Chapter 02 | Session B2

Simulation as an Avant-garde Form Exploration Tool: A Case Study with nCloth

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Abstract
Simulation is being used in the field of architecture in terms of building performance, energy, sustainability, and structural and environmental analyses. It produces solutions to architectural issues. Also, it gives architects, clients and students a virtual reality which helps them to imagine the space. However, simulation does not only refer to the time-based images but is also a metaphor that inspires architects and designers and leads them to explore avant-garde forms.

Simulation techniques have been improved in many fields including the film, manufacturing, military, transportation and medicinal industries since their discovery. The improvement of each fields contributed to advances in other fields so that all of them have benefited from the interdisciplinarity so provided. Over the past two decades, simulation methods have also been employed actively and increasingly in the architectural industry. In recent years, simulation dynamic tools like nHair, nParticles, nCloth, fluid dynamics, and swarm intelligence have begun to be used for the form-finding process in architecture.

In this paper, the use of nCloth, which is one of the Maya dynamics tools, will be discussed in terms of digital creativity, along with the presentation of architectural examples which have been designed using this method.

Introduction

Computer technology has been used in architecture since 1960 and has steadily gained momentum. In the middle of the 1990s, to undertake architectural practice without using graphic software was unthinkable. Currently, computer programs are not only used as presentation tools, but have started to become an element in the architectural design process (1). With the aid of these programs, in architecture and urban design, the search for new forms has begun and the resulting complex forms have been included in the projects. It is said that a new era, termed 'digital architecture', which includes various new methods applied in architecture such as parametric design and evolutionary design, has been started. Thus, the production stage of the structures, which have been designed as non-Euclidean geometry, was accomplished using 3D printers and robots.

Although the products of 'Digital Architecture' came into being with the help of technology and computer programs, such projects in fact have a long history . The consequence of the industrial revolution, and the accompanying desire for easy and extensive production led to the design of construction within Euclidean geometry. Accordingly, those geometries which could be produced by the machines of this particular period, came to the fore. Simultaneously, as a result of the influence of standardization, groups (such as Archigram, Metabolists and Superstudio), who oppose uniformity and believe in avant-garde architecture and urban design, have appeared. Although these groups remained in utopia at that time, they have provided an inspiration for many architects working with the complex geometries that exist today.

Félix Candela, who adopts a more experimental approach to architecture, used the hyperbolic paraboloid to develop structure in Mexico in the 1950s, and in this same decade Frei Otto used minimal surface to develop membrane structure in Germany. Additionally, the works of Fuller, Mengringhausen, Wachsman, Pearce, Burt, Emmerich and Baracs demonstrate innovative geometries (2). In 1988, in the exhibition under the name of 'Deconstructivist Architecture', held in the Museum of Modern Art, Coop Himmelblau, Peter Eisenman, Frank Gehry, Zaha Hadid, Rem Koolhaas, Daniel Libeskind and Bernard Tschumi (who can be included in today's avant-garde architecture of the pioneers), took place.

In this exhibition, in which "Traditional virtues of harmony, unity, and clarity are displaced by disharmony, fracturing, and mystery", as this sentence is written, the architects preferred to distance themselves from the sharp lines of Modernism in their works.

When the projects in complex geometry, began to be applied on an architectural scale, the possibility arose for the architect to satisfy the aesthetic quest, reach the desired spatial effects, and experience new construction techniques and new materials. As Kolarevic (3) noted, architects produce NURBS surfaces digitally and manipulate them. These surfaces not only add new aesthetic and impressive values to the shells of structures but also create tectonic and geometric complexities.

Today we find many avant-garde research projects, which are designed in many of the world's leading universities , where new methods are explored and experimental products are introduced. Again, the groups which carry out such studies and research, emerge in different parts of the world. We know that many different methods such as evolutionary design and parametric design are used during the avant-garde form-finding process. We also know that simulations are often used as the method for building performance analysis, and recently, we see that, these simulations are used during the avant-garde form-finding process.

Design via Simulation

Presently, animation and simulation software are being added increasingly to computer programs to develop and update them, which provide positive benefits to many professional areas such as design, architecture, interior design, game and industrial product design. Globally, leading architectural companies follow these innovations closely and adapt their designs. Today, building performance related simulations, which are added to computer aided design programs, are commonly used for sustainability and energy performance analyses. Additionally, different simulations based on biological growth, development and change, have started to be used as a tool for form-finding. As De Landa (4) has noted, "evolutionary simulations replace design, since artists can use this software to breed new forms rather than to merely design them".

