Signature Architecture Franchising: Improving Average Architecture Using BIM

MARK CLAYTON
Texas A&M University

OZAN OZENER
Istanbul Technical University

EHSAN BAREKATI
Texas A&M University

JAMES HALIBURTON
Texas A&M University

A VISION OF A NEW INDUSTRY PARADIGM

Although the focus of the architecture press is generally upon innovative but idiosyncratic works by acclaimed designers, architecture that is more prosaic largely determines the context for our lives in the tract homes, mini-malls, schools, branch banks, and examples of "average architecture". By exploiting the power of Building Information Modeling (BIM) one can envision a new form of practice, signature architecture franchising (SAF) that could be used to produce high quality architecture at price and speed such that it could become the norm for design of average architecture. This concept could raise the quality of average architecture and thus affect a large portion of the population in ways that acclaimed architecture does not.

An initial set of experiments suggest that the capabilities of BIM are sufficient for significantly expediting the design of a building to conform to a signature architectural style yet tune it to high performance. A BIM with integrated data and interoperable linkages to analysis tools is reusable from one project to the next. modified designer can easily modify the initial design to create alternatives that can be analyzed using interoperable tools. Furthermore, a system of constraints and components can capture the essential aesthetic, functional, and construction features of a particular signature style of architecture. From these three capabilities it is possible to create a software system that supports comprehensive design, engineering, and construction planning services for a stylistically consistent class of buildings of a particular type. Such a software system could be packaged as a product that is licensed to designers for use in a particular market, essentially franchising architectural skills that have been encapsulated in software. Signature architecture franchising could upset the entire industry of design and construction of buildings by changing the skill sets, roles, contractual relations and billing structure of every player in the design process. This paper presents the concept, a theoretical exploration of the concept, and initial empirical tests of the idea of franchising signature architecture.

Existing BIM technology can support this strategy. Our investigations suggest that a seed BIM file and its interoperable connections to simulations are reusable from one project to the next. Another experiment has demonstrated that relatively inexperienced designers can use the seed BIM to produce new designs very rapidly. Further study has shown that the seed BIM can be manipulated to model architecture of high repute in a signature style. Another study illustrates how dimensional and proportional constraints and kits of parts can enforce a recognizable

style. Additional studies are required to substantiate further the concept of signature architecture franchising, but the steps are clear and highly plausible.

This investigation has focused on home design, but it could also describe other markets for routine and not-so-routine architectural design. The contribution of this research is to design methods and methods of practice. We have not attempted to innovate in methods of computational design or invent new software.

STAR ARCHITECTURE AND COMMODITY ARCHITECTURE

Before objections arise that architecture is not a commodity that can be franchised, it is reasonable to point out that it always has been commoditized to some extent. Architecture involves a large amount of branding and marketing around designers and signature styles. So called "star architects" develop signature styles that are instantly recognizable and memorable, as shown by example in Figure 1. Le Corbusier provided a stark but wildly expressive modernism in works such as La Tourette Monastery, Chandigarh Government Complex, and Notre Dame du Haut at Ronchamp. One knows what to expect from Richard Meier in the design of a building: grids of white panels, glass curtain walls, round columns, and fine materials arranged in a highly formal way. Frank Gehry's architecture may be a greater contrast to convention, but it is certainly a signature style that is easy to recognize and is produced in a highly routinized process. Architects from centuries past too, developed signature styles. Palladio designed villas in a neo-Roman style, helping to promulgate Renaissance architecture. Christopher Wren is credited with designing 51 churches in London after the Great Fire of 1666.

The great styles of architecture history also inherently exhibit clichés and motifs that can be duplicated by designers who work in that style. Gothic architecture, neo-classicism, Japanese houses, Islamic architecture, and any recognizable style consists of consistent elements arranged in particular patterns. The rules can be codified into software.

The design of many building types is routine. Many firms specialize in building types such as schools, apartment buildings, banks, or mini-malls. The detailing, finishes, and much of the space layout is reused from one project to the next. At the extreme are "replicable buildings" whose plans can be approved for code compliance by a designated expert and then reused in multiple jurisdictions (Post 2010). Each building is a copy that is largely unchanged.

