SPATIAL COMPUTER ABSTRACTION: FROM INTUITION TO GENETIC ALGORITHMS

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Abstract

Many of the emblematic buildings constructed at present shows many formal and technological innovations that have not been satisfactorily resolved by the existing CAAD software. Frank 0. Gerhy's Guggenheim Museum in Bilbao is a good example of architecture whose shapes and design are very advanced from the concepts and tools used by CAAD.
The search for new creative resources, from the educational and professional point of view, must be a priority. This will be the only way to get that CAAD contributes essentially in the process of architectural innovation, instead of merely being a reproduction tool.
From this viewpoint the computer exploration of the three dimensional form is presented in here. The concept of abstract art, that has been successfully applied to painting and sculpture in this century is used as a way to experiment, design and create architecture.
This paper juxtaposes three approaches, three different ways of understanding the abstract character, with the purpose to create new objects and environments, which are exclusively characteristic for computer space. This juxtaposition shows how creative and innovative activities in the field of CAAD can be developed using different intellectual bases : intuition, mathematical formulas and genetic algorithms.

1. Introduction

Nowadays, many emblematic buildings search for a singular character in their conception and execution that is usually obtained leaving the formal and aesthetic ordinary cannons. So, the well balanced forms, ordered and symmetric, are progressively being substituted by others of more sculptural character and abstract nature.
The Guggenheim Museum in Bilbao, by the architect Frank 0. Gerhy, is an example of this type of architecture, whose shape and design is very advanced compared with the concepts and tools used by CAAD. It results paradoxical that a building symbol of modernity have not been conceived and represented by means of the current CAAD techniques, but by means of the use of models and scaled prototypes.
Although CAAD is fully integrated in all development phases of the contemporary architecture, specially when working in two dimensions, it seems to have less importance when used with hyper contemporary architecture. Maybe, this lack of interest is due to the great importance that many educators and final users give to architectural processes with a prevalence of merely representative tasks. Thus frequently, computers are understood just as an easy, fast and accurate way of representing architecture.

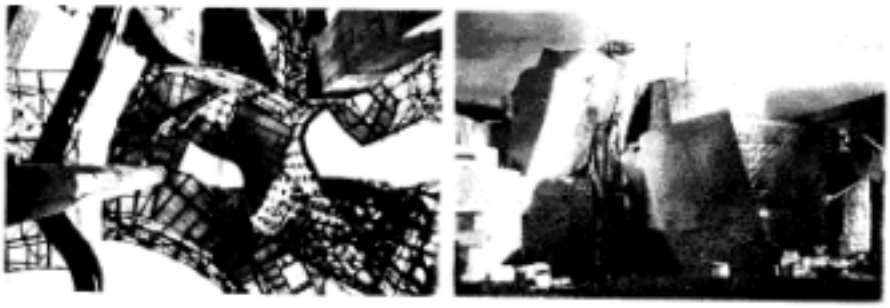

Figure 1. Guggenheim Museum (Bilbao, Spain) under construction.

Although we are living an incredible peak of high technology (Virtual Reality, Artificial Intelligence, Internet., even professionals with a marked computer addiction use mainly manual methods in their first designs of a project. The reason can be found in the few facilities that computers support during the processes that need creativeness and imagination.
The search for new creative sources, technological or intuitive, and the exploration of the form in the three dimensions should be a priority, especially from the educational point of view. This article proposes the utilisation of the abstract art concept, successfully applied to painting and sculpture during this century, as a way to experiment, design and create architecture.

