SUPRAFICIAL: Building (an) Information Network

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This paper explores the potential of using multiple software programs to generate an adaptable, cross-platform Building Information Network to unlock new territories of form-making and design. By using multiple software packages to overcome the limitations imposed by current BIM (Building Information Model) programs and mono-scalar design approaches, we can design a building's form, envelope, and materiality through an adaptable, parametric design process that uses the best features of each software program, allows non-computational input to inform form, and takes advantage of a designer's unique self-expression.

**Keywords:** Mimetic Design, Ornament, Building information network, Parametric array, Object-oriented design

Design processes are rapidly evolving as new programs are co-opted from other industries and technological advancements change the way we build. The experimental application of digital tools is being used to develop new tactics for design. Though tools have been developed to optimize a design's function or performance, optimization is not design in and of itself. The use of digital tools to develop multi-layered and multi-functional objects with cross-scalar properties made manifest in the object's form, performance, and physical properties opens new territory for designers that go beyond the use of digital tools for computation alone and offers a new form of architecture that reinforces design authorship and favors "extreme integration." (Wiscombe 2010, p.80)

This paper explores the potential of using several software programs and non-computational design input to generate an adaptable, cross-platform building information network and unlock potential new territories of form-making. A multi-platform design approach fosters a non-linear working method in which feedback between programs form a project-specific design sensibility that can operate at multiple scales. The qualities of the object that materialize at each scale feed one's subconscious, establishing a self-referential intuition that becomes a decision-making tool for producing novel form, surface and material expression. As Neil Leach (2006, p.44) observes, "human beings absorb external forms, incorporate them symbolically into their self-expression, and then rearticulate them in the objects they produce." This project-specific intuition forms a categorically diverse network in which even non-computational techniques can be included as design agents. By using multiple software platforms to integrate knowledge in the production of significant form (Clive Bell 2011, p.163), performative surfaces, and the meaningful integration of ornament, superficial surface conditions are replaced with supraficial spatial systems. By incorporating design at all scales through multi-platform tools and techniques, singular building information models become complex building information networks.
BUILDING INFORMATION MODELS
The rising popularity of building information modelers (BIM) poses a catch-22. BIM programs are a godsend for managing the diverse elements that go into the design and construction of a building. They excel at the coordination of every stage of the building process: situating the building in space, developing construction means and methods, and estimating costs. Local changes to the model parametrically update all associated components which are cross-referenced and, if necessary, globally applied. Unfortunately, this seemingly miraculous working method has deficiencies that are impacting both the practice of architecture and construction of buildings for the worse.

Though BIM allows for the easy management of a number of complex parts, these parts are still limited by the standardization of existing construction means and methods. By using a stand-alone BIM program, we are subject to the inadequacies of the program, namely the inability to develop fully integrated and specialized custom building components and construction methodologies. Mark Gage (2010) argues "that although these programs are intended to manage information they have formal biases as well that impact the creative process. These biases arise because the software not only includes but also omits particular formal tools." Popular BIM programs are developed to support the "Euclidean geometries on which the profession has traditionally relied, but the over-use of one software package by a majority of architectural firms poses a problem that the emerging built environment is being produced, almost exclusively, by the limited commands and limited geometries available in standardized architectural software packages." (ibid, p. 109)

Though there have been recent developments that allow for the design of unique and parametrically driven building components, there are still major limitations in the application of these tools and the ability to model complex geometry with them - specifically, the integration of building systems, details and material properties into curved surfaces. In the world of current BIM programs, the 4’ x 8’ module thrives, a standard made universal through our industrial era obsession with mass production.

If we reject the standardization of parts as a constraint in the design and construction of buildings in favor of a new modality, one that fosters progressive digital design and construction processes that allow for extreme variation and adaptability through cross-platform tools and techniques and the inclusion of non-computational input during the design process, we can explore the design and fabrication of complex continuous surfaces, various strategies for the componentization of a form and new techniques for ornamentation as an integrated design approach that rejects the cleanliness and constraints of orthogonal grids, monolithic form, and mono-scalar assemblages.

BUILDING INFORMATION NETWORKS
The use of a multi-program design platform increases the number of possible design solutions for any given project. Each program offers a discrete set of tools that when used in combination with one another significantly expand a designer’s toolset. The design process becomes more than the execution of a single technique; it becomes the by-product of tool hybridization. Though each tool might be well suited for the design of a particular attribute like a project’s form or material, when used in combination with tools from other programs and for something other than what the tool was designed, new opportunities arise prompting the emergence of novel assemblages. The number of possible design outcomes and the capacity for a design to affect change increase. As Reiser + Umemoto (2006, p. 38) note, "most architecture is not resolved within the logic of a single model, a single surface, or a single material only. Rather, architecture deals with assemblies involving multiple models, surfaces, and materials. Architecture is generally not one continuous, monolithic thing but is made of multiple parts and organizational models operating at different scales...The question then is how one manages or works with these diverse or-
ganizations and elements, not merely as an accumulation of the different, but as multiplicities within an emergent organization such that the whole is greater than the sum of its parts.

