered what I was doing. Was this a protest? They in turn had a strange sensation that my performance was not for them.

I remotely recorded the surveillance video footage representing a condition where I was simultaneously the watched and the watcher in real time; an unusual simultaneity of polarized power distribution. In the video I am seen holding up a large sign that says "SKUMASKOT" while people watch nearby.

A couple young men appear to help me keep the sign up in the wind. We all stare awkwardly together at the camera I've hacked, wondering what we stand for exactly—this precisely frames the emerging concern for digitally-mediated public spaces: that an ethics of privacy and use has yet to be established.

In Icelandic, "Skumaskot" means "a suspiciously cozy corner." I felt that this term was especially relevant to my experience of the public space I was enjoying—knowing that I hacked the camera that was watching me and recording myself. We all experience Skumaskot in places that appear on the surface pleasant, and welcoming but subtly mine our right to privacy.

A video of my performance is available at https://vimeo.com/127792484.

2. Urban Intelligence Platforms

how culture and perception shape digital urban modeling technology

Contributors

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Daniel Fink

Voxel Theory

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SMArchS Architecture '16

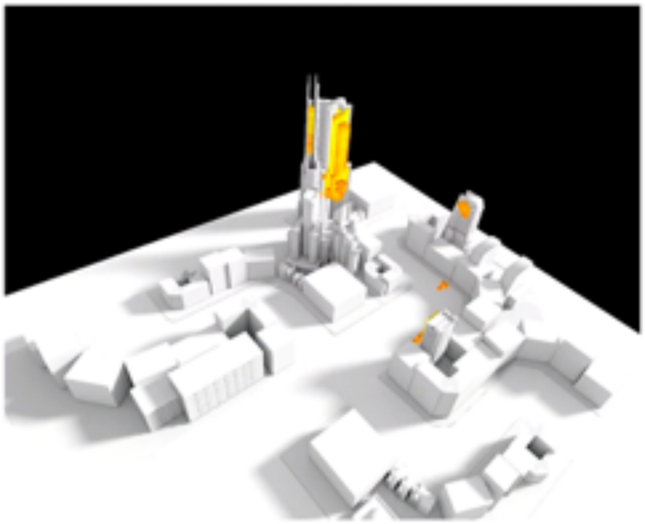
Imagine the territory you occupy is actually a 3D Cartesian grid of cubes like that of a vast Rubik cube. Each of these cubes contain encoded information about its position in space and subsequent properties. Perhaps more fascinating then the visualization of this 3D grid is the utility specifically to non human-users. The grid is vast and encompassing and considers the stack of data and space.

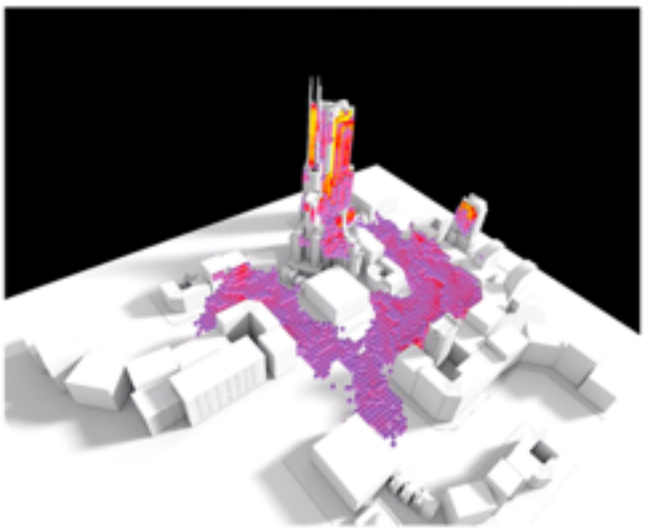
In response to Daniel Fink, voxel theory puts forward a new paradigm for the storage, processing, and organization of complex spatial data. One approach for adding a "three-dimensional dataspace" for architects, urbanists, artists, landscape architects, etc. – to represent spatial analytics, would be to add voxel to the point, polyline, polygonal data display collection of traditional geographical information systems. The addition of voxels as a representation of data in GIS only adds *Z axis complexity* to a system predicated on flatness. The current GIS platform, *graphically primitive*, is not capable of handling the complexity of spatial relationships beyond the XY plane. An advanced platform is structured more like a network and less like a cartographic map.

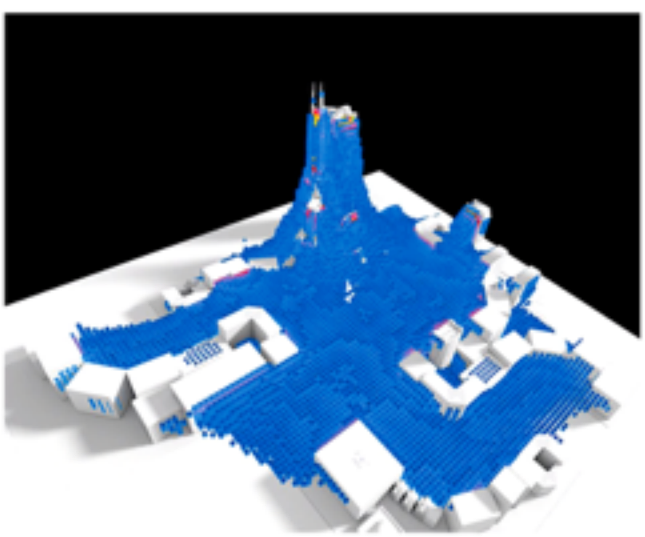
Voxels or 3-dimensional volumetric pixels, are cubes that contain information. Voxel theory holds together best when described as multi-dimensional subdivisions of space for the purpose of delineating territory and associated information. Unlike territory - irregularly subdivided and menaced by exceptions - the imagined schema remains highly ordered in form. Uniformity is maintained spatially and data dimensionally.

Voxel theory depends on 3 core principles. Each principle is dependent on its counterparts.

First principle is that each subdivision is a container of information. Each container is inherently spatially indexed and encoded with its location. A datum and the representation of physical space encapsulated in the subdivision are the first of many entries of information. Once localized, data can be generated and







associated to the datum established inherently. It is key and essential that all subdivisions are encoded using the same global projection.

The second principle is that all subdivisions of space are assumed to be isotopic in volume and data dimensionality. Meaning the subdivisions are the same size and shape. ie cube in the initial example but not limited to cuboidal form. In addition to uniformity of shape, each subdivision contains the same pattern of information or depth of data. No subdivision will have greater data dimensionality; all fields are to remain equal and consistent. This equality fosters augmentation of the system as a whole and simplifies direct attribute-to-attribute searchability.

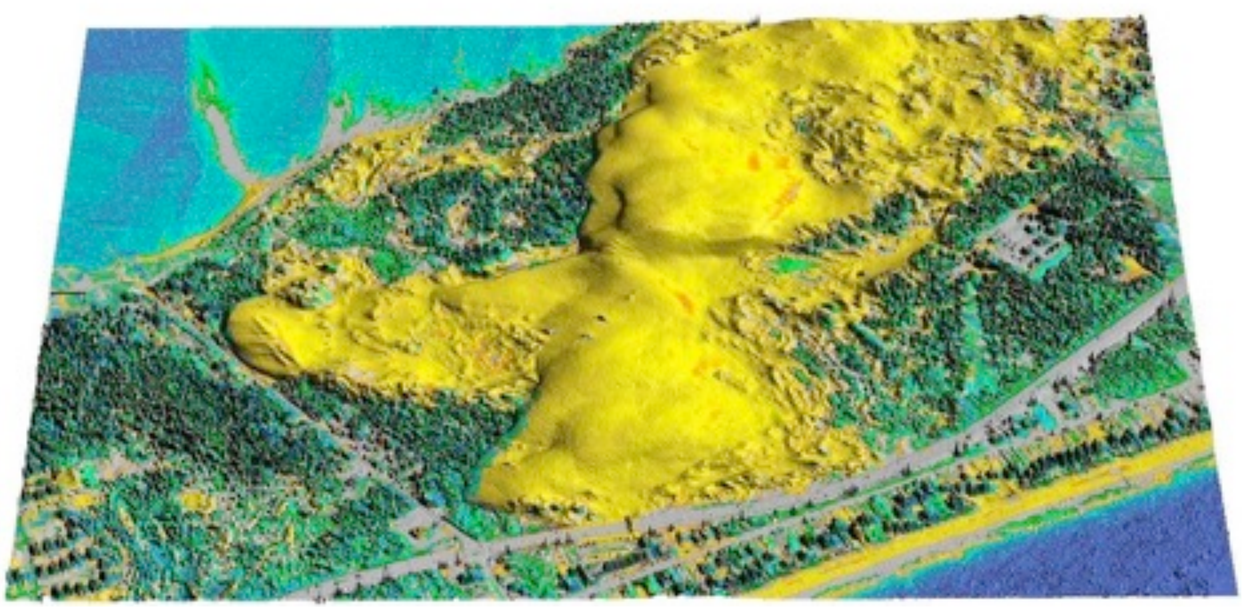
The third and final principle is relational completeness, uniform and atomized yet connected. It is important that each voxel is aware of the surrounding network of adjacent cubes and also aware of data adjacencies throughout the system. This principle also enables voxels to function like line or polygonal data structures. Because of the isotopic properties across the system, every entry can form a relationship spatially and data spatially.

