Architecture as an Expertise – A Shift from Modes of Representation to Modes of Simulation

Yasha J. Grobman

Abstract

The digital revolution is changing the representation language of architectural design. The intricacy of the digitally generated form and the shift towards nonstandard form and computer-controlled direct manufacturing have rendered the traditional 2-D representation language, which relies mainly on plans and sections, insufficient and inefficient in terms of both information and time.

Lately, several parallel processes are questioning some fundamentals of the singularity of traditional modes of representation in the architectural design. These processes include a move towards parametric and performance-oriented design, which is enhanced by a technological evolution in both architectural and simulation software, connectivity between architectural and simulation software, and the incorporation of simulation modules in architectural software. This shift also an expression of the increasing demands of the built environment in terms of performance - a reflection of the awareness to the globally decreasing environmental resources and the increasing global environmental and climatic problems.

This paper argues for a shift in focus of architectural design process from modes of representation to modes of simulation. Modes of simulation are based on a move to an object-oriented design that employs building information management (BIM) ideas, application of parametric design and code based form generation processes, and the assimilation of performance simulation processes directly by architects during the architectural design process itself. Employing modes of simulation in architectural design, challenges, to a certain extent, the ill-defined nature of the architectural problem by relying on defined parameters. It also posits that architects now potentially have a larger degree of control over the design, due to the complexity of the necessary calculations during form generation processes, to represent and modify the model outcomes and the often unexpected nature of the results. Moreover, architects' pursuit of modes of simulation could involve a shift in the perception of the profession. The use of simulation by architects could enhance architects’ responsibility for the performance of the architectural form, which in practice is associated with engineers. This, in turn, may have implications on the position of the architect within the building practice, on the architectural education and more importantly, on the architectural form per-se. The paper critically examines the possible ramifications of the shift towards modes of simulation in architectural design and attempts to incorporate them into a singular but multifaceted idea.

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Representation, performance and simulation

The digital revolution is changing the representation language of architectural design. The intricacy of the digitally generated form, the shift toward nonstandard form, computer-controlled direct manufacturing and object-oriented building information models (BIM)[1] has made the traditional 2-D representation language which relies mainly on plans and sections, insufficient and inefficient in terms of both information and time. In fact, the idea of the nonstandard calls into question the need for representation conventions at all, positing instead a one-off representation method for each specific project. A parametric 3-D computer model can embed the information on the architectural form which is needed for visualization, performance evaluation and also direct manufacturing.

Traditional modes of representation have been based on the importance of the qualitative, cognitive and perceptual aspects of the architectural form. Throughout the history of architecture, this idea sustained logocentric modes of operation and theories, which in turn promoted the image-based approaches to form, such as typology and shape grammar[2] . In this respect Vitruvius' Book of Architecture and Le Corbusier's 5 formal rules of architecture are based on a similar formal approach. This similarity was previously noted by Rowe in his essay on "The Mathematics of the Ideal Villa" (Rowe, 1976), which argued for the similarities between a Paladio villa to a modernist Villa designed by Le Corbusier.

In the article Towards City of Events Antoine Picon argues for a shift from the idea of form or imaged based design to the idea of event as a generating apparatus and a way to interoperate the contemporary urban form in architectural design (Picon, 2004). Picon connects the notion of event to unpredictability and argues that only recently; with the increase in computer power and

[1] Building Information Models (BIM) operates as a database that stores all building information. It facilitates a new kind of objects that embeds information on the physical world and translates it to an abstract computer representation (Magdy *et al*. 2001)

[2] A "shape grammar" is a design method that was first presented by George Stiny and James Gips in 1971. The method is based on a multiplication of changes of forms by means of rules, in order to create complex compositions (Stiny and Gips. 1971).

connectivity, the use of computer was able to create real, unpredictable events. An earlier and more general call for a shift to events base approaches in architectural design can be found in Bernard Tschumi's first Event Cities book (Tschumi, 1994). Tschumi argues that "the static notions of form and function long favored by architectural discourse need to be replaced by attention to the actions that occur inside and around buildings". In both Picon's and Tschumi's arguments the advance of technology in general, and the use of computer specifically, is considered as one of the key reasons for this shift. Currently, approximately 15 years from Tschumi's and 5 years from Picon's texts the idea of event in architectural design is reemerging in the new architectural discourse on performance. Since the simulation and evaluation of performance is one of the most obvious ways to measure and interpret events to the formal architectural language, the current discourse on performance can be considered a natural continuation of the preceding discourse on events. The shift of the discourse to performance can be simply explained by the progress of technology in general, and by a increasing development of computer form-simulation and generation algorithms and software, and by the increase of the application by architects of these tools and algorithms in the design process.

