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Strings Pavilion: design process

Gilfranco Medeiros Alves and Cynthia Nojimoto

Gilfranco Medeiros Alves is Architect and Master in Language Studies. Researcher at Nomads.usp - Center of Interactive Living Studies - at *Universidade de São Paulo* (USP). He studies Architectural Design, Communication and Semiotics in Architecture, Second Order Cybernetics, Cybersemiotics, Computer Graphics, and Education of Architecture and Urbanism.

Cynthia Nojimoto é Architect and Master in Architecture. Researcher at Nomads.usp - Center of Interactive Living Studies - at *Universidade de São Paulo* (USP). She studies design processes and complex systems on interactive objects.

Abstract

The paper presents the design process of Strings Pavilion developed during the Architectural Association School of Architecture's Visiting School Workshop occurred in Sao Paulo city, in July, 2011. The pavilion is an outcome from a collective creation process of five persons team working in an immersive way during ten days; they explored several possibilities of experimentation and hybrid processes from researches about materials features and behaviors as well as parametric software. Fundamental concepts such as loop, feedback and responsivity from Second Order Cybernetic and Systems Theory were included and applied in the creation process.

Keywords: design processes; Second Order Cybernetic; Complex Systems, parametric design; digital fabrication; interactivity.

1. Introduction

The complexities of the contemporary architectonic product and its respective demands drive architects and designers to experiment other possibilities for creation in a way that the available technologies for project development (such as parametric software, digital fabrication techniques and objects interactivity) have stimulated the search for design processes more compatible with contemporaneity phenomena.

In this context, the String Pavilion project was developed by the authors of this paper during the workshop organized by Architectural Association School of Architecture in Sao Paulo city, in July, 2011. The pavilion is an outcome of a design process which embraces shared creation, parametric applications, digital fabrication and interactivity in the project and production of the architectonic object, issues that have been the center of discussions and debate in the recent architecture scenario.

Besides appearing as a reflection on other design processes more coherent with the current constructive and projective technologies available, the Strings Pavilion also presents as an opportunity to put into practice theoretical concepts researched by the authors. Between them, it can be emphasized Cybernetics and Complex Systems. In the design process of Strings Pavilion, such concepts were used mainly as design criteria that guided the design team's decisions. Therefore, it is emphasized in the next section the relevance of some of these concepts applied directly in the project.

2. About Cybernetics and Complex Systems: design criteria in the process.

The term Cybernetics comes from the Greek *kubernetes*, which means the idea of a helmsman that controls the ship in a volatile environment. The idea of being controlling the ship in an unknown environment (therefore, susceptible of variations, unexpected events and changes) is essential for the helmsman. This happens because he must remain attentive and receptive to his environment and to its changes, protecting his ship along its course, defining his actions as reactions to the environmental conditions, in a way to produce a necessary reorganization in order to maintain the system’s balance. This is the control definition used by Cybernetics: the observer more like a guide than a top-down controller.

According to Wiener (1973), Cybernetics can be defined as "the science of control and of communication, in the animal and in the machine". To Ashby (1970), the Cybernetics is a "machine theory", yet it does not approach things, but behaviors. **It does not ask "what is this?", but “what does it do?"**

> [...] the Cybernetics typically treats any machine, particular, not asking "what individual action it will produce here and now?", but "what are all the possible behaviors it can produce?" (Ashby, 1970, n.p., our translation).

In this way, appears a science aimed to study the issues of **control**, **regulation** and **communication**, where information theory has a important role, insofar as it is characterized by dealing with a set of possibilities. Wiener concentrated many of his efforts on the study of the language and also of the messages.

The Cybernetics defined by Wiener in the 1940's deals with systems observation, having as one of its main concepts the circularity (also known as loop and feedback). To this Cybernetics was given then the name of First Order Cybernetics. In this context, the theory bases itself in observing systems on the perspective of regulation and communication using feedback. The system behavior can be observed by an external observer in which the purpose is to move to a goal. The Cybernetics essence is the circularity present in the loops and feedbacks which balance the system to achieve its goals.

In the 1970's Heinz von Foerster proposed a review of this science, with the inclusion of the idea of observer's observation. This review was called Cybernetics of Cybernetics or Second Order Cybernetics, which is, therefore, the "study of observation systems" (Scott, 2004, p.1373). Thus, the Second Order Cybernetic is a science which proposes the observation of systems, also concerning with the outcomes from the action of observing them on itself.