From the three principles and a tabula rasa, new subroutines begin to emerge. Questions from the cultural computation group included, questions of scale, commodity, and parallelization. One of the most compelling questions was “could a single voxel be traded on an open market?” A question that only indirectly is ever associated with traditional GIS. If a voxel were to be commoditized, it is likely to be similar to high frequency algorithmic trading because of the data richness and comparative complexity. Because of the clear subdivisions and uniformity over time many of the emerging subroutines will add to the depth of inferred information by compounding attributes. Traditionally ad-hoc evaluations of territory – analysis of space, property, and value- will find home in the structured data dimensionality enabled by voxel theory. By viewing the platform in which information is stored as a digital territory of itself, the simulacrum begins to represent the physical world in ways never before explored.

In reflection with CC President Emily Royall:

> "Changing the way we understand the built environment has implications for how we build our technology, and vice versa. In our excursions on games like Minecraft, we might imagine how to adopt this technology for "real" urban design. Furthermore, adding dimensions of information to each cube in the voxel framework may open up new avenues for BIM that incorporates high-resolution performance metrics, or data vectors whose interactions we can map to each other in more sophisticated ways. How might this change the values we use to configure built environments? Is floorspace traded by the square foot, or by the cube? Could we program each cube to contain a volume of data that has a specified market value? Could that market value be directly calculated and posted in real-time to a public market? Can we envision open-source communities that design and trade voxel-space, like online communities already do on minecraft?"

Perhaps this document serves more as a muse of ideal data representation systems or a pathway to improvement of existing systems. But beyond the practical value, in rethinking our traditional frameworks Is the truth gained from reprioritizing the inputs worth measuring. What Voxel theory prioritizes is that space - our locus of control - should be the container of information both in reality and in representation. Too often choices are made based on short term efficiencies. In the long term, what is manifest, is the accurate and insightful representation of our domain.



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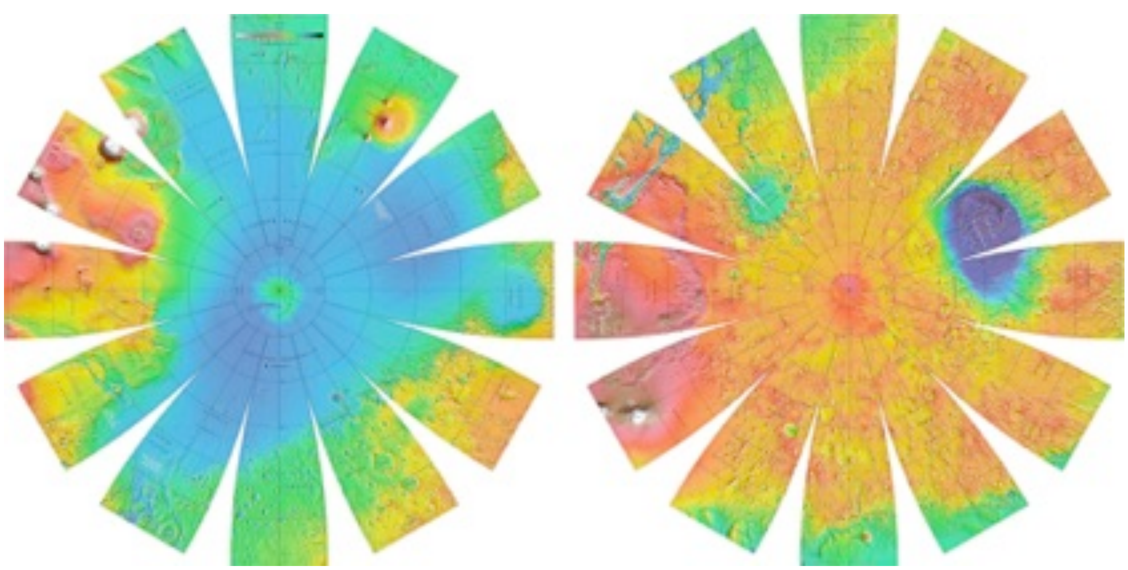
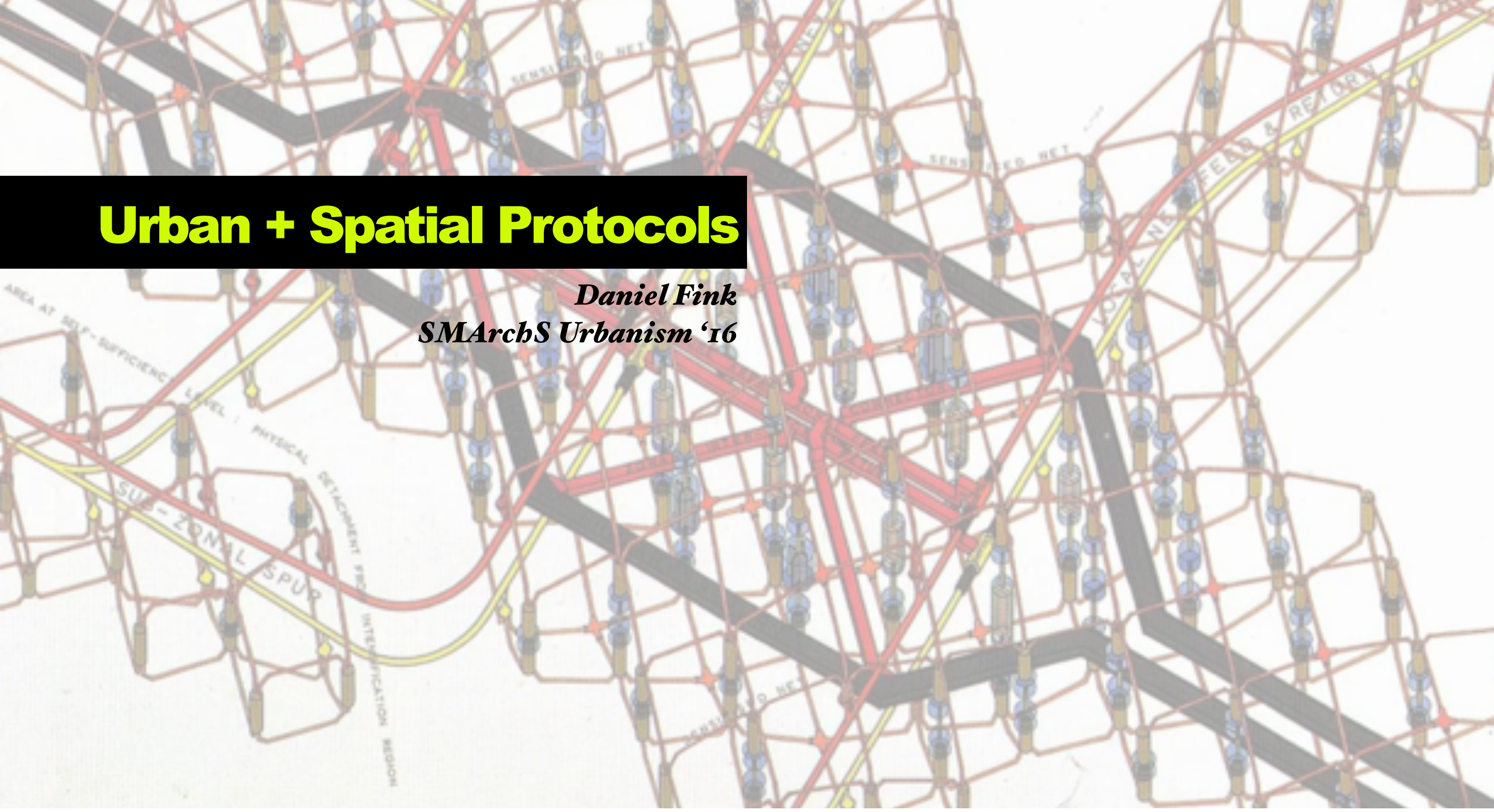