The notion of performance in architecture in its wider sense, which includes both performance of form as an object, and the performance of the human subject, calls for its generation and optimization as a product of technical utilization, while at the same time it would aim to incorporate cognitive and perceptual aspects of form. Form, in this case, would be more flexible, adjustable and free (Neuman and Grobman 2008). Its parametric origin and dynamic characteristics would elevate it to a new type of form, a "smart form" (Magdy et al. 2001. Capeluto, 2003 and others). A form based on performance as a design approach and method cannot be developed and evaluated within the frames of traditional linear[3] modes of representation. The dynamic, event based nature[4], parametric origins and formal complexity calls for a different approach to representation, one that would be able to negotiate and represent the dynamic nature of the new performance-oriented architectural form.

[3] Linear mode of representation refers to the linearity of a traditional design process in which a single design alternative is developed simultaneously.

[4] Dynamic nature refers to both the use of animated form during the design process that is essential in parametric design and the possibility to generate and work with several design alternatives simultaneously.

This paper will suggest such an approach. Following the assimilation of the notion of event, the increasing use of performative approaches in architectural design this paper argues for a shift in the focus of architectural design from representation modes to simulation modes. It begins with a background discussion on the idea of simulation. A discussion of the modes of simulation and their implication on architectural design follows. Finally, it examines the ramifications of the move to modes of simulation in terms of the education of the future architects and the position of the architect within the building profession.

Modes of simulation

Before we begin to discuss the shift in modes of representation we need to clarify the notion of simulation in architectural design. Simulation is a very broad idea. Generally, the idea of simulation is perceived as referring to simulation as a test process. It is an evolution from handbook-oriented calculations to what we know today as the computer simulation algorithms and software (Clarke, 2001). Recent years have seen the accelerating development of a large number of simulation tools and software programs in this realm. Indeed, the U.S. Department of Energy lists more than 300 different tools/software programs for simulation of energy performance alone[5], and this does not even include all the tools that emerged from the academic world. In architectural design the idea of testing refers to the examination of the level of fulfillment of certain performance criteria by an architectural form. Although simulation is usually connected with performance simulation, the most common use of simulation in architectural design is still for representation. In this case the performance criteria are visual and esthetic. Other modes of simulation include: Simulation as an evaluation process, which consists of developing a strategy for accomplishing a desired solution subsequent to the test process; simulation as an examination of the behavior of architectural form under extreme conditions in order to be able to foresee the point of failure, or catastrophe and simulation as a mode of form generation. The last type is, to a certain extent, an inverted version of traditional approach to simulation, which examines already existing form. It is performed by either utilizing dynamic, computer code driven parametric models, in which the architectural form is in a constant process

[5] See http://www.eere.energy.gov/buildings/tools_directory/

of change, or it can be done by negotiation process of multiple 3-D representations (i.e. performance envelopes) of a single criteria that generates a 3-D design space or concrete design alternatives (Grobman *et al*. 2008). Recent examples of the first type is the collaboration between the Mutsuro Sasaki and Arata Isozaki for the design of the Florence train station and other projects that involve the generation of complex structure using simulation software that was developed by Sasaki (Sasaki, 2007).

Computer code and simulation

One of the most evident modes of simulation in architectural design is the application of computer code. Using computer code in the design process liberates the designer from the limitations imposed by the software design tool. In that respect, the commercial design tool or software can be perceived as a collection of preset codes, designed to fulfill the need of the common design processes. Writing custom code in that context can be regarded as part of the nonstandard approach that characterizes the digital revolution in architectural design in which there is no common design process and therefore, no possible common tool can be used. Scripting[6], in that sense, is a compromise between independent code writing and the employment of commercial computer software. In scripting, the designer is not limited by the present commands of the specific software, but by its mathematic and graphic engines. All the above variations for the use of computer code in architectural design are increasingly being employed by architects. Early examples can be traced to Foster + Partners Swiss Re headquarters in London, and Chesa Futura project in St Moritz, Switzerland, which employed scripts development within Microstation software (Kolarevic. 2006); Makoto Sei's Watanabe Subway Station in Lidabashi, which developed algorithms to generate spatial configuration of web systems (Sei Watanabe. 2002); and the avant-garde projects by Karl Chu, which experiment in transforming mathematical formulas to architectural forms (Grobman and Neuman. 2008)

The transition to computer-based design indicates that the architects of the future will require a greater mastery of mathematics and computer code languages in order to be able to at least to adapt existing tools to their own needs, if not to actually write new code. On the whole, these

[6] Scripting in this context refers to both writing code and using visual code applications such as Grasshoper.

skills are not part of current architectural education (Gauchet,. 2009). This situation raises some questions regarding the necessity of architects mastering code at all, as opposed to using professional programmers (similar to the way consultants are employed during the design stage): should architectural education include mastering computer code at all, and if it does, what should be the level of code mastery architects have to achieve.

