

ARCHITECTURE IN-PLAY

INTERNATIONAL CONFERENCES JULY 11th-12th 2016

CONFERENCE **ISCTE**  **IUL**

Instituto Universitário de Lisboa

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EDITED BY NUNO GUIMARÃES, ALEXANDRA PAIO, SANCHO OLIVEIRA,
FILIPA CRESPO OSÓRIO AND MARIA JOÃO OLIVEIRA

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ISBN - 978-989-732-804-6

© Instituto Universitário de Lisboa (ISCTE-IUL), Lisbon, 2016.

Instituto Universitário de Lisboa (ISCTE-IUL)

Forças Armadas Avenue, 1649-026 Lisboa

Tel. +351 790 3000

<http://www.iscte-iul.pt/>

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This publication has its origin in the paper proceedings of the
that was held in Lisbon, from 11th to 13th July 2016.

Edited by Instituto Universitário de Lisboa (ISCTE-IUL)

Architecture InPlay Conferences 2016,

curated by Alexandra Paio,

Printed in Lisbon, Portugal, 2016

Paper ISBN: 978-989-732-804-6

Digital ISBN: 978-989-732-805-3

Index

Michael Fox - Catalyst Design	1
Syuko Kato, Ruairi Glynn - <i>Fabricating Performance: A dance of circular feedback processes in constructing spatial notion</i>	6
Abdulbari Kutbi - <i>A Robotics of Trivial Mechanisms: The Pirouetting Picket Fence, From Trivial Embodiment to Complex Behaviours</i>	14
Maria Genevieve Bezzone - <i>Interactive Architecture In The Digital Age- Parametric Design Of An Open Source Responsive Solar Filter</i>	22
Jessica In, Chee Kit Lai - <i>hTYPER [hahy-per] [tahyp]: Interactivity and Performance in the exploration of architectural narratives</i>	30
Begüm Aktaş and Şeyma Yıldırım - <i>Breathing Surface: Pattern Generation with Origami Tessellation</i>	38
Avanti Dabholkar and Daniel Cardoso Llach - <i>Biometrically-Responsive Architecture: Mapping Biometric Data to Dynamic Spatial Change</i>	46
Anna Grajper - <i>Playful experience within Interactive Architecture.</i>	53
Ruairi Glynn - Machine Life	60
Sarah Mansour - <i>Parametric Design as a Design Tool for Adaptive Reuse in Interior Architecture: Studying daylight simulation and shading devices for enhancing building performance</i>	69
Marie Davidova and Vladimir Koci - <i>Choosing the Material for Environment Responsive Screen Ray: The LCA Comparison</i>	78
Kevin Moreno Gata, Ernesto Echeverría Valiente - <i>Experimental Rooms: Integration of parametric tools for designing spaces. Structure, light and sound. Magic Spheres</i>	85
Guzden Varinlioglu and Gazihan Alankus - <i>Unfolding Ancient Architecture Through Low Budget Virtual Reality Experience</i>	93
Andrew Viny and Daniel Cardoso Llach - <i>[Y]OURS: Distributing Design Agency Through Playful Multi-Modal Interactors</i>	101
Maria João de Oliveira and Vasco Rato - <i>Passive Shading System - Towards Parametric Definition And Virtual Simulation</i>	108
Damjan Jovanovic, Adil Bokhari - <i>Games as a Model for Architectural Pedagogy: Production of architectural genres</i>	115
Arturo Tedeschi - Hyper-meritocracy and architecture	122
Giulia Curletto - <i>Rigid-Foldable Origami Structures: Parametric Modelling With Grasshopper - Geometric And Structural Issues</i>	126
Parantap Bhatt, Nicolo Bencini, Spyros Efthymiou, Antoniya Stoitsova - <i>Reconfiguring Structural Assemblies Using Augmented Reality</i>	133
Gonçalo Castro Henriques, Andrés Passaro - <i>Defying Gravity: From Statics To Dynamics, From Objects To Systems</i>	141
Ines Caetano, António Leitão - <i>Exploring Buildings' Surface Patterns</i>	149
Fernando Amen, Marcelo Álvarez, Víctor Vargas - <i>Uthopia. Digital Fabrication Of Non-Built Architectures</i>	157
Georgios Vlachodimos - <i>The Coherence Between Smart Objects And Artificial Intelligence In Architectural Digital Design Process</i>	163
Alexandros Peteinarelis - <i>Frei Otto's Contribution: Legacy To Parametric Design And Material Computation</i>	171
Michele Calvano, Alfonso Oliva, Mia Tsiamis - <i>Articulated Surfaces: A Parametric Approach to Form-Finding and Structural Evaluation</i>	178
Paul Jackson - Folding as a Language of Design	186
Katerina Anagnostopoulou-Politou, Kinda Al Sayed - <i>Spatial Cognition In Virtual Environment. Spatial Cognition In Videogames</i>	195
M Inês Chora, José Beirão, José Frutuoso - <i>Game Based Social Housing – Relocating Populations Via Game Based Participation</i>	203
Joaquim Reis - <i>Origami: History, Folds, Bases And Napkins In The Art Of Folding</i>	211
Cristina Veríssimo - <i>Cork: New Uses In Architecture</i>	219
Mohamed Ibrahim - <i>Two Problems: Two Concepts: Two Grammars, Grammatical Exercises To Inspire Problem Solving In The Beginning Design Studio</i>	225
Alessio Mazzucchi - <i>Modular Structures: A Kinetic Module Based On A Resch's Tessellation</i>	234
Susana Neves, João Sousa, Filipa Osório - <i>Interactive Design For Everyone - From Folding To Programing</i>	241