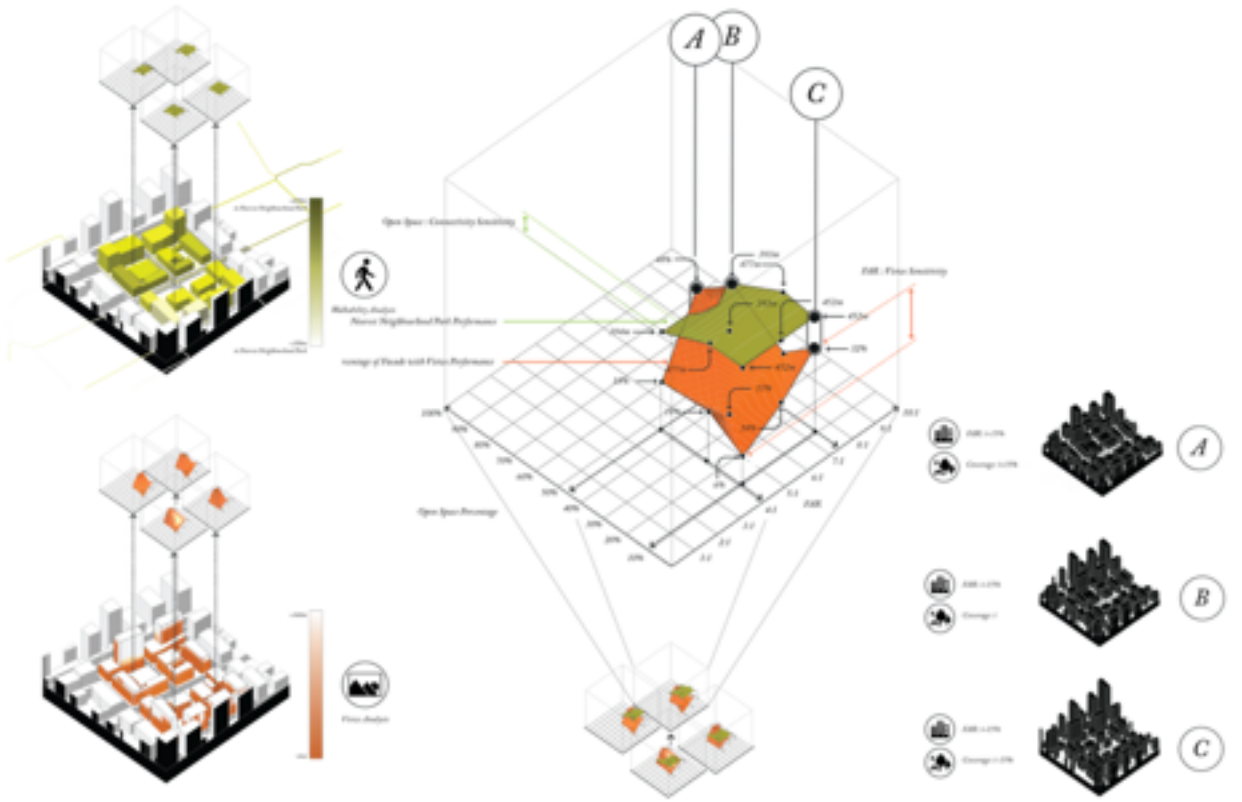
Urban + Spatial Protocols

Daniel Fink
SMArchS Urbanism '16

In 1996 the economist Paul Krugman ventured into interdisciplinary territory by admitting his admiration of evolutionary biologists in a talk he gave to the European Association for Evolutionary Political Economy. Krugman identified that evolutionists have better grasp of the 'useful fictions' used to cut through complexities, and economists must re-learn "that models are metaphors, and we should use them, not the other way around." The field of Urban Design, especially when framed through computational models and intertwined with associated disciplines like economics, planning, architecture, politics and engineering, must be doubly aware of this warning.

The purpose of this discussion is to understand our ongoing limitations, but also our progress in developing empirically based models of urban form. And importantly, at its core, the cultural and disciplinary biases that can limit and expand the frontier of urban and spatial models or protocols that ultimately influence the design and economic production from our cities.

Urban models and data limit our understanding of cities. The models we use to frame how cities work is often limited by the perspective or discipline of the modeller. Our sets of interests, the data at hand, and the availability of techniques to identify meaning in our analyses can limit the progress of our understanding. Even more so, we are often limited by our imaginations' ability to perceive what is data and what is not. Progress towards what is computable, but what is left to art and the political realm is often shifting between science and the humanities. And importantly, a model takes on a life of its own; it is reported upon and used in academia and beyond. This use of the model may create perversions in feeding assumptions about how the urban form works to begin with, in turn creating a self-fulfilling prophecy of how the complexities of architecture, design, engineering and economics come together in a cohesive urban fabric. In this way, what was once thought to be



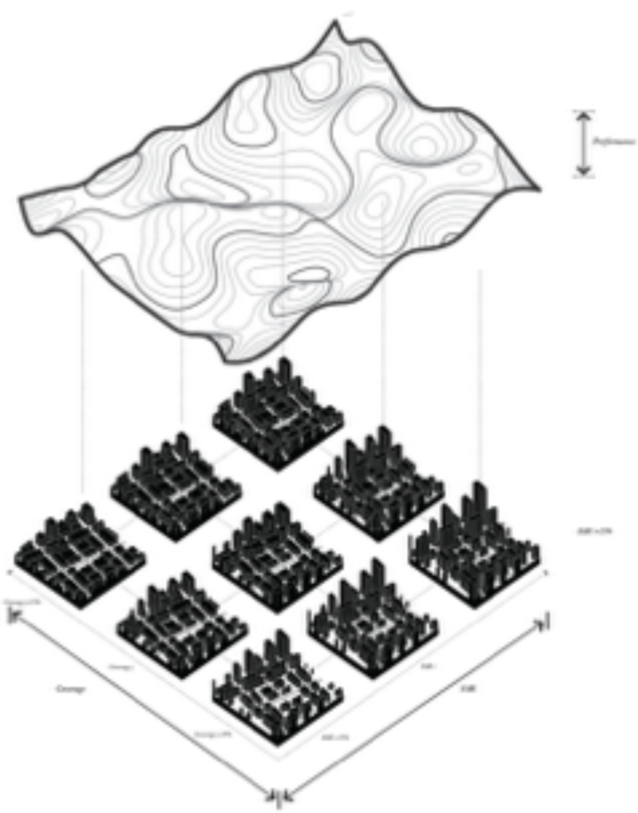
iterative process of scientific progress becomes an autoregressive tautology, where assumptions can develop into laws without a malleable and inter-disciplinary environment of rigorous questioning.

Although urban modelling remains in its infancy, its intellectual legacy has significant roots in one particular discipline: geography. Starting with the formulation of *cybernetics* by mathematician and philosopher Norbert Weiner in 1948 (a study of human and machine systems explained through feedback, control and communication mechanisms), it quickly generated newfound excitement in architects and planners for systematic approaches to analysing (and therefore shaping) cities. By 1964, Dennis Crompton of Archigram had already fantasized about network and infrastructural effects on urban living in *Computer City,* and ES Savas, professor of public policy at Baruch College, applied Weiner's principles to urban government in his 1970 *Science* article, *Cybernetics in City Hall.* At the same time, the landscape architect Ian McHarg's 1969 *Design with Nature* testified to the efficacy of layered hybrid maps to identify ecological sensitivity in the geographic domain, which has been heralded as the 'conceptual founding' of modern-day GIS (in fact, Roger Tomlinson's *Canadian Geographic System* had already set the stage for computational approaches to urban modelling by the late 1960s). Yet despite 50 years or so of 'urban computation', the writer and architect Anthony Burke points out in *The Urban Complex:*

> "Why has the urban condition remained so resistant to attempts to parametricise its inherent complexity? Put another way, why have the assumptions of urban systems models proven to be incompatible with the reality of the contemporary urban condition, and incapable of accommodating or recognising contemporary events and behaviours?"