There are no straightforward answers to these questions, mainly because this domain has not been widely examined by architects or researchers. Nevertheless, it seems logical to suggest that while architects will not require the qualifications of a programmer or a mathematician in terms of writing algorithms and computer code, they will need to achieve a certain level of understanding and ability to use and develop at least some level of in-house scripting. Hence, architects will need to be able to communicate with professional programmers and mathematicians in a new architectural and interdisciplinary language - the language of computer code.

Simulation and control over the design

In addition to questions on the evolution of architectural skills, simulation as a mode of architectural form-generation introduces a new discussion of the control architects have over the design due to the complexity of the needed calculations and the often unexpected nature of the results. Moving away from the descriptive nature of information that is related to image based design process towards performative-oriented design process changes the nature and level of information which is embedded in the architectural form. Thus, it is clear that the complexity of many contemporary architectural forms could not be either envisioned, nor represented or modified by designers, without the help of computers. This situation can be described as "losing control" over the design process in favor of a mode of collaboration with a new and highly capable partner – the computer[7]. Losing control is used in this context in a positive sense as a breakthrough from the limiting (in terms of creativity) forces of the human eye (Eisenman, 1992). Gaining a new type of control would point at the acquisition of certain knowledge or

[7] See also the discussion in Terzidis (2003) and Eisenman (Eisenman, 1992) on losing control over the architectural design.

ablity to foresee the outcome of the design process or methodology (De Landa, 2003; Picon, 2006).

Although the notion of control relies both on information and on action, it can be argued that increasing the amount of information on the design alone actually increases the designer's level of control. Simulation-oriented approaches raise, therefore, the level of information on the design form, and can be consequently considered as providing an increased amount of control over the design. But does increased control necessarily imply better design?

The question of the quality of the architectural design encompasses many factors that are only partly objective. Nevertheless, it seems fair to postulate that within the boundaries of the capability and talent of a single designer (or design team), the increase in the amount of information over the design is more likely to improve the design outcome (Hartog *et al*, 1998) or at least to bring the design closer to the designers' objectives, which can be independently examined for quality.

Representation within modes of simulation

As mentioned earlier, traditional 2-D representation of the architectural design is mainly communicated by mean of plans, section and elevations. These abstract views are shown from an impossible point of view to the human eye. The nature of the abstraction in these views was defined by Picon as the drawing paradox. It refers to the increase in abstraction of the representation with the increase in the specificity of the physical effect (Picon. 2004). This paradox arguably ceases to exist with the introduction of the parametric single model design approach. Designing with 3-D model allows both impossible views as plan and elevation, as well as views like perspective and walk-through animations that simulate a possible point of view for the human eye. Moreover, the notion of layers in the computer model allows an incremental representation in which the level of detailing is defined by the viewer according to need, starting from a 1:1 virtual representation of all the components that are part of a certain architectural element, to a less determined, schematic representation of basic contour lines. The same idea can be controlled by rendering engines that can produce a highly realistic and rather schematic

representation from the same 3-D model based on user preference.
Another implication of the shift to simulation modes is a change of attitudes of the digital form towards notions of scale and materiality. Early computer-based design projects from the 1990's, such as the early works by Stephen Perella (Hypersurfaces) and Marcus Novak (Liquid Architecture) existed only in the virtual domain. Their dimensionality and materiality could not be connected to a particular scale and material, but could match various material and scale conditions simultaneously. Moreover, form in these early projects was generally generated in animation software, which concentrated on the representational, visual aspects of the represented material. Thus, materials in these models were non dimensional wallpapers that wrap the digital form.
Using a parametric simulative design approach and tools, involves, by definition, a tangible scale and materials. A change in parameters of scale and material generates subsequent changes in the simulation results. A 3-D model in a simulative virtual environment is thus more than a representation of the physical environment. It is more like a parallel environment in which the amount of information embedded in the forms determine the level of accuracy and simulative behavior of this environment.