Our assumptions include the definition of architecture broadly to include all inhabitable buildings. We do not define architecture as only the design and building that enters the canon of fine art, but include the everyday fabric of our cities and communities. Like Frank Lloyd Wright in his aspirations for Usonia or Walter Gropius and his desire to assist the working classes through architectural design, our goals are democratic and egalitarian (Wright 1931, Gropius 1965). Furthermore, we accept the imperatives defined by the Intergovernmental Panel on Climate Change that improving the quality and efficiency of the average building is critical to reducing the negative consequences of climate change (IPCC 2001). Melding signature design while achieving high performance in routine buildings could have a profound positive impact upon our built environment by increasing beauty and reducing the degree of climate change.

DISRUPTING CONVENTIONAL PROCESSES

The term BIM is used by various authorities to refer to the products of software, the process for collecting and documenting a building, and the use of information in simulation and analysis to enable decisions about design (Eastman, et al. 2008). Whichever definition is used, BIM implies a conceptually different way of thinking about design. While in the conventional process, designers dissect, reduce and abstract the building into orthogonal drawings, the BIM process constructs a virtual building and simulates its performance, avoiding the abstraction steps (Ambrose 2007). Guidera notes that BIM has managed to automate many of the low level and tedious aspects of architectural production, such as 2D drafting production, schedules, and view coordination, that have been the dominant activities in both education and practice (Guidera 2006). These activities consume most of the billable time in conventional architectural practice but are largely streamlined and accelerated when using BIM. If time devoted to a project remains constant, a BIM-enabled project allows more time for consideration of issues of performance and optimization, as well as intangible issues of design quality and expression.

Figure 1. Examples of signature architecture styles: Le Corbusier, Gehry, Meier, and Palladio. (Photos by Mark J. Clayton).

However, BIM provides its full value when it is implemented with a careful reassessment of workflow: "Properly implemented, BIM will fundamentally change the way [architects] do business, both internally and with business partners and clients" (Smith and Tardiff 2009, 106). Integrated Project Delivery (IPD) is emerging as a powerful alternative to conventional approaches to project organization that dovetails well with the capabilities of BIM (AIA 2007). IPD is predicated on forming a team of owner, designer, and constructor at the inception of the project, removing incentives for adversarial behavior, and enabling decisions to be made collaboratively based upon open financial books and shared information. Although not inherent to the process, BIM is a natural tool for supporting IPD for its ability to rationalize decisions through simulation, coordinate information and eliminate clashes, and integrate across disciplines. IPD is a large step in conceiving of new forms for the industry, but it derives from design/build, construction management and other alternative delivery methods (AIA 2007). IPD restructures existing roles and relationships, but does not delete roles or invent new roles.

A more radical vision of the impact of computing was expressed in an old idea of integrated, intelligent CAD that could restructure the design process. Mitchell summarized the idea of "integrated CAD" as the concept of expert systems and other analytical software tools that addressed more clearly-defined parts of the design problem while a designer would address the messy, ill-defined parts of a design problem (Mitchell 1994). A salient aspect of the vision is that design is done by a single actor aided by software rather than a team of collaborators. Several research prototypes have explored the concept of integrating multiple expert systems with a CAD graphics system to either partially or fully automate the analysis of designs, including DICE, ICADS, ICATect and SME (Sririam, et al. 1991, Pohl, et al. 1992, Amor, Hosking and Donn 1993, Clayton, Fischer and Kunz, Rapid conceptual design evaluation using a virtual product model 1996). The SEED project employed case-based reasoning and automated design evaluation to generate candidate solutions for building design and check them against criteria (Flemming 1994).

Not only design analysis has been automated. A long and productive thread of architectural research has focused upon generating architectural designs

that are similar to those by recognized architects, usually at the conceptual or schematic level of detail, using shape grammars (Stiny 1980). Recently, a shape grammar has been integrated with a BIM authoring tool (Grasl and Economu 2010).

The studies from the era before BIM assume explicitly or implicitly that Computer-Aided Design should enable an individual to collect and integrate design analysis results from a variety of automated consultants. The premise was to aid the individual by performing automated analyses of design options and providing feedback to the designer.

