Natural Forms As Virtual Architectures

Kamon Jirapong
Faculty of Architecture, Sripatum University, Thailand
Robert J. Krawczyk, Mahjoub Elnimeiri
College of Architecture, Illinois Institute of Technology, USA
http://www.iit.edu/~krawczyk/

Abstract. The structures in nature are great lessons for human study. Having been in development for several billion years, only the most successful structural forms have survived. The resourcefulness of material use, the underlying structural systems and the profound capacity to respond to a variety of climatic and environmental forces make natural form tremendous exemplars to human architectures. The wholeness of natural form indicates that the form and forces are always in some sense of equilibrium. In most of natural forms, the quality of equilibrium may be difficult to recognize. However, seashells are one of the natural forms whose functions are simple enough to be approximated by a simple mathematical relationship. The focus of this study was to understand the seashell form as applicable to human architectures. Digital methods are the language to analyze, create, and simulate seashell forms, as well as, suggest a variety of possible architectural forms.

Keywords. Nature and Architecture, Seashell and Architecture, Virtual Architecture, Form Generation

Form generating process

The study of seashells has a long history, starting with Henry Moseley in 1838 and followed by many researchers such as Thompson (1961), Raup (1961, 1962), Cortie (1989), and Dawkins (1997). These researchers have outlined in a number of forms the mathematical relationships that control the overall geometry of shells. Our interest centers on an investigation of natural forms as a starting point to generate architectural forms.

As documented by prior researchers, the seashell geometry can be expressed by four basic parameters.

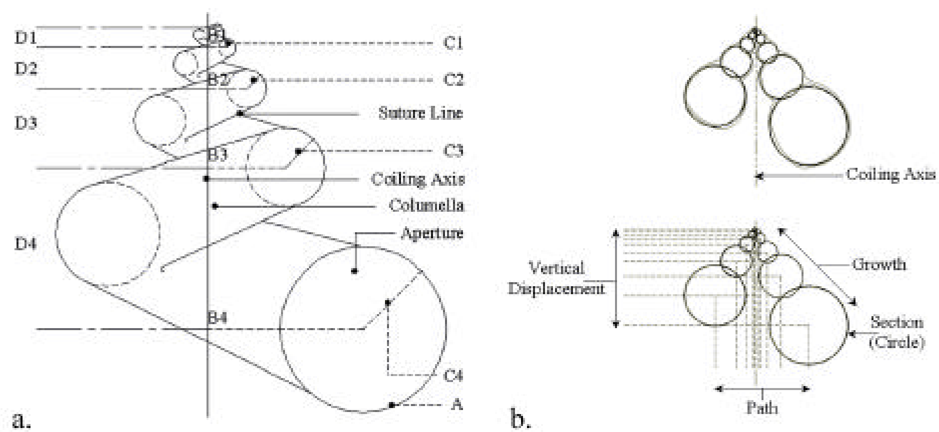

Figure 1. The four parameters

As shown in Figure 1a, A is the shape of the aperture or the shape of shell section, B is the distance from the coiling axis to the center of the shell section, C is the section radius, and D is the vertical distance between sections. To understand the mathematical relationship of these four parameters, one coiling shell of the gastropods class in the mollusk classification was selected for measurement and reconstruction. Its digital geometry is illustrated in Figure 1b.

Each seashell can be reconstructed in a digital form with variations of the mathematical relationships among the four parameters. The result of a specific mathematical combination reflects the shell form for a specific seashell specie. In this study, the concept of creating architectural form originating from seashell geometry can be accomplished by applying these same parameters to an architectural form interpretive exploring process.

Using mathematics as a tool of investigation in both the natural and architectural forms gives us an advantage of exploring multiple forms easily and allows us to implement new parameters into the mathematical framework. Architecture, which exists in a dramatically different environment from the seashell, has other parameters to be integrated during the architectural design process concerning its form. These parameters are designed to accommodate the practical requirements of architectural forms.

The method of generating architectural forms is developed by substituting each seashell parameter with other possible mathematical curves. Each selected mathematical curve represents a mathematical abstraction of a specific seashell parameter as it occurs in nature. This enables the exploring of new mathematical relationships to generate a variety of architectural forms. Figure 2 illustrates the architectural form generating concept and displays examples of other possible mathematical curves.

