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Experimental Rooms: Integration of parametric tools for designing spaces. Structure, light and sound.

Magic Spheres

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Abstract: The progress in architecture design has always been connected to the contemporary technology innovation. This new techniques have been associated to every scale and elements that compound an architectural design. Nowadays, computer-aided technology, besides the advantages on display, computer graphics and artificial experimentation with architecture, also allows us to create structures and elements that would be very laborious and sometimes impossible to carry out without them. These methods accelerate the designing process by connecting the parameters that compose them, in a way that, if we modify them, we will not have to redo the initial design. In addition, these parameters are able to store information, transform it, and produce graphic variations.

The Experimental Room is a real architectural space, where the user can interact to transform the environment. The subject to present for the congress deals with the research and exposition of a project which seeks for the complete integration of all the parametric processes. The purpose of this project is to prove that, thanks to the architectural space parametrization we can assign real and virtual variations to modify his entity.

Keywords: *Parametric Design; 3d Printing; Programming; Interactive Architecture; Virtual Reality.*

1. Introduction

Parametric structures not only allow us to configure spaces creating structures with mathematical developments, we can also build prototypes quickly using machining systems. It is also interesting include external factors as other design parameters, such as light, movement and sound, capable of being measured with digital tools and being participants in the design.

For the design and production of the pavilion it has been used tools and open source software like Grasshopper, Firefly, Arduino©, Repetier-Host and 3D printers using prototyping system of RepRap printers.

Currently "Experimental Rooms" is a research project that it is being conducted at Universidad de Alcalá, in the department of Graphical Representation, thanks to the scholarship program: "Introducción a la Investigación".

2. Precedent

Experimental Room belongs to the Magic Spheres series (Figure 1), proposals designed to be implanted in the cities by way of pavilions or temples of the new contemporary society where people could increase the relationship with architecture.

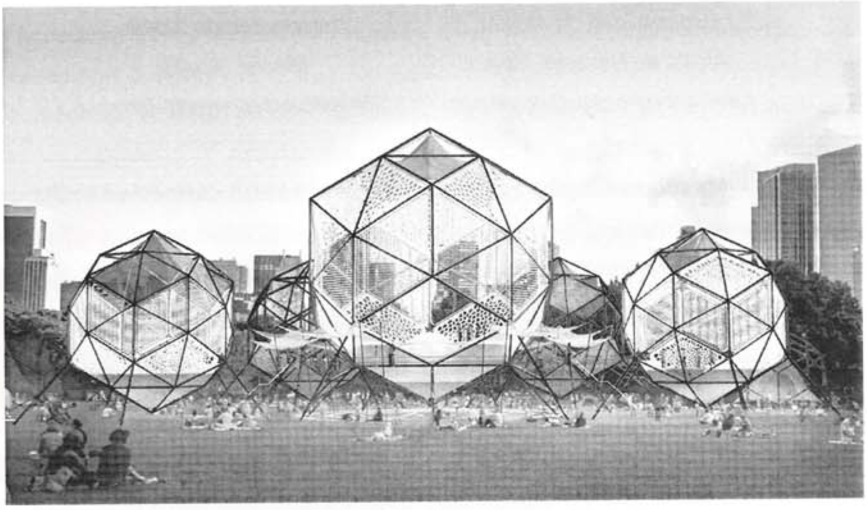

Figure 1. Magic Spheres. Utopian Pavilion which integrates all parameters.

However creating spaces for experimentation is closely related to the Expressionism of early 20th Century (Figure 1). Overlapping layers facades manages to create different optical illusions. These utopias are examples of experimental spaces whose function is also to be monumental and increase the perceptions with architecture.

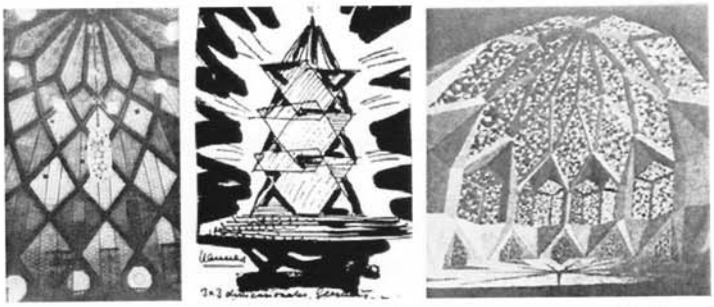

Figure 2. From Left to Right: Taut, B., 1914. Glass Pavilion, Cologne; Scharoun, H., 1920, Three Dimensional Glass House; Luckhardt, W., 1920.

