Computing the Performative in Architecture

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Abstract: The paper addresses performative architecture as an emerging design paradigm in which building performance, broadly understood, becomes a guiding design principle. It discusses the inadequacy of existing software for building performance simulation as usable tools in conceptual design, and proposes the development of software that can provide dynamic processes of formation based on specific performance objectives.

Keywords. Performance-based design, performance simulation, generative design.

Introduction

In contemporary architectural design, various digital generative and production processes are opening up new territories for conceptual, formal, and tectonic exploration, articulating an architectural morphology focused on the emergent and adaptive properties of form (Kolarevic 2003). In a radical departure from centuries old traditions and norms of architectural design, digitally-generated forms are not designed or drawn as the conventional understanding of these terms would have it, but they are calculated by the chosen generative computational method. Instead of working on a parti, the designer constructs a generative system of formal production, controls its behavior over time, and selects forms that emerge from its operation. The emphasis shifts from the “making of form” to the “finding of form,” which various digitally-based generative techniques seem to bring about intentionally.

The new, speculative design work of the digital avant-garde, enabled by time-based digital technologies, is provoking an interesting debate about the possibilities and challenges of the digital generation of form (i.e. the digital morphogenesis). There is an aspiration to manifest formally the invisible dynamic processes that are shaping the physical context of architecture (figure 1), which in turn are driven by the socio-economic and cultural forces within a larger context. According to Greg Lynn (1999), “the context of design becomes an active abstract space that directs from within a current of forces that can be stored as information in the shape of the form.” Formal complexity is often intentionally sought out, and this morphological intentionality is what motivates the processes of construction, operation and selection.

This dynamic, time-driven shift in conceptualization techniques, however, should not be limited to the issues of representation, i.e. formal appearance, only. While we now have the means to visualize the dynamic forces that affect architecture by introducing the dimension of time into the...
processes of conceptualization, we can begin to qualify their effects, and in case of certain technical aspects, begin to quantify them too. There is a range of digital analytical tools that can help designers assess certain performative aspects of their projects, but none of them provide dynamic generative capabilities yet.

**Performative Architecture**

The aesthetics of many projects of the digital avant-garde are often sidetracking the critical discourse into the more immediate territory of formal expression and away from more fundamental possibilities that are opening up. Such possibilities include the emergence of performative architecture, in which building performance, broadly understood, becomes a guiding design principle. This emerging kind of architecture places broadly defined performance above or on par with form-making. The performance in this context spans multiple realms, from financial, spatial, social, and cultural to purely physical or technical.

The emergence of performative architecture is largely due to a profound and wide-ranging reappraisal of what performance means in architecture. The increasing interest in building performance as a design paradigm stems in large part from the emergence of sustainability as a defining socio-economic issue and from the recent developments in cultural theory and technology. Understood in those terms, performative architecture can be described as a “meta-narrative” with universal aims that are dependent on particular performance-related aspects of each project.

Determining the different performative aspects in a particular project and reconciling often conflicting performance goals in a creative and effective way are some of the key challenges in this new approach to architecture. While the formal dynamics are incredibly interesting from a design point of view, their generative potential could be more grounded in the quantifiable and qualifiable performative aspects. The form of the building is undeniably essential for its environmental performance, as is its orientation, the placement of openings, the choice of materials, or the design of the various building systems.

There is currently an interesting gap in the aesthetics (and ethics) between form- or cultural performance-oriented designers (Frank Gehry, Greg Lynn, etc.) and those whose work aims at environmental performance (Thomas Herzog, Glenn Murcutt, etc.). On the other hand, there is another group of designers—the ones whose work is neither too formalist or environmentalist (Foster, Grimshaw, Piano, Sauerbruch and Hutton, Jourda and Perraudin, etc.). The design strategies in the projects of that group vary considerably as

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*Figure 2. The Swiss Re (2004) building in London, UK, by Foster and Partners.*
they respond to different cultural and environmental contexts. In many of the projects, formal and environmental performative agendas were successfully pursued in parallel. In the Swiss Re project by Foster and Partners (figure 2), the aerodynamic form enables wind to flow smoothly around this high-rise building, minimizing wind loads on the structure and cladding, and enabling the use of a more efficient structure. The spiraling form of the atria at the perimeter, which run the entire height of the building, is designed to generate pressure differentials that greatly assist the natural flow of air. In addition, the wind is not deflected to the ground, as is common with rectilinear buildings, helping to maintain pedestrian comfort at the base of the building.