To isolate all parameters of design into discrete elements and one digital model minimizes the cross-pollination of tools and rejects complexity in favor of simplicity. A building information network embraces complexity by promoting emergence to increase the potential outcomes of a design process. The looser the network, the easier it is to integrate other systems into a design process, whether they be digital tools from other software programs or non-computational design inputs. As Mark Taylor (2001, p.138) notes, "complexity is found by interweaving, interconnecting, and folding together different parts, elements, or components. Complexity not only harbors multiple implications, but is actually an intricate process of implication." Thus, a building information network is most effective when it remains loose, adaptable, and able to receive additional input.

By switching our design view from model to network, we open the design process to outside influence, providing even non-physical objects the opportunity to affect a design. This approach disentangles a projects parameters enough that additional parameters from outside sources can be stitched into the parametric network, introducing a more diverse set of attributes into the project. By allowing invisible factors of design to contribute to the resolution of real material and geometry, a building information network represents a design process that is, to some extent, object-oriented. As Ian Bogost (2012, p.23) explains, "objects of object-oriented thought encompass anything whatsoever, from physical matter to properties to marketplaces to symbols to ideas." In a building information network, the tools, as well as the interface, outputs, parameters, non-computational inputs, and every other thing that affects a design has some formative effect on the project's form.

**NON-COMPUTATIONAL DESIGN INPUT**

Though the use of digital tools from multiple software platforms is paramount to the realization of a building information network, so is the integration of outside agencies. The various experiments presented in this paper integrate the analysis of a biological organism into the design process (see Figure 1). Biological organisms share many of the cross-scalar, multi-functional, and spatial and performative qualities found in buildings. Both operate within a context and must adapt to an ever-changing environment. Like buildings, organisms exhibit rich material and formal expression across scales. The use of an organism as design fodder is just one example of how an external input can be integrated through a building information network, providing a framework for the development of a project. The input gained through analysis - specifically of organisms that exhibit unique characteristics of growth, mutation, behavior, and a rich, diverse set of physical properties including color, pattern, material and texture - load a designer's aesthetic and function-oriented sensibilities with a filtering device that helps one develop and evaluate each project beyond the simple execution of computational tools.

By employing mimetic design as a foundation at different stages of the design process, one can tie even the most disparate features of a design into a cohesive network. For a project to successfully use an outside agent as design input, they must take responsibility for the overall organization of the network and reestablish the role of authorship in design. In a building information model, one is limited by the commands of a single program. When a limit is reached in a building information network, additional inputs are added to remove limitations and expand possibilities. It is up to the designer...
to decide when, where, and how tools from multiple design programs are used to incorporate non-computational design input.

EVOLUTIONARY FORM CATALOG
Evolutionary design is a methodological approach that when strategically applied as a design process can unlock a better solution to architectural issues, especially when designing a building’s form. Using object modeling programs like 3ds Max or Maya, designers can produce hundreds if not thousands of alternative designs in the same amount of time it would take to come up with two or three proposals using a traditional design process (see Figure 2). Additionally, each design can be systematically modified to best fit the precise parameters given by the client and the conditions of the project’s environment. Every iteration is embedded with a genetic code that can be changed to modify the entire geometry or to adjust local, small scale attributes.

Figure 2
Selected forms taken from an extensive catalog. (Image: Author)

Biological evolution provides a similar developmental model to an evolutionary design process. The capacity for a model to transform is dependent on the complexity of the geometry and the amount of parameters contributing to the form. As Mark Kirschner (2009, p.28) notes, "aspects of our biology are constantly being retained despite tremendous amounts of mutation, because changes in these properties are lethal. Although mutational genes can be random, the types of modification you get out of an animal depend on the underlying structure of the animal and the ability of that structure to be modified." Each form produced has its own unique set of limitations which guide subsequent modifications and transformations of the model. As Ali Rahim (2009, p.44) notes, you “add more and more intelligence in the dynamical system...[and] establish certain goals for the project ... as soon as all these factors are simultaneously and mutually collaborating within the system and with each other, [you] know [you] have finished the design for a project.” The final form is the result of selective filtering according to project-specific constraints established at the outset, but also by the fitness of the model itself. When a subset of a successful form catalog is chosen, select forms can be tested at other scales.

RESPONSIVE COMPONENTS
If we scale down to building envelope design, tools and techniques offered by other software programs, like Grasshopper, Para 3d or other node-based programs, are well-suited for developing different componentization strategies for the current working network, or form (see Figure 3). An associative design approach in which parametric links are built between components of a digital model relies on the performance of each part as well as the processes that form the overall organization of these parts through growth, responsiveness, and contextualization. Moving beyond exercises of subdivision and tessellation, designers can integrate multi-functional building components with performative, geometric and aesthetic logics. Each logic influences the aggregation of multiple components, leading to possible tangential structures branching off the form’s original surface.