The Magic Spheres are compounded of self-built structure (Figure 3) that may vary with different panels witch cover the space: Textiles, translucent walls and LED screens. The latter are the most characteristic elements: the LEDs are mounted on a fine sub-structure, so that during the day, are turned off and it is possible to see through. In the evening, on the contrary, the pavilion lights and the user can experience a virtual environment of light and sound.

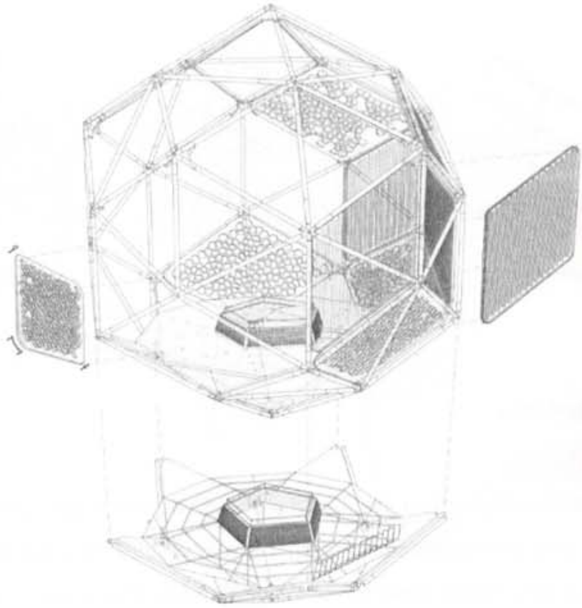

Figure 3. Structural composition of the proposed pavilion.

3. Geometry

The designed prototype is a sculpture 1:5 scaled of the original designed pavilion as a lamp that illuminates the space where it is placed.

The initial geometry is a Rhombic Triacontahedron, from the polyhedron family of Catalan Solids. Through a parametric design, based on its mathematical definition the structure is achieved. Tensioners are added in half rhombi to complete an isostatic structure.

The sculpture is designed to be suspended from its apex hanged with a cable (Figure 4). The side panels correspond to vertical surfaces where lighting panels are incorporated. It is a digital skin. In a dark space we see this geometry, a temporary and intangible space.

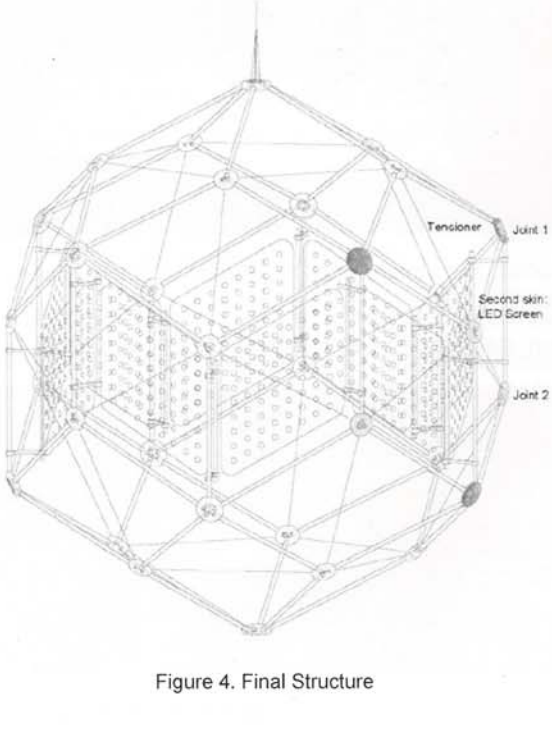

Figure 4. Final Structure

Figure 5. Building Process

4. Fabrication process

4.1 Structure design

Taking the initial polyhedron the structure is designed totally parametrised. In addition an algorithm allows to vary the dimensions of all the pieces, due to production tools, like 3d printers or CNC milling machines, could have different resolution. Therefore it could be fabricated almost everywhere.

4.2 Production.

For the structure they have been used threaded steel rods, 3D printed joints in ABS plastic and nylon thread for tensioners.

