The Use of Interactive Dynamic Simulations for the Purpose of Architectural Representation

Anijo Punnen Mathew  
College of Architecture, Art, and Design  
235 Giles Hall, Barr Avenue  
Mississippi State University, Mississippi 39762  
USA  
E-mail: amathew@coa.msstate.edu

ABSTRACT

Architects have always grappled with graphic representation as a medium to capture the corporeal experience of being in a space. It is difficult to present this nature of a design through the written or verbal language and almost impossible through representation (even digital) techniques. Perhaps it would be impossible for any medium of representation to truly capture the “placeness” of a place. Thus, new representation techniques should only try to get closer to the actual experience than actually hope to replicate it. This paper describes how the use of dynamic simulation and interactive presentation tools present architects with a more accurate and experiential representation of their design; perhaps moving them one step closer to achieving “placeness”.

1. INTRODUCTION

The essence of architecture still remains in the ideation of “human” creative endeavors and ephemeral glimpses or visions of owner(s), designer architects and builders. These exploratory dreams and visions exist beyond formulas and rational machine models (Barrow, 2000). In response, most digital media tools used by architects today are only computational equivalents of traditional drafting and presentation tools. For example, AutoCAD simulates the drafting board, 3D Studio replaces the watercolor rendering. McCann even argues that the digital tool itself is inadequate in capturing the true depth of perceived space - Computer modeling introduces the capability of viewing emerging designs perspectively, but with its virtually limitless depth it aggravates the tendency for the designer’s mind to “go out to wander” no further than the confines of the screen and the illusive depth portrayed there (McCann, 2004). Although it would be presumptuous to assume that digital media (for that matter, any form of representation) will be able to replicate actual corporeal experiences; this paper argues that the use of dynamic simulations for architectural representation can bring architects one step closer to the experience.

Dynamic simulations help the designer to model digital objects with physical qualities in digital space. So, curtains can be made of a specific fabric and hence respond to wind, furniture can have material qualities – mass and inertia, thus be affected by gravity and force. Couple this physicality of the digital space with interactivity and the architect can present the “experience” of his/her space – because instead of just moving through a digital model, the user can interact with the simulated space. Through the course of this discussion we will describe what dynamic simulation is, how it is different from traditional animations, analyze various digital tools and experiments to develop dynamic representations, and finally evaluate these tools in comparison to static images or key framed animations.
2. EXPERIENCING PLACE

When we leave a place, we remember not the place itself, but our experience of it. Echoes, smells, sudden changes in temperature when we pass from light to shadow, heat radiating from a sunlit wall, enframed or hidden views, a feeling of mystery, all contribute to our experience of architecture, and they all stem from the depths of our embodiment...lack of embodiment only produces concretized ideas and geometric constructs (McCann, 2004). Johnson however argues that not all experiences are corporeal; in his paper he mentions that we often have “virtual” experiences - ...dreams, imagination, fantasies, day-dreams, and hallucinations are all part of human existence. We remember dreams as vividly as we remember real experiences. (Johnson, 2002). Johnson further mentions that there may even be physical virtual spaces, stemming from our imaginations and our fantasies; for example, a child’s play structure may become a pirate ship; an elaborate theater set may become 18\textsuperscript{th} century England. What they share is a conscious and constructed reference to some other place, taking advantage of the link between memories and experience.

As virtual representation techniques become pervasive in the profession of architecture it is important to understand that digital reality is only “abstraction” of reality. Users do not actually interact with a digital object; instead what they have really learnt is to negotiate digital space to behave in a manner that they want by mastering the use of input devices. Bui et al. describe the point of “negotiated reality”, an event where the users decide to agree upon what is real and what is not. In this process, reality becomes simply more and more artificial while the virtuality becomes more and more real (Bui et al., 2005).

The experience of a real space also stems from our activities within and the resulting (predictable or unpredictable) reactions of that space. The sound of the floor creaking when we walk across it, the movement of a curtain when we brush against it, the interrupted flow of water when we extend to touch it; these everyday actions create the necessary complexity and unpredictability in our spaces that is difficult to represent through images and drawings. Causality is perhaps the most important criteria for perception of what is real and what is not. To the computer a curtain is no different from a table cloth on a table; it only sees data structures aligned differently. In reality though, the curtain is made of a lighter fabric than the table cloth, the curtain is hinged at one end while the table cloth is constrained only by the shape and size of the table, brushing against the curtain would cause a different set of reactions than brushing against the table cloth. Hence to attain “objecthood”, objects must have peculiar intrinsic qualities because of which interaction within the space would induce a set of causal reactions unique to that object.