Kevin Moreno Gata

Universidad de Alcalá

Alcalá de Henares, Spain

Kevin.morenogata@gmail.com

Ernesto Echeverría Valiente

Universidad de Alcalá

Madrid, Spain

Ernesto.echeverria@uah.es

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.

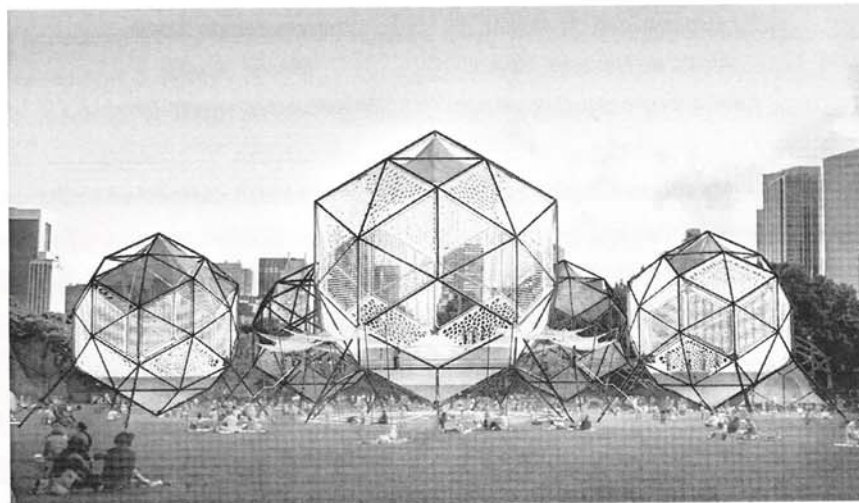


Figure 1. Magic Spheres. Utopian Pavilion which integrates all parameters.

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.

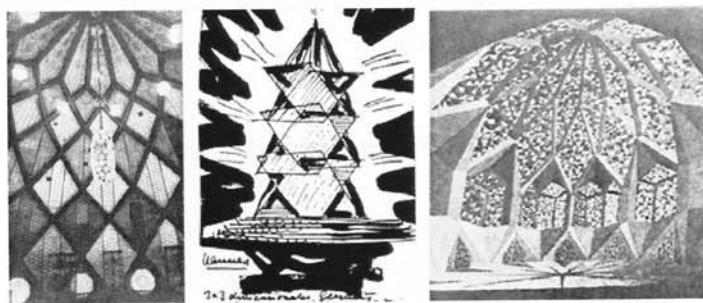


Figure 2. From Left to Right: Taut, B., 1914. Glass Pavilion, Cologne; Scharoun, H., 1920, Three Dimensional Glass House; Luckhardt, W., 1920.

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.