Vehement argument has suggested that architectural software should adapt to how people work rather than the inverse. However, our research takes a contrary view that the process of design itself can and should change to accommodate the capabilities of new software. Signature architecture franchising builds upon the radical traditions of integrated CAD and design automation, posing a new organization of the building industry that depends upon a lone designer who uses software as a lever to do the work of an entire design team. This approach to architectural design demands that the process be changed to accommodate the tool rather than expecting the tool to accommodate existing processes. Our approach is purposely disruptive of existing patterns of authority, prestige and action.

NECESSARY TECHNOLOGY

The conventional model of architectural design and practice is largely concerned with creating successively less abstract representations of buildings in the form of orthogonal projections. In contrast, the new process avoids the dependence on abstraction by a complete simulation of a building as the starting point for design. Design is then a process of modifying the starting point rather than inventing a new solution.

Our experimental testbed consists of a variety of BIM software tools as well as undergraduate students in courses and graduate students undertaking research. Our lab makes common use of an Autodesk environment including Revit, Green Building Studio, Ecotect, and Navisworks. We use Revit Application Programming Interface (API) with the Microsoft C# programming environment. Microsoft Project is a powerful tool for construction scheduling, and Microsoft Excel is a capable tool for cost estimation. Some of these tools are closely integrated with Revit, while others are easily made interoperable through exchange of files generated from Revit. In this paper, terminology from Revit will be used. In particular, the term "family" is used to denote a class of building components that may be instantiated with particular values for spatial or non-spatial parameters.

The experiments that we have conducted were not conceived a priori but arose as a set of reasonable steps. This research method is more akin to a process of design or invention that relies upon expedience and emergence of ideas rather than a predetermined set of activities. The research is exploratory and formative rather than definitive. Validity rests on logical argument and a certain post-facto self-evident quality. Reliability results from the large number of researchers and student participants who have contributed.

EXPERIMENT 1: THE SEED BIM

From experience teaching designers how to use BIM, a concept of a "base case" building emerged as the foundation for a new design method (Ozener 2009, Clayton, Ozener, et al. 2010). The base case idea derives from a climate responsive design process developed at UCLA (Milne 1991). In the Studio 21 design method, the base case is a simple, direct solution to the architectural problem expressed as a BIM solid model coupled to analysis tools such as cost estimation, daylighting simulation, energy simulation, and 4D CAD. Alternatives are then produced in an iterative process that uses rigorous analytical results to guide decisions. Iterations of new designs can be performed quite fast, often in a few hours. Iterations can also vary widely from the base case. The power of using the base case is that the difficult issues of interoperability are resolved in the base case and then simply used on all design variants.

The concept of the base case can be extended to a concept of a "seed" BIM that can be used not only within a project but across projects. The seed BIM consists of the solid model in a BIM environment, the constraints on dimension and proportion, and the set of families that define the characteristic walls, windows, roofs, floors, doors, columns, beams, equipment and furnishings. It includes conventional documentation laid out as sheets of plans, sections, elevations, schedules, and perspectives. It

Figure 2. Projects by sophomore students using a seed BIM of a house

also includes the interoperable pathways to a kit of analysis tools and the analysis tools themselves.

An initial experiment tested whether the seed BIM was a viable concept by reusing a seed BIM of a generic house in two widely varying projects. House plans were acquired from two commercial home builders and then modeled by modifying the same seed BIM (McGarity 2010). Naturally, the interoperable connections between the BIM model and the analysis tools were preserved, greatly speeding the analysis of the designs. This experiment demonstrated the idea of reusing the seed BIM from one project to the next.

