PARASITICAL ANALYSIS IN THE BUILT ENVIRONMENT: SCALES OF COMPLEXITY

Mike Christenson[1]
[1]North Dakota State University, Fargo, North Dakota

ABSTRACT: The built environment is a complex physical record created by people over time, and as such, it necessarily embodies contradictions and competing agendas. As part of the larger project of architectural epistemology, this research seeks to bring new technologies to bear on the built environment, as unique means of generating, structuring, exchanging, and activating architectural knowledge. To this end, the research describes and tests the method of parasitical analysis of digitally modeled built environments. As an analytical method, it is fundamentally comparative, effectively constituting a means of "reading" a digital model by indirect means. In order to illustrate the method, I consider a chronologically organized digital model of the Pruitt-Igoe housing project in St. Louis, Missouri. Pruitt-Igoe. Due to its chronological organization, the model contains geometry representing two distinct conditions, i. e., "before" and "after" the demolition of historic structures and construction of the Pruitt-Igoe housing project. Each of these conditions is subjected to parasitical analysis and the results compared. While parasitical analysis does not promise to resolve the multidimensional questions and contradictions embodied by Pruitt-Igoe, it nevertheless holds promise as a unique analytical method.

KEYWORDS: Parasite, Pruitt-Igoe, algorithmic design, architectural epistemology

INTRODUCTION

Urban environments are characterized by collisions between old and new, or collisions between competing agendas and between conflicting political desires. The well-known and now-demolished Pruitt-Igoe housing project in St. Louis, Missouri provides a potent example of just such an environment. The area formerly occupied by the Pruitt-Igoe project, north and west of downtown St. Louis, is generally bounded on the north side by Cass Avenue, on the south side by Carr Street, on the west by Jefferson Avenue, and on the east by North 20th Street. Prior to its near-complete demolition for the project in the early 1950s, the then predominantly African-American neighborhood contained mixed-use buildings including two- and three-story multi-family apartments, single-family detached and semi-detached houses, retail, warehousing, and some light industrial structures. In order to make way for the Pruitt-Igoe project, all of the buildings in the neighborhood were demolished with the exception of the St. Bridget of Erin Catholic Church (built in 1859 and demolished in 2016) and St. Stanislaus Kostka Catholic Church (built in 1891 and in use as of 2017), together with some minor structures ancillary to each of the two churches. The presence of the two churches in the neighborhood reflected the area's earlier Irish and Polish immigrant populations. Following the demolition of the historic neighborhood, the Pruitt-Igoe housing project, consisting primarily of 33 11-story midrise apartment buildings, was constructed on the site. The entire project (with the exception of its four-story public school) was abandoned and demolished within twenty years of its construction. The site, still largely vacant, has seen only incremental development since 1975.

Contemporary discourse widely characterizes Pruitt-Igoe as a politically charged and contentious project existing at the intersection of racial segregation, government involvement in public housing, economics, architectural design, and urban planning (Newman 1972, Bristol 1991, Birmingham 1999, Heathcott 2012). Scholars and designers of the built environment have much work to do before all of the divergent, politically charged questions surrounding Pruitt-Igoe can be adequately articulated, let alone answered, whether this attempt is grounded in history or carried out in a politically and emotionally intense contemporary social context (Ferguson 2015, Benton 2017). My research, while purposefully narrow in scope, proceeds with the expectation that relevant questions concerning Pruitt-Igoe can be productively highlighted and foregrounded through the use of digital technology, at least to the extent that they are embodied in digital models of the project buildings.

In this research, I define *parasitical analysis* as a set of methods for propagating forms within digital models and then subjecting these forms to analysis, with the aim of disclosing latent attributes of the models under study. I have chosen the term parasitical analysis purposefully, with the intent to convey that the method is analytical rather than form-generative, and moreover, that the propagated forms result from a direct, i. e., a "parasitical," reading of the initial model, i. e., the host. As a specific mode of algorithmic analysis, *parasitical analysis* constructs additional geometry within the digital model in response to the geometry that already exists; it relies on a very simple algorithm to generate form. The algorithm is parametric in that its basic structure can be made responsive to varying input. The additional geometry thus created can be defined as a *parasite* because it effectively depends on the host model for its structure and support, and its exact configuration depends on its ability to "read" the host structure and respond to what it encounters.