In the String Pavilion project, Second Order Cybernetics acted as conceptual basis, not only for the constant feedback done by the project's participants, but mainly for the expected development of interaction possibilities the pavilion would present in relation to the users and the ambient where it would be inserted.

Besides, in the design process concepts from Complex Systems science were also used. According to Mitchell, a complex system is:

> [...] a system in which large networks of components with no central control and simple rules of operation give rise to complex collective behavior, sophisticated information processing, and adaptation via learning or evolution (Mitchell, 2009, p.13).

The design team attempted to apply this idea of simple rules of operation in the project to create complex behavior on the system, in order to make possible the emergence of something unexpected and not determined. Thereby, it was expected that the simplicity of rules would produce the emergence of a complex spatiality and formal aspect, which would provide the pavilion a differentiation in terms of constructive aspects compared to other shapes and spatialities that it could acquire if conventional design processes had been used in its conception.

Thus, the experience described in this work becomes an example of creation processes in architecture involving issues related to Complex Systems theories and Cybernetics. Besides, represents the possibility and the relevance of exploration of theoretical researches through design practices, and more than this, the necessity of relations between architecture and these theories in order to stimulate different design attitudes. This sets an urgency of analysis and review of the building practices using tools and materials currently available and not yet explored in an intensive way.

3. The design process of the Strings Pavilion

The experience that resulted in the Strings Pavilion project was consequence of a collective work, developed during the Architectural Association School of Architecture's workshop in a program called Visiting School[1], between July 12th and 21st, 2011, in Sao Paulo city.

The workshop program involved students training with several software and programming languages (such as Rhinoceros, Grasshopper, Rhino Phyton, Processing and Arduino) and also lectures, practical activities and design activities. Thus, in the first workshop days, instructions about the mentioned software were taught, introductory classes about parameters and algorithms and lectures presenting projects developed by teachers and tutors in their professional or academic activities. After students training, was introduced a practical activity of material exploration and, after that a design activity.

The practical activity of material exploration was proposed by the architect Robert Stuart-Smith, professor at Architectural Association School of Architecture and director at Kokkugia, an architecture and urbanism office whose headquarters are located in London and New York. In this activity were used mainly fabric and cables. Thus, the methodology used intended to investigate different materials (Figure 1), its physical characteristics such as strength, behavior, deformation and distortion in order to understand the emergence based on non-deterministic laws.

[1] Visiting School is a program from Architectural Association School of Architecture. It organizes workshops in several cities in the whole world in order to apply its methodologies in other countries and in different contexts.

Figure 1. Exploration of materials behaviors. Source: authors, 2011.

The design activity proposed by the workshop organizers comprised an intervention at Paulista Avenue, an important reference point at Sao Paulo city. After collective discussions about the intervention space, the students were arranged in design teams of about 5 person for development of a projective proposal. At the end, the students should present as project products a physical model, a computational model, and the register of the team design process.

The space of intervention, Paulista Avenue, is important to Sao Paulo city in many ways. Besides being a geographical reference to the city, the Paulista Avenue is an important space for cultural, sportive and political events, although it is used more frequently as a passage than a place to stay. Maybe this happens because the avenue does not offer proper spaces in which cultural effervescence can manifest in different scales, unless when the transit flow is interrupted and pedestrians appropriate the avenue. Thereby, the starting point of the design team was, then, to understand the intervention area as a space of cultural events in its different scales. Thus, the pavilion design should cover several cultural events, such as exhibitions, musical presentations, among others. Besides, the pavilion should be rapidly assembled, disassembled and transported.

Figure 2. Pedestrians flow crossing the Avenida Paulista.

Figure 3. Rio Claro St., pedestrians passage between Paulista Avenue and São Carlos do Pinhal St.

Figure 4. Area below MASP - Art Museum of Sao Paulo. One of the few places to stay along the Paulista Av.

