New Digital Procedures through Animation

Brief History and Developments

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Several digital techniques are currently being used in architecture, and animation is certainly one of the most popular in the professional and academic realms. However, its use is frequently limited to representational purposes as an end stage in the creative process. This article will focus on the alternative use of animation techniques as generative tools.

It will show how such new generative tools can affect the creative process of form generation by contextualizing these phenomena within advances in complex system theory and in computation. Despite the use of such animation techniques be recent in architecture, the article will pinpoint some examples of how they were used to shape architectural form by taking into account the forces present in specific design contexts.

Keywords: Digital morphogenesis; generative tools; complex systems.

Introduction

The introduction of the computer in architecture, in the 70’s, intended to substitute the mechanical and repetitive tasks, optimizing the design and reproduction processes. Progressively its application augmented with the introduction of three-dimensional representation in the 80’s, to mimic reality and to anticipate the projects appearance. In the following decade it began to be employed in the simulation and form generation, as a conceptual tool. Architects like Greg Lynn (USA) and Bernard Franken (Germany), among others, began to explore animation software, importing it from cinema and video games industries, augmenting the available tools during conception. Presently, different digital fabrications methods encourage the creation, simulation and construction of artefacts in a digital continuum.

In the reference book “Animated Form”, Greg Lynn defined the methodological basis for “animated project”, in a vision based on the introduction of forces and gradient fields during the conception. This position contrasts with some “cinematic” approaches, which formulate the project in static virtual space of absence, and after the form is defined, as an isolated entity, applying to it optical techniques of movement (Kolarevic, 2005). Doing so, Lynn distinguishes the concepts of movement and animation: while the first one implies movement and action, the second implies the evolution of form and of their shaping forces (figure 1).
Bernhard Franken use of force fields emerges from existing physical entities and from other extrapolated from the context, defining the geometric basis of project. This data informs the configuration of form, and is used during all the process. In his case, he establishes frequently a digital continuum from conception to construction in an integrated practice.

The project Dynaform (figure 2), implied a reconfiguration of the isolated working process of disciplines, evolving them in simultaneous collaboration (architectural design, structural engineer, hydraulic and thermal optimization). The use of common protocols and formats is required to assure good exchange and accuracy in digital information, in real-time collaboration. His work flow process, integrating conception and fabrication, is more related to cars or aerospace industries, than to architecture.

Animation software, like 3dMax and Maya, can simulate contextual forces and inner characteristics of the material and thus guide the creation of forms under specific conditions. The use of such software has enabled to incorporate environmental factors in the design process, such as sunlight, wind, urban flows, and physical constraints, and then to use them in order to inform the functional organization of buildings and urban spaces. These techniques can encourage a practical and theoretical reconfiguration offering new procedures in the exploration of form, as subject to evolution, and influenced by inner characteristics and environment conditions. The recent developments in System theory can contribute to inform a new morphogenesis.

**System Theory and self-organization**

System theory (Bertalanffy, 1950) analyzes complex systems, their mathematic regularities, and rules that govern group and individual behaviours, independently of the specific context. The use of such software has enabled to incorporate environmental factors in the design process, such as sunlight, wind, urban flows, and physical constraints, and then to use them in order to inform the functional organization of buildings and urban spaces. These techniques can encourage a practical and theoretical reconfiguration offering new procedures in the exploration of form, as subject to evolution, and influenced by inner characteristics and environment conditions. The recent developments in System theory can contribute to inform a new morphogenesis.

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of their formal appearance or configuration. Complex phenomena, like the weather, that result from the interaction of several factors, are analyzed and described developing mathematical models. These models can explain, for instance, the formation of a certain type of clouds based on given wind and other environmental conditions. Models can also be used to construct artificial systems that possess similar complex behaviour. As such, systems theory through the use of computation has informed explorations in artificial intelligence, group theory, bio-informatics, market’s prevision, social behaviour of groups, and others. The argument of the paper is that it also can be applied to the field of architecture, using animation tools.

If we observe natural morphogenesis, we can find a family of related forms, patterns and mathematical regularities that result from its own process of becoming. Shape in nature is not a static entity but the result of a dynamic balance. In this line of thought, living systems and their components are understood as organisms that influence each other, and acquire their formation in an interactive process between external forces (exogenous or environmental) and internal ones (endogenous or material), subject to natural selection in time.