In summary, the research described in this paper seeks to position parasitic analysis as a mode of inquiry capable of revealing otherwise undisclosed, yet potentially significant and highly charged, differences between two sets of given conditions. Emphatically, it is not proposed as a comprehensive analytical method, but rather as a highly specific approach to reading and comparing models, in the hope of foregrounding latent attributes of the models and the environments which they represent. In a larger context, parasitical analysis is generally positioned as a part of the larger project of *architectural epistemology*, which inquires into the ways in which architectural knowledge is produced, structured, represented, and disseminated. It is an ongoing attempt to recover, from within a contemporary realm characterized by exuberant visual and formal complexity, a set of very old ideas concerning the mutually constitutive relationships between medium, thought, and act.

1.0 THE METHOD ILLUSTRATED

The basic methodology of parasitical analysis can be conceptualized as the production of endwise-connected rays within a given boundary; these rays in turn are used as the skeletal basis for modeled form. The first part of the method – the production of rays – can be thought of as like the tracing of a billiard ball's trajectory on a frictionless table, assuming that the ball rebounds from the table's cushions at an angle equal to its angle of incidence. The number of bounces can be allowed to continue until a defined threshold is reached, thus defining an arbitrarily long trajectory (Figure 1).

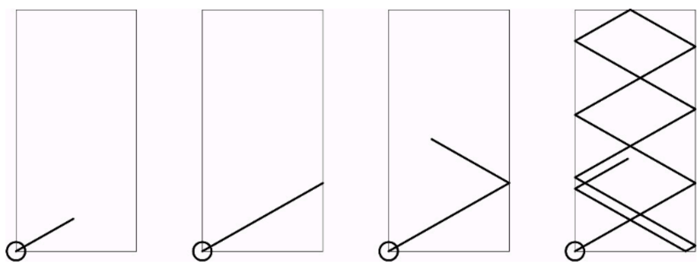

Figure 1: The "billiard ball" analogy, showing (from left) the initial trajectory, a collision with a cushion, a bounce, and the developed trajectory after 10 bounces.

It should be obvious that if the ball begins its journey in a different direction, or from a different location, different trajectories will result. This is also true if the boundary is reconfigured while keeping other variables constant (Figure 2).

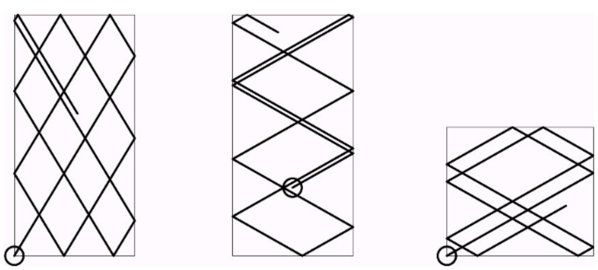

Figure 2: Variables leading to multiple trajectories. From left: same table as Figure 1, but with a different initial trajectory; same table with a different starting point; different table.

Two additional variations to the basic methodology are significant for the present discussion. First, obstacles (analogous to bumpers) can be introduced within the boundary, and second, the boundary need not be continuous, i. e., holes or openings (analogous to pockets) can be introduced. The ball's trajectory is affected by internal obstacles in the same way as it is affected by the external boundary, and should the ball's trajectory cause it to pass through an opening, the process stops.

In particular, we can define a boundary that represents the floor plan or section of a building (Figure 3). As with the simpler analogue, differing trajectories can be brought about by small changes to the initial "seed" location, the initial direction, and any changes to the boundary.

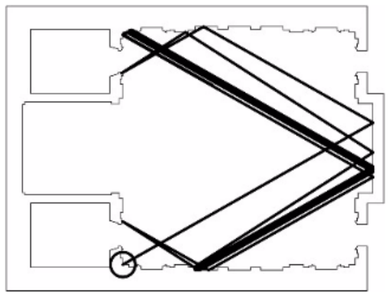

Figure 3: Floor plan as a boundary.