Simulation and optimization in architectural design

It is of course difficult to imagine architectural design representation that does not have some kind of visual aspect and that relies solely on computer code and raw geometric data. It is also clearly impossible to define the totality of the architectural problem and to solve it empirically, as aspired in purely scientific disciplines. Hence, it is hard to speak of full optimization or generation of form in the scientific/empirical sense without involving ill defined[8] or visual, qualitative parameters. In fact, the idea of full optimization can be dangerous for architectural

[8] Archer (1984) defines an ill-defined problem as "one in which the requirements, as given, do not contain sufficient information to enable the designer to arrive at a means of meeting those requirements simply by transforming, reducing, optimizing, or superimposing the given information alone." According to Goldschmidt, in a well-defined problem "the initial state is given, the goal state is either specified or it can be determined using stop rules, and the operators are controlled by known algorithms." In an ill-defined or ill-structured problem, "one or more of these constituents is either unknown or ambiguous" (Goldschmidt, 1997). In relation to the above definitions, Rowe's (1987) definition of problems as "wicked" emphasizes the lack of definitive formulation and the lack of stop rules.

design since it calls for going back to logocentric modes of functional thinking, which was already tried and abandoned in the 1980's, and ignores the notion of redundancy[9] in design. Moreover, in an optimization process that entails more than one parameter there must be a subjective definition of preferences in order to arrive at the "optimum". And even then, the optimum will always be specific, since the order in which the processes are activated, and the kinds of parameters chosen, change the final product. Hence, because of the subjective definition and the complexity of the architectural problem that involves reference to many parameters, the idea of optimization in architecture takes on a different meaning.

The problem is even more complex in regards to the cognitive and the perceptual dimensions of the concept of performance, because the initial definition of the parameters is done subjectively by a statistical translation of human desires and impressions. Therefore, some visual aspects of the modes of representation in architecture can be avoided only in design which involves simple, well define problems – usually single parameter problems, such as loads and quantity of light. However, even in these types of problems it can be argued that without a visual intervention at a certain stage, the design would not be thoroughly complete.

Architects and engineers - are engineers the new architects?

A shift in the perception of the architectural profession may come about due to architects' pursuit of new modes of simulation. Architects' would command more responsibility over the performance of the architectural form, whereas currently responsibility for performance is generally associated with the engineering profession. If, before this transition, the architect was responsible for the design and production of plans, which were the builder/contractor's job to realize, in performance-oriented design and manufacturing, the architect, in fact, produces the code that generates the form and the file from which the real object is produced, without any need for mediators. Moreover, in terms of the design process, the use of architectural simulation tools is constantly increasing and changing the traditional dominancy of researchers, advisers and engineers in using these tools. Similar to the use of computer code by architects, working

[9] See the discussion on redundancy in relation to generative architectural design in Weinstock paper on self organization (2006)

with simulation tools requires a higher level of scientific education. This level of knowledge is currently missing in the architectural education (Hobbs et al. 2003). Simulation processes setup requires tedious and correct data entry in order to be accurate. Architects today simply do not have the knowledge to be able to enter the data in order to run the simulation correctly. However, since in simulation algorithms simple mistakes in data entry will result in misleading predictions, ignorant user-preset modes could be developed. These modes would be able to provide worthwhile information to designers in the initial parts of the design, mainly for general and common design scenarios. Using these modes would also be a trigger to simultaneously increase the architectural knowledge, and develop designer-friendly simulation software, or the incorporation of simulation modules in state of the practice architectural software.

The move towards performance-oriented design and the use of simulation processes in design support contradicting claims regarding the future of the profession. On the one hand, the complexity of the tools and the knowledge required to work with it could support an argument that engineers are the new architects (Fortmeyer, 2006). on the other hand, the emergence of architectural use of simulation software and the move towards one model environment[10] based on BIM and controlled by the architects, elevates the architect's position within the industry in terms of responsibilities and influence. Although it seems that these changes do not do away with the need for professional advisers, nor decrease the roll of the architect in the near future, it does seems to point at professionalizing and fine tuning of the future architectural form.

The idea of the shift to modes of simulation, thus, tries to integrate multiple developments in the architectural practice, technology and theory into a singular idea. Although simulation as a process could not exist for its own sake in architectural design, understanding of the implications of engaging various mentioned modes of simulation could help designers to regain a new type of control over the architectural design while creating new possibilities for more performance-oriented and sustainable formal expressions.

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[10] One model environment refers to the possibility to conduct the entire design process of all the disciplines of the building industry using a single 3-D model and tool. This type of design process is currently used in other industries as the aviation, naval and car industries. In architectural design it is promoted by companies that produce software such as Digital Projects (www.gehrytechnologies.com) and Integrated Environment Solutions - IES (www.iesve.com).

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