We present three different approaches to the understanding of the abstract character, with the purpose of creating new objects and atmospheres exclusive of the computational space. With this experience, it is pretended to show how the creative and innovative activities in the field of the CAAD can be developed using three different intellectual bases: intuition, mathematical formulas and genetic algorithms.
The work of Adam Jakimowicz studies the possibilities of abstract modelling as a mean for simulation and creation. Intuition and individual creativeness are employed in order to explore a new way of composing spatial forms, using a standard popular software.
Javier Barrallo presents his Cybersculptures, a series of figures of mathematical nature generated by means of unusual geometrical objects and processes (Hyperrevolutions, parametric knots, Moebius bands, etc.).
The work of Eliana Maria Guedes is based on the ability of genetic algorithms for the creation of abstract models. The resulting figures have a marked organic character with many resemblance to living forms. The three collections described before constitute a representative sample of the possibilities of abstract models in CAAD.

2. Intuitive Abstract Modelling

No matter how much computers became popular and obvious devices in various spheres of the modem times, when they are already not only a domain of specific professions, but also private homes 'inhabitants', the sphere of interpretation, individualisation and improvisation, as conscious attitude to the possibilities they propose, is still hidden, concealed. This problem deeply concerns CAAD. The most obvious is the opinion, that there are only a few, proper and canonical uses of computers, which we could range as the one 'right' approach - i.e. rationalistic, effective, functional, and which should not be crossed or transgressed, which aims at a rigorous subordination to the rules imposed by software manuals. Such approach is an a 'priori' assumption.
The presented intuitive approach to computer based form making tries to face the mentioned problem. Computer, or rather 3D modelling software, as no other medium, enables us to visualise what is not yet rationalised or even mentally ordered, to produce certain forms, electronic realities, with very simple, basic, primitive input data (i.e. geometric primitives), as a material for geometric, formal exploration. This way of form making opens the user for the unexpected, for the new features of 3-dimensional space, visualising the idea before having it rationally formulated. All descriptions of modern arts (lets include architecture here too) are based on the subjective post-rationalisation of individual impression. Lets introduce it to the sphere of Computer Aided Architectural Design, not as an obligatory approach, but as an option, enriching architectural design as a whole. When Malevich introduced the idea of additional element to painting (...under Suprematism I understand the supremacy of pure feeling in creative art...), the affective approach to architectural computing (here - computer based architectural form making), can be an additional element in CAAD.