Contemporary perceptions of urban complexity have increased demands on the discipline to move beyond theory and into the domain of empirical testing. While the question perhaps places unfair demands on the outcomes of computerised modelling (a model that so finely predicts the complex interactions of urban form with culture, finance, politics, geography, etc., may be approaching the 'map-territory' relation limit), **the question of whether an urban model's assumptions and its intended (or unintended) productivity is important at the frontier of designing better cities.**

Modern GIS data-structures are predicated on two fundamental constructions of geography: two-dimensional layers comprised of either vector or raster-based information (i.e., data or imagery based information). This allows rapid compositions of heterogeneous data into coordinated hybrid maps (as envisioned by McHarg), thus enabling spatial analysis that interrelates multiple domains of knowledge. Combined with global reach (both geographic and population coverage) the productivity of the technology can be powerful: the U.S. Holocaust Memorial Museum's *Crisis in Darfur* project utilised crowdsourced and institutional datasets to map and analyse genocide in unforeseen detail. Yet it is important to recover what the writer and urbanist Keller Easterling characterizes as the "disposition" of this infrastructure: not the actual activities performed upon the infrastructure inasmuch as the *kinds* of activities both invited and inhibited by the compositions of the infrastructure's elements. What I wish to bring to the fore is the implicit assumption of *objectivity* given by the 'impartiality' and 'omniscience' of the two-dimensional map: while writers like landscape architect James Corner have already explored the inherent power structures employed in mapping by way of its ability to select and codify data, only recently have architects and urbanists explored techniques to map more subjective qualities of space.



In 1984, the urbanist and academic Bill Hillier published *The Social Logic of Space*, outlining new methods to graph and calculate networks of spaces that defined them by their experiential properties.

> "Culturally and socially, space is never simply the inert background of our material existence. It is a key aspect of how societies and cultures are constituted in the real world, and, through this constitution, structured for us as 'objective' realities. Space is more than a neutral framework for social and cultural forms. It is built into those very forms. Human behaviour does not simply happen in space. It has its own spatial forms. Encountering, congregating, avoiding, interacting, dwelling, teaching, eating, conferring are not just activities that happen in space. In themselves they constitute spatial patterns."

From this premise, 'Space Syntax' analytic techniques such as the isovist (or viewshed polygon), axial space, integration, convex space, and more were developed to enable observer-oriented descriptions of inhabitable places (rooms, buildings, streets, plazas, cities…), that could parallel the similar ways network analysis enabled calculations of flow, robustness & dependency, influence and so on of real and abstract graphs. By combining these metrics with multi-variate descriptions of urban density, typology and use-mix, we are now able to formulate computable relations that can yield insight into urban properties like the *character* of a neighbourhood, or its *atmosphere* – qualities that have been previously left out of urban spatial analytics.

Critically, some measurements in space syntax like the isovist, and Berhauser-Pont & Haupt's *Spacematrix* metrics for density require three-dimensional geometry structures. The importance of this extends beyond the desire for GIS-esque mappings of urban space to acquire higher fidelity or accuracy. Instead, three-dimensional dataspaces allow the entry of spatial designers – architects, urbanists, artists, landscape architects, etc. – to both represent and reproject spatial analytics into potential new forms and infrastructures.

The ability to build semantic properties of space from collections of syntactic descriptions (i.e., the ability to quantitatively describe phenomenal qualities of built typologies or floorplan layouts or urban fabric from their geometric properties) means that procedural computation to *produce* designs with desired properties is also possible. In this case, designers can author a set of operations that can be performed on geometry, and allow an algorithm to selectively choose and optimise those operations towards achieving a predefined geometric goal – whether it is the satisfaction of a density requirement, particular efficiencies in arrangement, or more corporeal effects. Further, the accessibility of massive computational power now allows exploration of

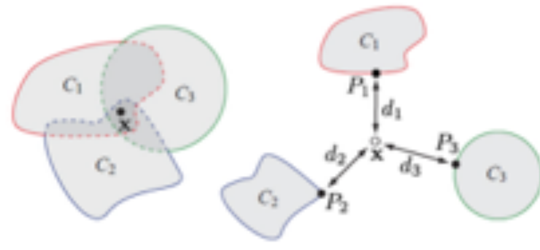


Figure 2: *The proximity function $\phi(\mathbf{x})$ is the weighted sum of squared distances $d_i(\mathbf{x})$ of the point $\mathbf{x}$ to the projections $P_i(\mathbf{x})$ onto the respective constraint sets C_i. Minimizing $\phi(\mathbf{x})$ yields a feasible solution if the constraint sets intersect (left), and a least-squares solution otherwise (right).*

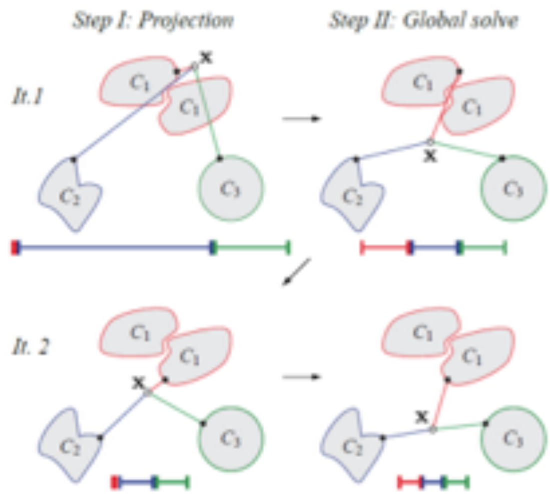


Figure 3: *Two iterations of the two-step minimization of the proximity function $\phi(\mathbf{x})$ with $w_i = 1$. Step I computes the projections using the current estimate $\mathbf{x}$. Step II updates $\mathbf{x}$ by minimizing $\phi(\mathbf{x})$ keeping the projections fixed. At each step, $\phi(\mathbf{x})$, illustrated by the sum of the error bars, will decrease, even if some of the individual elements increase.*

tens of thousands of these solutions; traversing a so-called 'design space' (analogous to the search- or solution-space in operations research or decision theory) and therefore also inviting modern optimization and sensitivity analytics as feedback mechanisms to design processes for complex projects.

In 1785, Thomas Jefferson proposed a land ordnance that would create a nation of "yeoman farmers" – a protocol for the surveying and conjugation of all land annexed by the United States in order for its subdivision and sale to speculators. Such a mechanism *territorialized* new terrain within the bounds of its technological disposition; new cities arose with their blocks demarcated at mile-markers; cropfields followed Cartesian axes rather than topography; and infrastructures were constrained to orthogonal boundaries. The intended –and unintended– effects of this technology substrate can be traced to those initial assumptions and constructions of two-dimensional mapping and surveying protocols and their appeals to objectivity and omniscience. With our newly formulated capabilities that can situate more subjective or observer-oriented constructions of territory alongside our traditional ones, what new possibilities will emerge – both intended and unintended – for the formation of new ways of living, producing and constructing meaning?

