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FABRICATING A LIVING SYSTEM - UPLOADING THE DESIGN PROCESS INTO MATERIALITY PERFORMANCE

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ABSTRACT

This paper presents a key area under investigation in Vitruvius FabLab at ISCTE-IUL, Lisbon. A new and unexplored convergence between material and computation is rising up. The increasing capacity of architects to integrate more multidisciplinary and complex design information combined with technological developments and industrial logics are leading the Vitruvius FabLab researchers into a context of computer-controlled manufacturing and fabrication. Our pilot experience was held by an interdisciplinary Lisbon Workshop "Discursive Wall – a Living System" held at the Vitruvius FabLab-IUL, in March 7th-11th (LS_01) and March 29th-April 1st (LS_02), 2012. The main challenge presented in this workshop was how the combination of traditional and national materials like cork and Valchromat (color MDF derived) with mechanical devices could be able to built a 'Discursive Wall' that physically responds to movement, interacting spatially and temporally with the environment and its inhabitants. Understanding, studying and knowing the material natural properties, performance, limits and strengths, was the key to determine and conceive the design, performance and assembly processes of the super 3x5m wall panel. In other words, form follows performance that follows material. More than expecting to find architectural surfaces solutions, this experience enables us to explore materials SWOT's leadings us into new behavioral forms and performance according to different surroundings and inhabitants.

Key words : Materiality, Performance, Digital Fabrication; Morphogenesis.

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1. INTRODUCTION

"Material properties, characteristics and behaviour can now be employed as active design generators, and the microscale of material make-up and the macroscale of material systems in architecture can now be understood as a continuum of reciprocal behavioural characteristics and performative capacities. (Menges, 2012:16).

In the last decades several questions related with performance and interactions in architecture have come into the interest of architects (Hensel and Menges 2008). The increasing development of digital fabrication, manufacturing technologies, and design computation provides possibilities of integrating physical and material behaviour as generative drivers in the architectural design process (Volkov et al. 2008). Instead of conceiving by drew, modeled or even digitally generated geometrical parts, computational design material elements are defined by material physical properties, their components, coexistence and complexity just like a truly living system. The autopoiesis theory (Maturana and Varela 1971) seems to contain the necessary knowledge to enable the creation of individual self-producing systems at least up to the definition of the fabrication parameters; but several architects argued that going further, the implementation of locally-sensitive differentiation, achieved through morphogenetic responsiveness, can produce more flexible and interactive architecture (Kronenbur, 2007; Fox & Kemp, 2009).

1.1. Related work

The first relevant study (never built), was lead by Cedric Price, "the fun Palace" project. This project explores the central idea of belief that through the use of new technology the public could have full control over their environment and as a consequence, have a building which could be responsive to its visitor's needs and activities. The project was composed by modular panels and pre-fabricated elements that could be inserted or removed as an open framework that could be adapted according to different needs. More recently, in 2001, Mark Goulthourpe leads the "Aegis Hypo-Surface" project. The system is composed by a metallic surface, subdivided in thousands of triangles, that has the ability to physically deform itself, in response to electronic stimuli from movement, sound and light. In 2003 Michael Silver develops the 'Liquid Crystal Glass House'. The project aimed to solve sunlight and heat issues, through the development and constantly adaptation of the electronic building skin, shifting from transparency to opacity. Recently, Anshuman developed a smart surface designed to regulate light, solar radiation and views, as well as display dynamic signage called 'Pixel Skin'. Pixel Skin is an electrographic surface which allows the integration of illumination and view controls with real-time communications media. During the last decade, several projects aiming at exploring the material behavioral and performative potencial led the Living System definition to a new level. Some examples of architectural production, resulting from this principle, can be cited, like 'Differentiated Wood Lattice Shell' (Huang and Park, 2009), based on the development of a wooden truss establishing a dialogue between the property of the material, the behavioral system, the generative computational process manufacturing and robotics. The project explores the unfolding of material through the performative capacity of wood. The Hygroscopic Envelop Prototype (ICD, Stuttgard, 2010), based on a structural system responsive and hygroscopic, consists of a structural surface composed of several regions sensitive to local humidity, cóncentration moving and adapting to climate change. The AAETH Pavilion (AAEmTech and ETH Zurich, 2011), consists of a structure entirely derived from the performance characteristics and potential of the wood.