The practical activity involving the exploration of the materials was incorporated into the design process. The materials defined for the pavilion were fabric - elastane more specifically - and cables. The models were used to study various types of cables, from wire to steel strings for musical instruments and steel cables in various thicknesses. To join one material to another, sewing patterns for the cables' passages were designed and manufactured. In the setting of those standards, the definition of complex systems was used as a design criterion, as mentioned above. We looked for definitions of simple sewing patterns, so from these patterns could emerge forms and spacialities not determined.

Figure 5: Reaction of elastane in the face of imposed stresses by tension and the stitch pattern.

Thus, from the knowledge of the features of the materials acquired through various models of study, and application of some simple rules and its repetitions, we obtained some results that, although unexpected, were important for understanding the behavior of these materials when working together.

Figure 6. Elastane and steel strings working together.

The pavilion would also present formal movements and adjustments according to local conditions, such as the lighting or the presence (or not) of users, according to the concepts of Cybernetics. From these adjustments, new patterns of light and presence of people would be changed, and then the adjustments and movements would be constant, keeping the pavilion always moving. At this stage of the project, the movements of the model were still done manually, but after they were made with the Arduino, an open-source platform for experiments with interactivity in objects.

To simulate the movement of the pavilion a computer model was made using the Rhinoceros and the Grasshopper software. In this model, the behavior of the cables was parameterized so that it would be possible to visualize different possible configurations of the pavilion.

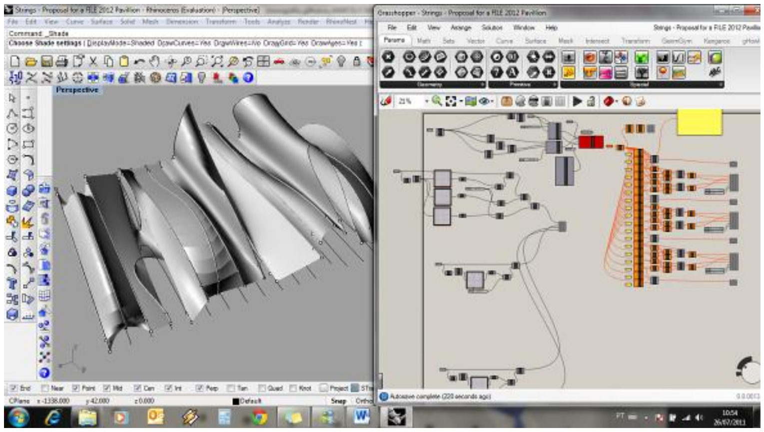

Figure 7. Configuration of the project in the software Rhinoceros and its plug-in Grasshopper.

However, there was difficulty in accurate simulation of material behavior in the digital environment. Although the project team was able to simulate the behavior of the cables, the same did not occur with elastane. Some behaviors of elastane could not be visualized because of the difficulty to set parameters of certain material properties. So we come to a satisfactory variety of models that reproduced some of the desired movements and reactions between cables and elastane, with the determination of controlled values for the parameters of the project. Yet we could not exactly simulate the materials, this allowed visualize the spatial movement of the cables and elastane.

After many studies models to test the behavior of the materials, settlement patterns between fabric and cables and possible movements, began the process of building a physical model to be presented as final product of the project at the end of the workshop. For this model, built in 1:20 scale, it was decided that the pattern of attachment between the cable and elastane should follow a simple rule, so from these rules a different behavior would emerge, and if so, what emerge should be from different shapes and spatialities. The positioning of the fixing points of the pavilion should also follow a simple pattern. To do this we created a regular perforated grid in a wooden base to explore the possibilities for placement of the steel cables on that basis and therefore verify the spatialities that could be generated.