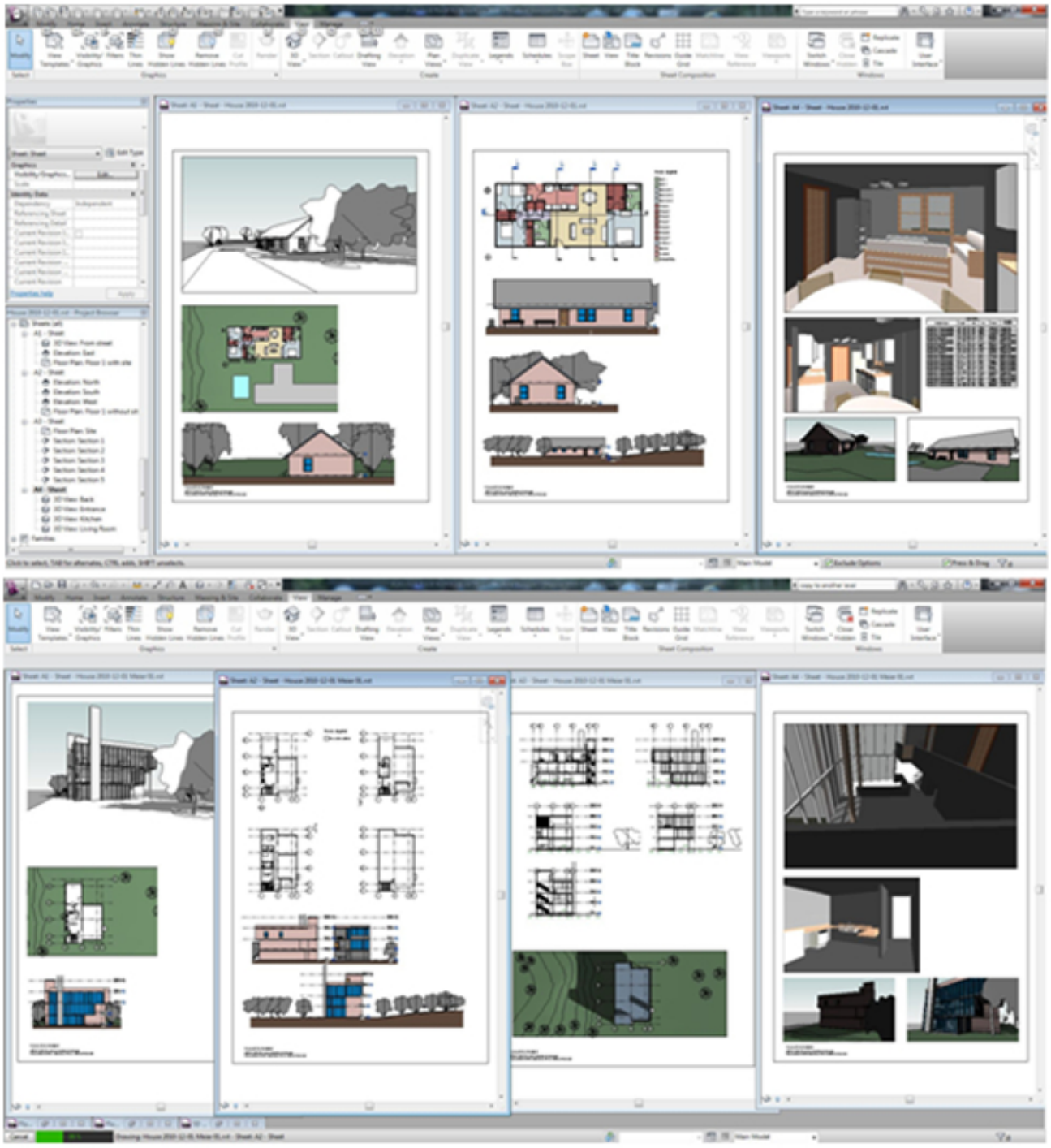

Figure 3.Starting point and ending point of adapting the seed BIM to portray a house inspired by a Richard Meier design.

EXPERIMENT 2: FRANCHISING THE SEED BIM

The second experiment explored the question of whether other people could use the seed BIM in their own design work. A secondary question was whether the seed BIM would overly constrain and limit the creativity of the designers. A seed BIM was given to a sophomore architectural design studio with the in-

structions to modify it repeatedly to make five house designs. As the sophomore students were expected to focus more on spatial issues and documentation issues, this seed BIM did not include the links to analytical tools. However, the seed BIM included elaborate view settings, views, camera locations, and sheet layouts so that as students worked, an entire schematic design presentation appeared on the sheets. Figure 2 illustrates the common presentation format and some of the designs that were produced.