The production of rays within three-dimensional space can be conceptualized as tracing the path of a moving particle which encounters reflective surfaces within a spatial volume (Figure 4). Once again, the parameters of initial seed location, initial trajectory direction, and the manifold configuration of the boundary result in an arbitrarily large number of possible distinct trajectories. Just as the two-dimensional case can correspond to plans and sections, the three-dimensional case can correspond to three-dimensional models of architectural form (i. e., buildings or neighborhoods).

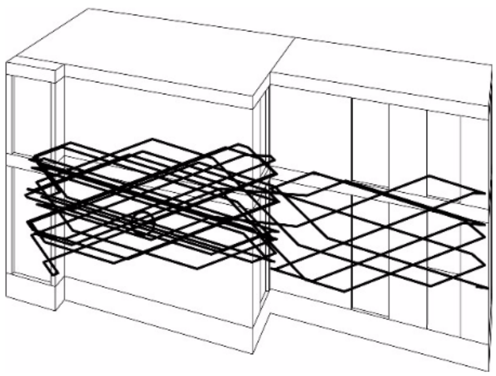

Figure 4: 3D digital model as boundary.

Finally, consider any given trajectory T1 produced within a digital model. The trajectory consists of several endwise-connected vectors (V1, V2, ... Vn) such that the entire trajectory has length L1, i. e., it is a three-dimensional polyline. Several trajectories (T1, T2, ... Tn) can be averaged for length, number of "bounces," and so on. Furthermore, any set of two or more trajectories can be *lofted* in order to create modeled surfaces (Figure 5). In this respect, the trajectories form the skeletal basis for modeled form in three dimensions. These aggregated data and modeled forms make up the raw material for analysis.

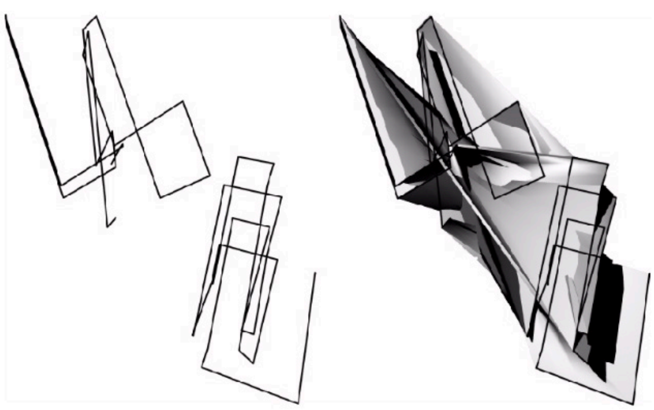

Figure 5: Lofting. At left: two trajectories. At right: Lofted form.

2.0. THE METHOD IN ITS SCHOLARLY CONTEXT

Considered generally, an algorithm or series of algorithms can be capable of revealing latent attributes of an existing building. I discuss such an approach in Christenson (2009), in which I compare the processes of parametrically modeling two buildings in terms of meaningful (digital) parameters and their associated semantic relationships, resulting in the foregrounding of certain latent qualities. Similar approaches, related specifically to parameterization, are also evident in Burry & Burry (2006), Potamianos & Jabi (2006), Barrios (2004), Barrios (2005), and Potamianos, Turner, & Jabi (1995). The method of parasitical analysis is positioned as a unique means of generating, structuring, exchanging, and activating architectural knowledge. Despite its unique approach, the method borrows from other research and design such factors as *aggregation phenomena* (Branzi 2005), *weathering* (Mostafavi and Leatherbarrow 1993), *repurposing* (Brand 1995), and *appropriation* (Papalexopoulos 2003). The method as described here also shares some features with the tools of Space Syntax research – for example, *isovist analysis* (Benedikt 1979) – because it involves the production of graphical information within models or drawings in order to facilitate analysis of the built environment. Additionally, parasitical analysis shares some features with algorithmic modeling, because it relies on algorithms (for example, as initiated with Grasshopper) to produce form.

