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Teaching strategies for Digital fabrication

Digital fabrication workshop UIC Master Biodigital

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Abstract

Most designers have adapted their methods of designing to digital technics. This article explains the strategies used for develop a panel, realized with three different techniques of digital manufacture.

Keywords: 3dPrinting; Cnc milling; Laser cutting; Teaching.

Introduction

The design strategies related to digital manufacturing and digital thought have offered new approaches to design practice, such as parametric modeling techniques. There are also significantly enriched digital processes, which have affected the nature of the materials and construction processes. Computational tools require from us not only ways of doing but also ways thinking.

Finally, contemporary digital fabrication techniques allow an efficient connection between design and production.

"We become what we behold. We shape our tools and then our tools shape us." - Marshall McLuhan[1]

General objectives

Combining digital fabrication techniques, we had a double interest. For one side to understand the possibilities of design and creation software, that offer to us, in terms of geometry and representation. On the other hand, enable the construction of projects through three CNC machines. Through the proposed project, the student will come naturally to understand procedures from basic to advanced levels in terms of digital tools.

The objective of the seminar was to bring the students in practical ways of dealing with the new technologies applied to the design and digital manufacturing. In the specific case of this workshop, parametric techniques, which enable the analysis of processing solutions applied panel. The classes used exhaustively the Rhinoceros, necessary for the proper development of the proposed project and Repetier[2], RhinoCAM[3], RhinoNest[4], Grasshopper[5] program.

Similarly set the workflow collaboration through collaborative and parametric design, enriching the teaching line you are working, where the base is solid knowledge to design from the strategies and tools.

Throughout the Master BioDigital Architecture[6] students develop series of projects related to digital design strategies. The workshop´s main idea is to prepare students to deal with digital fabrication machines, then know how to prepare files for production models. Strategically this workshop is given right at the beginning of the master.

As seen below, the exercise needed for proper coordination between the parties, thus achieving the fit and assembly of all com-

1 "Media: McLuhan's Message." 2003. 26 Mar. 2014 <http://www.cyberartsweb.org/cpace/infotech/asg/ag6.html>

2 "Repetier Software | The software driving your 3d printer." 2006. 26 Mar. 2014 http://www.repetier.com/

3 "RhinoCAM - MecSoft Corporation." 2013. 26 Mar. 2014 http://mecsoft.com/rhinocam-software/

4 "RhinoNest, nesting for Rhino." 2005. 26 Mar. 2014 http://www.rhinonest.com/

5 "Grasshopper - algorithmic modeling for Rhino." 2006. 26 Mar. 2014 http://www.grasshopper3d.com/

6 "Biodigital Architecture Master -" 2010. 26 Mar. 2014 http://www.biodigitalarchitecture.com

ponents. Thus, we have demonstrated the accuracy and efficiency of the machine.

The workshop was developed by the evening and the morning students attended conferences with professionals who have been able to teach their line of work and research, as is the case of Architect Juan Pablo Quintero (MedioDesign director), Carlos Perez (McNeel Europe) and the teachers themselves. This initial input has aroused the curiosity and examples presented allowed a broad reading on digital design and fabrication, always marked by a speculative nature and seeks innovation.

Research and Methodology

The lectures have established a tool for immediate application in the project. So exercise, practice and manage software consolidate their learning themselves. The lectures were based on some basic knowledge of science or concepts that we consider important and that have been present throughout the workshop. Analogies helped in times of greater abstraction.

We selected three authors: Gilles Deleuze, Norbert Wiener and Marshall McLuhan, for his "theoretical" contribution without direct links to architecture or design. Rhizome[7], Cybernetics[8] and Communications Theory[9] have been discussed in class, and then applied to the context of the exercise. So theories that have preceded the development of technology, and they have provided theoretical basis then have been able to help the conceptualization needed to generate codes are linked.

Through the case study that has been previously designed by teachers, where they have experienced strategies of digital manufacturing, and based on the concept of "bottom -up approach", i.e. how from knowledge of the tool students achieve project based on the same technology.

Clearly it is important to delve into various factors that influence this process as programming tool, knowledge of materials, manufacturing strategies in order to achieve architecture from the global point of view. That is, how knowledge from technical and theoretical basis students can develop projects where the goal is digital fabrication using various techniques. It is therefore important to study workflows from seeking education, allowing students to delve into this sector is essential today, and is marking the production of contemporary architecture.

The teaching method is based on some concepts clearly identifiable, where the sum of these permits comprehensive understanding of technology. Being a heterogeneous group of students from different parts of the world and with different knowledge, seeks to recover what each can contribute individually.