De Landa studied organizational processes with the aim to understand the probabilities of computer software that are known as genetic algorithms. He says that the evolutionary simulations take the place of conventional design methods during the production of new forms using these computer programs. De Landa used the concept of genetic algorithms for forming unusual rich areas and those possible configurations with the open-ended possibilities, which are unpredictable for designers. With this technique, rather than a static single object, the emergent organizations of many variations can be created.

De Landa says that, for the use of genetic algorithms, three types of philosophical thoughts must be defined in detail, as are referred to by Deleuze: populational, intensive and topological terms. De Landa is of the opinion that Deleuze brings these concepts together and establishes the basis for the emergence of genetic form. When he explains populational thought, he mentions the multiplicity concept in the evolution process and discusses the possibility of the selection of one among many potential forms. He also considers the variation concept for intensity thought, and provides the following examples: that the same species can create differences by changing their forms such as the form changes of water by evaporation and form changes of embryo growth; while for topological thought, he makes discourse about the calculation of the ratio of change and gives differential calculus in mathematics as an example. He asserts that instead of replacing a grid system on different forms, it would be better to instead define the location of each point on representative curves in space. De Landa indicates that, in all these cases, genetic algorithms are, in reality, search algorithms (5).

The use of Maya nCloth simulations for form-finding process

Cloth simulation, which started to be used in the animation field, has been developed over a long time. The development of Cloth began with dressing the characters which are created in the computer media, and then began to serve different branches. In time, different parameters such as weight, friction, material type and gravity were added to Cloth simulations and, depending on the need of the user, could be applied in different situations.

In the project (Figure 1), the sections from the form formation process at the dynamic simulation of nCloth in the waterballoon presets are listed. In the simulation, those frames which have the most obvious distinctions in the form change, were selected and a form analysis was undertaken. As seen, a polygonal flat plane takes different forms in each frame from the very beginning of the evolutionary simulation. When this form morphogenesis is made, again by changing the settings, the same plane gives different results. As in this example, algorithms were used as a form-finding mechanism. After the form with the required characteristics is determined, the design is carried out and necessary manipulations are undertaken. In this project, it is intended to use the simulation technique for forming a marble mass.

In the other project (Figure 2), the form-finding process was investigated by performing the collision during nCloth simulation. The collision effects the form of polygonal planes in the nCloth simulation. When such a collision occurs in nature, the same situation can be observed, but the nCloth simulation allows us

Fig 1. Form-finding process with nCloth (designed by Asli Agirbas)

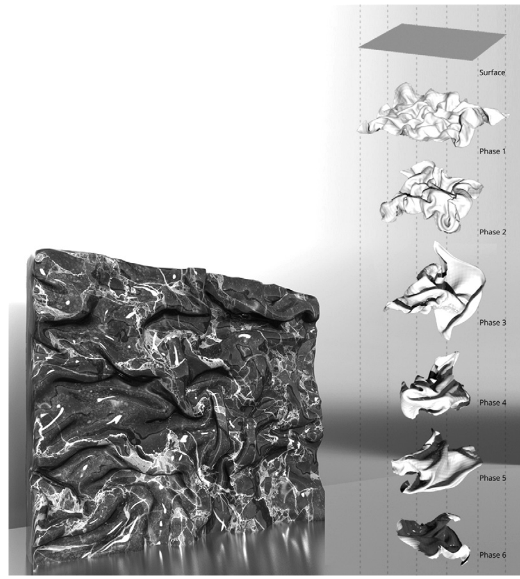
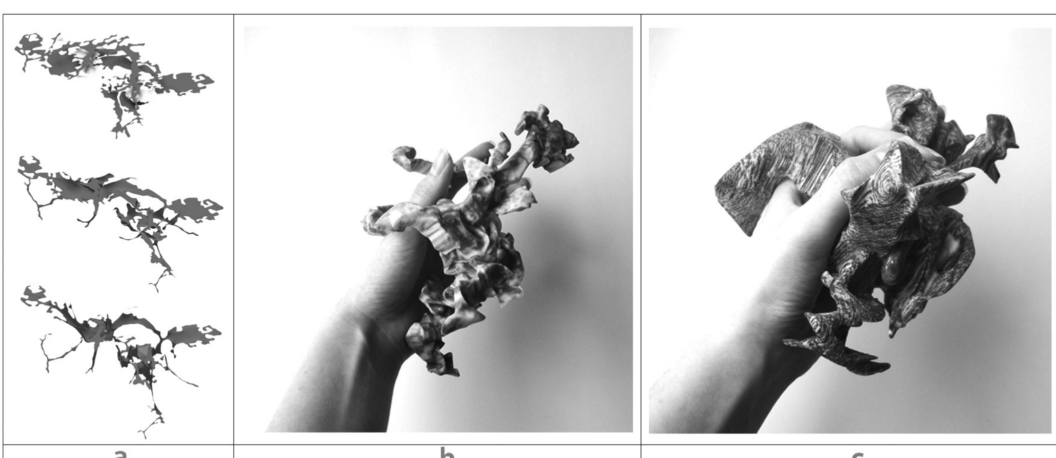