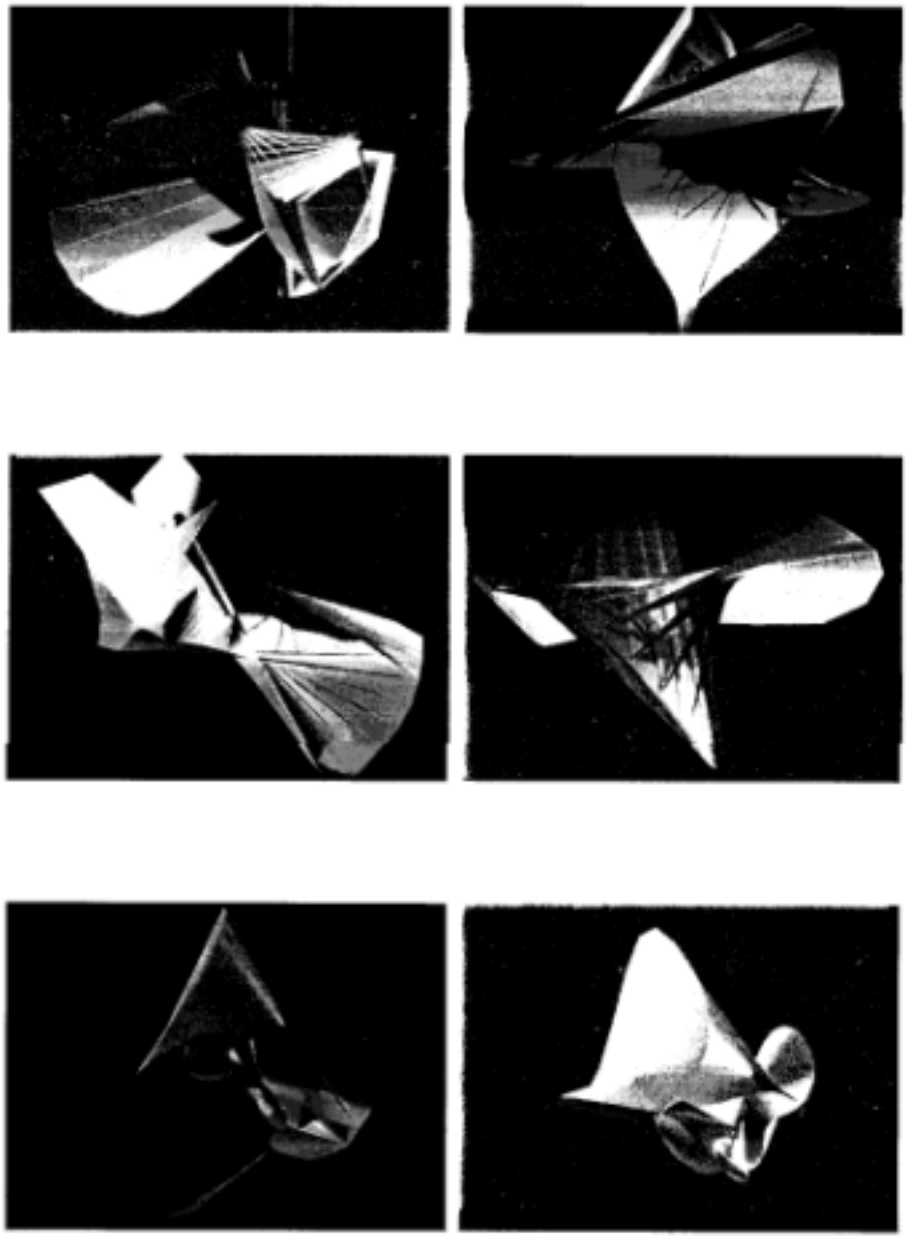

Figure 2. Intuitive abstract modelling.

Even when we have 2-dimensional images as the visible result, silent pictures of artificial reality, these simple experiments bring very deep message of the essential perceivable 'languages' of forms and relations with the value of discovering the new or even impossible.
All these are the games for the essential information. Rules are certain but liquid. Every formal system can be widened individually, even when our work is not received according to our intentions. The evaluation criterion is to be received 'hot', when receiver becomes emotionally involved. Receiver as well as the author is allowed to define his own perception of the given thing - and in such case the intention can be reversed.
In this context, we can here formulate two general approaches to computing in the context of architectural design:

- simulative approach
- creative approach

Simulative approach focuses on making a computer representation of the object, which can be regarded external to computer space. Computer space is used to simulate a reality of that object, which exists (or will exist) independently and externally. In most cases this approach concerns various sorts of analyses.
Creative (generative) approach, concerns making things, which are not just models, but original creatures of the environment they were done in. First of all this approach concerns synthesis : formal, geometrical or aesthetic.
The work presented here as an intuitive spatial abstraction intentionally represents one of the possible aspects of creative generative approach to architectural computing.
Making this electronic, virtual domain a part of our reality, work, thoughts and life - let us not forget that it can be a source of the personal, and not necessarily selfish pleasure.

3. Mathematical Abstract Modelling

Since most ancient cultures, until the contemporaneous artist movements, mathematics have been specially relevant in many processes of artistic creation. There are many examples present in sculpture, painting or architecture, showing proportions or shapes based on the classic geometry (by example, the use of perspective in painting, the golden number in sculpture, or the geometric shapes in architecture).
Nevertheless, in the last years of the XIXth century and in the beginning of the XXth, century a group of mathematicians led by Koch, Peano, Cesàro, Hilbert, Julia, Pointcaré, etc. started the study of the possibilities of new geometries, clearly different from the shapes and basic principles used until this moment, and opposed in its conception to the euclidean geometry, preponderant until this moment.
Simultaneously to this precursors of modern geometry appears a new way of understanding and conceiving art, radically different from all the artistic tendencies developed until this moment and destined to be considered the most important artistic expression of the XXth Century: we are talking of abstract art.

