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**Local Code: The Critical Use of Geographic Information Systems in Parametric Urban Design**

Local Code uses geospatial analysis to identify thousands of publicly owned abandoned sites in major US cities, imagining this distributed, vacant landscape as a new urban system. Deploying GIS analysis in conjunction with parametric design software, a landscape proposal for each site is tailored to local conditions, optimizing thermal and hydrological performance to enhance local performance and enhance the whole city's ecology. Relieving burdens on existing infrastructure, such a digitally mediated, dispersed system provides important opportunities for urban resilience and transformation. In a case study of San Francisco, the projects' quantifiable effects on energy usage and stormwater remediation would eradicate 88-96% of the need for more expensive, centralized, sewer, and electrical upgrades. As a final, essential layer, the project proposes digital citizen participation to conceive a new, more public infrastructure as well.
1 Introduction

Between 1971 and 1974, it took Architect-turned-Artist Gordon Matta-Clark months of methodical sifting through microfiche to locate the fifteen vacant and moribund sites—fragments of New York real estate—that form Fake Estates: Reality Properties. (Matta-Clark et al., 2005) Using a contemporary geographic information system, or GIS, the same search can be accomplished in minutes, and locates thousands of marginal, city-owned vacant lots throughout the five boroughs of New York—or any other urban landscape (Figure 1).

When Matta-Clark’s Fake Estates were first presented together in 1992, the mere fact of their existence and documentation was cause for attention. Alleys, gutters, weedy no-man’s-lands, they are also spaces between organizational and informational space: virtual fragments as well as real. A détournement of property’s traditional media, Fake Estates is essential in considering how we might respond to the growing ubiquity of digital information about space and instrumentalize more, and better information in the digital practice of urban design.

2 Space and Garbage

One truism of historic computation borne by much of contemporary, data-driven architectural practice goes back to the very first days of programmable devices. In his Passages from the Life of a Philosopher of 1864, Charles Babbage recounts with incredulity, “On two occasions I have been asked,—’Pray, Mr. Babbage, if you put into the machine wrong figures, will the right answers come out?'” (Babbage 1855, 67) While the seeming certitude of data will lead even the finest minds to assume the infallibility of computing (Babbage’s questioners were Members of Parliament), the fact remains that the data-driven output of a computational (e.g., parametric) process is by many standards only as good as its input. The acronymic efficiency of 20th-century computing has reduced the principle to a single mnemonic, "GIGO" or "garbage in, garbage out."

At precisely the same time as Babbage was perfecting his differential engine, the physician and epidemiologist John Snow was seeking to alter the practice of medicine with the publication of his essay “On the Mode of Communication of Cholera” (Snow, 1855). Supplementing an earlier edition of the essay—which advocated germ theory for communication of the disease over the competing thesis of causation by unclean ‘miasma’—was a revolutionary map of the Soho district of London (Figure 2).
As well as showing the physical disposition of the neighborhood, the map was the first to spatially superimpose non-spatial data, in particular, cases of the water-borne disease. The clusters of cholera infection revealed a clear correlation to a single, contaminated water source, the Broad Street pump. (Johnson, 2006)

Even as it was for Snow and Babbage, the purpose of an informational practice is to manipulate, process, and superimpose data. And, when we give up the fidelity of vellum (or vinyl) for digital bits, we do so not for the cramped values that sampling brings, but rather for the myriad and newly fluid ways in which the resulting bits of data can be inter-related and transformed. Recent data-driven architecture, however, has focused almost exclusively on a virtuosity of output, and not on a critical examination of the data it ingests. While solar and other environmental variables have begun to shape digital architectural practice, many more, crucial possibilities exist. In particular, we propose to integrate the contemporary profusion of spatial data to imagine new—and potentially crucial—practices of digital design. (It should be noted that a related proposition is currently being proposed from the world of electronic mapping. ESRI, the largest supplier of GIS software, has recently unveiled a ‘Geodesign’ initiative, which while so far focusing on a simulation of the kinds of tracing exercises accomplished with layered acetate maps pioneered by Ian McHarg in the 1960s and 70s, holds the possibility of more data-driven design practice as well (see ESRI, 2010).

