Technic Praxis learning: A design studio embedding digital and physical knowledge

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ABSTRACT
Following the recent development in digital technology and the emergence of sustainability as a crucial socio economic concern there is an increasing attention in interactive prototyping as an answer to the new architectural paradigm of the 21st century. Architecture schools are creating digital fabrication laboratories to provide their students the skills to support new learning processes and scientific innovation linked to this new challenge. This paper describes the results of a pilot experience held by an interdisciplinary Lisbon Workshop "Discursive Wall – a Living System" held at the Vitruvius FabLab-IUL.

KEYWORDS: Design Studio; Interactive systems; Digital Fabrication; CAD/CAM and Arduíno.

Introduction

> *"Digital design and fabrication technologies have given architects the means to invent new architectural languages and communicate them directly to production facilities, allowing for the construction of projects with unforeseen complexity. Yet the impact of digital fabrication goes far beyond the mere production of complex geometries. A growing number of architectural practices and academic research groups are exploring the new-found freedoms in the close connection between digital design and production, investing new design processes, material applications and building scenarios based on opportunities found within the use od digital fabrication technologies."* (Male-Alemany et al., 2011, 40)

Traditional architecture design process starts from principles that architectural structures are singular and fixed, well integrated and separated from their environment or context. Emergence design processes and technologies require the opposite, interactive complex structures as part of an environment or context.

The responsive surfaces are related to physical interaction and digital computation: Ubiquitous Computing (Ubicomp). In 1991, Mark Weiser described a vision for 21st century computing, that countered the ubiquity of personal computers. Weiser anticipated that as technology advanced, becoming cheaper, smaller, wireless and more powerful, it would begin to recede into the background of our lives and taking a lifestyle-integrated form (Payne, 2012). In 1997, Ishii and Ullmer explored the logics that allowed transform architectural spaces through computational processes and digital information: GUI - Graphical User Interface and TUI - Tangible User Interface. The addition of these influences has resulted in a perfect symbiosis of interaction (sensory interaction), bits (computation), atoms (material) and movement (motion) – Sensory bits.

The materializing of a responsive surfaces need to have multidisciplinary approach towards developing intelligent artifacts (Goulthorpe, 2008). Digital fabrication offers opportunities to produce non-standard elements, which have the potential to create physical spaces with specific characteristics and economically viable (Bonewetsch et al, 2008). Recent research and experiences went deeper into the prototyping phase, providing the viability to the hypothesis (Kolarevic, Klinger, 2008, Hensel et al., 2010, Sheil, Glynn, 2011, Burry, 2011).

In order to explore these new architecture challenge, a multidisciplinary group of researchers proposed "a living system – discursive wall" workshop, held at Vitruvius Fablab-IUL. The goal was to design an acoustic structure to a coffee shop, using parametric, generative, programming and fabrication computer supported techniques. The 3 x 5 meters wall prototype has to physically respond to movement and interacting with the temporary space, establishing a direct dialog with the inhabitants, constantly reshaping their perception, and minimizing acoustical problems of the space. The acoustical issue was determinant to understand the need of the real scale model, and to establish the material to be used in the model: Black Cork for the front effect material and Valchromat (MDF) for the structure. The scope was going through all the lifecycle of the design solution: thinking digital to physical knowledge.

Physical interaction and digital computation

The Lisbon Workshop "Discursive Wall – a Living System" held at the Vitruvius FabLab-IUL involved three main partners: VitruviusFablab-IUL, FabLabEDP and Rhino3DPortugal/DigitaLab. The workshop explored the: (1) parametric patterns - Tessellation; (2) digital fabrication - materialization; and (3) advanced interaction (Figure 1).