The establishment of a unique panel, assembled from three different materials requires coordination between all the components that determine the panel. They tested the degree of accuracy required to make everything fit and work. The result allows "confidence" of students in the techniques, allowing open digital manufacturing methods based on knowledge of concepts and principles, namely:

Computing: generate information, data. This must be perfectly understood, manipulated, exchanged. The "extensions" of each file has its peculiarities. The rigor and control must be present at every stage of the process, without losing the target. In this way, students learn to generate code, work with algorithms, programming.

Mechanics move machines. Deposit or remove material. In short, controlling the position of the tools is critical. It is about defining when, where and how each technology will be acting, not to end can generate the necessary codes and algorithms. In the case of using the CNC milling machine, the issue of minimum essential strawberries and knowledge speeds production machining strategy is. We opted for the plug-in RhinoCAM, by virtue of being embedded in the "front-on" Rhinoceros[10]. Allows greater flexibility in design and automatic reprogramming of G-code.

Electronics: sensors, calibration, controller cards, drivers. It was first chosen to the understanding of a 3D (Felix Printer[11]) printer because it is an "open" machine smaller (it is portable) and where each of the components are reliable.

Geometry: absolute control of three-dimensional space. Given its ease of use, has opted for 3d modeling program Rhinoceros. Based on NURBS geometry, allows the modeling of any shape necessary for the production of objects control. Also, the plug-in Grasshopper visual programming has contributed to the parametric approach to handling components.

Materials: properties and applications. PLA[12], Polypropylene[13], polyurethane foam. Students have been "provoked" to test, cut, bend and experience all the properties of each material. The choice of equipment is made of "natural" way depending on the material.

We believe that the understanding of these sciences is what will allow the emergence of a consistent design and linked to digital fabrication. The lack of knowledge on any of these issues compromised the final result.

Therefore the method we apply is to let emerge, in a natural way, at the same time conducted; to use common sense to delve into this area in a safe and controlled manner. We believe in a classroom and highly participatory approach. At various points the students themselves just dictating the pace and the questions that arise appear on the most appropriate times. It's much different when instead be dictating by the teacher, students are asking range of questions. No doubt that this method is much easier for memorization and ability to understand, it is "bottom-up" from the students themselves.

7 "Rhizome (philosophy) - Wikipedia, the free encyclopedia." 2006. 26 Mar. 2014 http://en.wikipedia.org/wiki/Rhizome_(philosophy).

8 "Cybernetics - Wikipedia, the free encyclopedia." 2004. 26 Mar. 2014. http://en.wikipedia.org/wiki/Cybernetics.

9 McLuhan, E. "Marshall McLuhan's Theory of Communication: The Yegg."2008.http://www.gmj.uottawa.ca/0801/inaugural_mcluhan.pdf.

10 "Rhinoceros." 26 Mar. 2014. http://www.rhino3d.com/

11 "FELIXprinters: Home page." 2013. 26 Mar. 2014 http://shop.felixprinters.com/

12 "Polylactic acid (PLA) - Wikipedia." 2005. 26 Mar. 2014 <http://en.wikipedia.org/wiki/Polylactic_acid

13 "Polypropylene - Wikipedia, the free encyclopedia." 2003. 26 Mar. 2014 http://en.wikipedia.org/wiki/Polypropylene

The role of teachers is to connect the concerns of students. This is achieved with practice and group classes.

In a second instance, and direct and personalized way, teachers help students to generate their own designs and codes. Each student is responsible for generating their own files, and teachers review it, suggest or remove doubts. The idea is always to give the student the responsibility for what is generating. The whole process is very thorough, and requires concentration and ability to penetrate across programs, exploring them and taking full potential of each.

The Project

The main focus is given about the ability of the project has to be executed with the use of three digital manufacturing technologies from conception to completion. The project was developed in this workshop consisted of a panel of Foam, Polypropylene and PLA.