Magic Spheres

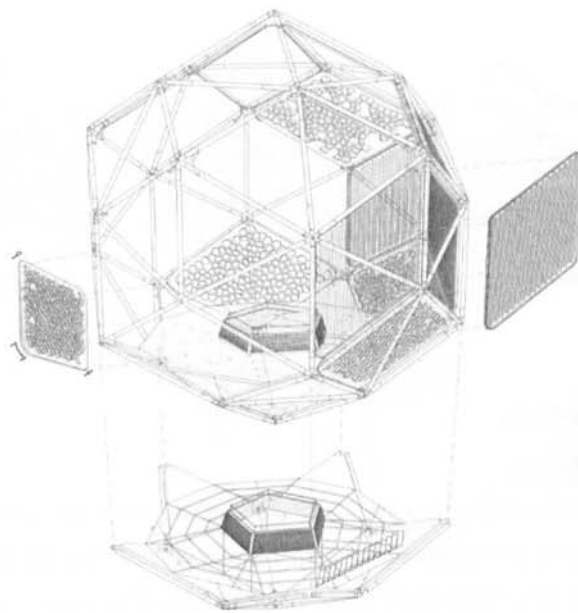


Figure 3. Structural composition of the proposed pavilion.

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.

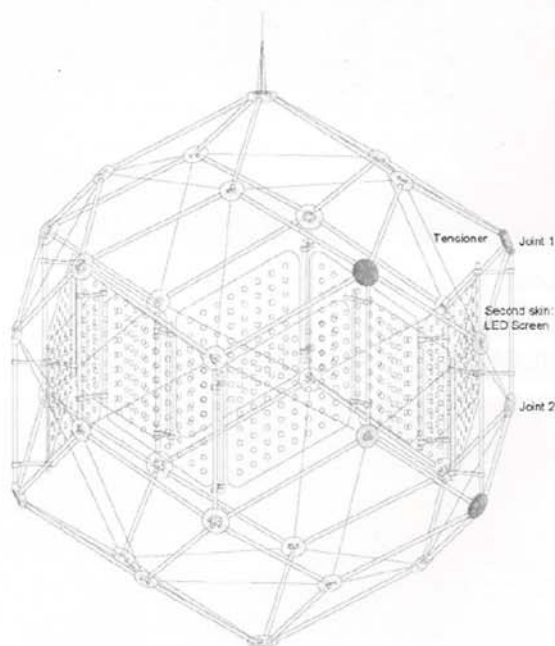


Figure 4. Final Structure

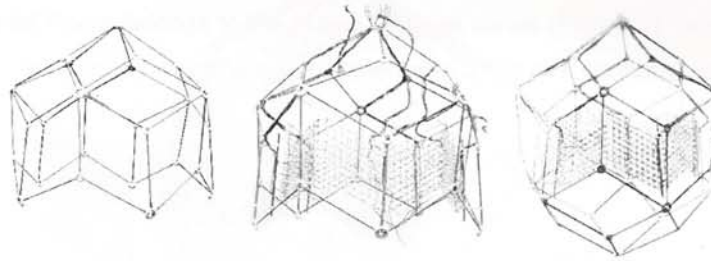


Figure 5. Building Process

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.

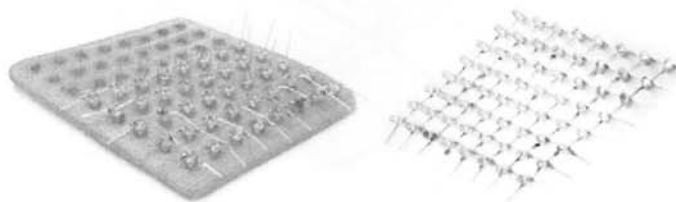


Figure 7. Printed mould and LED matrix panel.

Magic Spheres

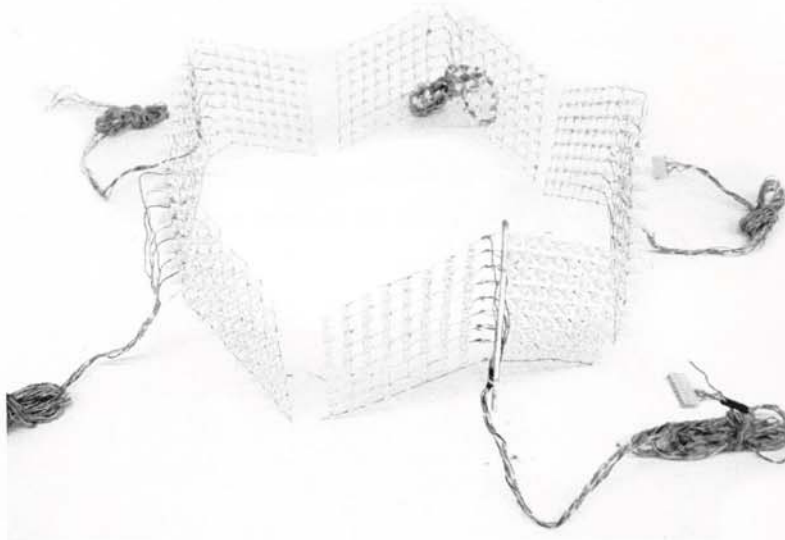


Figure 8. LED Panels

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.

