Hybrid connections
Computational mapping methodologies for Mexico City

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Abstract. The digital age is facilitating an ever increasing trend of globalized language and culture. Environmental issues are no longer a static concept as climate change and population growth force concepts of adaptability. What does this mean for the academy? How do we educate students to contemplate future urban scenarios and make some organization out of this more dynamic, complex future? The following paper seeks to disseminate a spring 2014 design studio at The University of Arizona where these issues were addressed, with Mexico City as a test bed. Computation has become a vital tool in the organizational process of these complex issues and big data. Various digital tools and platforms were explored in the studio to determine which ones would be most useful in modeling, mapping, designing and processing some of the complex relationships that are present in urban environments today.

Keywords: digital methodologies, urban design, complexity, hybridized networks, adaptability.

1 Introduction

Non-linear networks are central to the study of complexity in nature, with core disciplines in the areas of dynamics, information, computation and evolution.[1] Seeing our cities akin to living organisms that relate to the concepts of metabolic flows, self-organization and emergence are great role models for students to learn from. As humans have the ability to plan, think and design in a way that other forms of life cannot the design challenge today is to balance this ability for top down planning approaches, with some bottom up strategies that encourage adaptability in a more dynamic, humane sense. This implies the need to create hybridized, rich opportunities and design strategies that encourage increased diversity, on multiple levels, verses reductionist or top-down controlling solutions.

Globally there is a growing body of research relating to informal, more bottom-up communities as they become more pervasive across the planet. It is estimated that “by 2030, about 3 billion people, or about 40 per cent of the world’s population, will need
proper housing and access to basic infrastructure and services such as water and sanitation systems. [2] As research and definitions of informal communities develop, pre-conceptions need to be transformed. Positives of the informal sector are generally their economies, low ecological footprints and strong social structures with negatives being the lack of various infrastructures, public space and related health issues.

“It has been argued that the informal economy is neither good nor bad, it is simply a fact...a new knowledge of the city might emerge from a better understanding of the informal economy as a driving and determining force in major cities.” [3]

Mexico City is a great, example of a mega-city, with multiple environmental, economic and social inequity issues. The city’s growth is predominantly informal with the informal economy counting for 60% of housing construction and jobs[4], but unlike many informal regions of the world, several areas are hybrids of formal planning with informal growth.

One of the goals of the following fourth year undergraduate, architecture options studio was to introduce students from more traditional, top-down planned, western communities to the global informal sector. This was in part a pedagogical strategy to explore more sustainable hybrid design solutions; embracing environmental, economic and social issues on a level that had been previously unconsidered.

1.1 Data visualization methodologies

The design process began with research and readings on contemporary urban design theories and methodologies, as none of the students had any previous knowledge or background in GIS or working at an urban scale. Later this research became more focused on Mexico City. Theresearch was initially conducted from the United States, luckily with some fluent Spanish speaking students, with a physical trip planned for mid-way through the semester [5]. Students were allowed to work individually or in groups for the first time in a studio setting. The studio’s goal was to create design proposals based off the research, i.e. design as research. Intentionally, there were no prescribed design goals/limits at the outset of the studio, the pedagogical aim was to allow the analysis to dictate what the solution(s) should be i.e. it would emerge in a more bottom-up fashion directly from the specific research, hopefully in a more organic way than traditional design studio formats where a program and site are usually handed to students in a more top down fashion. This came from a desire to encourage more critical thinking and pro-active sensibilities from students; a necessary component today in a changing profession. It also seemed to mimic the complexity of urban conditions, that solutions could hopefully flow and emerge in a more bottom-up, self-organized way, with consultation from the top-down professor; a more team, hybrid teaching approach than the traditional autocratic one.

Simultaneous to the more theoretical research were assignments that allowed students the freedom and time to explore various digital methodologies that would help them obtain and visualize existing data on Mexico City. This step was crucial, although there are several required classes at the University of Arizona that teach
students various digital tools, there are no opportunities, prior to this class, where they are given official time to develop these skills in a studio design setting.

