Back to the Future: Performative Architecture
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The paper addresses performative architecture as an emerging design paradigm in which building performance, broadly understood, becomes a guiding design principle. It traces the origins of this approach to design to Tom Mayer’s visionary work in early seventies, discusses the inadequacy of existing building performance simulation tools in conceptual design, and proposes the development of software that can provide dynamic processes of formation based on specific performance objectives.
1. Performance-based design

At the beginning of the 21st century a new kind of architecture is emerging, using building performance as a guiding design principle, and adopting a new list of performance-based priorities for the design of cities and buildings. This new kind of architecture places broadly defined performance on a par with, or above form making; it utilizes digital technologies of quantitative and qualitative performance-based simulation to offer a comprehensive new approach to the design of the built environment [1].

The current interest in building performance as a design paradigm is largely due to the emergence of sustainability as a defining socio-economic issue and the recent developments in technology and cultural theory. Framed within such an expansive context, performance-based design can be indeed defined very broadly – its meaning spans multiple realms, from financial, spatial, social and cultural to purely technical (structural, thermal, acoustical, and so on.). If understood in those terms, performance-based design, or performative architecture, can be furthermore described as a “meta-narrative” with universal aims that are dependent on particular performance-related aspects of each project.

It is important to note that performative architecture should not be seen as simply a way of devising a set of practical solutions to a set of largely practical problems. In other words it should not be reduced to some kind of neo-functionalist approach to architecture. The emphasis shifts to the processes of form generation based on 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. 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 emerging approach to architecture.

Such performative design thinking, sketched briefly above, framed by a broadly defined performance agenda and supported by a range of digital performance analysis and simulation tools, was envisioned decades ago. Back in late sixties and early seventies, Tom Mauer and his colleagues at ABACUS (Architecture and Building Aids Computer Unit Strathclyde), at the University of Strathclyde’s Department of Architecture and Building Science, proposed that the building design be directly driven and actively supported by a range of integrated “performance appraisal aids” running on computer systems [2].

Digital building performance “appraisal aids” and performance-based design were at the very center of Tom Mauer’s research interests for more than three decades – he pioneered many of the essential concepts and techniques. As is often the case with visionary thinkers, his work was far ahead of its time both conceptually and technologically. But its time has come, as performance-based design is slowly but steadily coming to the forefront of architectural discourse.
2. Then
As described by Tom Maver in his SIGRADI 2002 paper [3], the first use of computer graphics for building appraisal was in 1966, the first integrated package for building performance appraisal appeared in 1972, the first computer generated perspective drawings in 1973, etc. The seventies resulted in “generation of a battery of computer aids for providing the designer with evaluative feedback on his design proposals,” enabling architects to “obtain highly accurate predictions of such building performance measures as heat loss, daylight contours, shadow projections and acoustic performance” [4].

PACE (Package for Architectural Computer Evaluation), developed at ABACUS, was introduced in 1970 as a “computer aided appraisal facility for use at strategic stages in architectural design,” which, unlike many of the efforts at that time, aimed “not on optimization of a single parameter but on production of a comprehensive and integrated set of appraisal measures” [2]. The program was an implementation of appraisal measures developed in late sixties by the Building Performance Research Unit at Strathclyde, under the direction of Prof. T.A. Markus [2].

PACE was one of the first digital performance analysis tools to emerge. The program was written in FORTRAN and run on a time-sharing system; the “conversational interaction” was through a teletypewriter terminal. The program measured costs, “spatial performance” (i.e. environmental performance, and “activity performance.” The “spatial performance” component measured site utilization (plot ratio) and plan and mass compactness. Computing the environmental performance resulted in “plant sizes which [would] give adequate environmental conditions,” while taking into account the heat gain and loss. The “activity performance” module measured “the degree to which the relationships input under activity information are satisfied by the proposed scheme.”

The program would instruct the designer how to change geometrical or constructional information, i.e. how to modify the design concept to improve performance and then submit the modified design for “re-appraisal.” In the end, the “repetitive man/machine interaction” would lead to “convergence of an ‘optimum’ design solution.” The interesting aspect of the program was the built-in capacity to “learn;” if the designer was satisfied with the scheme, the program would update the stored mean values used in assessments. The program also offered eight perspective views of the scheme, which were drawn on a “graph plotter” driven by the paper tape produced by the program.

3. Now
Today, digital quantitative and qualitative performance-based simulation represents the technological foundation of the emerging performative
architecture described earlier. 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. By superposing various analytical evaluations, design alternatives could be compared with relative simplicity to select a solution that offers optimal performance.

The current building performance simulation software, however, operates at the systemic level in the same (passive) fashion as two or three decades ago. Tom Maver described computer aided appraisal back in 1980 as consisting of four main elements: representation, measurement, evaluation and modification [5]:

"The designer generates a design hypothesis which is input into the computer (representation); the computer software models the behaviour of the hypothesized design and outputs measures of cost and performance on a number of relevant criteria (measurements); the designer (perhaps in conjunction with the client body) exercises his (or their) value judgement (evaluation) and decides on appropriate changes to the design hypothesis (modification)."

Maver then notes that “if the representation and measurement modules of the design system can be set up and made available, the processes of evaluation and modification take place dynamically within the design activity as determinants of, and in response to, the pattern of explorative search,” which is a fairly accurate description of how performance analysis (“appraisal”) software is being used today.

4. Challenges

As noted by Tom Maver in 1988, designing buildings that perform (i.e. “which work – economically, socially and technically”) is a central challenge for architects [6]. He called for the development of “software tools for the evaluation of the technical issues which are relevant at the conceptual stages, as opposed to the detailed stages, of design decision-making.”

The challenges of developing such software, however, are far from being trivial [7]. 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, modelling, 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 remodeling. Providing a certain degree of representational 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 already articulated, as is currently the case, analytical computation could be used to actively shape the buildings in a dynamic fashion [1], in a way similar to how animation software is used in contemporary architecture [7]. In other words, the performance assessment has to be generative and not only evaluative. For that to happen, however, a fundamental rethinking of how the digital tools are conceptualized is required.

Ulrich Flemming and Ardeshir Mahdavi argued in 1993 for the close "coupling" of form generation and performance evaluation for use in conceptual design [8]. Mahdavi developed an "open" simulation environment called SEMPER [9], with a "multidirectional" approach to simulation-based performance evaluation. According to Mahdavi, SEMPER provides comprehensive performance modeling based on first principles, "seamless and dynamic communication between the simulation models and an object-oriented space-based design environment using the structural homology of various domain representations," and bi-directional inference through "preference-based performance-to-design mapping technology."

I have proposed in a recent paper [1] the development of generative tools based on performance evaluation in which, for example, 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. Such a 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 criterion (for instance acoustic, or thermal). 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 does not 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. This would be 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 1).

5. Conclusion

In conclusion, the new “performative” approach to design 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 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.

The field for the development of design software that is simultaneously evaluative and generative is wide open. As Tom Maver wrote in his SIGRADE 2002 paper [3]:

“What is certain is that the next 30 years will be every bit as
exciting and challenging as the first 30 years. ...The more we can appraise the more we can decide; the more we can decide the more we can act; the more we can act the more we can shape; and the more we can shape, the better the chance that we can leave for future generations a truly sustainable built environment which is fit-for-purpose, cost-beneficial, environmentally friendly and culturally significant."

I hope Tom Maver will be with us over the next thirty years to hopefully see his vision at least partially fulfilled.

References