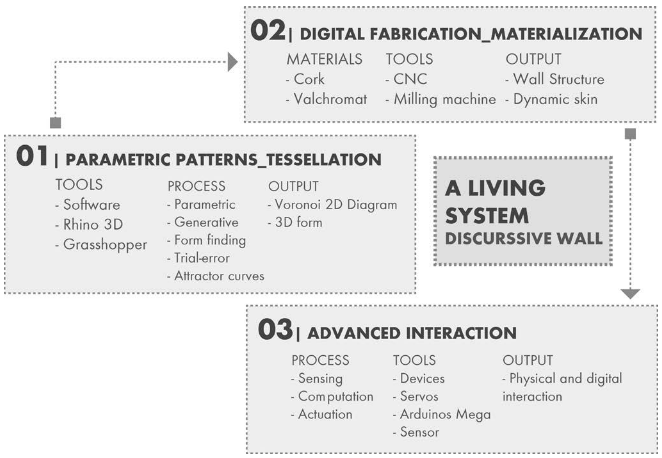

Fig.1. Discursive wall - a Living System, process diagram.

The parametric patterns-tessellation allowed creating a parametric pattern based in form finding, trial error and bottom up generative processes. The digital fabrication - materialization used CAD/CAM tools to simulate and prototype 3D interactive architectural solutions. The advanced interaction (Sensing - Computation-Actuation) explored the physical interaction and digital computation using parametric Rhino Grasshopper plug-in, Firefly add-on and micro-controller Arduino. Firefly add-on developed by Andrew Payne (2012) allowed the connection between Grasshopper and low cost open source Arduino developed by Massimo Banzi. The arduino is based in processing (C/C++), and has been used for creating interactive objects, art installations, small robots, among other applications. The parametric grasshopper interface articulates a set of specialized components with firmware protocol, which together operate the link between hardware (devices) and software (Grasshopper).

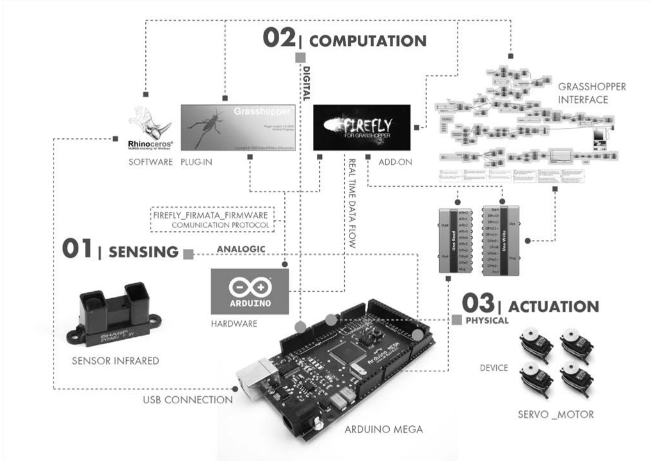

Fig.2. Discursive wall - a Living System, framework.

Methodology

The workshop methodology was divided in 2 modules: (1) LS_01 - Firefly + Grasshopper + Arduino and prototyping (Figure 2, Figure 3); and (2) LS_02 - Design Studio – Discursive Wall (Figure 4).

The first module was dedicated to the creative process using Grasshopper. The participants developed several form finding design logics based in 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.

The final phase of the module was the construction of the first test physical model. Four 1 x 1 m 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 (Figure 3). Design, weight, robustness and movement effect were the election parameters to be voted for the construction of the final 3 x 5 m wall.

The second module was to adapt and fabricate the parametric structure (Figure 4). 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 x 5 m Discursive Wall.