The present research also proposes three distinct characteristics of parasitical interventions: *infiltration*, *resistance*, and a mechanism or process of *self-propagation* for new geometry. *Infiltration* refers to the possibility of thorough inhabitation or propagation within an existing model (i. e., as distinct from attaching to the surface of an existing model). *Resistance* refers to the possibility of parasitic geometry to recognize the simultaneous resistance and support of its host: it needs to be seen to push against the host model, and the host shown to be capable of resisting, sustaining, or steering the parasite's propagation. Finally, a mechanism for *self-propagation* means that there should be a simple algorithm or set of rules (e. g., a Grasshopper definition or a procedure in Rhino) guiding the process of the parasite's growth or its extension through and beyond its host.

To expand on the distinction between forms of knowledge and novel architectural form – both of which allow for, and indeed encourage, the possibility of complexity – this research acknowledges a debt to contemporary research and design strategies aimed at generating architectural form from various inputs (Shi and Yang 2013), or as a means of integrating performance requirements (Turrin, von Buelow, and Stouffs 2011), or as a strategy for optimizing a solution space (Besserud and Cotten 2008). Furthermore, parasitical analysis shares some aims and strategies with researchers who rely on algorithmic techniques to reveal design principles specific to a body of work (Gomez de Silva Garza and Maher 2001) or principles of a building's structural behavior or energy performance (Díaz-Vilariño, Lagüela, Armesto, and Arias 2013).While the formal results of parasitical analysis share some attributes with contemporary algorithmic design, the research method is firmly intended to constitute a *way of seeing* rather than a *way of building*. Thus, it seeks to position parasitical analysis as a hybridized approach in which techniques usually associated with form-generative design are employed for analytical purposes.

3.0. APPLICATION OF THE METHOD

3.1. Pruitt-Igoe as a Test Case

Parasitical analysis facilitates comparison between models, although as mentioned, the comparison is not necessarily accessible in quantifiable terms. Yet, fundamentally, the main use of parasitic analysis is comparative, and to illustrate this, the research described here compares two different conditions at two different scales. The specific choice of comparable examples – in the case of this research, selected "before" and "after" conditions at Pruitt-Igoe – derives from two radically differing motivations for structuring urban space. On one hand, parasitical analysis is tested against a "before" condition representing a typical nineteenth-century urban neighborhood, characteristically dense, finely-scaled, low-rise, and high-density. On the other hand, the method is tested against the "after" condition following the demolition of the historic neighborhood and the construction of the Pruitt-Igoe project – a powerfully expressed example of twentieth-century large-scale, mid-rise, high-density housing. Both "before" and "after" conditions are tested at different scales (neighborhood scale and room- or building-scale) using representative digital models from two years: 1917 (prior to the demolition of the historic, pre-Pruitt-Igoe neighborhood) and 1967 (following the demolition of the historic neighborhood, but prior to the demolition of the Pruitt-Igoe project).

3.2. Application of the method at the district scale

Given the two digital models of the district, a grid of *seed points* is established. Each seed point serves as the origin of a *seed vector* indicating one of several initial trajectories to be studied. The disposition and configuration of the seed grid is arbitrary, and as discussed above, different choices of seed location and initial trajectory direction should be expected to produce different results. However, for purposes of comparison the two conditions should be studied with identical seed grids.

Any seed point which falls within the plan outline of a building is ignored in further calculations, and seed points which fall outside the perimeter being studied are similarly ignored. Once the seed points are determined, the bounce algorithm is initiated for all seed vectors (Figure 6).