1.2. Discursive Wall – a Living System

The Lisbon Workshop "Discursive Wall – a Living System" was held at the Vitruvius FabLab-IUL, in March 7th-11th (LS_01) and March 29th-April 1st (LS_02), 2012. The workshop involved three main partners: VitruviusFablab-IUL, FabLabEDP and Rhino3DPortugal/DigitaLab.

Discursive Wall – a Living System was composed by four main factors: A) explore the integration of Black Cork and Blue Valchromat – both national production; B) the design of the Wall should be entirely conceived through parametric tools; C) to produce the movement of the Discursive Wall, virtual simulators and low cost technology should be used; D) the fabrication of the Wall should be entirely made through CNC resources, avoiding any kind of supplementary materials for assembly. So the physical goal of this workshop was to produce a periodic structure, customized using the digital fabrication processes. The main focus of this pilot project was the transformation of different data, from the materials, performance – wall components into the simulation and fabrication of the mutable and constant design and re-design process – behaviour of the wall when facing its environment and inhabitants (Oliveira *et al.*, 2012).

2. OBJECTIVES

2.1. Project scope

This paper presents a description of the process and results of the Workshop 'Discursive Wall – a Living System' held at the Vitruvius FabLab, ISCTE-IUL, in Lisbon, during March of 2012. The objective of this workshop, was to produce a 3x5m wall panel, constructed by national/traditional materials and low cost technology, that reacts and dialog with its environment and inhabitants. Discursive Wall – a Living System was divided in two main modules, (A) LS_01, Firefly + Grasshopper + Arduino and Scale Model Fabrication and (B) LS_02, Design Studio – Discursive Wall. The workshop had the participation of students and professionals from different areas of knowledge (architecture, product design, fashion design, sculpture, engineering, electronics, and programming) from different countries. The workshop explored materials properties and characteristics – understanding plasticity, lightness, resistance and robustness and its self limits; the use of Rhino Grasshopper plug-in – for the form design of the wall, enabling the participants to integrate several material characteristics components and defining form through the use of material limits; Firefly add-on – for the creation and movement simulation; and Arduino – as creative and technical movement tools.

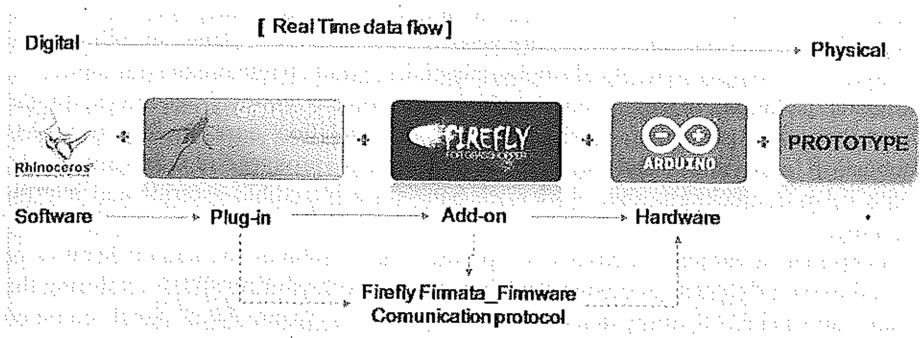

Figure 1. Workshop Framework (by Brimet Silva).

2.2. Goal

The goal defined for the 'Discursive Wall – a Living System' was to create a responsive wall to human interaction, using black cork, Valchromat and low cost technology through the use of digital fabrication processes and resources. Based on the hypothesis of an architectural living system the wall is constantly being designed and re-designed through its inhabitants and environment. This autopoiesis wall prototype organism has 3,0x5,0m, and physically responds to movement, establishing a direct dialog with the inhabitants, constantly reshaping their perception, minimizing acoustical problems of the space. The acoustical issue was determinant to establish the scale and the material of the prototype – Valchromat and Black Cork.

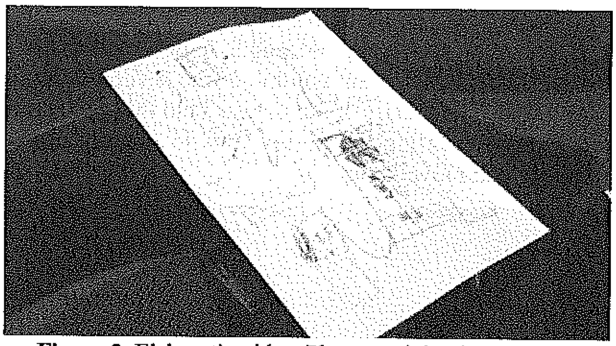

Figure 2. Elaborating idea. Photograph by the Authors.

