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# Dynamic Architectural Constructs

by Ganapathy Mahalingam

The advent of **form•Z** 6.0 has brought with it a new range of tools for the animation of objects. Hitherto, tools for the animation of cameras for walkthroughs and flybys have been available that have made the dynamic visual exploration of architectural forms possible. Early adoption of such animation techniques had designers assuming the role of film makers and directors (Temkin, 2003). However with these initial animation tools, the modeling of dynamic architectural constructs based on performance has not been possible in **form•Z**, until now. This new set of animation tools provides an exciting opportunity to explore architectural designs using radically new approaches.

In his book *Animate Form*, Greg Lynn provides many provocative insights into the use of animation tools for architectural design. According to him, "the challenge for contemporary architectural theory and design is try to understand the appearance of these tools in a more sophisticated way than as simply a new set of shapes. Issues of force, motion and time, which have perennially eluded architectural description due to their "vague essence", can now be experimented with by supplanting the traditional tools of exactitude and stasis with tools of gradients, flexible envelopes, temporal flows and forces. It is not necessary for architects to perform the differential equations that generate topological forms, as the equation for even the simplest spline is too complex for most architects to calculate. Instead, designers must understand the patterns of topology as they unfold dynamically with varying performance, rather than understanding them merely as shapes." (Lynn, 1999) In doing so, Greg Lynn distinguishes digital media as being different from paper and pencil by highlighting the three fundamental properties, which are different in digital media than inert media, such as the paper and pencil, typology, time, and parameters. He goes on to define this approach as an "organic tradition" that often involves non-dialectical relationships between matter and information, form and time, and organization and force. This resistance to treat form, time, and motion discretely is what he says is equivalent to an organic tradition. He believes that the development of "animate forms" is the creation of new symbolic forms in architecture. He says, "The use of parameters and statistics for the design of form requires a more abstract, and often less representational origin for design. The shape of statistics, or parameters, may yield a culturally symbolic form, yet at the beginning, their role is more inchoate. This marks a shift from a modernist notion of abstraction based on form and vision to an abstraction based on process and movement." (Lynn, 1999)

In the fall semester of 2006, in the Department of Architecture and Landscape Architecture at North Dakota State University, an advanced digital design studio was offered to students. The main focus of the design studio was the generation of architectural forms based on specific performance criteria. The intent of the studio was captured in the title, "Forms of Performance." **form•Z** was chosen as the vehicle to conduct these design explorations. Students were not required to have prior experience in using **form•Z**. This allowed us to test whether it was possible to quickly learn the various tools in **form•Z** and become productive within the scope of a semester. **form•Z** is often chided for its steep learning curve. Our experience has pointed out that though it takes time to understand the intricacies of how **form•Z** works, it is indeed possible to start afresh and become productive in the use of **form•Z** in a matter of weeks.

One of the problems that the students worked on was a design exploration called "Volumes of Heat." Students were asked to start with a quantity of heat in British Thermal Units (BTUs) and asked to derive a volume of air that would contain that quantity of heat at optimum conditions of human comfort (75 degrees Fahrenheit and 55% Relative Humidity). This they did using the specific heat of air and the density of air at the appropriate conditions of temperature and humidity. They were then asked to derive an architectural form that contained that volume of air and locate it on a site. Using the climate data for that site and the site orientation of the architectural form, they then calculated the heat gain and losses of the architectural form over a period of one year. Instead of pumping air or water in and out of the architectural form to regulate the temperature inside the form through heat exchanges, the students were challenged to make their architectural form a dynamic construct that changed and adapted in order to preserve the interior optimum conditions of comfort. The architectural form became a breathing "lung" that was homoeothermic. The architectural form was treated as a dynamic construct that changed to preserve the optimum interior conditions of comfort. As the form changed dynamically, it was important to keep track of the heat gains or losses created by the changing form. These tasks turned out to be non-trivial. Strategies that the students used to create the dynamic architectural constructs included changing the volume of the form, changing the size and position of glazed windows, retractable louvers, retractable wall panels, retractable volumes, etc.