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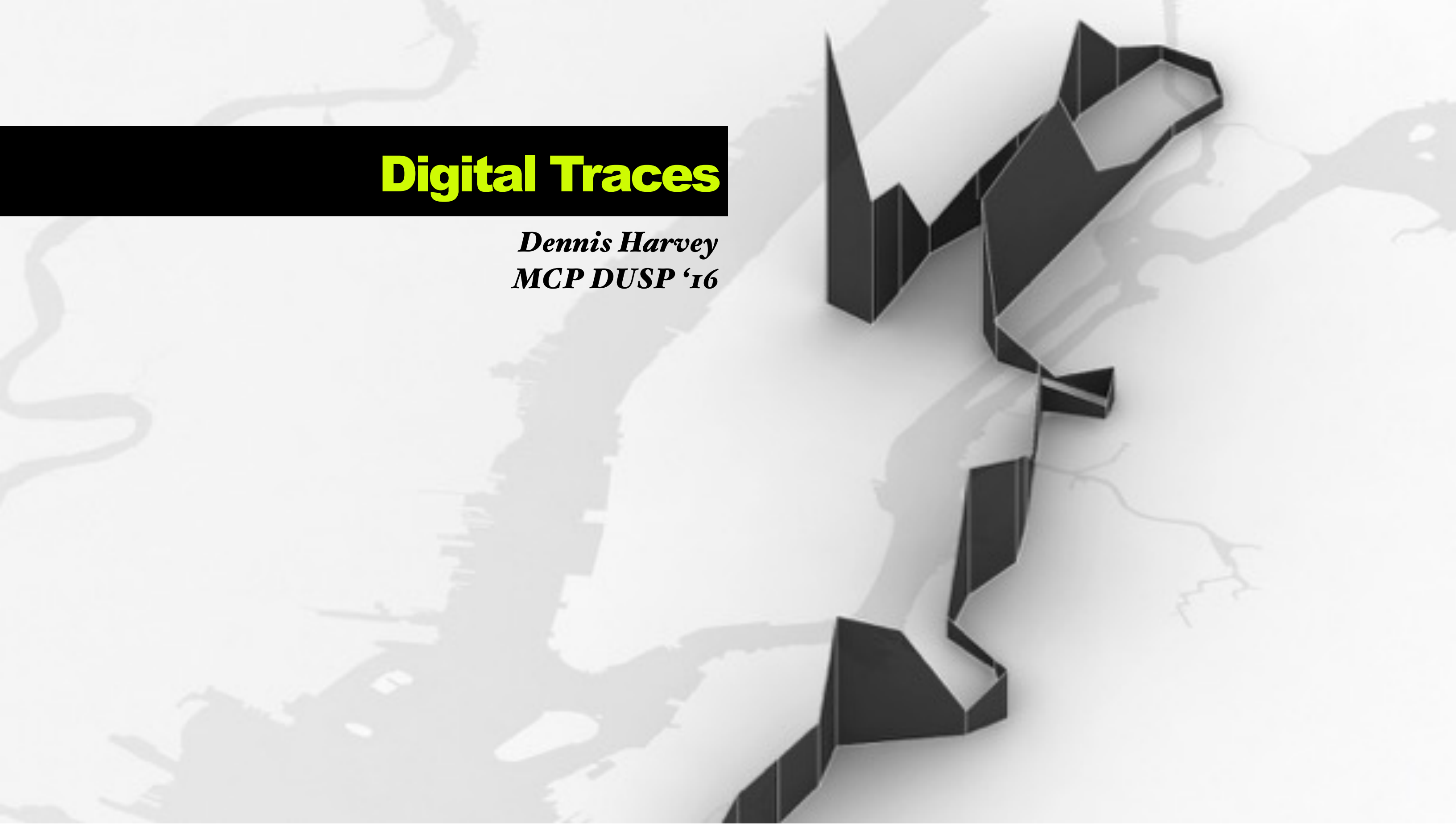


Digital Traces

Dennis Harvey
MCP DUSP '16

Computation is not only a tool, but a lens through which we can understand the world. The notion that human behavior and decision making can distilled and coded into a set of rules is increasingly informing how we look at complex systems like cities. In the following two projects, I explore how computation and data visualization can help us understand urban phenomena.

Development patterns are often generated from a rule-based system that establishes a code of conduct for private actors operating in the urban context. These rules have often been codified into zoning laws in more developed cities. Urban form is partially the result of multiple actors following the same set of rules. Few places display this more clearly than Larung Gar Buddhist Institute. This city of roughly 40,000 monks and nuns is based around a Buddhist university at the center of the town. Students who join the university for anywhere from 9 to 13 years of study must occupy or construct a hut to live in during their stay. As small, autonomous dwellings made from timber, these huts reflect the simple and contemplative lifestyle the students must maintain.

The requirements of building a hut, as well as providing adequate space for circulation has resulted in a set of tacit rules that govern the form of this city. Since each monk constitutes a decision making agent, agent-based modeling provides a simulation of this type of development. The principles of the Boids algorithm model, in particular, best describe the pattern. The 3 basic principles which can explain the generation of this form are separation, cohesion, and alignment. Separation provides room for autonomy and circulation, cohesion ensures efficient use of space, and alignment of each hut's long side to the mountain slope is the easiest way to construct it. An additional behavior is obstacle avoidance, which can be seen in how hut construction responds to the presence of a wall, road, or temple. The result of this uniform set of rules is the appearance of uniformity across the city, despite each hut being built by different actors. Much like the construction of huts in Larung Gar, large events like the New York City Marathon draw large numbers of spectators. Each spectator is an agent making decisions about where and how to view the marathon based on a large number of factors. Because of large amounts of exhaust data becoming available through public API's, we now have the ability to track and analyze human behavior in these circumstances. In order to explore how these numerous decisions aggregate in a single event, I used Twitter data from the day of the New York City Marathon. In order to capture the Twitter data, I scraped all of the Tweets that had the hashtag #NYCMarathon and were posted between 9am and 9pm on race day. While to total number of Tweets was more than 45 thousand, only 995 of them were geolocated. By mapping these Tweets, along with the time of day that they were posted, the event is reconstructed through its digital traces. As the day progresses, Tweets slowly redistribute from the starting line to the finish line as spectators follow the numerous waves of runners. When quantifying the number of Tweets per neighborhood, it's clear that the highest numbers tend to be in the higher income neighborhoods. This could represent the preferences of spectators as a whole, but more likely shows a skew in the data representing the demographics of Twitter users. This shows that, despite the tremendous quantities of exhaust data being generated by urban spectacles, there are limits to what it can tell us because of the means by which it is collected.

3. Machine Detected Futures

using modeling and machine learning in urban political contexts

Contributors

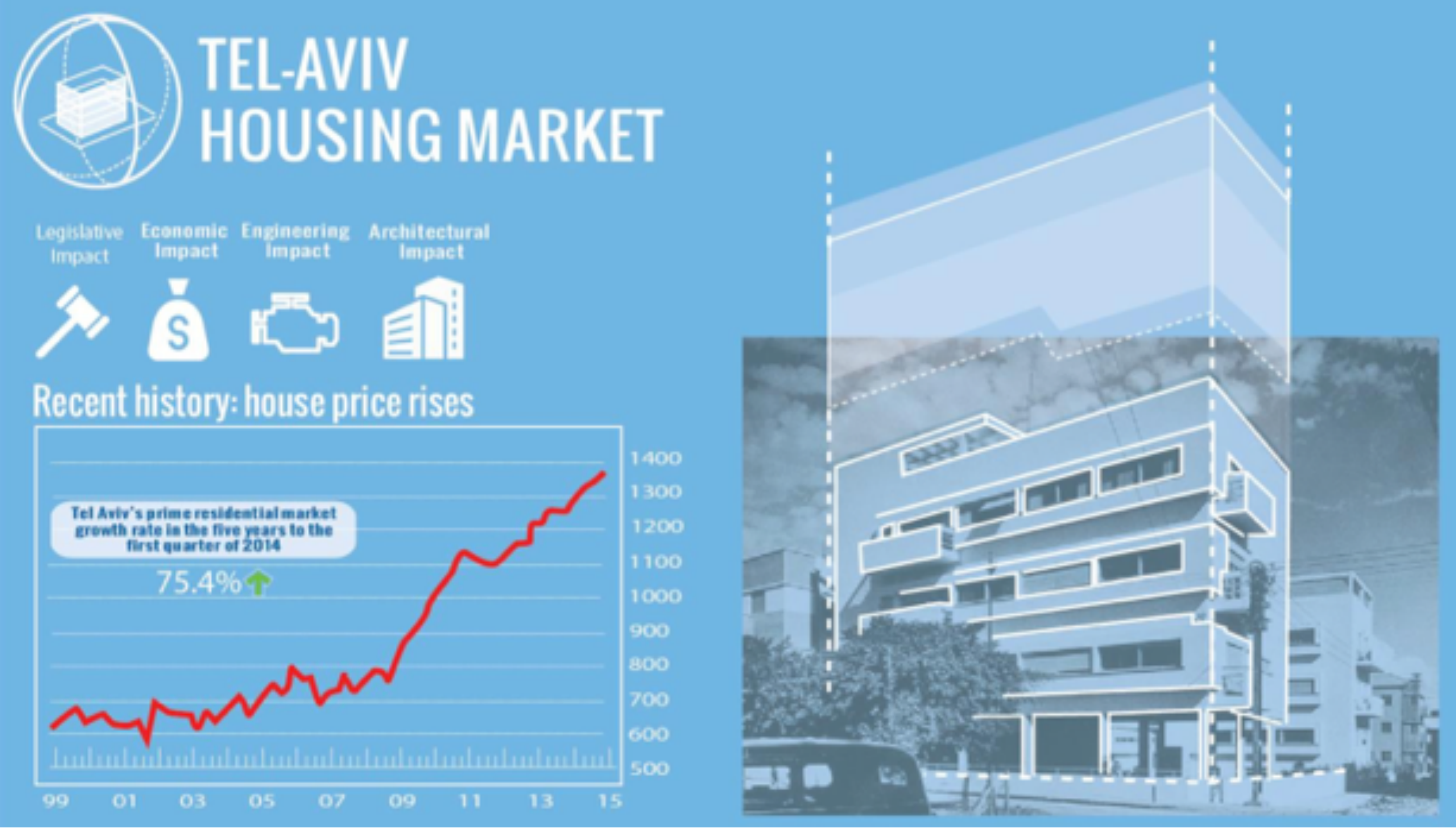
Yair Titelboim
Emily Royall

The White City

Yair Titelboim
Architect Practitioner

This project deals with the urban and architectural build-able potential of Tel Aviv. The objective was to develop a knowledge discovery database for the city – an interactive tool that visualizes various parameters of a site-specific destination and enables the personalization of building information for the benefit of multiple users. The project combines computational logic, architectural design strategies and urban data systems - meant to organize, simplify and personalize the complex procedures involved in creating democratized urban environments. This study details the chronological conditions that led to the conception of the platform project - designed to cross reference specific geo-spatial information extracted from different datasets with relevant limitations and restrictions derived from the new city building code database.