2.3. Materials

Discursive Wall was built by two different materials: black cork as a front effect panel and valchromat as structure and movement mechanism. Cork is one of the principal raw material in Portugal. Nearly 720.000 hectares of cork oak trees and bark of the cork oak is known as cork. The mediterranean climate of Portugal is extremly apropriated to cork oak cultivation. Used in several products such as cork stoppers, in fishing rods and floats, in buildings as floor tiles and thermal and acoustical insulation, for artistic purposes, in pharmaceutical plants, in military and automobile industries etc. Its elasticity, plasticity, good characteristics for sonar and climatic isolation, makes it one of the most popular national resources. In the workshop we used black cork which is an insulation cork mainly used has acoustical, anti-vibratic and thermal panels. Generally produced in 0,5x0,5m panels, with 0,1m of thickness, this black cork panels are incredible exterior and interior coating.

Valchromat (a variable of MDF) is a product that combines the natural features of wood to the brightness of colours and, because of its flexibility, allows exploring the third dimension, textures and engineering. It is a wood fibre panel coloured throughout, impregnated with organic dyes and chemically bonded together by a special resin which gives Valchromat unique physic and mechanical features. There are available on the market panels with different sizes and thicknesses, enabling the consumer to analyze and choose the most indicated for each specific use. Not being a natural structural material, Valchromat presents a range of several characteristics that allowed us to make use of its resistance, robustness and elasticity.

3. METHODOLOGY

The workshop methodology development was divided in four phases: (A) LS_01 Grasshopper+Arduino+Firefly; (B) LS_01 Prototyping; (C) LS_02 Design Studio; and (D) LS_02 Discursive Wall.

3.1. (A) LS_01 Grasshopper+Arduino+Firefly

The A phase was dedicated to the creative process and the production of the cork units using the Grasshopper. The participants developed several design logics, like membranes of fibers over the cork, Voronois logics, Metaballs and the Pixel concepts, always regarding density and volume of the several units for each applied motors capacity and cost. The creative process was held through parametric software Grasshopper and Firefly, enabling the participants to control and define different conditional parameters and movements.

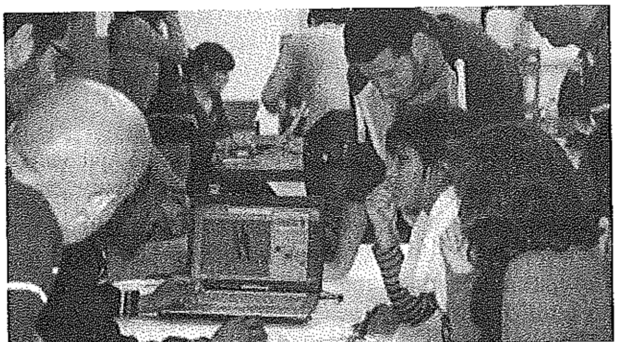

Figure 3. Essay movement with Firefly. Photograph by the Authors.

3.2. (B) LS_01 Prototyping

The B phase was the construction of the first test physical model. Four 1,0x1,0m structures with four different black cork design solutions supported by the pre-designed parametric structure, gave rise to specific customized structures so that a best possible match was achieved. Design, weight, robustness and movement effect were the election parameters to be voted for the construction of the final 3,0x5,0m Wall. A poll was held among the participants and trainers and the Voronois was the winner solution.

Figure 4. The four final prototypes from the first module of the Workshop. Photograph by Bárbara Varela.

3.3. (C) LS_02 Design Studio

The C phase was to adapt and fabricate the parametric structure. In the first two days of the second module, participants and trainers dedicated their time assembling the modular structures that together would form the 3,0x5,0m Discursive Wall. The full scale prototype is composed by five 3,0x1,0m independent blue Valchromat modules and a total of one hundred and thirty five 0,33x0,33 mobile black cork pixels. The first phase of construction was the structure, then the assembly of the movement rails and all electronic wires, motors, arduinos and power supplies and at last, the fixation of the pixels black cork.