The joints seek optimization design with a minimum resolution that a 3d Open Source Printer could give (Figure 6). They are designed as rings which screw the steel rods, leaving enough space to adjust the length or to introduce another rods in complex positions (Figure 10).

Figure 6. Printing Joints.

4.3 LED Screen Panels.

As an inner skin, 640 LEDs in 10 different panels (Figure 8) form the virtual space of the project. With a printed mould (Figure 7) the LEDs are placed for the correct position and welded with each other getting a small 8x8 matrix.

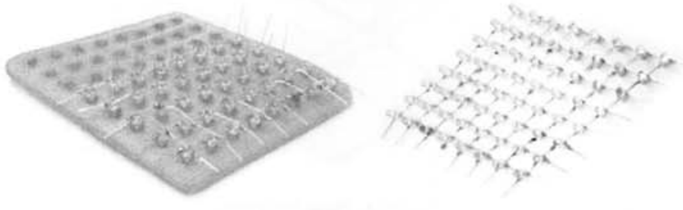

Figure 7. Printed mould and LED matrix panel.

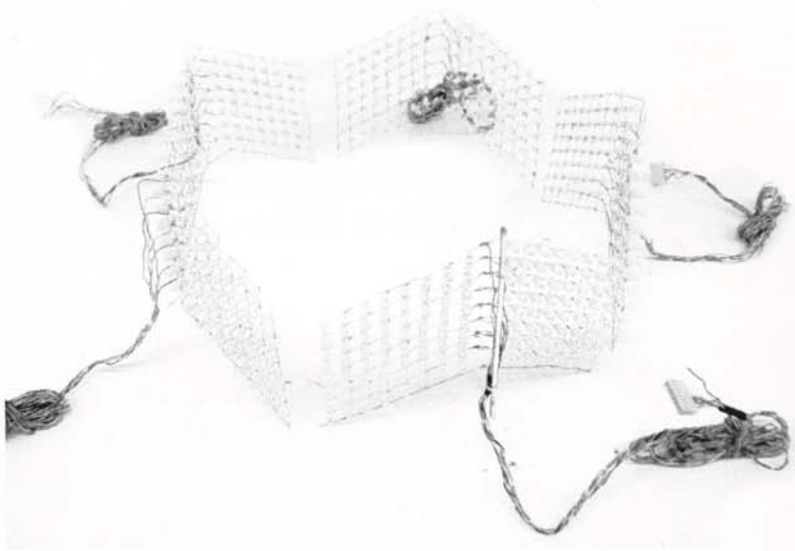

Figure 8. LED Panels

5. Graphic simulation.

According to a parametric design, these LED displays are set as another parameterized element that could be controlled in real time. These screens are connected to a micro-controller board (Arduino©). This open source tool can be controlled from his own programming software or with the same parametric design program: Grasshopper with Firefly. With them it can assign geometric parameters mixed with programming tools like C # script or VB.NET script. Additionally it is used a motion sensor (Xbox Kinect©), which enables to select geometric points of the human body. We can analyse that data to send information to Arduino and control the LED screens. On the other hand Firefly gives us the possibility to analyse other physical parameters such as sound or other movements using external tools.

A typical visitor starts to move him inside. Immediately the motion sensor transmits the changing state of the visitor in real time to the micro-controller, which regulates the LED screen in accordance to its spatial position at every instant. The actuated movement causes the appearance of a motion-related light configuration (Figure 9).

The actuation of such a relatively big structure and the intuitively understanding of its own dynamics, is joyful and satisfying. Finally, within the original concept, through this pixel screen the structure abstractly communicates with the visitor achieving a mimesis between people and architectural components, or between the individual and the city elements.