3 Formal and Geographic Systems

Facilitated by techniques of electronic map projection invented for America’s postwar nuclear defense, and forged in the mid-century optimism of systems-based planning, the first urban geographic information systems (GIS) appeared in the late 1960s and early 1970s (Smith, 1992). In 1966, the term ‘geographic information system’ was coined by British geographer Roger Tomlinson to describe an attempt to electronically map both agricultural resources and geographic boundaries for the Canadian government. (Maguire et al. 1991, 21-41). The techniques of digital cartographic projection used by Tomlinson, as well as Howard Fisher (another founding figure of GIS based at Harvard’s Laboratory of Computer Graphics), had their origins in display techniques developed for the Semi-Autonomous Ground Environment (SAGE), a nuclear defense shield developed by the air force from 1947 to 1958. (Redmond et al. 2000).
Half a century later, even as the provision of Web-based geospatial data creates fundamental changes in our relationship to place and proximity, a range of forces, including the rift between architecture and planning that is one of the legacies of failures in 20th century planning, continue to militate against the systematic use of geospatial data by architects. Even as some designers employ the power of digital cartography as a creative and political device (for example, Eyal Weizman or Laura Kurgan), our current ability to interrogate places using geospatial data remains substantially absent from the toolbox of digital design.

Given the foregrounding of parametric computation in today's architectural culture, and the growing trend to deploy parametric software at an urban scale, such an absence seems particularly curious. Perhaps here we should remind ourselves of the debt that today's data-driven practice owes to a quite different child of the 1970s, the 'autonomous' and formal practices which signaled Modernism's retreat from the broad claims of social and systems-based design. Forming part of Matta-Clark's own architectural education at Cornell University from 1962 to 1968, the methodology was ultimately held by him in violent disregard—most famously when he destroyed the windows of Peter Eisenman's Institute for Architecture and Urban Studies (IAUS) with an air rifle. (Jacob, 1985, 96) The violence of the act, at least for Matta Clark himself, deliberately recalled the abandoned, shard-shrouded interiors of New York's great modernist housing projects, which by the 1970s were far more abandoned and blighted than the ostensibly obsolete urban fabric they replaced. (Jacob, 1985, 95).

Gordon Matta-Clark's interest in such abandoned public realms returns us to his parallel, cartographic research, and to the prospect that a digital survey of urban leftovers could drive not just an exercise in curiosity, but an instrumental deployment of parametric design. As already illustrated, a digital search for leftover space in the modern fabric of New York reveals not just Matta-Clark's original discoveries, but over two thousand additional remnant lots, together forming an area larger than Central or Prospect Park. And, at least in this regard, New York is not unique. Analysis of other American cities shows a similar pattern—thousands of remnant parcels, and hundreds of acres of fallow public land.

4 Local Code : Real Estates

We have focused particularly on the case study of San Francisco, where we have not only completed a survey of city-owned leftover space (Figure 3), but also proposed a parametrically designed urban landscape proposal for each of the 1,625 spaces our digital analysis revealed.

The systematic invisibility of these sites is particularly worrisome when overlaid with other layers of public information. As in the case in many other cities, a study of data on public health and crime in San Francisco show abandoned sites to be precisely located in areas most in need of a safe and healthy environment. And perhaps also unsurprisingly, these sites are focused in areas most burdened by energy inefficiency, poor water management, and airborne contaminants (Figure 4).

Forming a distributed surface that rivals Golden Gate Park, a parametrically designed, land-banking renovation of these sites has enormous potential to relieve the very same problems the presence of the sites seems to track. Such a system would not only improve urban thermodynamic performance, but its distributed, modular, and incremental nature would vastly increase the resilience of the city's essential infrastructure. As Planners Peter Newman, Timothy Beatley, and others have observed, such distributed, resilient infrastructure will be essential to the survival of cities in the 21st century (Newman et al., 2009). It is to the design of such a proposal that we have explored new uses for, and connections between, Geographic Information Systems and Parametric Design tools.