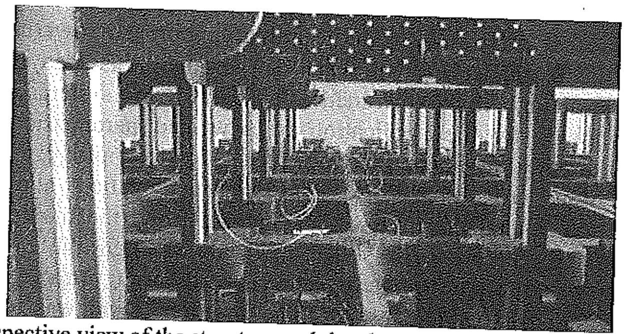

Figure 5. Perspective view of the structure and the electronics incorporation. Photograph by Bárbara Varela.

3.4. (D) LS_02 Discursive Wall

In the D phase, after all the electronics and the cork panel were assembled in loco, it was needed to establish the location of the movement sensors. A major movement area was chosen, a passage zone. Then it was needed to validate the 1,0x3,0m modules movement, making sure that all the motors were responding and working correctly. This was a delicate issue, since this electronic material is specific to micro scale tests, their durability and precision were very sensitive within this larger scale model. The solution found was to control their velocity and concurrency of movement. The final challenge was to make sure that all of the five independent structures were able to work together and could produce a unique and continuum movement.

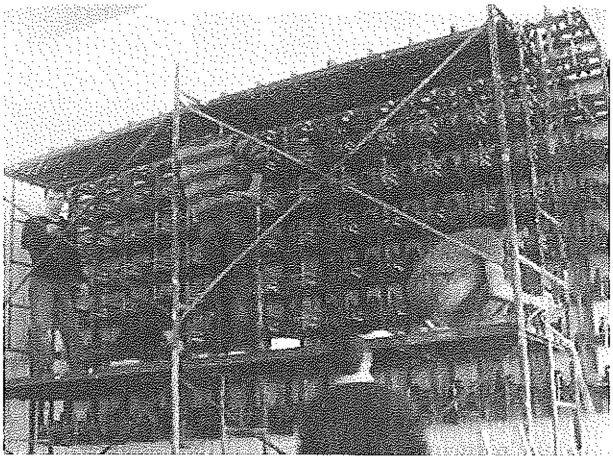

Figure 6. Fixing the Discursive Wall. Photograph by Bárbara Varela.

4. CONCLUSION

This workshop proved that architecture is no longer just a drawing exercise. The relations between traditional materials, performance and digital tools offers the possibility of incorporating processes of manufacturing and fabrication in the beginning of design process.A Multidisciplinary approach towards architectural thinking was the particular characteristic that brought this idea to reality. The challenge of translating complex geometries based in living systems into a physical artifact was allowed by the application of advanced parametric 3D modeling techniques that directly were linked to CNC fabrication technology, using traditional materials and low cost technology. The parameterization allowed a quick adaptability to the several elements of the structure, and the manipulation of the assembly parts only with simple assembly logic through the use of material properties parameters. The greatest difficulty was to improve the motors performance within the bearing system. The solution found was to improve the continuous movement with a shorter and slower step-by-step movement. This solution was still able to create the illusion of a continuous movement.

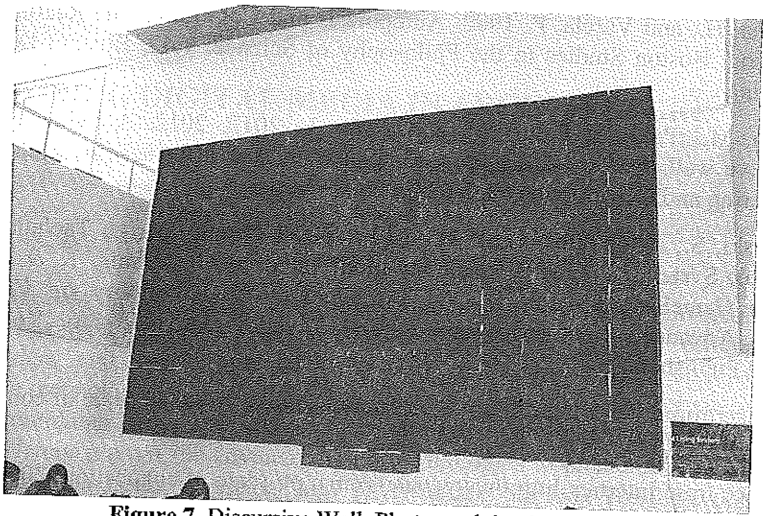

Figure 7. Discursive Wall. Photograph by the Authors.

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