In the digital world because there are no intrinsic physical constraints, causation is simulated (Kirsh, 2001)

3. DYNAMIC SIMULATIONS

3.1 What is a Dynamic Simulation?

Physical objects obey Newton’s three laws. They have mass and hence inertia, so it takes force to move them and force to stop them. They have resistive capacity so any force applied to them encounters an equal and opposite force. None of these attributes are true of digital objects. Digital objects are computationally generated elements that can be displayed in wall projections, on screens, or be used in computer programs. They exercise no resistance; they have no mass, inertia, no intrinsic color, shape, size, or solidity. (Kirsh, 2001). In early digital representations, the work concentrated on computer graphics; it was highly demanding to generate a scene because of processing capability and memory usage. Modeling an environment was usually taken to mean describing the appearance of an object: geometry, texture, lighting and so on. Attributing object behaviors was not a consideration made for architectural representation. In general, the person exploring the environment could do nothing unless the person constructing the environment anticipated it (Willis, 2004).
As computers became more powerful and intelligent, it became possible to render large behavioral models. The gaming industry responded first with the creation of algorithms that replicated real world physics through collision detection, fluid simulation, and rigid/soft body dynamics. These gaming engines (like the Unreal Tournament engine) are used today to create interactive games that afford users multiple levels of interactions with the environment they are in: object manipulation (that which can be grabbed, moved, so as to initiate physical processes); and triggers (that which can start a certain process with the environment’s objects) (Cavazza et al., 2004).

Dynamic simulations allow the designer to infuse digital objects with specific intrinsic properties and physical constraints within a digital space. Digital objects are no longer intangible data structures created by a computer to enhance a space; they become objects designed to react to physical forces (like gravity, wind, human interaction). By not keying qualities of the object itself, the designer now affords the space an order of unpredictability – abstracting the experience of being in a real space. Mediated interaction with an object or a certain family of objects can initiate other objects to react in often unpredictable manners. Thus, digital representation evolves from a “beautiful picture” to a true abstraction of reality and causality.

3.2 Animation vs. Simulation

Architects have traditionally used animations and walkthroughs to present their designs. Walk through simulations allow the designer to move perspectively through a sequence of spaces in an emerging design...movement is part of the experience, causing elements to realign and alter visually in relation to other elements (McCann, 2004). Traditional animation techniques use a method called “key framing” or “tweening” to animate objects in digital space. “Tweening” comes from the word in-between; referring to in-between artists who would take two of the animator's “key” frames and draw the frames in between.

Today the computer replaces the in-between artist through the process of tweening. When a designer wants to animate a ball moving down an incline, he/she first sets the ball on the inclined plane; defines the first “key” frame and the last “key” frame, showing the initial and final position of the ball. The computer then uses its resident animation algorithm to generate the in-between frames and “animate” the ball rolling down the incline (see fig. 1).

The problem with key frame animation is that the computer only does what the animator asks the computer to do. The animation will run predictably and unchanged every time you run it. The animator has to carefully align the ball to the incline and make sure that the computer does not tween the ball through the incline at any point in the animation. In short, neither the ball nor the incline holds any native intelligence; and to the computer they are both data structures with no individual character except shape, size and position.
Dynamic simulations on the other hand create objects with individual properties of material and mass. Objects are defined as hard bodies, soft bodies or constraints; each with different properties and reactive qualities. The objects themselves react to forces like gravity and wind and as simulations become more intricate, objects may take on additional properties like friction, air resistance, and bounciness. Dynamic objects can build into themselves inertia and momentum based on the configuration of external forces. Hence, dynamic objects hold within themselves a defined complexity of intelligence and character which is absent in other digital objects.

