The folding lectern

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Introduction

Hyperbody organized the 3rd Game, Set and Match symposium in November 2016, also known as GSM3. The main theme of GSM3 was next generation buildings with subtopics robotic manufacturing and S.M.A.R.T environments. For this symposium a stage was designed by the students of Hyperbody that embodied both topics. This paper will present a critical reflection on the design process of the foldable lectern designed by me, Olav van der Doorn and Stephen Renard.

Design

Robotic manufacturing gives architects the possibility to design without standardized building elements. This opportunity allows an increase in building performance by designing elements that perfectly align with the design qualities defined by the architect. Using S.M.A.R.T environments, or embedding intelligence within architecture, allows the architect to satisfy more or improved needs by allowing the space to react to or inform the user. The stage for GSM3 shown in figure 1 uses both approaches. The variating building blocks, which have been created in a previous year, have been enhanced with an LED grid and projector to inform the speaker and audience in multiple ways. The foldable lectern can either provide the speaker with an elevated platform to hold presentation material or become one with the stage again to allow the speaker to interact more with his/her audience.

Fig. 1: The stage of GSM 3 with a folded lectern

With the help of a 3D model of the stage and a CNC machine it became possible to create an exact piece of the puzzle that fits within the overall design. The lectern not only has to open up, but also has to be stable enough for the speakers to lean on and carefully mount their laptops. A touch screen instead of a laptop would have been more practical, but was something we could not afford with our budget.

The parametric software Grasshopper allowed us to script the movement of our lectern, but more importantly allows you to easily change the design without losing any data. The design limitations we defined were the shape of the block, maximum and minimum deviation of the linear actuators and the stage itself because it could block the movement if the lectern starts twisting. The final Grasshopper script allowed us to define folding lines on the surface and it would automatically start rotating and twisting towards a platform that could be used as a lectern. After this it just became a matter of choosing the most favorable design depending on aesthetics and the limitations. The parametric environment resulted in the production of 3D models for renders, specification sheets for manual labor and the CNC files.

Fig. 2: CNC machine the wooden plates

Manufacturing

The accuracy and speed of a 3-axis CNC milling machine (fig. 2) allowed us to produce plates that would exactly fit within the stage. However a 3-axis milling machine is quite limited compared to 5 or more axis of freedom. The extra axis allow from the side or with an angle, this allows bevels to be made for example. Having side plates with beveled edges saves a lot of time during the assembly and provides a high quality finish. We created the bevels manually which is always prone to human error and depends on the quality of the power tools. The end result was sloppy seams between the side plates. Luckily, we were able to cover this up with filler and paint (fig. 4), but yet again we were reminded that the quality of the robotic production tool is essential for the finish of a product.

Fig.4: Painting of the lectern

Fig.3: Assembly and testing of the lectern

Behavior
S.M.A.R.T environments are still very hard to find within architectural projects. Although the internet of things is being embedded within many products nowadays, actual reconfigurations of a space can be difficult to implement because of durability and safety issues and the acceptance of the users.

The lectern's main behavior is as followed:

- Turn LED strips on **IF** pressure plate is activated and start blinking LEDs rapidly, **IF** activated for 3 consecutive seconds **THEN** go to state 2
- Start extending linear actuators and blink LED strips slowly **IF** actuators reached target extension **THEN** go to state 3
- Start blinking LED strips rapidly **IF** top part is open **THEN** go to state 4 **OR IF** 30 seconds passed **THEN** go to state 6.
- Turn LED strips on **IF** top part is closed **THEN** go to state 5
- Retract linear actuators and blink LED strips slowly **IF** fully retracted **THEN** go to state 1