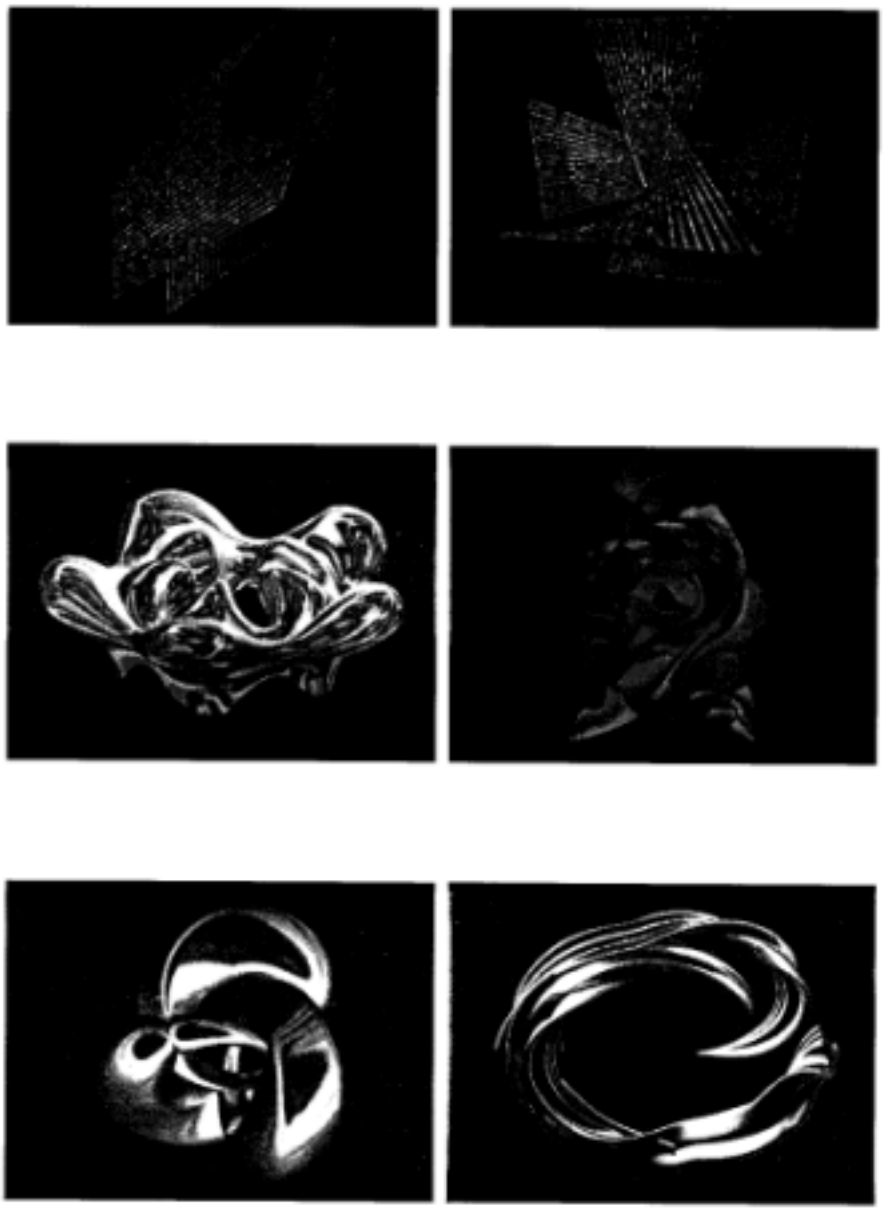

Figure 3. Mathematical abstract modelling

The parallelism between the works made in the field of contemporaneous mathematics and abstract art is surprising, both in its revolutionary conception as in the use of an amazing conception of aesthetic, very different from the past. In this context, new branches of mathematics, like fractal geometry or chaos theory, cause a revolution in the scientific world generating an exciting family of images.
With the purpose of exploring and experimenting the three dimensional space, we have designed a new family of objects, whose aspect reminds the one of abstract sculpture and called 'Cybersculptures', due to its virtual character and the fact that their first exposition was made in the Cyberspace of Internet.
They are virtual three dimensional objects, so they can only exist in a computer, although can be visualised and animated from every scale and position. Cybersculptures are created mathematically by mean of mathematical formulas programmed in C language. Their basic generation elements are not Euclidean objects manipulated under a CAD program, but formulas and mathematical processes belonging to contemporary Mathematics.
The mathematical character of these objects could seem that their creation is something automatic, cold and distant from the sensibility and intimacy that is supposed to creativeness, but this is not true. The use of mathematical formulas to model objects simply constitutes a tool to work, like the hammer and chisel of the sculptor or the brush of the painter.
It is true that a mathematical formula is a quite restricted tool according to its range of actuation, but modern Mathematics have many objects whose aesthetic is really amazing, and their artist possibilities almost infinite (multiple torus, hypercubes, Moebius bands, parametric knots, etc.)
The complex shape of these Cybersculptures, and the huge volume of calculations needed to represent them graphically convert the computer in an indispensable element in the creation process. But, far away from being a simply visualisation tool, the computer establishes a close relationship between the author and his work being converted in the umbilical cord joining both.
Factors like illumination, the point of view or the texture can change completely the final aspect of the Cybersculpture and allow the expression of sensations by means of the use of materials with unexpected shapes and colours, impossible lights and objects that float challenging the law of gravity. Is this lack of coherence with the real world what made easy the creation of virtual objects with no comparison with the shapes of our environment.