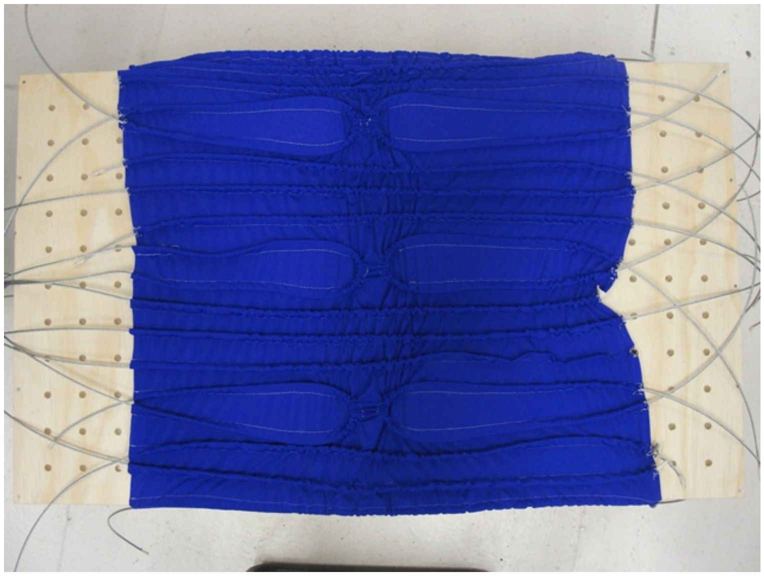

Figure 8. Sewing standard for the passage of cables in elastane.

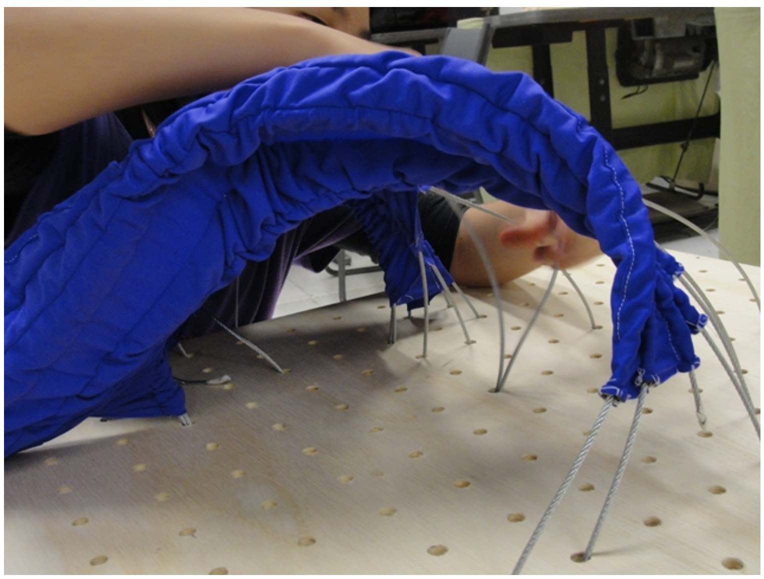

Figure 9. Wooden base with regular grid.

At this point, the tests with the Arduino begin. On this platform was developed the programming involving sensors and actuators to perform the desired movements of the pavilion. At first we used presence sensors. These sensors could detect the number of people inside the pavilion and based on the amount of people there would be various different behaviors. In the reduced model, they would be installed in front of the object, using two infrared sensors.

However, the pavilion showed to be much more reactive than cybernetic, in the sense of feedback, as desired conceptually. The presence sensors were replaced by light sensors so the environmental restrictions could be worked out. With these sensors it was noted that the feedback system would be possible if the light sensors were installed inside the pavilion. Each brightness value detected by the sensor would be determinant of a certain movement of the pavilion. The pavilion would move and, from this movement, new brightness values would be detected by the sensors, creating in this way, new movements, keeping the pavilion always in motion, that is, it feeding back itself constantly (Figure 10). The Arduino would detect environmental data, in this case the brightness values through sensors, and would process this information, via a determined programming, in a movement made by specific actuators, that in the Strings Pavilion were servo motors.

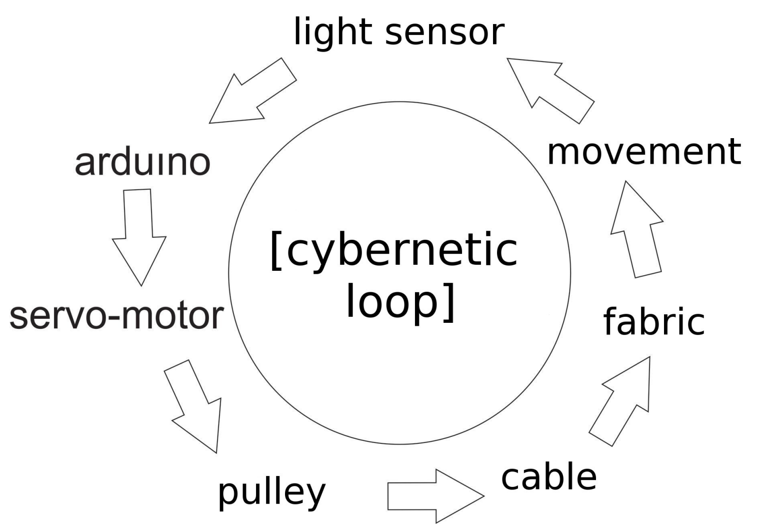

Figure 10. Cybernetic loop.