5 Site Strategy & Parametric Design

A local model of water flow, sun, and wind movement parametrically govern the dispersal on each site of a range of hardscape and softscape, precisely mediating air quality, drainage, and energy loads, to enhance not only the site's performance, but that of the whole city. Established models of thermodynamic, drainage, and insolation are used to analyze each site in ArcGIS. This data is then transmitted, along with the geometry of the site's context, to the Grasshopper parametric plugin for Rhino, where Visual Basic and C# components allow the integration of such data with the creation of a fixed local geometry that maximizes energy-performance on a site-by-site basis (Figure 5).
Figure 5. Site Analysis and Parametric Form Determination. ArcGIS Analysis mapped into Grasshopper/Rhino modeling scripts.

Figure 6. Community Interface Prototype (with Berkeley Center for New Media).

Figure 7. Final Design Proposal for a selection of San Francisco Vacant Lots (detail of selected sites).

Figure 8. Parametric Funding Diagram, San Francisco Case Study (200 sites highlighted; savings in grey).
Once each site's urban performance is maximized, its design can be engaged and extended for local benefit. Based on existing models of community design, as well as new research on digital democracy (See, for instance, the Berkeley Center for New Media's Opinion Space project, http://www.opinion.berkeley.edu). We envision the use of place-based media to gather opinions, engage communities, and even aggregate finances and funding. A prototype interface developed with the Berkeley Center for New Media shows an online system used as a structured forum for each project's development, as well as a resource for design and implementation (Figure 6).

6 Precedents & Policy

Our final proposal for San Francisco (Figure 7) draws substantially from established and important precedents in neighborhood greening at the local scale—including projects in Los Angeles, Chicago, and Baltimore.

These efforts, however, have been justified on substantially social and political grounds. Through parametrically optimizing the energy performance and water storage and remediation potential of these sites, however, we can make a policy argument that such social and political benefits should be funded on the basis of global performance, as well as local sustainability. As but one example of such a justification, a 1.5 billion bond measure was approved last year to upgrade the capacity of San Francisco's combined sewer system to better manage peak flow (The San Francisco Sewer Master Plan, currently under environmental review). Using established engineering metrics and the parametrically-derived form of each of our 1500+ design proposals, we estimate that between 88 and 96 percent of this investment could be replaced by the surface spending we propose—at half the cost of underground work. These calculations are based on established assumptions about urban stormwater flow and mediation (SFPUC, 2003; Moll, 2002; McPherson et al., 1994; Chau, 2007).

We are especially confident in these projections because a large component of the 'code' of local code mediates funding, as well as form. In this illustration, 200 of the 1625 sites considered in our case study are parametrically funded according to maximum infrastructural impact, as well as the specific availability of location-based grants, such as from Caltrans (Figure 8).

7 Life and Cities

An essential caveat to this system-driven process, however, is provided both by a previous generation of architectural practice, and by the intriguing inaccuracies in today's parametric design discourse.

Gordon Matta-Clark's father, Robert Matta, had worked for two years in the studio of Corbusier before rejecting the master's work as suitable only for a (nonexistent) 'creature that lived in perfect harmony with the society and his work' (Miller, 1982, 19) Matta-Clark traced his own interest in adaptive reuse to the observation that 'the availability of empty and neglected structures [is] a prime textual reminder of the ongoing fallacy of renewal through modernization' (Matta-Clark, 1974).

One of Matta-Clark's last, unfinished works was the physical construction of a community centre on an unused site on Manhattan's Lower East Side, for which he was preparing a proposal at the time of his death in 1978. Matta-Clark described the audience for his own community centre proposal as precisely 'a network of community groups and individuals engaged in open space and rehab projects, sweat equity, community gardens, playlots, cultural events, alternative living structures, etc', adding that the proposal 'has brought these groups together' (Matta-Clark, 1976).

Matta-Clark's use of the word 'network' is notable. At the same time, as he engaged his own design work more and more with the real and social fabric of cities, Matta-Clark also became intrigued by, what was at the time, the state-of-the-art in digital practice. For a nascent project, combining urban pneumatic architecture into what Matta-Clark termed "network enclosures," the artist wrote shortly before his death to both MIT and UCLA requesting use of digital architectural, mapping, and visualization software (Piere, 1975), declaring the use of computers "a part of my search to chart and reoccupy space" (Matta-Clark, 1975).