Rather than just animate by changing affine transformations, the students actually changed the architectural forms in time by changing the quantities involved in the various parameters of the architectural forms. In order to create these dynamic constructs they had to engage most of the tools in the animation toolset of **form•Z**. To achieve a fine level of control of the dynamic architectural form, they had to get into the intricacies of the Animation Editor and pay close attention to how animations were set up in **form•Z**. This design exploration was an excellent way to get introduced to, and become proficient in the use of the set of animation tools in **form•Z**. The design exploration also served to integrate two areas of the architecture curriculum that are seldom integrated, digital design media and environmental control systems. Functional animation that results in environmental control is the product. In this process, animation is transformed from an aesthetic process to become a functional process as well through dynamic architectural constructs. In addition, an often overlooked set of tools in **form•Z**, the Query tools were used extensively to find out the volumes of forms, the areas of surfaces and the areas of openings. The Query tools are invaluable in making informed decisions about architectural forms, especially when they have to be manipulated to achieve specific performance criteria, which are not limited to environmental performance criteria. Structural design comes to mind with the availability of mass properties of forms. Tools such as the Scaling tools also became critical for making marginal changes in volumes and surfaces of objects that drove the setting of animation keyframes.

The students used Microsoft Excel spreadsheets for all of their calculations. They manually transferred the results of the calculations to the operations in **form•Z**. This was a process that was prone to error and required constant care. It would have been a more seamless exercise if they had been able to use the **form•Z** scripting language to perform the calculations and then directly drive the animations of the dynamic architectural forms within **form•Z**. The ability to perform basic, trigonometric and logarithmic calculations using the scripting language would be an invaluable asset in **form•Z**. This is something we look forward to being available. Given that many of the students were using **form•Z** for the first time, learning to use the scripting language was not within the scope of the studio. In the future, with additional knowledge of the scripting tools, it may be possible for students to develop and execute dynamic architectural constructs from within **form•Z**. This is something we are looking forward to implementing next year.

In conclusion, our design explorations using the new set of animation tools in **form•Z** has enabled us to successfully consider the "dynamic architectural construct," an alternative to static buildings in the achievement of environmental performance. This is also conceptually connected to interactive and responsive architecture, where architectural forms respond to information gathered from spatially distributed sensors that measure various environmental performance criteria. An early project that epitomized this concept was the Aegis Hyposurface project (Goulthorpe, Burry and Dunlop, 2001). Such projects did not emerge initially from the **form•Z** user community simply because the animation tools required to model such projects were not part of the toolset of **form•Z**. However, Tristan d'Estree Sterk won a **form•Z** Joint Study Award in 1999 for a responsive architecture project that was presented without animations, and could have benefited from such animation tools that are available today to reveal the full complexity of his project.

The animation tools currently available in **form•Z** lend themselves easily to the modeling of the effects of sensor+actuator based systems. Conceptual models for sensor+actuator based systems have been developed in recent years by the author, which are the initial steps to modeling such systems (Mahalingam, 2005; Mahalingam, 2001). One can now show through animations how dynamic architectural constructs can respond to human inhabitants. The Hyperbody Research Group at TU Delft in the Netherlands, under the direction of Kas Oosterhuis, has demonstrated the viability of responsive and interactive architecture projects by building full-scale prototypes whose development was most likely the result of using robust animation tools. Difficult implementations such as the 'tunable' auditorium have now become possible with the availability of such tools and are being investigated by the author.