Today, as technology advances, there is an increasing emphasis on incorporating information and data into the design and analysis of the increasingly urbanized, built environment. Various ecological issues related to this shift have led to an increased desire for more performative smart cities and buildings and designs that focus on design drivers of behavior rather than pure form. "A second generation of digital architects and theorists are emerging who have placed an emphasis on open models of practice where the application of technology promotes technique rather than image."[6]

Data visualization or graphics is a fairly recent phenomenon that if well-designed, can be "the simplest and at the same time the most powerful" means of communicating [7]. Edward Tufte speculates that the recentness of the invention is perhaps because "of the diversity of skills required – the visual-artistic, empirical-statistical and mathematical"[8]. All of which are ideal traits for architecture students. Tufte continues to assert that "The purpose of an evidence presentation is to assist thinking" and that "Graphics reveal data. Indeed graphics can be more precise and revealing than conventional statistical computations."[9-10]

Digital visualization tools are a necessary component of understanding these complex urban conditions. Ideally we would have a 3d digital model linked in a live way to endorsed data sources. What if this does not exist? How do we work with information in a smart way if we do not have easy access to it and a limited amount of time in a semester to get and process the data? Various cities and countries have different strategies to their information, some have web-sites with various open source information. USGS sites are often a starting point for projects in the United States, but what about the rest of the world, where information may not be so immediate or cities that do not want to share their information? The following spring 2014 studio researched this scenario with Mexico City as a test bed.

It soon became apparent that relevant and desired areas of data were not available in convenient GIS shape files with geo-tagged information [11]. This meant that research was needed into finding new methodologies and processes to visualize this disparate information in order to help with the design process. These initial studies and goals were about determining a strategically designed focus/site for the future project and/or proposal by understanding the existing. The methodologies discovered, on reflection, are also relevant for global sites with ‘smarter’ existing documentation, as in this information age new sources and levels of data are continually becoming available to designers.

Initially one of the students, Cesar Rodriguez, looked at the growth and change of the density of the city over time [Figure 1]. Other census and environmental data was also researched, one of the best sources of data he found was in a published document with colored raster based image files [12]. Cesar initially created a matrix to overlay all the information against each other [Figure 2].
He realized he wanted a smarter way of analyzing these maps, beyond the visual, so he compared various ways of processing these images digitally. Initially he used the adobe software programs. Photoshop’s “Histogram Analysis” tool allowed him to see a range of color values within an image, which gave him a mean value for the various statistics. A further web-based analysis, called the “Image Color Extract PHP” allowed him to understand the percentage of pixels within an image that contained a specific color [13]. Both of these methodologies were slightly limited though, as they
were not relationship based i.e. they gave statistical breakdowns of the data, but one could not accurately analyze where specific information was located [Figure 3]. He was able to achieve this geographic relationship with the use of Rhino Grasshopper’s “Image Sampler”. Cesar created a script that related each color to various visualization tools. In the published example he created a concentration of circles whose diameter related to the geographic proximity of the color concentration. With this methodology multiple maps were overlaid to understand the proximities and/or main areas of interest. In this particular case he was looking for an area in transition from an informal to formal settlement [Figure 4].

Fig. 3. Digital methodology showing how raster based data could be analyzed and overlaid. (source: Cesar Rodriguez, B.Arch graduate 2015)
Fig. 4. Grasshopper tool: the size of the circle was directly related to the housing quality, i.e. larger circles designated more informal neighborhoods. The green area, Neza, shows the area selected by the student for further study (source: Cesar Rodriguez, B.Arch graduate 2015)