Today, much of contemporary algorithmic design borrows a network language, particularly the language of complex, non-hierarchical natural systems. One of the earliest critics to connect such biological theories of emergence with urban design was, like Matta-Clark, a student of Manhattan.
When, in the last chapter of her 1961 opus The Death and Life of Great American Cities, "The Kind of Problem a City Is," urban activist Jane Jacobs sought to articulate a metaphor for urban planning distinct from the "collection of file drawers" (Jacobs, 1961, 428) she abhorred, she turned to recent work at the Rockefeller Institute, which had provided her with funding and an office to assemble her manuscript. There, her neighbor, Dr. Warren Weaver, had specifically identified new thinking in the Natural Sciences describing "organized complexity" (Rockefeller Foundation, 1958). Quoting from Weaver's essay, Jacobs makes a case for the special affinity between urban landscapes and biological systems. Invoking the example of a single urban park, she submits that any attempt to isolate the variables, however many, leading to the success or failure of an urban enterprise is inherently dubious and akin to reducing life itself to mathematical variables. Even if possible, such variables are too numerous and interconnected to give an exhaustive picture of success of failure.

8 The emergent discourse of parametric design

Warren Weaver, and the Rockefeller Foundation's efforts played a catalytic role in today's interdisciplinary discussions of emergent form. This contemporary revolution in life sciences, much like the revolution in cybernetics and systems controls of the last century, is currently having its effects on the rhetoric and technique of the architectural profession, most notably in digital proposals for architecture and urban design.

In several best-selling monographs, (Hensel et al., 2004, 2006) the Emergence Design Group at the Architectural Association in London have laid forth an explicit agenda of "morphogenic" architecture, relying on "data, genes, and speciation." (Hensel et al., 2004, 40) In a 2004 essay, Karl Chu, head of the Institute for Genetic Architecture at Columbia, declares, "We are now in a position to articulate a more comprehensive theory of architecture, one that is adequate to the demands imposed by the convergence of computation and biogenetics . . . a monadology of genetic architecture." (Chu 2004, 86) And, in a recent essay advocating parametric design at the urban scale and a general "parametricism," Patrick Shumacher affirms that the "danger of overriding real-life [urban] richness is minimized because variety and adaptiveness are written into the very genetic make-up of parametricism" (Shumacher, 2009, 22).

The apparent systematic quality of biological systems, however, may turn out to be just that. Recent work in evolutionary biology has gone so far as to assert that "although mutational change [that is, change in genetic instructions] is needed for phenotypic change [change in the visible architecture of life], the two are simply not related" (Jurscner & Gerhart, 1998, 420-27). "Genes," it is revealed, "may have an effect on the phenotype, but this effect strongly depends on other genes" (de Visser et al., 2003, 1959); which is to say that the relationship between genetic content and resulting form, far from occurring measurably, are interconnected, numerous, and as Jane Jacobs said of urban variables, "as slippery as an eel" (Jacobs, 1961, 433; Wagner, 2005).

9 Conclusion

As is increasingly revealed, genes do not perform directly, or even transitively, but rather through a complex web of shifting relationships, disturbed even by our own observation of them (Piatagorsky, 2007). While revealed through modern digital tools, a contemporary biological picture of the organism turns out to resemble much less a deterministic, virtual, and digital space, and much more space as we experience it—especially the contingent, adaptive, and emergent fabric of the city. Such a vision of the city as contingent, adaptive, and evolutionary is provocatively reinforced by recent scholarship that relies on the same GIS data that supports Local Code.

Recent studies on urban form, infrastructure, and even intellectual productivity have revealed uncanny parallels between biological systems and the robustness and morphology of urban systems that occur under any number of superficially imposed design strategies (Bettencourt et al., 2007). In such a context the city is not, as was proposed first by Norbert Wiener in 1950, simply an "information …system," to be in turn manipulated by data (Wiener, 1951), but rather, a contingent, emergent, and adaptive system that will often thrive not as a result of our best design efforts, but, often, despite them. With its attempt at the catalytic, and systematic processing of urban data, it is to this vision of the city that Local Code aspires.
References


Matta-Clark, G. undated and unaddressed proposal, c 1974, Estate of Gordon Matta-Clark.