In order to simulate the same ball moving down an incline, the animator defines the ball and the incline as two separate hard bodies with collisions between them. The animator then defines object properties like mass, friction, air resistance; and finally the force of gravity acting downwards (in digital space, there is no up or down, no top or bottom; you can define forces to act in any manner that you choose). On simulating the scene, the computer's native simulation algorithm makes the ball react to gravity and looks for collision with the incline. Since gravity acts downwards and the ball has a certain mass, the ball will start rolling down, colliding with the incline as it does so (as in real life). Depending on the friction and air resistance, the ball also picks up or loses momentum as it rolls down (see fig. 2).
Once the native character of the objects and those of the forces have been defined, the computer will essentially simulate the scene without the supervision of the animator and the simulation will almost always give different results depending on the alignment of forces in the space.

4. RESEARCH METHODOLOGY

The Design Research & Informatics Laboratory (DRIL) is a multi-platform platform for carrying out interdisciplinary research projects; the exploratory nature of the DRIL enables faculty and students to carry out multiple levels of design research, including research into the use of digital media at various levels of architectural design and education. Recent research is being conducted primarily with post-professional graduate students enrolled in the Masters of Science in Architecture program at Mississippi State University’s College of Architecture. Graduate students have a foundational ‘design process’ education, enabling them to more easily learn how to integrate various levels of digital media into their traditional hard copy design processes. For this project, the students were introduced to different tools for dynamic simulations and encouraged to use interactive simulation methods to represent their designs. The use of these techniques and tools employed by the students were analyzed as a part of the continuous evaluation of digital media in the graduate design studio. Surprisingly, even though we have students from many different disciplines; we have found that only students with a background in architecture or engineering prefer to use dynamic simulations for representation. Other students seem to understand the potential of the technology but are often hindered by their lack of knowledge in physics and structures.

The students work mainly with two softwares: Discreet’s 3D Studio Max and Alias’s Maya Complete. Although Maya has a more flexible dynamics engine, the students find 3D Studio Max’s interface more learnable. The HAVOC engine on 3D Studio Max also supports interactive presentations and is easier to use in an architectural environment because of support from Autodesk’s AutoCAD and Revit. Both softwares are capable of rendering movies in extremely high photo-realistic outputs; but we find that 3D studio Max with its Radiosity/Brazil/Mental Ray engine has more output options than Maya with its Mental Ray engine.

5. USING SIMULATIONS FOR ARCHITECTURAL REPRESENTATION

With the help of our students, we analyzed different methods of using dynamic simulations to represent architectural space and/or phenomena associated with space. The challenge was to take a technology that has been used for quite a while in other industries and adapt it for architecture and design. For this paper, we shall briefly elaborate on two of the methods students used: the first one is a “baking” method for animation; and the second one is an “in-software” method that creates interactive presentations.

“Baking” animations:

The set up of this scene is similar to other dynamic simulation setups; each object is given peculiar physical qualities and forces are set up in the scene as per the requirement. The simulation is run and if the designer is satisfied, that simulation is “baked”. During the process of baking, the computer creates key frames and frames for the scene like a traditional “tween” animation but this time using information from the simulation. The designer may choose to change the set up of the space multiple times until everything works best within the described constraints. The final animation can be rendered at whatever quality the designer requires. This method is most effective because the output is in the form of a movie (Windows Media or QuickTime) and software independent, thus universally viewable on most computers.
“Interactive” simulations:

Although there are a few extra conditions to consider (real-time mediation, object manipulation and triggers) when setting up the scene, the basic premise still remains the same – each object has its own properties and reacts to forces in the scene. The difference in this method is that the output is left open for user interaction. The user not only moves through a space but also interacts with systems and objects in that space. Each object, based on its native property reacts differently to different mediated inputs. Although current representations are very controlled, we are in the process of developing complex dynamic simulations for interactive architectural presentations. One drawback of this method is that the output is software dependant and hence cannot be viewed universally. Since the power of this method is in the interactivity, we are currently working with software manufacturers to look at the possibility of making the interactive window software independent.

Although both methods are equally plausible techniques for representing architectural space, we feel that only interactive simulations, because of its experiential nature, can truly represent “placeness” of a design.

In the end, it is important to understand that true power of simulations will eventually be harnessed when a professional architect can use it to visualize as well as communicate the subtle nuances of his/her design. Our graduate students continuously push the boundaries of simulation on their desktops and notebooks, with the sincere hope that one day their work will find its way into the design studios of architectural practice.

The author would like to acknowledge the following students whose work was used for this publication: Mythili Bagavandas, Namratha Emmela, Kalyan Balasubramanian, and Guochang Wang.

REFERENCES