Although not all students produced five schemes, the students produced several dozen schemes in less than two weeks. The schemes varied widely in concept and parti, and naturally the quality of architectural design also varied widely. This experiment demonstrated that relatively inexperienced designers (sophomores in a design course) could make use of the seed BIM to produce designs very rapidly and with a great deal of variety.

EXPERIMENT 3: MAKING ARCHITECTURE WITH THE SEED BIM

The immediate and predictable criticism from colleagues was that the quality of architecture was not impressive and that the low quality must be due to the use of a BIM tool. A third experiment addressed this criticism by using the same seed BIM as the starting point to model works of architecture that are recognized to be high quality. Co-authors have modeled houses by Richard Meier, Mies van der Rohe, and Mario Botta. Each model has required about four hours to construct from the seed BIM. Each house is fully documented with plans, sections, elevations, renderings, and schedules in a uniform format at the level of detail and presentation typical of an educational studio project. Figure 3 shows the starting point and the ending point for modeling a house similar to one designed by Richard Meier. Clearly the seed BIM does not limit one to mediocre architecture.

The process of modeling a house by Mies and a house by Botta is documented in You Tube videos. Please see http://www.youtube.com/user/ebarekati Cammarata has amply demonstrated that BIM tools can be used to model works of great architecture, describing efforts to model several hundred published works by modern and contemporary architects (Cammarata 2009).

EXPERIMENT 4: USING CONSTRAINTS TO CONTROL FORMAL RELATIONSHIPS

The experiments have shown that the seed BIM can be varied widely and even wildly into essentially any design. Creativity and personal expression do not appear to be constrained. This can be construed as a failing; the goal of the research is to constrain the designs to only "good" architecture. To explore the capability of Revit to constrain designs, the researchers constructed a model of a prototypical Louisiana plantation house. The BIM makes extensive use of grids, alignments, and locks to limit the model dimensions to regulating lines that are typical for the Louisiana plantation houses. Figure 4 consists of two images of the same BIM but with its grid proportions varied to depict each of Destrehan Plantation and Oak Alley.

FUTURE EXPERIMENTS

These four experiments provide strong evidence that the concept of a seed BIM is reusable across projects, usable by non-professional designers, capable of being the starting point for modeling great works of architecture, and able to incorporate constraints that restrict designs to particular rules of order and proportion. Nevertheless, the research is not conclusive with respect to establishment of signature architecture franchising. Additional experiments can increase validity and reliability, and evolve a wild and primitive concept into a more robust and convincing method. Some of the planned experiments include:

- Stabilize and expand the interoperable connections to simulation tools and field them in design studio courses. This experiment, planned for the fall of 2011, will establish whether the full process of using the seed BIM and performance-based decision-making can be taught, adopted, and made routine.
- Constrain the population of designs to a signature style using API programming. Shape grammars and other definitions of style will be implemented as plug-ins to Revit. This experiment is meant to constrain the output of the system to only architecture of recognizable styles that are accepted as high quality. A shape grammar approach similar to that used by Grasl and Economou may be used to embed stylistic constraints into a BIM.

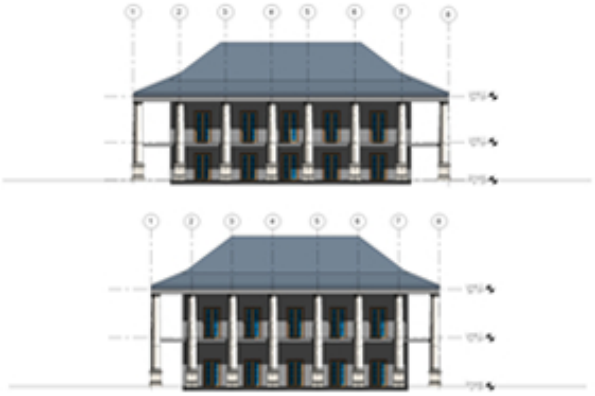

Figure 4. Constraints to grids and manipulation of proportions to create models reminiscent of Destrehan Plantation and Oak Alley Plantation.