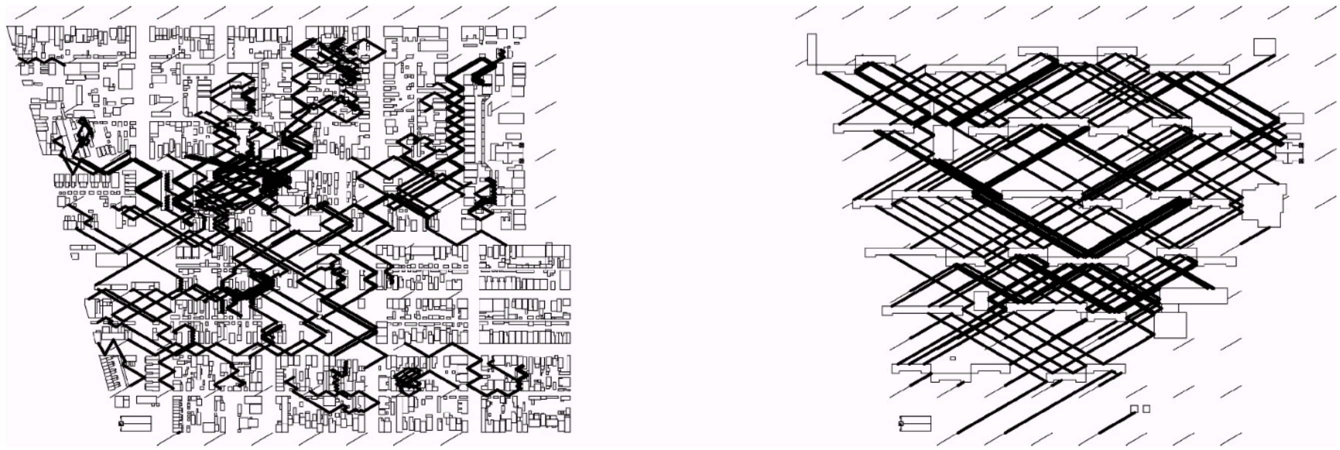

Figure 6: 1917 condition (left) and 1967 condition (right), showing bounced trajectories.

Finally, the resulting bounced trajectories for each condition are lofted to produce a three-dimensional form (Figure 7).

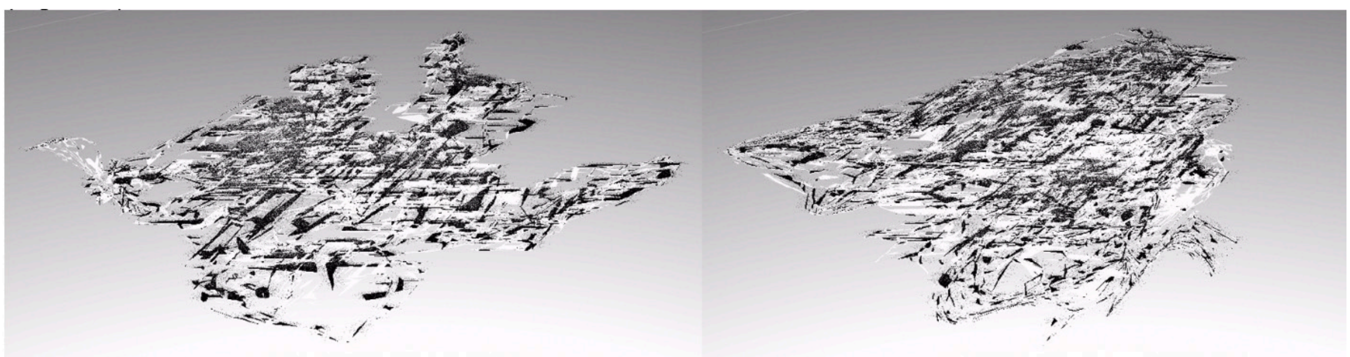

Figure 7: Forms resulting from lofting the trajectories shown in Figure 6 for the 1917 condition (left) and the 1967 condition (right).

3.3. Application of the method at the building scale
The method can also be applied to a digital model of a group of rowhouses along Jefferson Avenue (prior to the demolition for Pruitt-Igoe) and by comparison to a digital model of a residential building in the Pruitt-Igoe project.