The evolutionary process, long ago theorized by Darwin, had a further development, in the beginning of the century by the zoologist D’Arcy Thompson. He was one of the firsts to analyze “material forms of living things as a diagram of forces that have acted on them” (Thompson, 1961). He used coordinate systems to map organic forms, and deformable grids to relate their changes in time, due to environmental factors like the temperature. This technique is the basis of a well known computation technique, known as “morphing” relating the transformation of meshes points of two forms, transforming one into the other.

Self organization or collective behaviour can be observed in the dynamics of many natural groups: in swarms of bees, flocks of birds or in school of fishes. The group rules, as their array configuration are more dependent of a group order than of hierarchy. These phenomena have been applied for the development of autonomous computation systems, used, for example, to manage the heavy traffic of airports.

The basis of these types of systems, designated for their actuation as bottom-up, in opposition to the traditional hierarchy system or top-down, consist in the interaction of simple rules in the micro-scale that are used to generate complex behaviours at the macro-scale. The application of these “emergent” factors is used, in architecture, by Mike Weinstock (among others) to calculate, simulate and generate growing formations.

Figure 3
Practical experiences

The paper will demonstrate these capabilities in a project developed within a Master course called “Cyber Eco” and in the orientation of a group of students in a practical experience in digital morphogenesis entitled “Force Fields”.

a) Project Cyber-Eco

This project is part of a wider investigation, developed in Barcelona, at the ESARQ-UIC, and questions if it is possible to build using the wind.

An investigation of dune morphology was undertaken, relating specific winds, material in motion and type of soil. From the interaction of these factors it was possible to establish a model, explaining the formation of different dune types as linear, transverse, parabolic, barchans and star dunes among others. Using this information to understand how environmental conditions inform dune’s formation, a new system was created in a computation environment, simulating the wind forces on particle systems, using 3dmax. Looking for a constant wind reference in force and direction a place in the Sahara desert, near Agadez in the Niger Republic was chosen. Animation software enabled the simulation of kinetics forces and physical laws in a dynamic system.

The form finding process included the mediation of different factors, like material conditions of the particles (superficial tension, dimension, and geometry) and some aspects of the external context (wind directions, force intensity, variation in time). Factors like gravity and inertia were introduced, creating also additional obstacles to the normal flow of particles, evolving the group adaptation. In this process of simulation, form emerges from the interaction of different parameters and their mediation, and cannot be predetermined or preconfigured. Different families, or formal configurations, where obtained and then analyzed.

Figure 4
Cyber-Eco, Gonçalo Henriques, 2004 – Evolutionary design, through the manipulation of forces and gradient fields that could be attainable in an integrated digital process. Attributing a physical location and specific wind force and direction, an individual proposal could emerge, but, for the final materialization, a multidisciplinary collaboration would be required.
A human scale was attributed to the particles systems, regarded as interior space. The wind was used to define actively the inner characteristics of space, inducing a phenomenological experience, and doing so, was not merely an external factor.

The constructability and materialization of a chosen form was investigated and could be attainable using digital fabrication, with computer numerically controlled machines (CNC).

b) Digital morphogenesis course

The course of digital morphogenesis was part of the international workshop of digital design processes, and was oriented by X-REF, at the ESAP, in
Porto (Portugal) in 2006. The project “Force Fields”, was an opportunity to explore animation tools and incorporate them in the form finding process. Using a vacant site near a new metropolitan center (materialized by the building Casa da Musica, by Rem Koolhaas), the participants were encouraged to extract and quantify existing forces and relations at the site and in the urban context, like traffic intensity (persons and vehicles), paths and existent boundaries. By mapping this factors separately, and then joining them, some existing patterns and defining factors where codified, relating the existing situation and the possible use of public space.

Using animation this patterns where used to shape the space: using space modifiers and changing their intensities in time, different results where obtained. Contextual forces defined a different set of solutions for the public space.

These two cases represented a practical experiment that yielded encouraging results, regarding the feasibility of the proposed methodology in other design contexts.

Conclusions

Digital tools, like animation, enable new approaches to the design process that can complement traditional ones and reveal new, increased capabilities. These tools can assist the creative process in a more immersive manner, in which form is more the emergent result of the interaction of a set of rules and constrains, than a pre-defined entity. In this context, the architect becomes the facilitator of an integrated multidisciplinary process that coordinates different inputs and uses them to define the matrix of a design. Nevertheless, the design does not become simply the result of the interaction of a set of mathematical rules. There are still design factors, not captured by the model, which still require the architect’s instinct and skills. Animation can offer abilities that were not available in traditional design methodologies, but its use as a design tool should not dismiss a critical position and conscientious choice by the architect.

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References