- Test the production of large numbers of building designs. The seed BIM for specific architectural styles will be tested in design studio courses to produce multiple designs.
- Establish an improvement program to collect feedback and criticism and then incorporate improvements into the software system.
- Develop a process by which an architect can reliably create a signature architecture seed BIM for either internal use by employees or for franchising.
- Investigate the set of contractual relationships, risk factors, supply chain, and value propositions for implementing signature architecture franchising. Liability and pricing issues must be resolved. Regulatory work flows must be established.

CONCLUSIONS

From these experiments, one may conclude that BIM technology is largely adequate as the technology to aid production for signature architecture franchising. The seed BIM can bundle graphic presentation, families for a palette of construction materials and form, relationships and dimensional constraints, and linkages to analysis tools. The seed BIM can be used by relatively unskilled users. The seed BIM can be used as a starting point to model beautiful architecture. The seed BIM provides performance analysis ready-at-hand so that it can influence the decisions of the designer.

If one projects this way of doing architecture onto the market, one can anticipate both massive economic advantage and disruption of conventional roles. On routine projects for which a comprehensive seed BIM is available, consulting fees could be reduced as the engineering consultants are supplemented by automation. By employing the concepts in the Studio 21 design process, design schemes could be analyzed by using simulations for energy use, construction cost, construction time, structural performance and other criteria to enable selection of high performing schemes. Construction management fees might also be reduced due to automation of construction scheduling tasks on routine projects. Additionally, benefits to construction are also gained through clash detection and reduction of Requests For Information and Change Orders. Profits for the franchisee should accrue from volume of projects as well as improved quality.

The seed BIM vendor, or franchiser, could assume responsibility for developing the seed BIM, validating the results of analysis tools, providing a high quality user interface, training franchisees, and obtaining regulatory approval for the products of using the seed BIM in design. The franchiser would also assume responsibility for marketing the franchises, defining and enforcing limits to franchises (perhaps by geographic region), and combating software piracy. The seed BIM franchiser would upgrade the seed BIM periodically to improve performance and usability based upon post occupancy surveys, rigorous scientific study of performance, and careful analysis of markets for materials and construction methods.

Clients of signature architecture franchising could expect to gain a building in a recognizable signature style that performs at a high level as validated by analysis software. The efficiencies in production could be passed to clients as expedited schedules or lower fees. The biggest opportunities may be to address markets that are currently poorly served by the architecture, engineering and construction management professions or that are currently served through routine design. Signature architecture franchising arguably could increase the quality of routine design by employing signature architecture styles and achieving high performance. As such, this concept for architectural design and delivery services could play a role in addressing major challenges to the industry, such as crippling cost overruns, low productivity, and imperatives to reduce energy consumption (LePatner 2007, Teicholz, Goodrum and Haas 2001, Architecture 2030 n.d.).

The potential disruptions to established practices and authorities are likely to foster strong and strident resistance from those who are vested in the status quo. Liability issues and regulatory issues may be very difficult to overcome. Adoption of signature architecture franchising may occur first in markets that are marginal to those occupied by established professionals.

Signature architecture franchising is inherently a limited approach to architecture. The seed BIM is intended to limit the solution space to designs of a particular type, style, and quality. The designer using signature architecture franchising should not expect to have the freedom to design anything. This limitation is what makes possible the relatively tight integration of analysis tools to the BIM authoring environment. Arguably the designs that result are routine and not innovative, although arguably they are no more routine than the designs of most architects. However, the experiments suggest that this approach can produce a large number of designs of demonstrably high quality very fast. Signature architecture franchising may play an important role in addressing reduced energy consumption, demographic shifts, disaster recovery, and demands for sustainable design. The approach may help designers to provide high quality design solutions for the enormous market for average architecture.

REFERENCES

AIA. Integrated Project Delivery: A guide. White paper, Washington: American Institute of Architects, 2007.

Ambrose, M. A. "BIM and integrated practice as provocateurs of design education." Proceedings of the 12th International Conference on Computer-Aided Architectural Design Research in Asia. CAADRIA, 2007. 283-288.

Amor, R., J. Hosking, and M. Donn. "Integrating design tools for total building evaluation." *Building and Environment*, October 1993: 475-482.