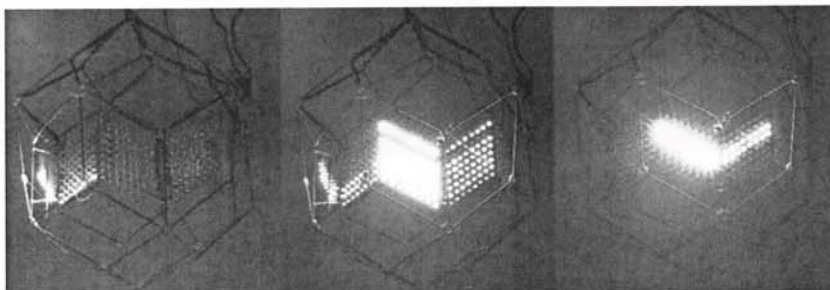


Figure 9

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 as 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.

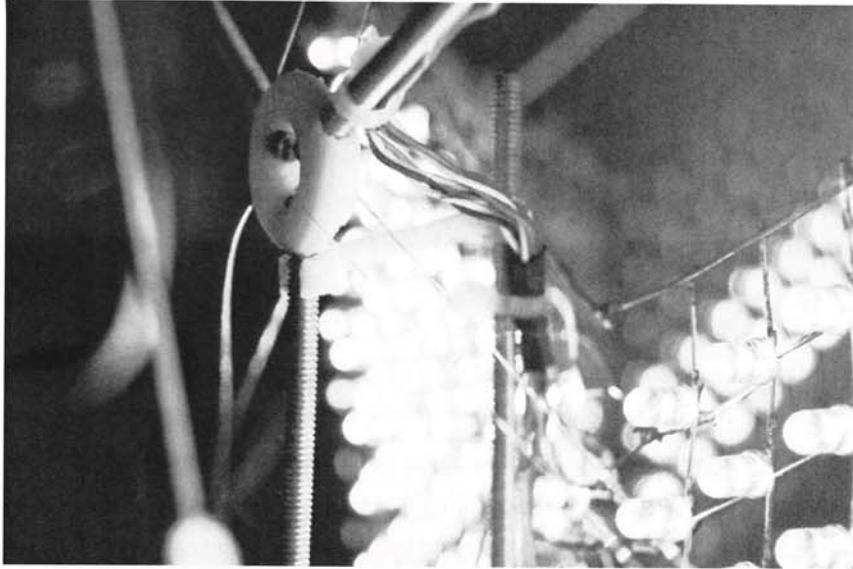


Figure 10. Detail of Joint 2. Tensioners tied in the knot and LED panels hanging from the structure. The cables are attached to the structure toward the apex.

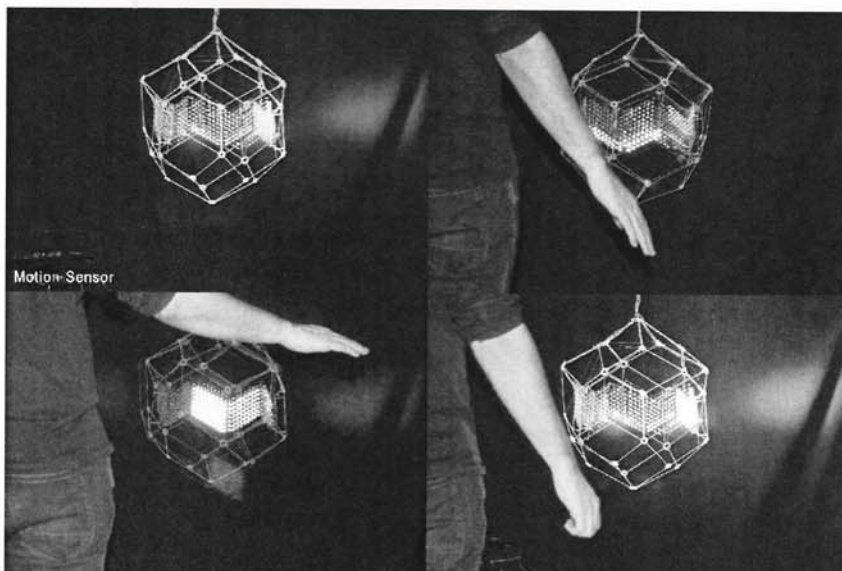


Figure 11. Motion sensor controlling the display.