Tel Aviv's real estate market has experienced a significant influx of entrepreneurial multi-tenant condominium projects with a rise of 75.4% in real estate market prices over last five years. This phenomenon is a direct result of the National Outline Plan for Reinforcement of Existing Buildings against Earthquakes (NOP38). Approved by the Israeli government on April 14, 2005, this extensive plan details a series of guidelines for urban development across the State, detailing specific tax benefits and incentives for the propagation of private residential structural reinforcement. The importance of this plan was amplified by an expanding projectile threat following the second Lebanon war in 2006 and the events leading to the 2014 Israel–Gaza conflict. During this time over 5,000 rockets were launched into Israeli cities, including Tel-Aviv - causing much destruction and fear. NOP38 and its structural reinforcement protocols were actively promoted by the Israeli Defense Department, with the clear directive of securing both military and civilian targets within the city. The new and improved NOP38 policy draws influence from an important architectural element present in every home built in Israel in



the last 15 years - “Safety Rooms” (Merkhav Mugan) are secured residential spaces constructed from reinforced concrete, are therefore designed to support 2 objectives - structural support for the building in case of earthquakes and defending against a perpetual projectile threat.

By the end of 2012, the Tel-Aviv municipal government introduced a new plan to integrate NOP38 guidelines (called the Quarter Plan) interpreting the State's plan and incorporating specific city requirements for urban renewal into a series of detailed street sections. Not long after the introduction of the new city plan Tel-Aviv launches a new GIS system - the most advanced transactional (OLTP) system in the country - allowing relatively easy access to the city information database, making available detailed instructions and restrictions for individual lots. Predictably enough, this plan had a few undesirable side effects. One particular and frequent concern is the exceeding number of mediating agents that serve as translators for the new plan, and are continuously involved in the process of executing NOP38 urban renewal projects. These mediating agents, lawyers, developers,

architects, contractors, local and governmental authorities make the planning process ineffectual, cumbersome, difficult to manage, and exceedingly expensive as each stakeholder speaks a different language and interprets the plan accordingly. This problem could be mitigated by providing customizable accesses to an analytic forecasting system for buildable potential. Such a system could extract relevant information from public datasets and allowing for potentially limitless participants to take part in the transformation of the built environment by creating an interactive democratic tool that would help simplify the rules of urban engagement and encourage local and community oriented collaborations – essentially serving as a communicating device for neighbors to access information about their immediate environment.

With this system in place it would be easier to analyze the basic conditions necessary for the initiation and continuous articulation of NOP 38 type projects. Extrapolating site specific buildable potentials and cross referencing this information with both state guidelines and local site restrictions - affectively interpreting national policy, municipal restrictions, local environmental conditions and economic potential into a relational database management system. Working on this concept with residents, developers and city officials it quickly became apparent that this new system for intelligently extracting and analyzing contextualized geospatial information could have great economic value. This new platform Is designed as an analytical (OLAP) API oriented system (based on Hadoop \ SDI infrastructure which supports both SQL and distributed computing) – to allow a limitless report viewing of site specific "what if scenarios".

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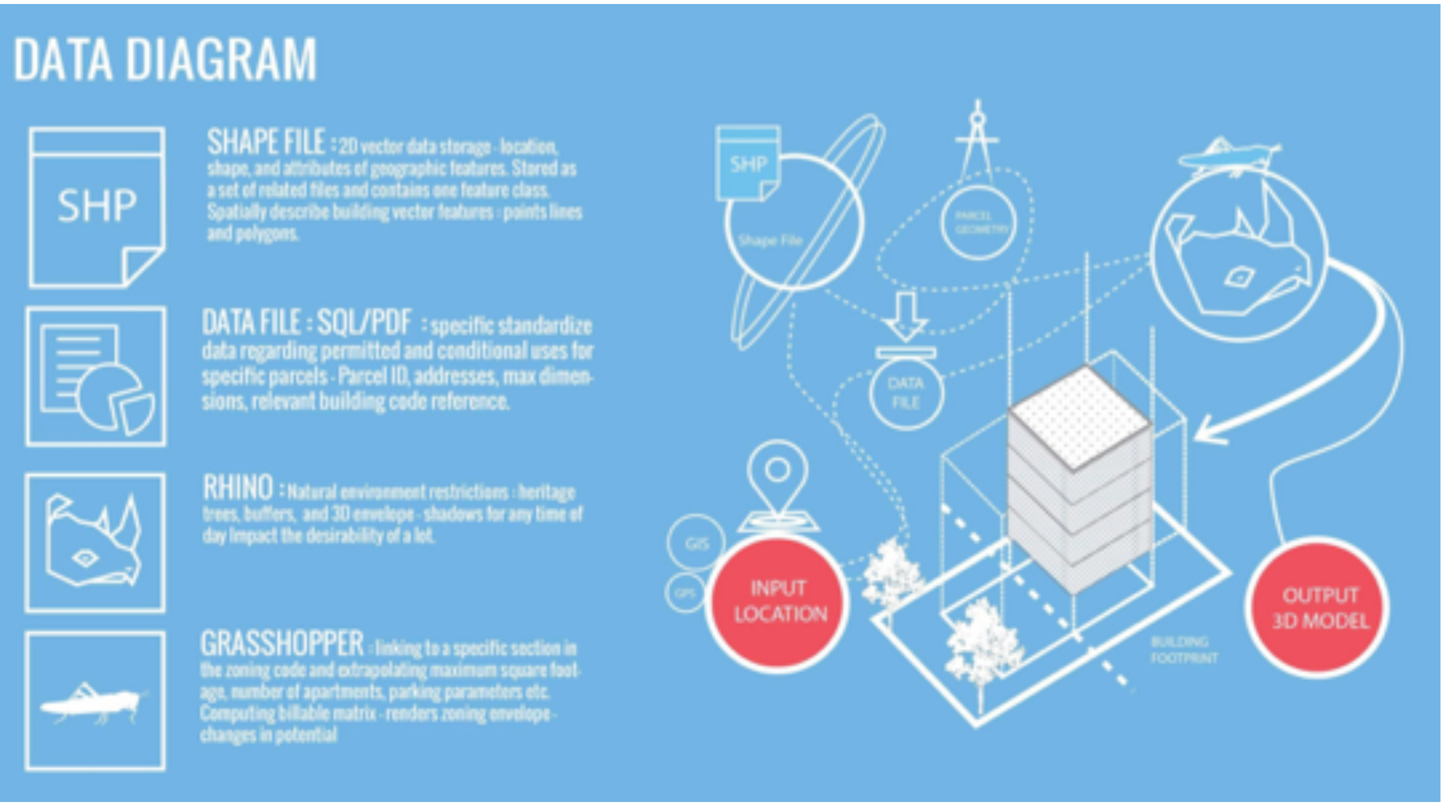
3. *Image 01*
4. *Image 03*
5. *Image 02*
6. *http://www.gdmc.nl/publications/2001/Spatial_data_infrasructure.pdf*
7. *http://video.esri.com/watch/3876/big-data-and-analytics-with-arcgis*