The full scale prototype is composed by five 3 x 1 m

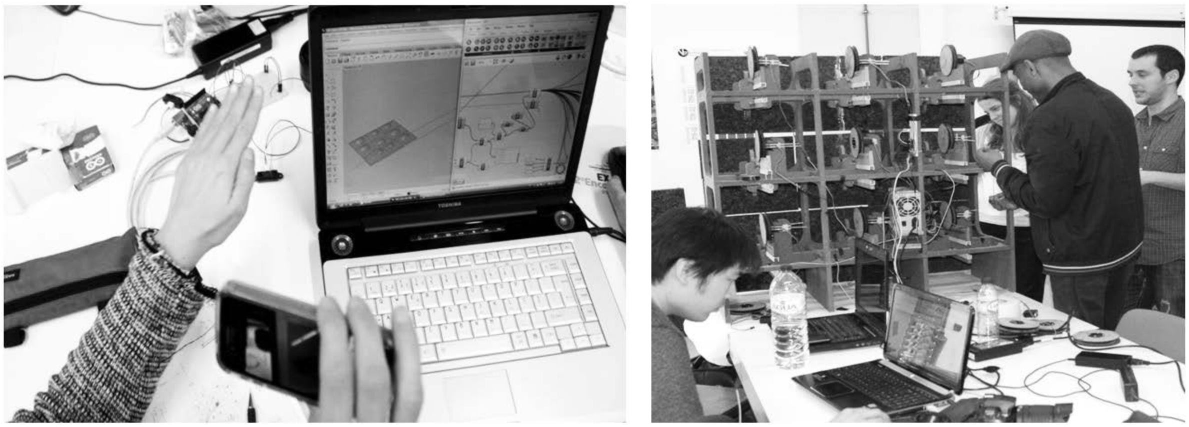

Fig.3. LS_01: Firefly + Grasshopper + Arduino and Scale Model Fabrication.

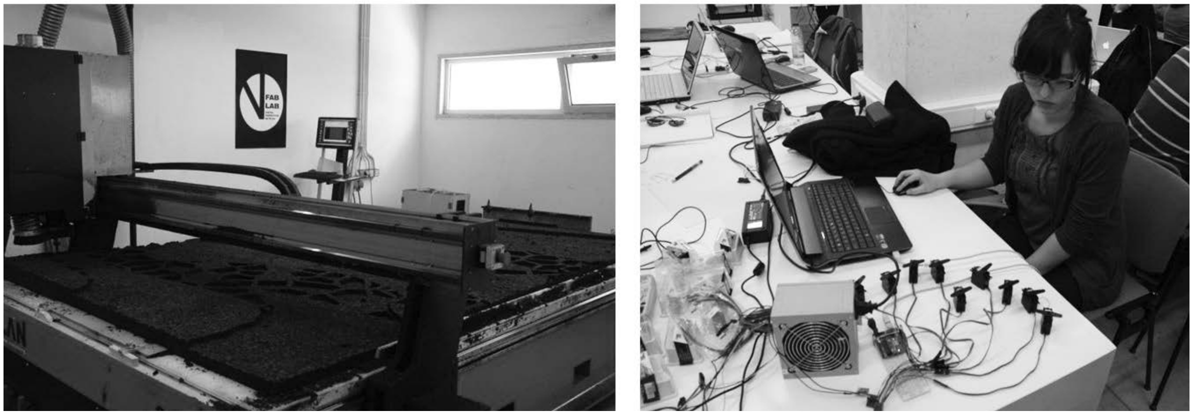

Fig.4. LS_02: Design Studio – Discursive Wall.

Fig.5. Discursive wall at coffee bar ISCTE-IUL, Lisbon.

independent blue Valchromat modules and a total of 135 mobile black cork pixels. The first phase of construction was the structure, then the assembly of the movement rails and all electronic wires, 91 servo motors, 3 arduinos mega ADK, 2 Sharp Distance Sensor GP2Y0A2 and 3 power supplies and at last, the fixation of the pixels black cork (Figure 4).

The movement of the wall was carried out by servos motors (large full rotation). The input data were computed on the grasshopper interface using the add-on firefly, transformed into parameters, numerical values responsible for discursive wall changes. The parametric definition generated a set of ten animations based on formal logic random, attractors, weaving and sinusoidal functions. This digital process was absolutely essential not only for reading but also in optimizing values of the animation of the discursive wall (Figure 5).

Conclusion

The results presented in this paper showed how interactive prototyping based in CAD-CAM-Arduino tools are facing advancements in both geometric representation and design methods integration. A Multidisciplinary approach towards architectural thinking was the particular characteristic that brought this idea to reality. Parametric design, interactive prototyping, digital fabrication and traditional materials approach not only allowed working with digital tools and physical prototypes, but also towards a new integrated architectural design strategies based in computing simulation in the beginning of design process. The challenge of translating geometries 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. This allowed bringing out new patterns that would hardly be conceived and manufactured with traditional tools. This paper suggests that if such design practices were to become extensive used, the architectural education and praxis in general need to be updated.

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More information: http://alivingsystemiscteiul.wordpress.com/workshop/