A student team, comprising of Joseph DiMatteo, Casey Kell and Joseph Miranda initially created maps as a way of identifying trends in various census data. This process began with “Live Tracing” pdf maps in Adobe Illustrator to gain vector boundaries and layers that were imported into Rhino. They simultaneously developed a three tier approach to issues of importance, based on their readings, related to various socio-economic and environmental factors affecting human needs [14]. This was created to provide a hierarchy and focus for their mapping data [Figure 5].
The rhino data was parametrized with grasshopper as a way of visualizing how neighborhoods had changed over time, by allowing parametric vectors to connect and show how geographical areas had physically moved and changed over time, utilizing the “Closest Point” grasshopper command. This enabled the fourth dimension to become part of this more dynamic, graphical equation. Ultimately maps were overlaid with each other and with other collected data relating to proximities of various infrastructural elements like water and transportation. This combined graphic database led the group to choose a site based on extreme diversity, they saw these as “tumultuous areas,” and the most opportune sites for implementing incremental change [Figure 6]. Even though these maps incorporated time into the equation, they were still two dimensional representations of two-dimensional data.
Fig. 6. Top row shows maps of existing conditions, the bottom row creates parametric relationships in Grasshopper from these conditions to show relationships and proximities over time. (source: Joseph DiMatteo, Casey Kell and Joseph Miranda, B.Arch graduates 2015)

High resolution Digital Elevation Models (DEM) of the site were found via NASA’s Shuttle Radar Topography Mission website [15]. Various open source tutorials were found on the web which showed how to create 3D topographical maps from this image based data, the most useful sites the students found were Harvard’s GIS manual and Ted Ngai’s “atelier nGai” site [16]. The data was extracted and meshed with Rhino and the freely available LandSerf tool [17]. LandSerf was preferred, especially for large sites, due to the ease of issues related to memory management.

Fig. 7. Topographic maps for Mexico City created with Landserf software. (source: Joseph DiMatteo, Casey Kell and Joseph Miranda, B.Arch graduates 2015)

Computational methodologies and tools are improving daily, with traditional architectural educational environments often being in a position of playing catch up to other fields. Interaction and inter-disciplinary work has become a necessary norm to combat these complex demands. Unfortunately in this particular studio there were no official collaborations with other disciplines, but there were various arranged field trips to stimulate the work. One of these was to a newly created department on campus whose focus was computer information and art. Here students were introduced to other web-based programs and the Processing programming language [18]. One student, Dulce Arambula took on this particular challenge to create her topographic maps through this interface and to start using the 3rd and 4th dimensional capabilities of this software to design network connections. Nodes were placed in an environment which would connect when they reached a defined degree of separation; conceptually she saw these as representing walkability and public transportation. The topographic map was layered with geological information and future precipitation data to start a hypothesis on how future water decentralization strategies could aid in sustainable futures[19]. The concept was that this decentralization would leave the city less vulnerable in a crisis, such as an earthquake etc. The nodes would also relate to essential infrastructural elements beyond transportation such as water collection, food production and bio-fuel generation. Depending where the nodes were related to the geology below, they would also help to replenish the aquifer. All these designs and methodologies were presented in a live, animation format.
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Finally, student Lisa Martinez used climate change data to select her site [20]. She selected the western region of Santa Fe in part due to this data and also for socio-economic reasons [Figure 10]. The area consists of geographical ravines that originally brought much needed water into the city from the mountains to the west. Projected data showed an increase of precipitation in Santa Fe, while decreasing in the rest of the city. Currently large parts of this area have become desirable, rich suburbs, with adjacent informal communities often pushed across or up the ravines in any available land, exasperating erosion and polluted run-off issues. This treacherous situation will doubtless increase with future population growth and rain.

Fig. 10. Projected future precipitation and vulnerable area overlay (source: Lisa Martinez, B.Arch graduate 2015)
Slope analysis was studied further using the Sonic plug-in for grasshopper [21]. It enabled Lisa to visualize how water would flow during rainstorms related to existing and/or proposed structures. Grasshopper was used to visualize the anticipated soil erosion related to these flows: the steepness of the slope and the degrees of curvature of the water paths were related to corresponding visual aids to emphasize these issues. This was also used as a methodology for anticipating how the water could be harvested, future positioning of buildings and relating hillside steepness to specific remediation and retaining strategies [Figure 11].