Epidemiology of Gentrification

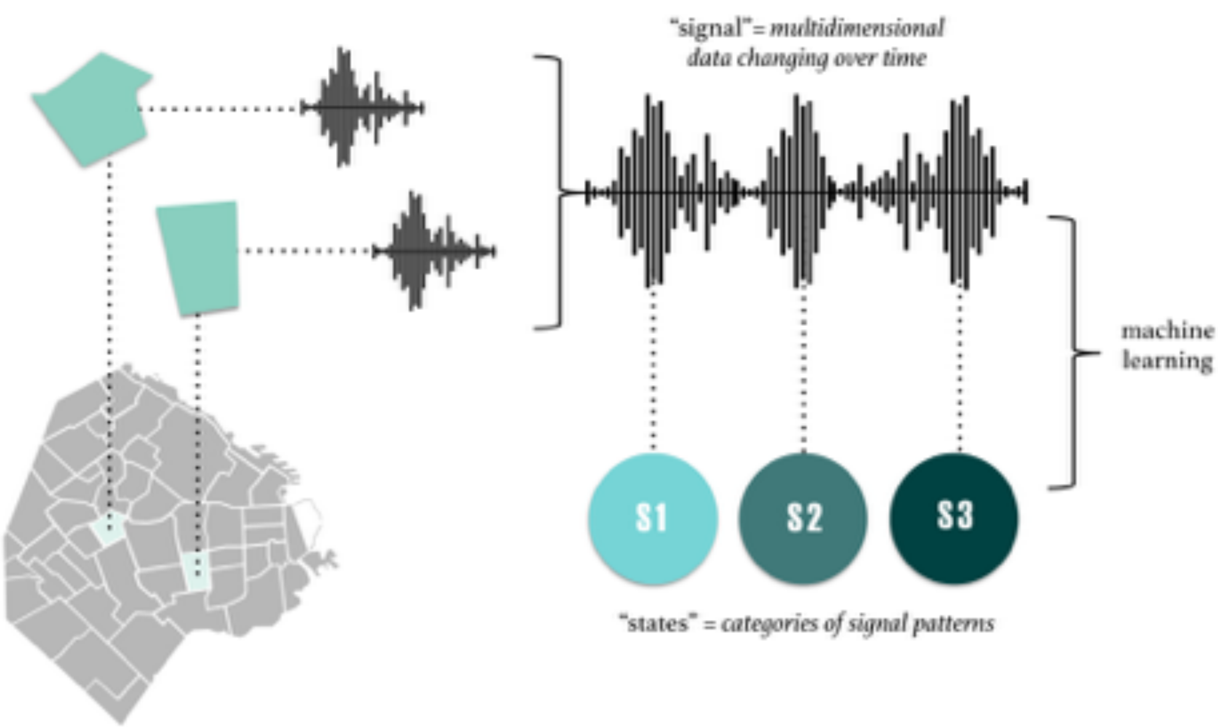
Emily Royall
Masters City Planning '15

"Do cities compute?" The question demands contributions from contemporary discourses in computer science, urban design, neurobiology and social justice, and articulates a concern with both the nature and artifice of cities as products of human perception. Even deeper---it implies a shared mechanism of information processing that binds the two. In a way, this project is more about understanding the question than finding an answer. Here I outline a theory and exploratory methodology for answering "Do Cities Compute?" as well as an application of the method to a contemporary urban challenge: gentrification. Like with any really good question, the findings point to more questions, and hopefully the *possible development of a design process capable of propagating human values in urban development by understanding urban phenomena as scalable human behavior*.

So what does this question mean? In the simplest terms, asking this question implies that information is processed by cities. But before we can understand this implication, we must first wrap our heads around what "Cities" and "Computing," are. In their most elemental form, cities are the artifacts of human adaption to environmental constraints. Simon outlines the boundaries of the artificial as being 1) synthesized by humans, 2) able to imitate the appearance of nature without being nature, 3) characterized in terms of functions or goals and 4) discussed in terms of imperatives as well as descriptives. 1-4 are certainly the case for the cities and urban design, where cities 1) only exist in the context of humans, 2) can appear natural but are not products of nature, 3) are historically discussed in terms of their "behavior", and 4) evolve to meet or dissent from political, economic or social imperatives. Artifice is understood to not be apart from nature (Simon, 1969), as artifacts cannot violate natural law and are adapted to human motives. Also central to the description of artifacts are the goals that link "inner" and "outer" environments (Simon, 1969). That is, an inner system is an organization of natural phenomena capable of attaining the goals in some range of outer environments (the surroundings in which it operates) (Simon, 1969; Rosenbluth, 1943). So, as artificial systems, cities can be understood as an inner system of goal-seeking phenomena subject to environmental constraint as experienced by humans. Cities are consciously or unconsciously designed and experienced by people, which adds a special quality to their artifice: they are the result of collective human perception, and implicitly, the *processes* that generate perception.

Processes that generate cognitive perception do so through information processing, or computation. In humans, information processing uses stimuli collected from sensory organs (vision, smell, touch, taste, and hearing), and compiles these into higher order cognitive functions, such as emotional states. Information processing occurs through "neuronal firing," or propagated transactions of electrical signals between cells in the brain (Purves, 2008). A complex transaction between neuronal firing in various brain centers determines certain forms of behavior, such as decision-making. This sketch represents a rough outline of how information is processed in the brain, which is one of many plausible forms of computation. Computer scientists and neurologists have further developed a suite of analytical tools to model how information is processed in the human brain. These tools primarily fall under the category of Pattern Classification or Machine Learning, which is a subfield of Decision Theory. The key objective of a pattern classification methodology is to recover generating mechanisms of an observed or sensed signal pattern. As such, they are particularly useful for the study of brain processes, learning, and complex networks.

I propose that to answer "Do Cities Compute?" we must apply the tools we use to model perception processes in order to understand cities as the outcomes of those perception processes. If cities are indeed the results of human perception, then they can be studied as such. Machine Learning is a suitable tool to this end as it finds mechanisms responsible for



computing observed outcomes. Furthermore as an evolving field, Machine Learning shows great promise in terms of providing countless new avenues of investigation into human perception, and the processes that generate it. I propose that a machine learning study of an observed outcome or urban phenomenon, is a plausible means of uncovering the mechanism that generates it, i.e., the hidden computational processes by which it unfolds.

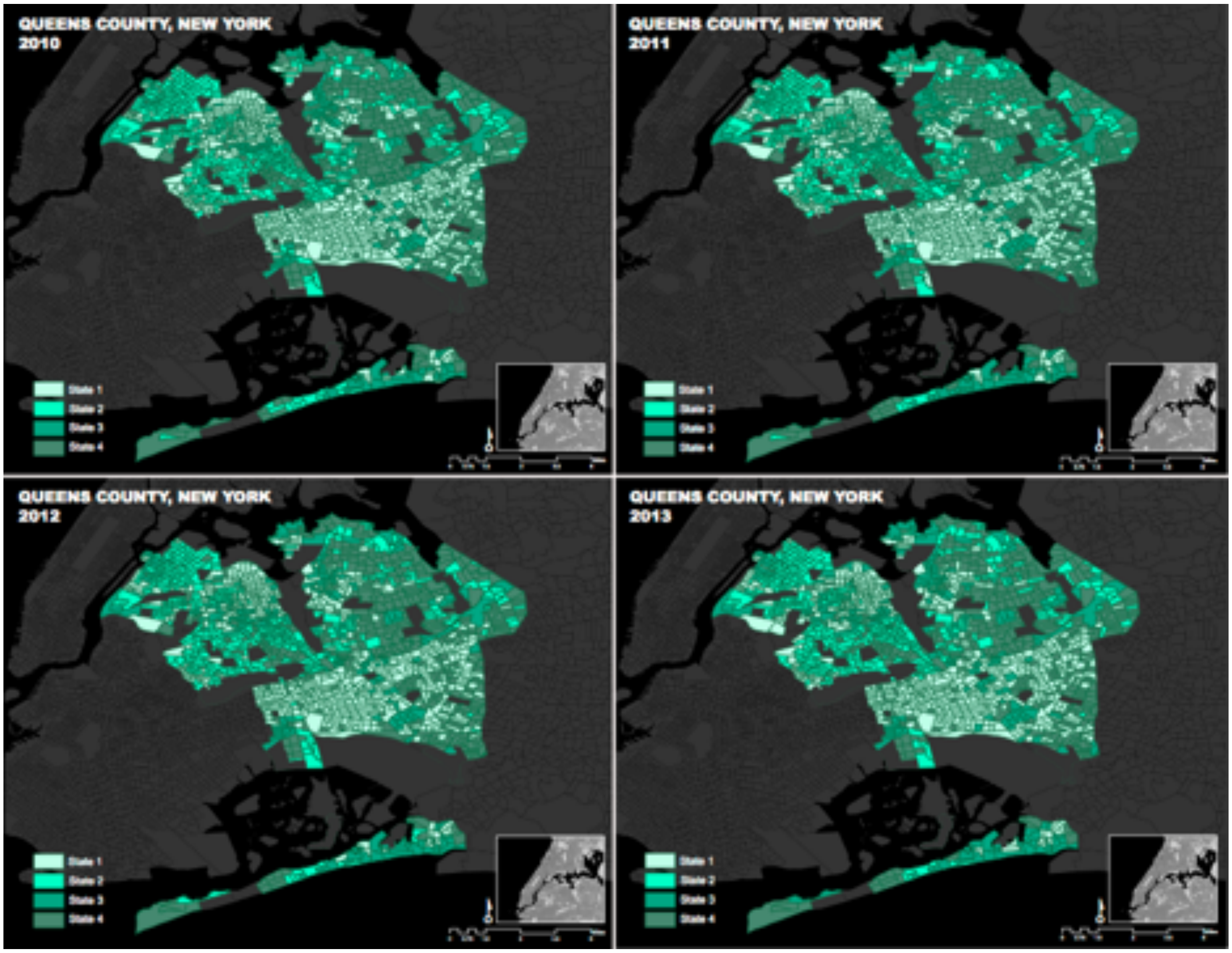
To demonstrate this possibility, I take gentrification as a case study and apply a machine learning methodology to analyzing it using hard data for the five boroughs in New York City.