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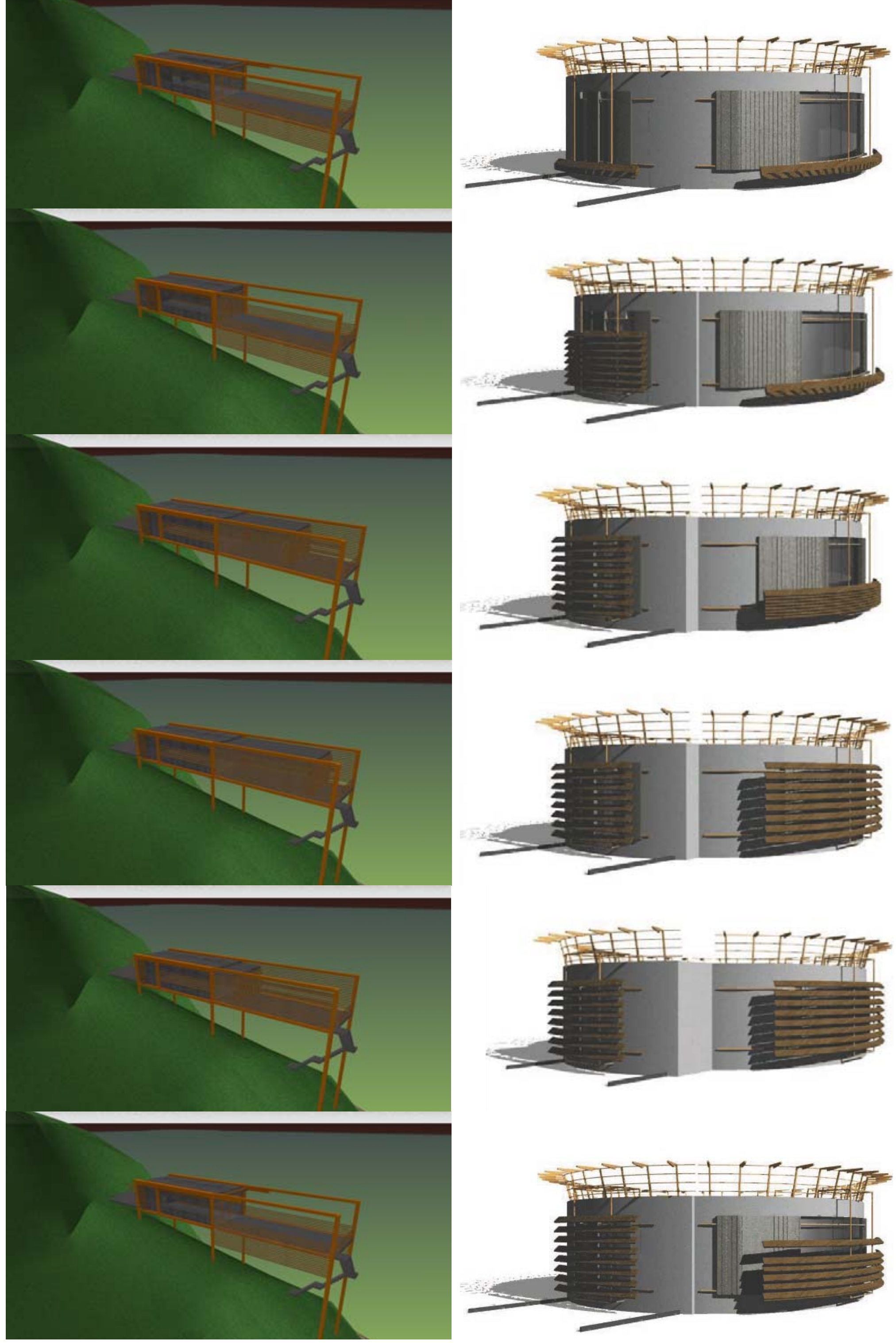

**Animation sequences** by **Andrew Eitreim** (left) and **Matthew Moore** (right).


**Ganapathy Mahalingam** is an Associate Professor and Architecture Program Director in the Department of Architecture and Landscape Architecture at North Dakota State University in the U.S.A, where he has taught since 1993. He was awarded a Ph.D. in Architecture by the University of Florida in 1995 for a doctoral dissertation on the application of object-oriented computing in the development of design systems for auditoriums using a process called acoustical sculpting. He recently served as the President of the Association for Computer-Aided Design in Architecture (ACADIA) from 2001 to 2003. He has presented papers in numerous national and international conferences and has developed software for the design of auditoriums using Smalltalk and the VisualWorks programming environment. His current research interests are focused mainly on the computational modeling of architectural entities and processes using object-oriented computing, graph theory and virtual finite state machines. He has taught numerous courses in computer-aided architectural design at three U.S. universities, Iowa State University, the University of Florida and North Dakota State University. He continues to strive to resolve the computability of architectural design.