Fig 2. Form-finding process with nCloth collision (designed by Asli Agirbas)

a- Different sections from the formation process of the collisions of 3 amorphous polygonal surface with the same nCloth nucleus are shown.
b - 3D print of a specified frame, the morphology of which is formed via the collision, was taken to observe the details of its morphology in the real environment.
c - The partial 3D print of the same frame was also taken to observe the details of its morphology in the real environment.



to stop the simulation at any point we desire. Thus, although the formation of form morphogenesis occurs in living systems , we can not observe it visually , but we can discern it by means of nCloth simulation. In the nCloth collision used in the present project, the simulation has been stopped at a specified frame and the changes of the form and differentiation have been observed. Architects are attracted by the aesthetic beauty of these formational changes. In this process, with a contrary attitude to the 'form follows function' dictum of the Modernism period, architects pursue a deductive process, that is "function follows form".

In the examples given as a case study, the form-finding has been carried out by simulation and the form formations have been examined throughout the process from the whole to the part. In this type of form morphogenesis processes, the occurrence of unpredictable forms excites the designer and the designer begins to create new forms and ideas in his mind, therefore, this process resembles the sketch stage in a concept design process (6). This occurrence, not only makes the designer free on the basis of the forms, but also encourages the development of ideas concerning how the architecture can be shaped by different parameters.

Conclusion

Form-exploration with nCloth have similar features with evolutionary systems. Today, although the current design technologies with evolutionary systems are based on the algorithm sequences with the models of biological growth and formation, the use of biology and nature as metaphors in architecture, relies on the past. Forms and formations in nature have always been a source of inspiration for architects. As Knippers and Speck (7) noted, "the architects transferred the variety of natural shape and form directly into their work is alternated with those of strict geometrical order". Today architects are still influenced by formations in nature, carry the evolutionary process to the algorithms and then use the algorithms as design principles.

According to Frazer (8), development / evolution of architectural concepts defined as a production sequence, can be coded numerically. As the author noted, the canonical codes can derive numerous prototypes and these unexpected prototypes can be evaluated and expanded according to the different parameters. As a sub-concept of evolutionary architectural approaches, genetic algorithms in the medium of a computer has a canonical structure and functions like the genes that provide the formation of the living organisms. The values in these canonical algorithms used in the architectural design process, constantly change throughout the design process. Among the resulting different products which show similarities with each other, that which is appropriate to the intended criteria and objective is selected.

Notes

(1) Rivka Oxman, "Theory and design in the first digital age," Design Studies 27, no.3 (2006): 229-265.

(2) Haresh Lalvani, "Building Systems with Non-Regular Polyhedra Based on Subdivisions of Zonohedra," US Patent 5623790A filed April 25, 1994.

(3) Branko Kolarevic, Architecture in the Digital Age: Design and Manufacturing (London: Spon Press, 2003),39.

(4) Manuel DeLanda, "Deleuze and the use of the genetic algorithm in architecture," in Rethinking Technology, ed. William W. Braham and Jonathan A. Hale (New York: Routledge, 2007), 389.

(5) Manuel DeLanda, "Deleuze and the Use of the Genetic Algorithm in Architecture". YouTube video, 1:24:36, Art and Technology Lecture Series, April 9, 2004, posted by Colombia University, April 28, 2009, https://www.youtube.com/watch?v=50-d_J0hKz0 .

(6) Asli Agirbas, "The Use of Digital Fabrication as a Sketching Tool in the Architectural Design Process - A Case Study", Real Time - Proceedings of the 33rd eCAADe (Education and Research in Computer Aided Architectural Design in Europe) International Conference, Volume 2, Vienna University of Technology, Vienna, Austria, 16th -18th September (2015) :319-324.

(7) Jan Knippers and Thomas Speck, "Design and construction principles in nature and architecture," Bioinspiration & Biomimetics 7, no.1 (2012): 1-10.

(8) John Frazer, An Evolutionary Architecture (London: Architectural Association Publications, 1995),65.