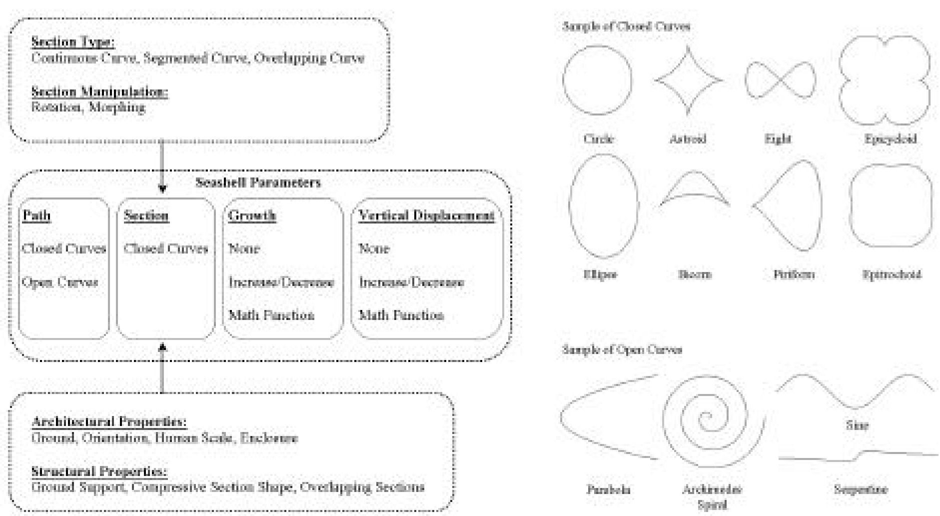

Figure 2. Architectural form generating diagram and mathematical curves

To illustrate the possibilities of architectural forms generated in this process, samples of basic and unconventional architectural forms are presented in Figure 3. Figures 4 and 5 exhibit the idea of how these forms can be used as architectural applications. Each form displays a virtual quality of architecture and is ready to be developed further to a real architecture with proper material and structural system selection.