4. Genetic Algorithms Abstract Modelling

Genetic algorithms were originally developed and characterised by John Holland (1975) and are based on the principles of evolution by natural selection. With this programming technique, solutions to a particular problem are subjected to the action of genetic operators such as recombination and mutation.

Modelling with genetic algorithms is inspired by natural systems and how they often rely on the repetition of very simple steps such as crystal growth or the creation of stalagmites by water dripping in underground caverns, these natural systems have a huge potential for creating artistic forms. The first experimental system for art generation, 'FormSynth' was created by William Latham in 1989. It was a system for drawing on paper in which repeated applications of rules generate an evolutionary tree of unexpected forms, some of them with architectural quality.
The images presented here are based on 'Mutator', an algorithm created by William Latham and Stephen Todd. This algorithm displays geometric forms under the action of associated gene values.
The basis of the graphic process lies in a very simple gallery of euclidean objects (cubes, cylinders, pyramids, spheres, ...) and a collection of mutation processes based on natural systems (tree branch, spider web, DNA helix, ...). The combined action of one or more of these objects with a mutation process results in new forms with an imaginative and increasingly complex structure. The user must explore the resulting forms and select one of them, so only the most aesthetic form is allowed to survive and reproduce.

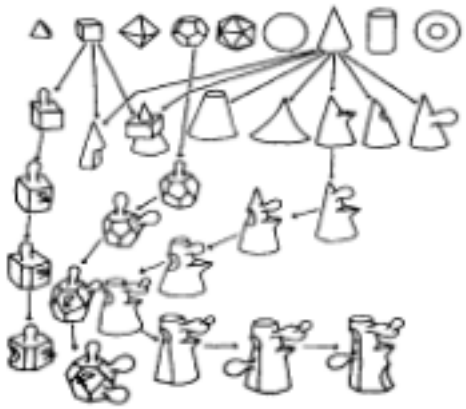

Figure 4. Small hand-drawn genetic tree.

These techniques provide a way to explore form space, making subjective decisions about the quality of forms. The computer does not allow changes based on structure definition, so the user does not need to have such analytic knowledge, only pure subjective exploration of form. In nature, new forms of life are created by mutation and marriage and the fittest survive in a process of natural selection.
Inside the computer space exists an artificial world by defining systems and structures for form generation and the user acts as a judge driving selection, using aesthetic judgements to breed artwork.