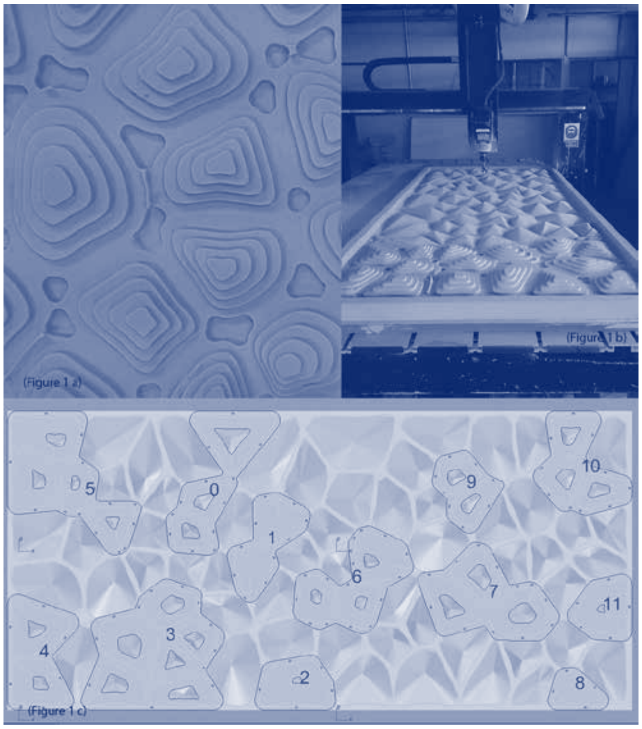

Figure 1: Horizontal Roughing and Component organization.

The idea is that the proposed project is "feedback" of digital design, and to justify their production in digital media. Knowing the tools of production, it has managed to generate a collaborative design. Each of the parties identified in a global context.

Design Phase.

We have previously prepared the project using Rhino and Grasshopper, based a foam block of 2000x1000x50mm, starting with an outer frame of 50mm, then generating 72 cones on points based of a Voronoi pattern and leaving 15mm from the base.[figure 1 c]

Parametrically were added polypropylene sheet layers that intersected and group 50% of these cones. These layers were added at different height. Around these grouping contours we added a connecting hole for the polypropylene and foam location, wich where we add an anchor arrow that allow supporting them together.

Production Phase.

Once we started the workshop days we explained to students the logic design interconnections between the parties and the degree of freedom that would occur in each case. The definition file and were shared with students. The mechanical work was the development of dividing his work into three panel machining techniques, considering it would have 5 days, 6 hours a day of workshop. [figure 1]

Each evening has been a key issue, devoting almost 2 hours for the explanation of each of the 3 techniques. How was first approach, there have been little practical exercises, from the simplest to the most complex. All of them sought a constant feedback between design and manufacturing. A detailed follow each:

Being an open source program, called Repetier to control the 3d printer (Felix Printer), each student was able to install it on your own computer and generate the own G-code. This program allows you to view, in real time, the code being executed. In manual control allows controlling the movement on 3 axes, understand some important concepts, such as "home", coordinate control, displacement. That allows us to understand the close relationship between design and manufacturing, as the students can see the machine in operation, in this case by depositing PLA on a platform. The control is done by the correct temperature and speed of how the PLA is deposited, and a good strategy setup for generation of "slices". With this technique we have obtained the connecting pieces.[figure 3 a]

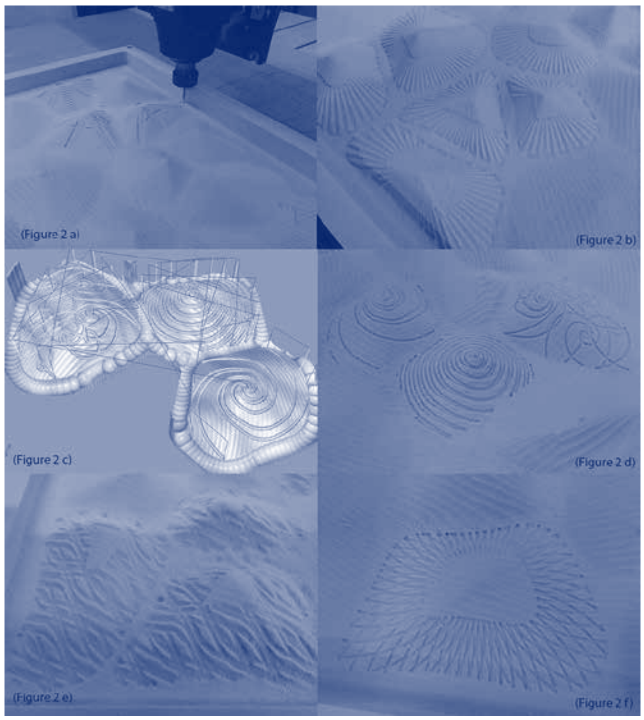

Figure 2 CNC technics.

CNC Technics.

Perhaps learning more complex techniques of the three we have chosen a geometry that required the use of several strategies machining, both 2d and 3d. For this we used a block of polyurethane foam 2000x1000x50 mm, medium density, which allows rapid mechanization. Strategies have been applied in a logical go ever more approaching to the final shape.

Milling Machining Operations Applied.