In addition to all the programming on the Arduino, it was also necessary to develop the physical mechanism for the movement of the small physical model of the pavilion. For this was elaborated a system of pulleys connected to the servo motors. This group would be responsible for pulling the cables of the physical model, thus moving the pavilion. The design of the pulleys as well as the support for its attachment to the wooden base was made in Rhinoceros and produced in the laser cutting machine. The wooden base with regular grid to engage the attachment points of the pavilion was also produced in the CNC milling, from a design developed in Rhinoceros.

Figure 11. Cutting of the pieces to the movement mechanism of the physical model in laser cutter machine.

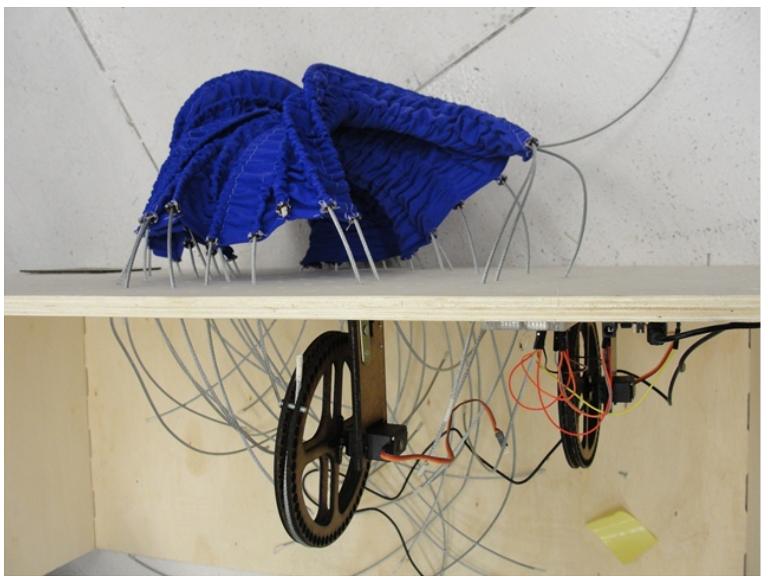

Figure 12. Test with Arduino and servo-motors.

The physical model presented at the end of the workshop met the expectations of the project team. Despite the difficulties encountered as, for example, the amplitude of rotation of the available servo motors, which was only 180 degrees, thus limiting the movement of the pulleys, or the amount of servo motors available, allowing the assembly of only two pulleys, the products shown, both the computer model as physical model could represent the Cybernetics concepts and Complex Systems worked on the project.

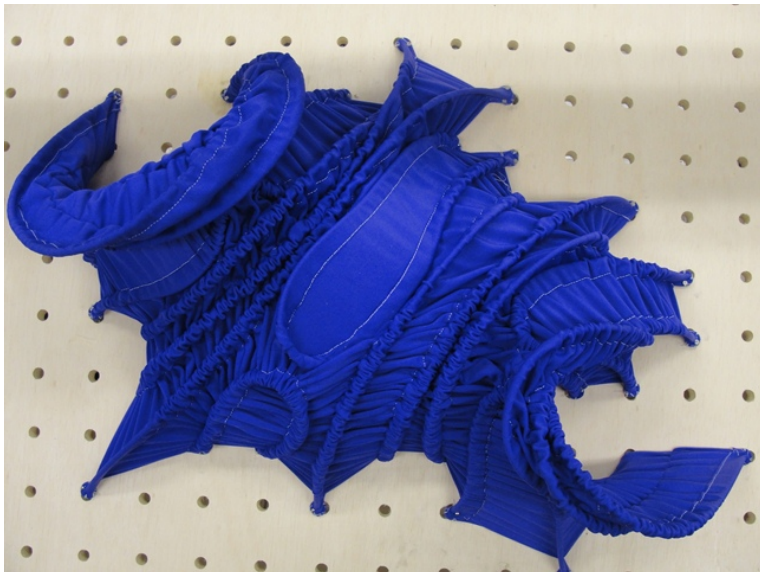

Figure 13. Finished physical model in 1:20-scale.