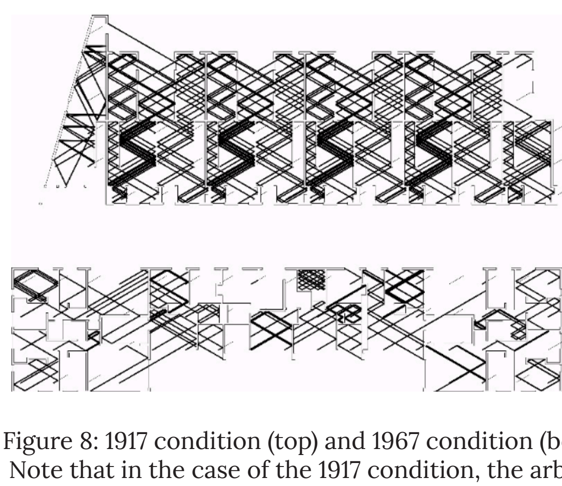

Figure 8: 1917 condition (top) and 1967 condition (bottom), showing bounced trajectories.
Note that in the case of the 1917 condition, the arbitrary module for the seed grid coincides with the module of the rowhouses. This has the effect of generating a repeating pattern on the same module. The same module applied to the 1967 condition (Figure 8, bottom) produces a non-repeating condition.

Figure 9: Forms resulting from lofting the trajectories shown in Figure 8 for the 1917 condition (left) and the 1967 condition (right).

The lofted forms shown in Figure 9 reflect the repetitive trajectories generated and shown in Figure 8.

CONCLUSION

Although the method of parasitical analysis necessarily results in the production of novel forms, its goal is not novelty, but rather the implementation of a particular lens through which to study and compare one or more digital models. In particular, forms produced through parasitical analysis can be aggregated and compared, with the aim of revealing unique characteristics among a collection (or population) of models. The forms thus produced exhibit characteristics typical of chaotic behavior: they are sensitively dependent on initial conditions, insofar as small changes in the "seed" location result in radically different formal outcomes (Lorenz 1963). It follows that parasitical analysis does not aim to explain observed conditions in reductive terms, but is rather a form of reflection upon those conditions, a means by which one kind of complexity can be visualized as another. Unlike certain other methods for analyzing digital models of the built environment, parasitical analysis is not easily susceptible to quantification. For example, it is unlike the kind of analysis carried out with Revit, which due to its hierarchical and categorized approach, enables multiple approaches to quantification (e. g., energy analysis, structural analysis, lighting analysis, etc.). Rhino, coupled with Grasshopper, can also introduce multiple forms of analysis, insofar as a given digital model is the result of parametric or algorithmic operations.

This research is ongoing, and is being developed in two distinct trajectories. As it potentially impacts pedagogy, I have tested its implementation within a final-year M. Arch. design studio, focused on the design, using algorithmic methods, of a parasitical intervention within, attached to, and atop an existing building, or "host." The evaluation of student projects in this studio addressed, among other factors, how well the projects make the host building and the city uniquely perceptible (Christenson 2014). Furthermore, as an independent research project (Christenson 2013), I continue to test parasitical analysis as a process of reading and extending existing buildings: the project centers upon scripts for generating self-replicating geometries within digital models of existing buildings.

Future work will attempt to further specify the applicability of parasitical analysis over an extended range of scales. Furthermore, aggregate data for a given set of trajectories (for example, average trajectory length, average number of segments or "bounces", percent of "unbounded" trajectories) could potentially be seen as indicative of certain qualities held by the digital model (e. g., degree of openness, density of forms, etc.). Comparisons of such aggregated data between two projects, or applied within a single project at various scales, could in turn reveal additional qualities of the built environment otherwise remote from direct perception.

ACKNOWLEDGEMENTS

The author wishes to gratefully acknowledge the support of Assistant Prof. Malini Srivastava of North Dakota State University, for her constructive critique of this developing research.

REFERENCES

Barrios, C. 2004. "Parametric Gaudi." In *Proceedings of the 8th Iberoamerican Congress of Digital Graphics* (SIGraDi), p. 213-215.

Barrios, C. 2005. "Transformations on Parametric Design Models: A Case Study on the Sagrada Familia Columns."

Proceedings, Eleventh International Conference on Computer-Aided Architectural Design Futures, p. 393-400. Dordrecht, Netherlands: Springer.

Benedikt, M. 1979. “To Take Hold of Space: Isovists and Isovist Fields.” *Environment and Planning B* 6, 47-65.

Benton, Mark. 2017. “Just the Way Things Are Around Here.” *Journal of Urban History* (doi: 10.1177/0096144217696988).