It is interesting to note that many of the designers mentioned earlier – notably Norman Foster and Nicholas Grimshaw, once labeled High-Tech and renamed Eco-Tech by Catherine Slessor (1998) – have explicitly stated their intentions to improve the environmental performance of their often highly visible buildings (figure 2). While one could question the methodological consistency in their projects and whether certain performative aspects, such as energy efficiency, were indeed maximized, these architects did manage to consistently push the technological envelope of environmental performance in their buildings.

An interesting example of a recent project that seems to capture the broad agenda of performative architecture, from cultural to environmental performance, is Renzo Piano’s Tjibaou Cultural Center for the Kanak population of New Caledonia (figure 3). The “cases” that dominate the design, and that formally reference (but don’t imitate) Kanaks’ huts with their truncated cone-like shapes, were conceived with a particular cultural performance in mind. The cone-like shapes were truncated for a more efficient environmental performance. The natural air flow within the building is then further enhanced using a system of computer-controlled louvers on the inner skin in “cases,” which was design and developed through wind tunnel testing and computer simulations by engineers at Ove Arup and Partners and the Centre Scientifique et Technique du Batiment in France.

As mentioned earlier, the performative design strategies can vary considerably as they respond to different contexts. Peter Cook’s and Colin Fournier’s Kunsthaus in Graz (figure 4) features an expressive, biomorphic blobby form, and an acrylic glass “skin” whose primary function is to be a “communicative membrane” – a low-resolution computer-controlled skin, a “media façade” that, through the display of signs, announcements, and images, hints at the activities within the building. Here, the performative aspects of building are all geared towards an “urban communication strategy.” The expressive form is not accidental – its performative intent is purely socio-economic: by attracting people to the area, the building will act as a development catalyst.
just as Frank Gehry's Guggenheim Museum in Bilbao has so successfully demonstrated (in what has become known among urban development strategists as a “Bilbao effect”).

Interestingly enough, there is not a hint of environmental performance in the Kunsthaus project, as if to suggest that the formal and environmental agendas are often incompatible (which can’t be farther from the truth). Foster and Partners’ City Hall in London (figure 5) imbues an iconic, biomorphic form with a logic of environmental performance that calls for such a form in the first place. (The origin of the project was purely formal – it attained its environmental logic later in the development.) The “pebble”-like form of the building resulted in the end from optimization of its energy performance by minimizing the surface area exposed to direct sunlight. The building’s form is a deformed sphere, which has 25% smaller surface area than a cube of identical volume, resulting in a reduced solar heat gain and heat loss through building’s skin (figure 6).

Foster's performative approach to the design of the City Hall building, for example, could imply a significant shift in how “blobby” forms are perceived. The sinuous, highly curvilinear forms could become not only an expression of new aesthetics, or a particular cultural and socio-economic moment born out of the digital revolution, but also an optimal formal expression for the new ecological consciousness that calls for sustainable building.

**Performance-Based Simulation**

Digital quantitative and qualitative performance-based simulation represents the technological foundation of the emerging performative digital design practice...
architecture. Analytical computational techniques based on the finite-element method (FEM), in which the geometric model is divided into small, interconnected mesh elements, are used to accurately perform structural, energy, and fluid dynamics analyses for buildings of any formal complexity. These quantitative evaluations of specific design propositions can be qualitatively assessed today thanks to improvements in graphic output and visualization techniques (figures 7-12). By superposing various analytical evaluations, design alternatives could be compared with relative simplicity to select a solution that offers optimal performance.

Future Systems, a design firm from London, used the computational fluid dynamics (CFD) analysis in a particularly interesting fashion in its Project ZED, the design of a multiple-use building in London (1995, figure 9). The building was meant to be self-sufficient in terms of its energy needs by incorporating photovoltaic cells in the louvers and a giant wind turbine placed in a huge hole in its center. The curved form of the façade was thus designed to minimize the impact of the wind at the building’s perimeter and to channel it towards the turbine at the center. The CFD analysis was essential in determining the optimal performance of the building envelope.