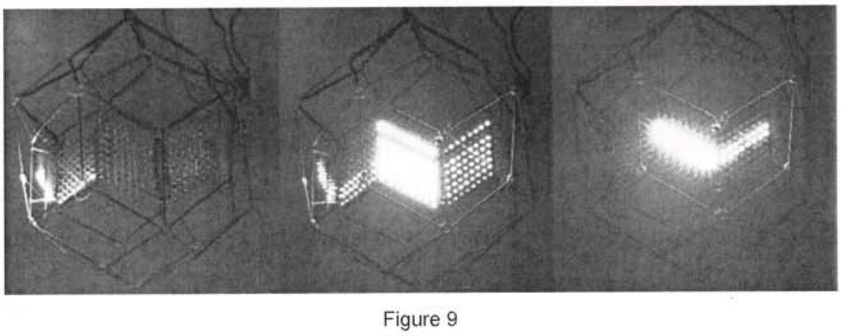

Figure 9

6. Innovative applications.

To end, using interactive skins allows architects to redesign spaces, add new applications and design virtual spaces to show information or project other realities such anamorphic effects. In addition, overlapping layers of graphic elements like digital skins changes the perception of living space producing immaterial effects through programming and creating walls where there are not.

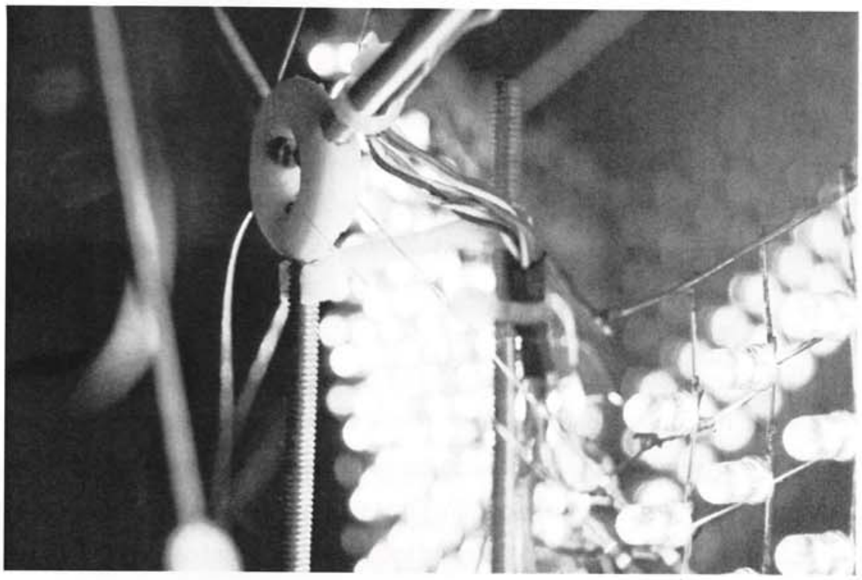

Figure 10. Detail of Joint 2. Tensioners tied in the knot and LED panels hanging from the structure. The cables are attached to the structure toward the apex.

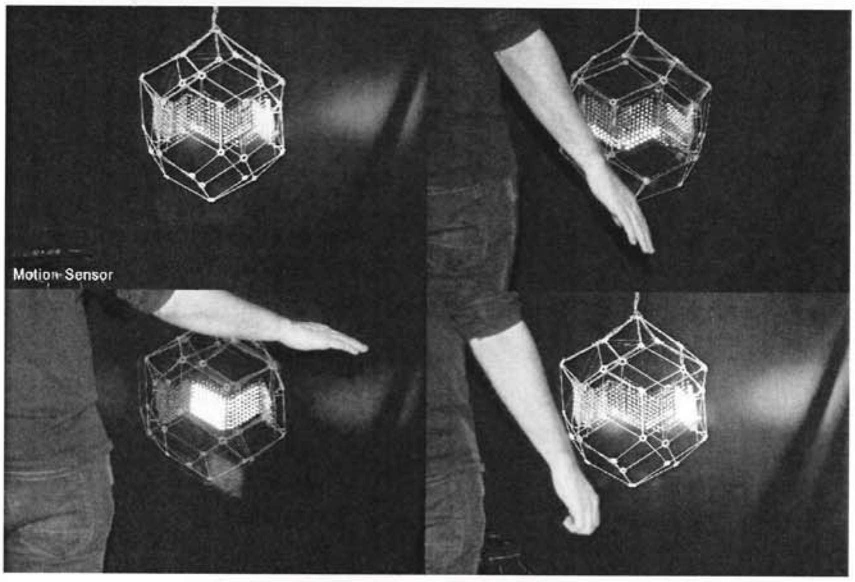

Figure 11. Motion sensor controlling the display.