Magic Spheres

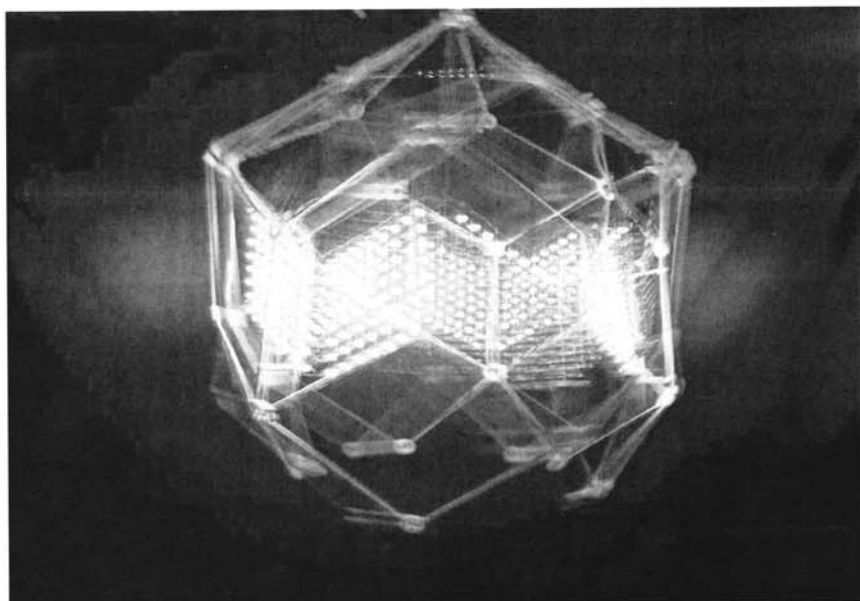


Figure 12.

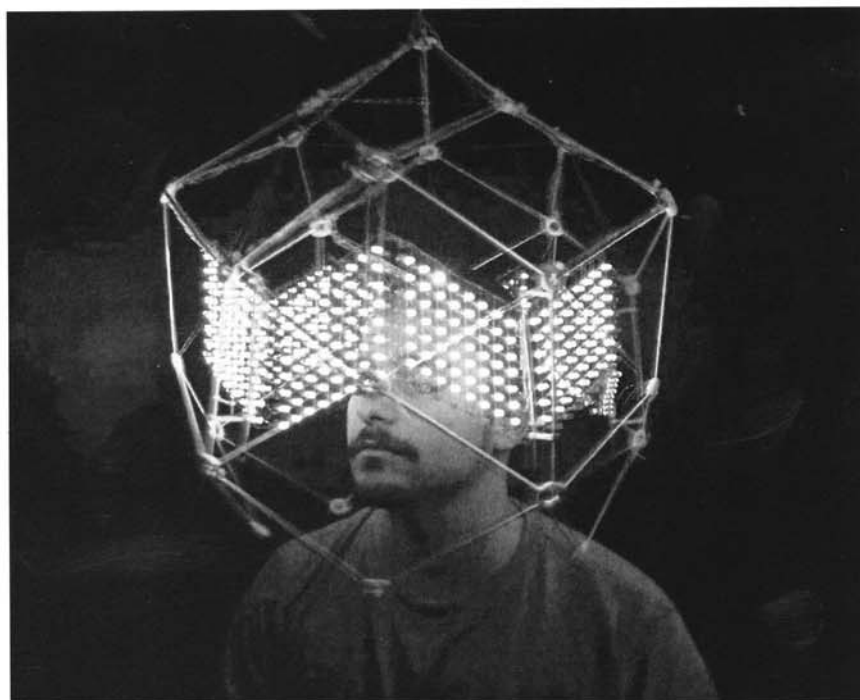


Figure 13.

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 Economía 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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