The original blobby shape of Peter Cook’s and Colin Fournier’s competition winning entry for the Kunsthaus in Graz, Austria (figure 10), was altered somewhat after the digital structural analysis by consulting engineers Bollinger+Grohmann from Frankfurt revealed that its structural performance could be improved with minor adjustments in the overall form, by extracting the isoparametric curves for the envelope definition not from the underlying NURBS geometry but from the structural analysis. Likewise, Foster and Partners’ design for the main chamber of the London City Hall (figure 11) had to undergo several significant changes after engineers from Arup analyzed its acoustical performance using in-house developed acoustic wave propagation simulation software.
It is important to note that performative architecture, or more specifically, performance-based design, should not be seen simply as a way of devising a set of practical solutions to a set of largely practical problems. Here the emphasis shifts to the dynamic processes of formation based on more performative strategies of design that are grounded, on one end, in intangibilities such as cultural performance and, on the other, in quantifiable and qualifiable performative aspects of building design, such as structure, acoustics, or environmental design.

Performative Morphogenesis

Although digital technologies, in particular performance based simulations, have made the notion of performative architecture possible, challenges and opportunities do exist in the ways these technologies are being conceptualized and used.

Most of the commercially available building performance simulation software, whether for structural, lighting, acoustical, thermal, or air-flow analysis, requires high-resolution, i.e. detailed, modeling, which means that it is rarely used in conceptual design development. This shortcoming, and the lack of usable "low-resolution" tools, is further compounded by the expected degree of the user’s domain knowledge and skills. Another frequently encountered problem is that certain performance aspects can be analyzed in one environment while other performative simulations must be done in other simulation software, often resulting in substantial and redundant remodelling. Providing a certain degree of representation-al integration across a range of “low-resolution” performance simulation tools is a necessary step for their more effective use in conceptual design.

Assuming that analytical and representational integration can be achieved, and that intuitive “low-resolution” performance simulation tools can be developed, additional challenges are presented by the need for active design space exploration. Instead of being used in a passive, "after-the-fact" fashion, i.e., after the building form has been articulated, as is currently the case, analytical computation could be used to actively shape the buildings in a dynamic fashion, in a way similar to how animation software is used in contemporary architecture (Lynn 1999).

An already structured building topology, with a generic form, could be subjected to dynamic, metamorphic transformation resulting from the computation of performance targets set at the outset. This dynamic range of performative possibilities would contain at its one end an unoptimized solution and on the other an optimized condition (if it is computable), which might not be an acceptable proposition from an aesthetic or some other point of view. In that case, a sub-optimal solution could be selected from the in-between performative range, one that could potentially satisfy other non-quantifiable performative criteria.

This new kind of analytical software will preserve the topology of the proposed schematic design but alter the geometry in response to optimizing a particular performance criteria (acoustic, thermal, etc.). For example, if there is a particular geometric configuration comprised of polygonal...
surfaces, the number of faces, edges, and vertices would remain unchanged (i.e., the topology doesn't change), but the shapes (i.e., the geometry) will be adjusted (and some limits could be imposed in certain areas). The process of change could be animated, i.e., from the given condition to the optimal condition, with the assumption that the designer could find one of the in-between conditions interesting and worth pursuing, even though it may not be the most optimal solution (figure 12).

In this scenario, the designer becomes an “editor” of the morphogenetic potentiality of the designed system, where the choice of emergent forms is driven largely by the project's quantifiable performance objectives and designer's aesthetic and plastic sensibilities. The capacity to generate “new” designs becomes highly dependent on designer’s perceptual and cognitive abilities, as continuous, dynamic processes ground the emergent form, i.e. its discovery, in qualitative cognition. Even though the technological context of design is thoroughly externalized, its arresting capacity remains internalized. The generative role of the proposed digital techniques is accomplished through the designer’s simultaneous interpretation and manipulation of a computational construct (topological configuration subjected to particular performance optimizations) in a complex discourse that is continuously reconstituting itself – a “self-reflexive” discourse in which graphics actively shape the designer’s thinking process.

Conclusions

The increasing emphasis on building performance and the underlying digital simulation technologies are fundamentally redefining expectations of the building design, its processes, and practices. Performative architecture is emerging in such context as a design paradigm in which building performance, broadly understood in financial, social, cultural, spatial, physical and material terms, becomes a guiding design principle. This shift from pure form-making to what could be described as “performative formalism” requires, at a purely instrumental level, yet-to-be-made digital design tools that can provide dynamic processes of formation based on specific performative aspects of design. There is a currently an abundance of digital analytical tools that can help designers assess certain performative aspects of their projects post-facto, i.e. after an initial design is developed, but none of them provide dynamic generative capabilities that could open up new territories for conceptual exploration in architectural design.

References