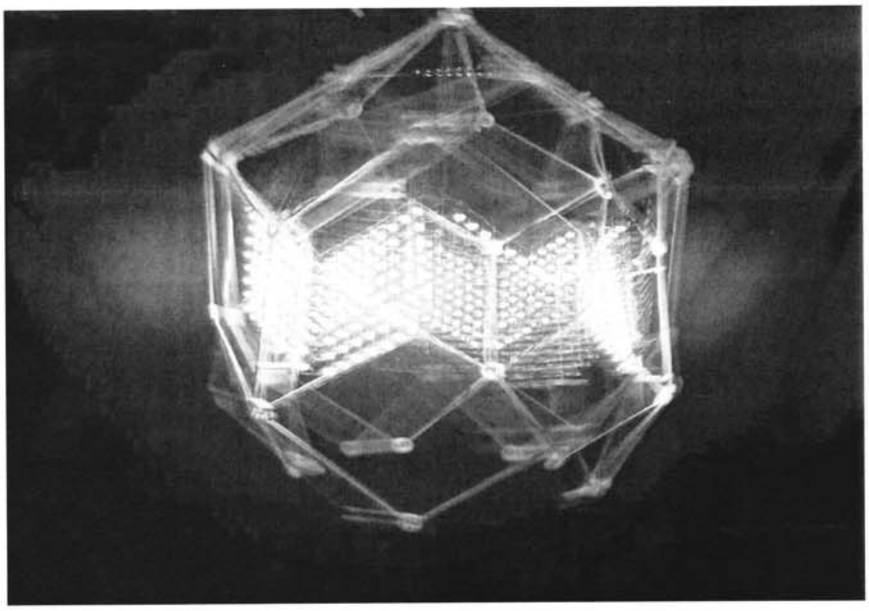

Figure 12.

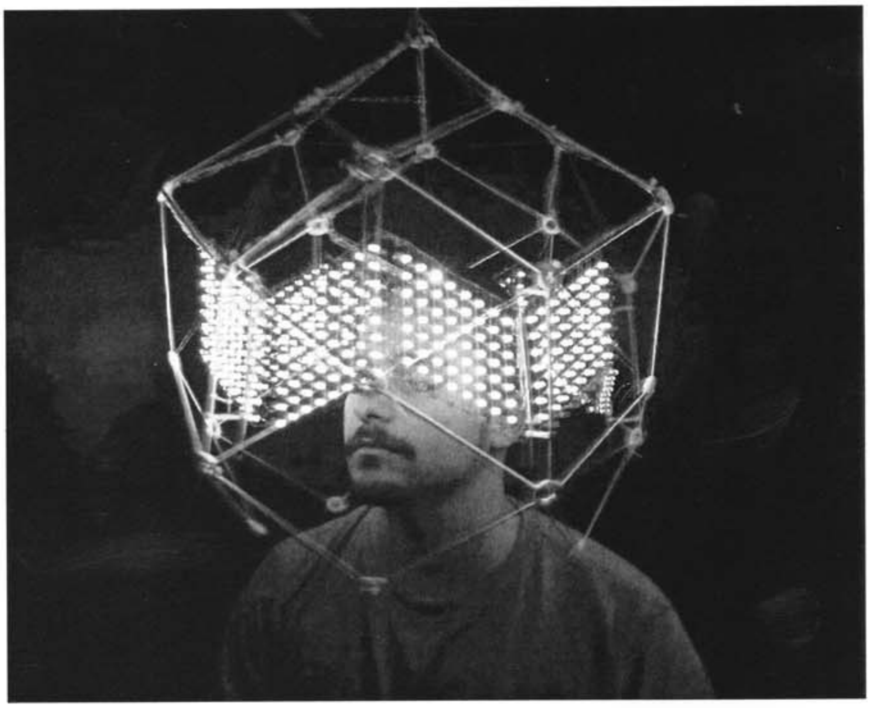

Figure 13.

7. Energy Saving.

On the other hand, with the acquired knowledge of parametric tools, it is complementing another research project in collaboration with Universidad de Alcalá de Henares and financed by the "Ministerio de Economia y Competitividad": ENE 2013-48015-C3-2-R, "Integrated energy optimization systems and CO2 reduction: BIM Technologies, Indoor Mapping, UAV and energy simulation tools.", in which design strategies seek to find constructive solutions for energy savings in existing buildings.

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