The form of these semi-dependent structures rely heavily on the development of component to component seams. The seam between components provides additional opportunities for secondary branching structures to form. As Lars Spuybroek (2009, p.36) points out, "lines deploy a multitude of connective agencies: they can slide along each other, or bounce, or even lock into each other; they can entangle, merge, bundle, split, anything. This means the flexibility and variation lie not only in the curvature of the figure itself but also just as much in the connective strategy, in the richness of agency."
Figure 3
Para Fish project. Replacing a form with a component. (Image: Author)

Figure 4
Para Vault project. Using bitmaps to control component distribution and type. (Image: Author)
A successful componentization of a building form is based on the aggregation's capacity to perform but also the complexity and depth of the object's physical properties as new aesthetic qualities emerge.

To componentize a surface, sections of the form must be redefined as a series of node-based inputs and outputs defined by the parameters and limits of each node. This is not a simplification of the working network, but a way to isolate particular regions and further enmesh new features into the developing form. Sliders that have minimum and maximum input values are commonly used to introduce variation, but bitmaps offer a greater range of variability and can be linked between different software platforms with minimal to no translation. The color values of an image are used to differentiate all parameters to which they are linked. In addition, bitmaps can be swapped, forcing immediate changes to local parameter values and a redistribution of component types. Bitmaps can also include animated motion files that affect a networks parameters over time, further increasing the possible design outcomes for a project.

The UV map that is generated during the initial form development in 3ds Max or Maya provides a means to redeploy the componentization of each region back into the original form. The UV map contains texture and pattern coordinates which are also used to further develop material and surface ornamentation (see Figure 4).

**ORNAMENTATION**

Surfaces that are spatial, highly-performative and responsive can be generated using performance-driven parametric design techniques, but the success of a project should not rest on issues of performance and optimization. A design approach that relies so heavily on measurable valuation might lead to a design that functions effectively but lacks what Greg Lynn (2010, 21) refers to as an “aesthetic discourse.” He points out “the wealth of hideous well-engineered form that exists.” To rely entirely on performative design strategies is to essentially remove the author from the design process. Strategies for ornamentation that integrate new matter (color, pattern and texture) into the digital model helps to imprint intuitive and authorial aesthetic sensibilities back into the project.

At the material scale, designers can use programs like Mudbox or Z-Brush to sculpt geometry into the evolving model. It is through surface that we understand and associate with objects. When we view an object, we feel an immediate emotional response. Objects rouse empathetic feelings in us, translated by our perception of an object’s physical properties. This response is based on qualities more than quantities, on artistic license rather than measure. Objects begin to exhibit geometric and aesthetic tendencies as they develop, and these tendencies establish an intuitive working method that expedites and sometimes leads the design process. It is through these subconscious actions that we reinforce conditions already present in an object’s definition and can further coax the potential for external agency to impact the design, in this case, the analysis of the biological organism.

Our frequent review and critique of a design during the design process via different representational means further engrains an aesthetic and geometric sensibility in the designer that is particular to the project. David Freeberg and Vittori Gallese (2011, p. 312), collaborators in the field of cognitive science, point to the discovery of mirror neuron systems (MNS) in the human brain to support this hypothesis: "beholders find themselves automatically simulating the emotional expression, the movement or even the implied movement within the representation. Simulation occurs not only in response to figurative works but also in response to the experience of architectural forms." Through mechanisms of repetition and simulation, we subconsciously train ourselves to evaluate and pass judgment on what we produce in real-time, allowing more time to consider alternative models and further expand our range of production. By incorporating a thorough analysis of an already functioning and complete network that is the organism,
Figure 5
Form catalog and componentization of selected form using UV texture mapping. (Image: Author)
we are able to translate the input both consciously and subconsciously to our development and evolution of the project as it emerges from the Building Information Network. Parametric inputs fuse with non-computational inputs and both inform the project’s final resolution.

**CONCLUSION**

A cross-scalar approach to design has direct aesthetic consequences that result from using the best features of multiple software programs, but also project-specific sensibilities that develop during the design process (see Figure 5). Architecture is the artful proposition of three-dimensional objects and the designer is the primary agent in any architectural endeavor. At times, the process is driven by accurate data translation and rule-based form-making, but as David Ruy (2012, p.42) suggests, "a successful object-making event cannot be completely encapsulated by a methodology that might repeat the success ... as difficult as it may be to accept, the individuality of the architect, needs to be recognized in order to claim more authority because every maker is one of a kind." By using various software programs while simultaneously working through a generative and evaluative agenda distilled through a biological organism, a designer develops what Ali Rahim (2010, p.27) calls an 'elegant aesthetic sensibility.' This sensibility works consciously and unconsciously to inform one’s final design.

Though still parametric, a building information network suggests a different kind of parametricism. A parametric network remains loose and fosters emergence through hybridization. It is inclusive, rather than exclusive, and supports complexity over simplicity. A building information network reinforces the role of designer in design and better links computational tools with non-computational input to promote entirely new architectural propositions.

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