Gentrification is viewed as both as a tool and a force--as a systematized vehicle for class based oppression and racism, and an empirical force of change based on social, environmental and economic interactions. This complexity makes it challenging for researchers to study the impact of gentrification, for planners to anticipate the effects of gentrification with planning policy, and for developers to foresee investment outcomes. Current planning policy addresses the symptoms of gentrification, without defining the underlying construct of the process.

I examined latent constructs of gentrification through a data-driven process that identifies emergent states of change and assigns them to a Markov process, i.e. a process that assigns probabilities to potential "state" changes over time. For census block groups in four boroughs of New York City, this model takes three steps: 1) cluster census block groups into latent states defined by ACS socioeconomic and demographic data, 2) derive a Markov model by tracking transitions between states over time, and 3) validate the model by testing predictions against historic data and qualitative documentation. Using this process I was able to

find emergent typologies of urban change, locate gentrifying neighborhoods without any spatial input, and uncover sequences of patterns that reliably predict socioeconomic outcomes at the census block group level. Through the design of a machine learning framework for gentrification I discovered the importance of using algorithms that learn rather than reproduce assumptions, the value of distilling large and complex data relationships into nuanced intuitions, and the challenges of embedding computational modeling in political frameworks.

A conceptual reframing of gentrification as the form of artifice described by Simon, lends it to computational study using machine learning---closing the gap between natural and artificial interpretations of the phenomenon. Furthermore, the history of computational analysis of urban change and gentrification, as situated in the political construct of Cybernetics emerging in Los Angeles in the 1970s, ultimately led to the demise of quantitative practices in urban planning and design (Light, 2011). I suggest that the



conceptual framework provided here, can help shift practitioners and theorists away from the historic pitfalls of Cybernetics and towards a more inclusive, genuine practice of computational analysis in urbanism. This perspective is drastically needed to ameliorate the "cultural split" (Portugali, 2006) between the natural and social sciences, and "space" vs. "place" perspectives of urban geography known to stifle innovation and progress in urban studies.

More importantly, gentrification is a condition of modern urban culture that is unsustainable for many communities around the world. Current policy frameworks combat gentrification by treating its symptoms: rent control programs insulate neighborhoods from urban change, stabilization vouchers try to assuage displacement, property tax freezes protect longtime residents from the effects of rising property values. Notably, many of these programs emerged under strenuous bureaucratic and political climates and are more or less successful given these powerful constraints.

Why does it matter? Mechanisms can be understood and redesigned, whereas symptoms can only be treated. Interventions should occur as a design processes at the mechanism level, not the surface level. Jane Jacobs said as much in terms of the direction future urban design should take:

"My idea, however, is not that we should try to reproduce, routinely and in a surface way, the streets and districts that do display strength and success as fragments of city life...if we understand the principles behind the behavior of cities, we can build on potential assets and strengths, instead of acting at cross-purposes to them."

Our job as planners and designers is to uncover the mechanisms or "perception processes" that generate the emergent outcomes we observe. In the case of gentrification, where the symptoms are so controversial and contribute keenly to the commodification and decomposition of cultures and communities, further study and action is desperately needed.

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1. *Such is the discourse of the Biomimetics movement, see Oxman; (http://www.materialecology.com/publications).*
2. *See Jacobs, The Death and Life of Great American Cities, 1961.*
3. *Brenner, Neil, Peter Marcuse, and Margit Mayer. Cities for People, Not for Profit: Critical Urban Theory and the Right to the City. London: Routledge, 2012. Print.*
4. *See Simon's treatment of the term in The Sciences of the Artificial (pg. 4); "Our language seems to reflect man's deep distrust of his own products...I am using 'artificial' in as neutral a sense as possible, as meaning man-made as opposed to natural."*
5. *The definition of computation itself is changing rapidly in the 21st century, as our understanding of both the brain and computer systems are growing, see: What is Computation? (Horswill, 2007).*
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Contributor Bios

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Andrea Chegut is a Research Scientist at the MIT Center for Real Estate. Andrea's research agenda focuses on the economic outcomes of innovative real estate products in commercial real estate. From green buildings and data centers to urban food farms and micro-apartments, she looks at the asset pricing, uptake and diffusion of new products in commercial real estate markets. In addition, Andrea works and publishes on the development of global property price indices and dynamic urban economics issues.

Andrea holds Bachelors in Philosophy and Economics, a Masters in Economics and a PhD in Finance from Maastricht University. As a teacher, she was the Academic Advisor to students for the Cornell International Real Estate Case Competition, and taught courses on Real Estate Finance and Economics and Corporate Finance and teaching assisted in Bond Markets and Securitization, Corporate Finance, Entrepreneurial Finance and Banking.

Emily Royall

Emily is an artist, technologist and urban planner. Her academic and artistic/curatorial work focuses on digitally mediated public space, dealing in particular with civic engagement & experience, and IoT. She focuses on opportunities for, and ethical implications of emerging technology that shapes our cultures, cities, and selves. This agenda has driven her to pursue projects for diverse clients like cities, slums, state governments and art galleries.

Emily holds a B.S. in Neuroscience from the University of Texas at Austin and a Masters in City Planning (City Design & Development) from MIT.

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Jamie Farrell

Jamie is a graduate student (2017 SMArchS Urbanism) at MIT and researcher at the MIT Sustainable Design Lab - previously at SMMA and Boston Architectural College. Jamie's work ranges from large scale urban simulations to coffee delivering robots. His research agenda is to explore the boundaries of the discipline while strengthen the core.

http://www.codeformed.com

Gizem Gumuskaya

Gizem is a cellist, architect, and currently becoming synthetic biologist, whose research focuses on creating systems that trigger novel means of communication between the agents of various scales from human to bacteria. She completed her Bachelor's Degree in Architecture at Istanbul Technical University in 2015, where she was focusing on designing urban sound responsive public spaces to foster dialogue between the inhabitants of a city. Her graduate work has been focusing on deploying and harnessing interactions in the built environment for developing bottom-up solutions to complex-emergent problems. She is expected to receive her dual master's degrees from MIT Department of Architecture, with a focus on Design Computation, as well as from MIT Department of Electrical Engineering and Computer Science, with a focus on Synthetic Biology, in 2017.

www.gizemgumuskaya.com

Daniel Fink

Hailing from Australia, Daniel is the former director of Urban Agency is a research and design bureau focused on computational approaches to large-scale urban development. He is currently a SMarchS 2017 candidate at MIT. Daniel received an M.Arch in Urban Design from Sydney University, and is the recipient of several awards including the UTS Open Agenda research grant and NSW RAIA Student Architecture award.

Yair Titelboim

Yair Titelboim is a professional architect and designer, graduated the Faculty of Architecture and Town Planning at the Technion - Israel Institute of Technology, Haifa with a B.Arch degree in 2012. Since graduation he worked for several architecture firms is Israel, China, and the US - focusing on data driven design methodologies and the way in which big data oriented hierarchies can assist in the process of decision making in the field of architecture and land development.

http://www.titelboimyair.com/

Dennis Harvey

While initially trained as an architect at Syracuse University, Dennis Harvey's curiosity has repeatedly led him astray from typical building design and construction. In the years following school, he did digital fabrication for the sculptor Diana al-Hadid, as well as urban design and computational façade design for Bjarke Ingel's Group. It seems he may have finally abandoned any hopes of a traditional architecture career after coming to MIT for a Master in City Planning degree. He currently works for the Sarah Williams of the Civic Data Design Lab on data analysis and visualization for web based mapping projects.

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