Horizontal Roughing: The first technique used for machining of a Foam which has a round tip and leaving 20mm of stock and 5mm above the geometry of the cones, allowing variations for finishing.[FIGURE 1a]

Parallel Finishing: Throughout the seminar the students, the work area was divided by two cones voronoi for each student to apply and develop a pattern type of finishing or engraving strategies RhinoCAM in their respective assigned area where applied the " inputs " provided by teachers. Each case was analyzed individually and in this case is given complete freedom of design. Thus, the participation of students in the general context is recognized. [FIGURE 1b]

Profiling: this is done in order to allow the parts fit polypropylene cone fairly. We used a small cutter radio.

Drilling: was use simply to mark the position of each connecting element.

Post-Processing: Each of these milling strategies have been sent to the cnc machine depending on the tool you use, because the machine does not have automatic tool change. Each student has created their specific G-code and has accompanied the process of mechanization of the sector.

3d Printing Technics.

Total 110 pieces of 35mm, 40mm, 45mm, 50mm, 55mm. [figure 3 b]

The purpose of 5 types of anchors is to achieve with their different heights and anchor of its kind with polypropylene clamp head, and the bottom anchor to the foam.

Each student had to analyze the position of the plate within the general context and thus parametrically define the necessary heights, where to compute the number of parts required.[figure 3 c]

Laser Technics.

12 pieces of Polypropylene. Were cut 12 pieces to be arranged in 5 different heights which fit precisely in the respective cones. It has given freedom to define openings (circles) as well each student had to prepare the file , and then organize it into layers has released the file to the laser cutting machine. For optimization of the material was used RhinoNest program. By small trials, we have reached a good combination of speed and laser power. [figure 3 d].

Operation of Machinery.

In collaboration with the responsible Models Workshop, Daniel Wunsch, students have learned to place the machines running. From the lighting of the same, check operations, file loading, handling costs specific programs. Finally placing materials and machining.

Figure 3 Assambly.

Assembly.

On the last day the students have assembled the panel, setting the sheets of polypropylene FOAM through connections made by 3d printer. At this time the accuracy of the technology is tested and whether they have achieved the intended visuals. [figure 3]

Machines used.

- AXYZ cnc router 3 axis type.
- Felix 2.0 3d printer
- C02 laser cutter PC 10/80 KII

Materials used.

- PLA 1.7mm white spool
- 1 Foam 50x1000x2000mm
- 3 sheets of Polypropylene (plakene), 0.5mm

Conclusions

Despite the short time, we have seen the effectiveness of a classroom course with high demands, which require their own techniques employed. Being next to the machines has been fundamental. The students have shown great interest and have dedicated satisfactorily.

The role of teachers has been simply to lead the group and teach the possible ways. The result is the mastery of technique, intuitively, aiming that students use technology as an extension of their capabilities, both for generating design (project) as implementation. We targeted a symbiosis between design and manufacturing. [figure 4].

Figure 4 Final Panel.

Bibliography.

DELEUZE, GUATTARI, Mil mesetas, Capitalismo y esquizofrenia. Valencia, Pre-textos, 2002.

Dollens, Dennis. Digital to Analog . Sites books , New Mexico 2001.

ESTEVEZ, Alberto... [et al.] , Genetic Architectures . Sites books , ESARQ (UIC), Barcelona 2003.

ESTEVEZ, Alberto... [et al.] , Genetic Architectures II . Sites books , ESARQ (UIC), Barcelona 2005.

KIERAN, Stephen & TIMBERLAKE, James. Refabricating Architecture. McGraw -Hill . New York 2004

MCLUHAN, Marshall & FIORE, Quentin, The Medium is the Massage. Paidós Ediciones, Barcelona, 1988.

MEREDITH, Michael... [et al.] . From Control to Design. Actar, Barcelona , 2008

Negroponte, Nicholas, The digital world. Ediciones B, Barcelona 1995.

OOSTERHUIS, Kas. BCN speed and friction. Sites books, ESARQ (UIC), Barcelona 2005.

ORCIUOLI , Affonso . Arquiteturas Non Standard . AU Magazine # 119 . Sao Paulo 2004

ORCIUOLI, HALABI AND BOOT. Several articles. BCN Speed and Friction : the Catalunya circuity city. Sites books, ESARQ (UIC). Barcelona 2004

POTTMANN, Helmut ... [et al.] . Architectural Geometry. Bentley Institute Press. Exton, USA 2007 .

SCHODEK, Daniel ... [et al.] . Digital Design and Manufacturing. CAD / CAM Applications in Architecture and Design. John Wiley & Sons . New Jersey 2005.

STEELE, James. Architecture and Digital Revolution. Gustavo Gili , Barcelona , 2001.

WINER, Norbert , Cybernetics and Society. Edicions 62, Barcelona 1965.