The figures 5-9 show the different configurations. The feedback given by the lectern was both with light and sound. The LED strips around the pressure plate started blinking faster if the user was supposed to act, blink slower if the user has to wait and just turn on if the lectern could be used. In addition, the sound of the pressure plate should trigger the user to look down and notice the feedback of the LED strips. The basic feedback however was not enough for a public event. S.M.A.R.T environments, specifically reconfigurable environments, in public buildings have to give feedback that can be understood by anyone. If this is not the case, the product will be used incorrectly or cause dangerous situations. Rosenberg (Spring 2010, p. 22) believes all possible situations have to be known before the implementation of any kind of responsive building components. This is why reconfigurable environments are so hard to implement within public buildings. Private buildings however are an exception because the inhabitants can be trained into using a configurable space properly. In addition, the main behavior described above will not be bullet proof if used in an uncontrolled environment. The actual script for the lectern also takes potential threats into account to prevent the laptop from being thrown off or the lectern destroying itself. What if suddenly the power shuts off and the system resets or what if someone is leaning on the edge of the lectern when the actuators are still running. These potential threats have to be taken into account to assure the safety of the product and the user.

Fig. 5: Walking

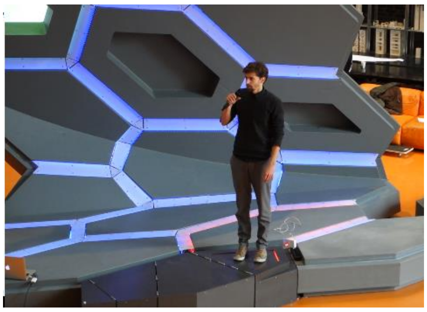

Fig. 6: Standing on pressure plate

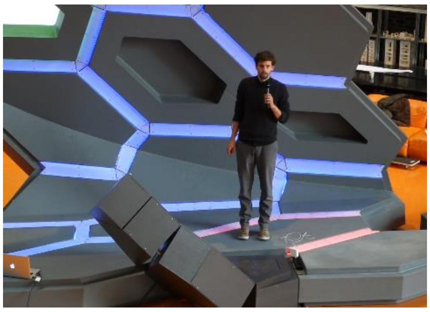

Fig. 7: Folding up

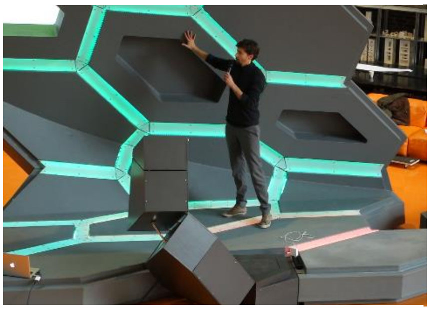

Fig. 8: Waiting for manual fold

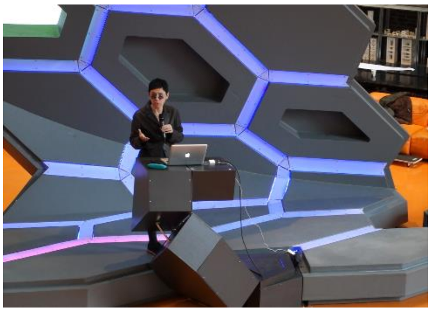

Fig. 9: Using lectern

Conclusion

The design of the lectern got a very good response from the audience and speakers of GSM3. Both the unfolded and folded design fit within the overall stage design. The quality lacked a little bit due to a low budget, inexperience in manufacturing and the use of an inferior CNC milling machine. The quality of the robotic production tool is directly related to the quality of the end product. Especially with CNC milling having more axis of freedom allows a designer to embed more intelligence within the material and save time during the assembly process.

Reconfigurable environments are still quite lacking in architecture due to the increase in possible scenarios that can happen compared to static designs. Both the end states and in-between states should not be able to harm the user or the product. Foreseeing these problems requires extensive testing. Especially, when entire spaces can reconfigure, the strength of an actuator can be in this case life threatening. Teaching the inhabitants into properly using the reconfigurable space or product is a way of limiting the possible scenarios. However not all buildings control who comes in and out, such as public buildings. Especially these building can benefit from reconfigurable spaces.

Literature

Rosenberg, D. (Spring 2010). Indeterminate architecture: Scissor pair transformable structures. *Footprint: Delft School of Design Journal, 6*(Digitally Driven Architecture), 13-39

Illustrations

All photos are shot by Shuwei Zhang