Fig. 11. Visualizing watershed and erosion (source: Lisa Martinez, B.Arch graduate 2015)

1.2 Findings

Map projections and distortions are a large topic in itself beyond the scope of this paper. It became clear that this differential in representation was an issue with the multiple sources of data that were found, but due to the large scope and hypothetical nature of the studio, this was not a major focus. Apart from mapping the more obvious forms of data, there were conscious efforts to make more invisible information visible, like pollution, future climate change, infrastructure below grade etc. This initial research portion was verified as much as possible when the studio visited the proposed sites in Mexico City. Apart from understanding the city fabric, systems and scale to another level, we were able to see issues that the virtual interface and remote location had not allowed. Traveling to the Centro de Abasto, the largest wholesale marketplace in the world, at 5am is hard to comprehend virtually [22]. We were also fortunate to meet with many local architects and urban designers who had more history and knowledge of the local issues including the leader of the new Urban Agency, Agencia de Gestion Urbana de la Ciudad de Mexico, Fernando Aboitiz Saro [23]. Here we saw the beginnings of their digital live information center and heard about specific concerns related to the City. Students were also able to present their project hypotheses and get feedback.

It was clear that this more research centric process, compared to typical architecture studios created a more emergent design process, where defining the problems and processes became more important than the solutions. Generally projects emerged that embraced the ideas of adaptability, agency and dynamism that the studio
had hoped to develop, with several students creating projects with elements of time and phasing, related to feedback loops into their final design proposals [Figure 12].

Fig. 12. Design proposal showing density network centered on transportation node, with aggregation logic diagrams over time to the top right. (source: Joseph DiMatteo, Casey Kell and Joseph Miranda, B.Arch graduates 2015)

1.3 Conclusion

Although architecture cannot resolve all social and environmental issues, especially in a semester, it is imperative for students to be exposed to the complexity of global issues. With increasing pressures from Universities and Professional Accreditation Boards for performance standards, it is important to allow room for exploration that is less deterministic. Students reacted very positively to this freedom and to the ability to travel internationally. Fortunately this particular studio had no specific accreditation demands related to the course, but there was still pressure to perform and show a ‘product’ at the end of the semester. Although this paper mainly focuses on the mapping methodologies, the design proposals that resulted were in most cases exciting, solution-based, relevant commentaries on our global precarious situation.
Big data and information is becoming more and more pervasive. Learning to be an active participant in this editing and software hacking process is key to ensuring the continued impact of designers on this creative process in our superficially more scientific environment. It is also imperative to understand that data, representations and software programs are not neutral entities. We need to understand the source of this data and the related ethics that may be in question [24]. Even though in this particular case none of the data was in the form of a live stream, there were creative ways of incorporating time into the design process to understand these issues in a more dynamic way, understanding that the model is always in flux.

This was the first studio that had a largely informal, mega-city, Mexico City as its focus. In part due to the proximity to Tucson, Arizona, it is hoped that this work will continue and be built upon to advance the knowledge and research in this increasingly important, complex area. Many of the mapping methodologies were also disseminated to lower level classes to aid in basic site acquisition information and modeling.

References
1. From the Santa Fe Institute’s Complexity Explorer online course, “Introduction to Complexity” taught by Melanie Mitchell et al. http://www.santafe.edu/
4. Ibid
5. This trip was intentionally designed to be very affordable, as many current opportunities for study abroad options in our program are cost prohibitive to many students.
8. Ibid
11. Various plug-ins for grasshopper currently exist to translate GIS data into its parametric platform, e.g. Meerkat GIS created by Nathan Lowe and Heron created by Brian Washburn
12. Information came from a study conducted by the Autonomous Metropolitan University, Mexico City. http://ocim.azc.uam.mx/
14. Their main influential text was Spatial Agency: Other Ways of Doing Architecture, by Awan, N., Schneider, T., and Till, J. (2011)
17. http://www.landserf.org/
18. https://processing.org/
19. Topographic map was created in Processing, methodology was helped by information from onformative, founded by Julia Laub and Cedric Kiefer based in Berlin, Germany. http://www.onformative.com/lab/creating-contour-maps/
20. Information found in an unpublished document created by the Mayor’s Task Force, (Leon et al)’ “Mexico Case Study Overview. Climate change, disaster risk and the urban poor: resilience

   This specific meeting was organized with the help of Jose Lever, the Director of the University of Arizona Mexico Office.