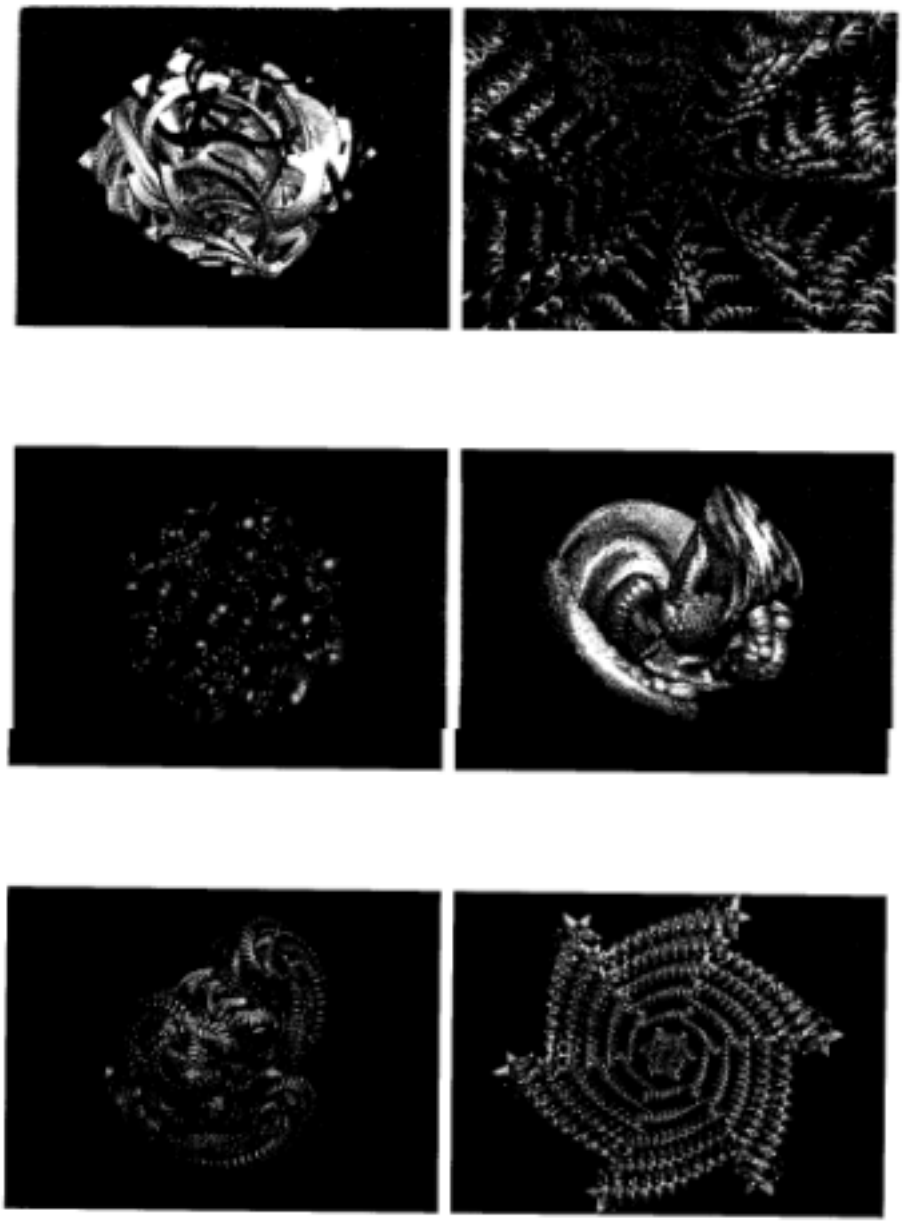

Figure 5. Genetic algorithms abstract modelling.

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