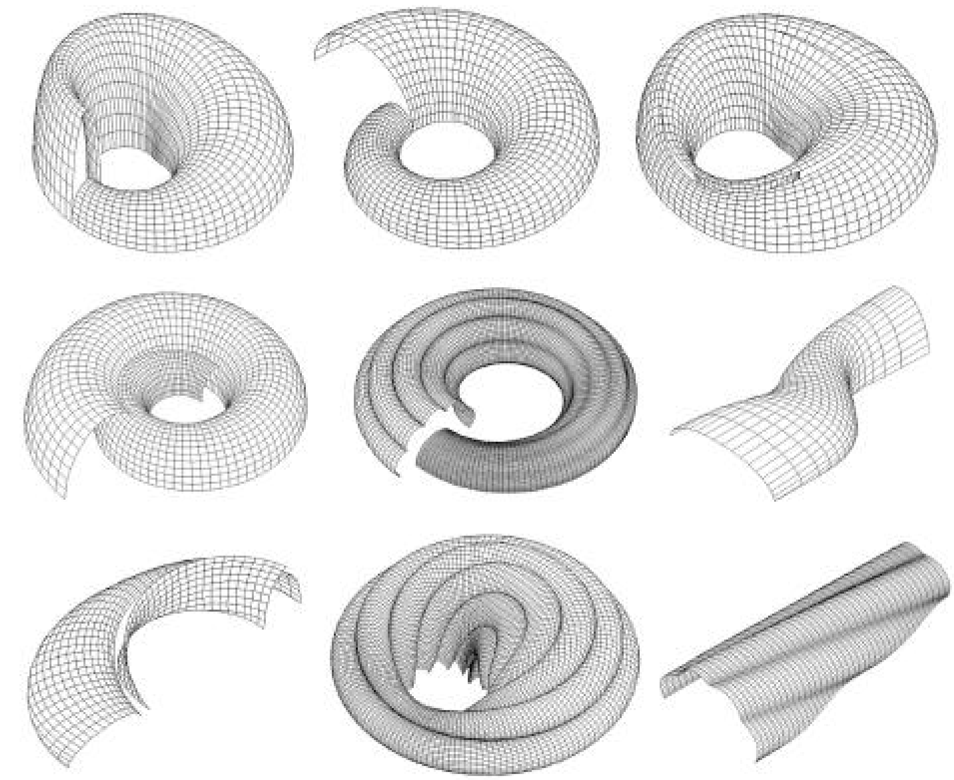

Figure 3. Sample of the results

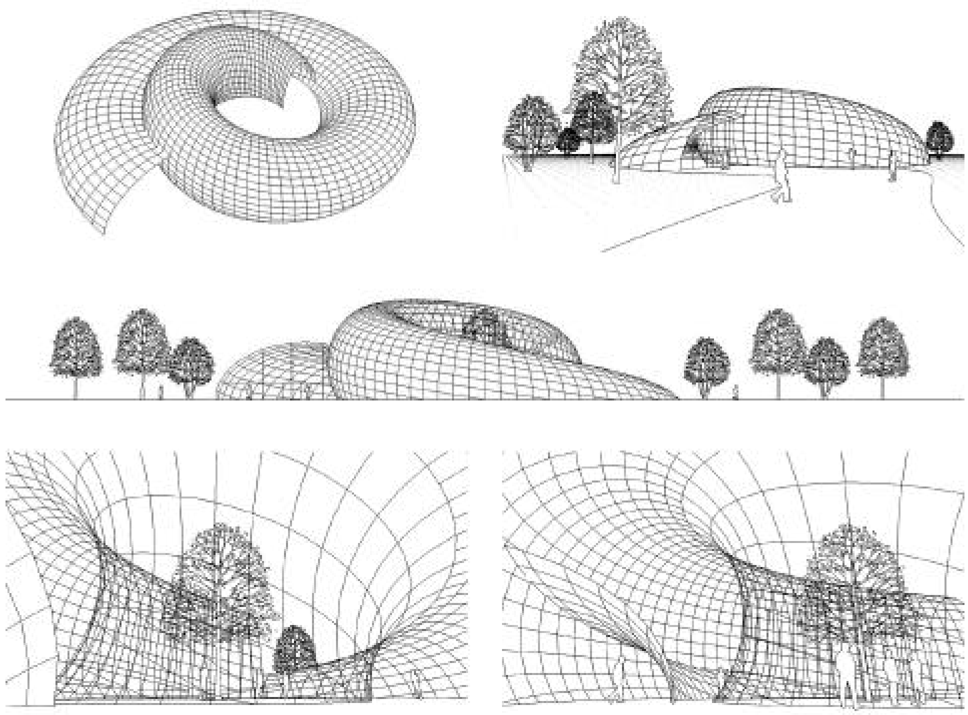

Figure 4. Form as a virtual architecture, example 1

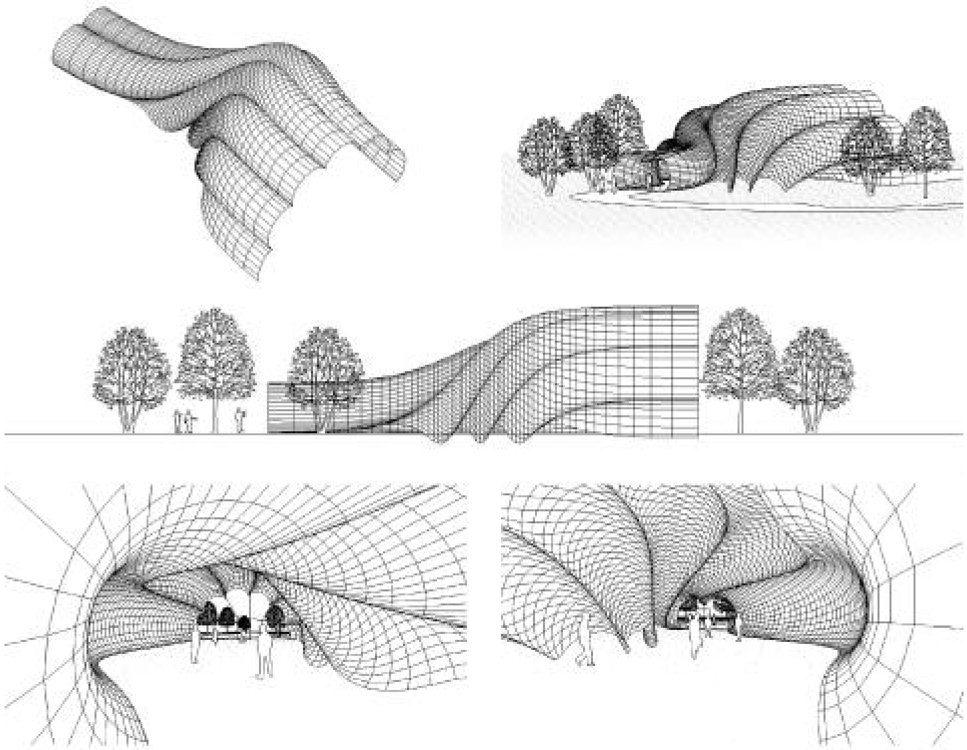

Figure 5. Form as a virtual architecture, example 2

Observation and conclusion

This research concluded that the value of the study of nature is not only for its power of inspiration and influence, but also for its abstract geometric properties. If the abstract properties can be described by the as mathematical relationship, they can then be developed into a built form. The translation of abstracted nature in conjunction in concrete mathematical terms and by applying prerequisite architectural considerations is the fundamental concept of this form development.

The value of this research is the process of developing mathematically definable models into an architectural form. The process is flexible enough to be adjusted to a variety of parameters according to the specific requirements of each architectural project. The results are a family of architectural forms based on one simple mathematical comprehensive relationship.

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