Architecture 2030. *Architecture 2030*. n.d. http://architecture2030.org/ (accessed September 17, 2011).

Cammarata, A. "Rebuilding architecture: An analysis and critical investigation practice." Proceedings of the Arab Society for Computer Aided Architectural Design (ASCAAD 2009) . Manama (Kingdom of Bahrain): ASCAAD, 2009. 121-134.

Clayton, M. J., M. A. Fischer, and J. A. Kunz. "Rapid conceptual design evaluation using a virtual product model." *E*ngineering Applications of Artificial Intelligence 9, no. 4 (1996): 439-451.

Clayton, M. J., O. Ozener, J. Haliburton, and F. Farias. "Towards Studio 21: experiments in design education using BIM." *SIGraDi 2010: Proceedings of the 14th Congress of the Iberoamerican Society of Digital Graphics*. Bogota, 2010.

Eastman, C. M., P. Teicholz, K. Liston, and R. Sachs. *BIM handbook: a guide to building information modeling for owners, managers, designers, engineers, and contractors* . Hoboken, NJ: Wiley, 2008.

Flemming, U. "Case-based design in the SEED system." *Automation in Construction 3*, no. 2-3 (1994): 123-133.

Grasl, T., and A. Economu. "Palladian Graphs: Using a graph grammar to automate the Palladian grammar." *Future Cities: 28th eCAADe Conference Proceedings*. Zurich: eCAADe, 2010. 275-283.

Gropius, W. The new architecture and the bauhuas. Translated by P. M. Shand. Cambridge, MA: The MIT Press, 1965.

Guidera, W. "BIM applications in design studio: an integrative approach developing student skills with computer modeling." *Synthetic Landscape: Proceedings of the 25th Annual Conference of the Association for Computer-Aided Design in Architecture]* . Louisville, KY: Association for Computer-Aided Design in Architecture, 2006.

IPCC. "Summary for policy makers." In Climate Change 2001: Mitigation. Intergovernmental Panel for Climate Change, 2001.

LePatner, B. *Broken buildings, busted budgets*. Chicago: University of Chicago Press, 2007.

McGarity, A. Development of a method using BIM Technology to determine the utility bill and total cost of ownership of a single-family home. Undergraduate thesis, College Station, TX: Texas A&M University, 2010.

Milne, M. "Design tools: future design environments for visualizing building performance,." Education, Research, Applications: CAAD Futures '91 Conference Proceedings . Zurich: Computer Aided Architectural Design Futures, 1991. 485-496.

Mitchell, W. J. "Three paradigms for computer-aided design." *Automation in Construction 3*, no. 2-3 (1994): 239-245.

Ozener, O. O. Studio education for integrated practice using building information modeling. PhD dissertation, College Station, TX: Texas A&M University, 2009.

Pohl, J., et al. A computer-based design environment: implemented and planned extensions of the ICADS model. Research report, San Luis Obispo, CA: School of Architecture and Environmental Design, Cal Poly State University, 1992.

Post, N. M. "Guide to streamline review of 'replicable' building projects." *Engineering News-Record 265*, no. 9 (2010): 14.

Smith, D. K., and M. Tardiff. Building Information Modeling: A strategic implementation guide for architects, engineers, constructors, and real estate asset managers. Hoboken, NJ: John Wiley and Sons, 2009.

Sririam, D., R. Logcher, A. Wong, and S. Ahmed. "An object-oriented framework for collaborative engineering design." In Computer-Aided Cooperative Product Development, by D. Sriram, R. Logcher and S. Fukada. *Springer-Verlag, 1991*.

Stiny, G. "Introduction to shape and shape grammars." *Environment and Planning B 7* (1980): 343-351.

Teicholz, P. M., P. M. Goodrum, and C. T. Haas. "US Construction labour productivity trends, 1970-1998." *Journal of Construction Management and Engineering* (American Society of Civil Engineers) 127, no. 5 (2001): 427-429.

Wright, F. L. Two lectures on architecture. Vol. 2, in *Frank Lloyd Wright Collected Writings*, edited by B. B. Pfeiffer. New York: Rizzoli, 1931.