Figure 14. Photomontage with the possibility of deployment in Alameda Rio Claro.

However, these theoretical issues not only become design criteria for an architectural product, as also indicate a possible methodology for analysis of the design process as a whole, especially in dialogues between project team members, teachers and tutors.

Thus, it is possible to establish a cybernetic relation of the design process when the continued condition of come and go over the architectural object and the discussions between the team and collaborators can be considered as actions that feedback this process. This feedback movement becomes essential for the analysis of the adopted solutions and the constant review of their decisions about design.

The dialogues that occurred during the project development of the Strings Pavilion also represent the collaborative nature of the process. There was not in the team the image of an architect or designer on the top of the process managing the team. But each team member, each one with his knowledge and skills, working collectively to develop the project. Perhaps this process is slower than one that depends on someone to make decisions. On the other hand, the decisions take start from collective reflections, and both errors as hits are constantly discussed by everyone, in a feedback process that ultimately minimizes incompatibilities between design and built object.

4. Conclusions

The presented project demonstrated, from an experiment, the use of recent technologies such as parametric applications, digital manufacturing and interaction as possible catalysts for a methodology that seeks to investigate other processes consistent with contemporary context. Moreover, brings concepts studied by the authors, such as Cybernetics and Complex Systems theory to a projective activity, combining thus the theoretical aspects with practical experimentation.

We concluded that the complexities of the design process in architecture, so to speak, require other approaches, as was reported in the experiment design. The digital media and the use of parametric design, for example, encourage a change of approach to the creative process in architecture. The project described is the result of a collective process, experimental, and it is expected that in some form can contribute to current discussions going on about creative processes in architecture using digital media and contemporary technologies available.

The next step of this discussion will be the construction of the pavilion in 1:1 scale. Thus, new challenges must be overcome, since the physical model only represents the design and the mechanisms adopted to simulate the movements of the pavilion, as developed in the physical model in 1:20 scale, can not be faithfully reproduced in 1:1 scale. New systems should be developed, and new members, each one with a distinct and specific knowledge, should be incorporated into the project team. From this reorganization of the team collaboration between all of them, something new can emerge. In this case, it is expected the emergence of an architectural object that can present another formal aspect and design solutions in relation both to material and interaction. However, if this pavilion will be completely different from the previous one, this does not mean a new process starting, but the feedback of the same one. Thus, again the cybernetic character seems to permeate the design instance as a whole, both in product and process itself.

Forecast of upcoming workshops and activities to be developed

WORKSHOP 1 – MATERIAL + STRUCTURE SCALE MODELING AND PROTOTYPING
Dates: 11/29/2011 to 12/02/2011

WORKSHOP 2 – MATERIAL AND STRUCTURE 1:1 PROTOTYPING
Dates: 01/24/2012 to 02/03/2012

WORKSHOP 3 - DIGITAL FABRICATION OF FINAL ELEMENTS
Dates: 04/03/2012 to 04/12/2012

WORKSHOP 4 – ASSEMBLAGE
Dates: 07/03/2012 to 07/12/2012

Credits:

Year: 2011

Forecast 1:1 scale construction: 2012.

Initial design of the Strings Pavilion: Cynthia Nojimoto, Flávia Ghirotto Santos Alves Gilfranco Medeiros, Humberto da Mata and Rafael Morozowski Ardjomand.

Teachers and tutors of the workshop the Architectural Association School of Architecture in London: Franklin Lee Anne De Save Beaurecueil, Robert Stuart-Smith, Affonso Orciuoli, Thiago Mundim, Ernesto Bueno, Arthur Mamou-Mani, Sandro Tubertini, Yoo Jin, Victor Sanderberg, Lucas de Sordi.

Web site: http://saopaulo.aaschool.ac.uk/?page_id=1358

Videos: http://www.youtube.com/watch?v=GhNm6Enao3k

http://www.youtube.com/watch?v=WAWYarWf_eI&feature=related

http://www.youtube.com/watch?v=P3l5_oN5_lw&feature=related

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