Besserud, K. and Cotten, J. 2008. “Architectural Genomics.” In ACADIA 2008, 238–245.

Birmingham, Elizabeth. “Reframing the Ruins: Pruitt-Igoe, Structural Racism, and African American Rhetoric as a Space for Cultural Critique.” *Western Journal of Communication* 63, no. 3 (1999): 291-309.

Brand, S. 1995. *How Buildings Learn: What Happens After They’re Built.* Harmondsworth (UK): Penguin.

Branzi, A. 2005. La progettazione degli interni nella città contemporanea, quoted by Gerosa, G.: 2013, “The design approach of Rooftop architecture”. Available from: <http://www.craftingthefuture.se>

Bristol, Katharine G. “The Pruitt-Igoe Myth.” *Journal of Architectural Education* 44, no. 3 (1991): 163-171.

Burry, J., & Burry, M. 2006. “Sharing Hidden Power: Communicating Latency in Digital Models.” In *Proceedings, 24th eCAADe Conference*, p. 786-793. Volos, Greece: University of Thessaly School of Engineering.

Christenson, M. 2009. “Testing the Relevance of Parameterization to Architectural Epistemology.” *Architectural Science Review* 52 (2), 135-141.

Christenson, M. 2013. “Scripting Parasites.” In *Unconventional Computing: Design Methods for Adaptive Architecture*, Rachel Armstrong and Simone Ferracina, editors, p. 120-127. Toronto: Riverside Press.

Christenson, M. 2014. “Comprehensive Parasites.” In *Rethinking Comprehensive Design: Speculative Counterculture* (Proceedings, 19th International Conference on Computer-Aided Architectural Design Research in Asia, Kyoto Institute of Technology, Kyoto, Japan), p. 771-780. Hong Kong: The Association for Computer-Aided Architectural Design Research in Asia.

Díaz-Vilariño, L., Lagüela, S., Armesto, J., and Arias, P. 2013. “Semantic As-built 3d Models Including Shades for the Evaluation of Solar Influence on Buildings, *Solar Energy* 92, 269–279.

Ferguson, Roderick A. 2015. “Michael Brown, Ferguson, and the Ghosts of Pruitt-Igoe.” *Cultural Critique* 90,140-142
Gomez de Silva Garza, A. and Maher, M. 2001. “Using Evolutionary Methods for Design Case Adaptation.” In ACADIA 2001, 180-191.

Heathcott, Joseph. 2012. “Pruitt-Igoe and the Critique of Public Housing.” *Journal of the American Planning Association* 78 (4), 450-451

Lorenz, E. 1963. “Deterministic Nonperiodic Flow.” *Journal of the Atmospheric Sciences* 20, no. 2: 130-141.

Mostafavi, M. and Leatherbarrow, D. 1993. *On weathering: the life of buildings in time.* Cambridge: MIT Press.

Newman, Oscar. *Defensible Space: Crime Prevention Through Urban Design.* New York: Macmillan, 1972.

Papalexopoulos, D. 2003. “Parasites, their receptacles and digital interconnections”. Available from <http://www.archsign.gr/default01.html>

Potamianos, I., & Jabi, W. 2006. “Interactive Parametric Design and the Role of Light in Byzantine Churches.” *Proceedings, 24th eCAADe Conference*, p. 798-803. Volos, Greece: University of Thessaly School of Engineering.

Potamianos, I., Turner, J., & Jabi, W. 1995. “Exploring the Proportions of Middle-Byzantine Churches: A Parametric Approach.” In *Proceedings, Sixth International Conference on Computer-Aided Architectural Design Futures*, p. 483-493. Singapore: National University of Singapore.

Shi, X. and Yang, W. 2013. “Performance-driven Architectural Design and Optimization Technique from a Perspective of Architects.” *Automation in Construction* 32, 125-135.

Turrin, M., von Buelow, P., and Stouffs, R. 2011. “Design Explorations of Performance Driven Geometry in Architectural Design using Parametric Modeling and Genetic Algorithms.” *Advanced Engineering Informatics* 25 (4), 656-675.