Introduction

The project is located at the Delftse Hout. The location is well known for its natural environment and is used for a lot of different recreational activities. The first step was to collect data from the location by going to the site, on multiple occasions. On-site we observed users and captured them on camera for further analysis. In addition, we gathered data from online documentation about the location and used EPW weather statistics. *This strategy resulted in a bottom-up data-driven design process,* which will be discussed in the first paragraph.

Data extraction became vital to the design process as it transformed the initial design model into more specific design results. Within this bottom-up approach, architectural intuition was used to identify the most desirable result within the considered time frame. All models have been informed by a number of selected activities that are common to take place at the selected location. Until now four models have been created and analyzed based on criteria like spatial requirements, movement, number of people and time in accordance with the selected activities and site qualities.

The second step was to integrate constructional integrity, functionality, technology and esthetic qualities into the model. This was done by further developing the model from macro to micro scale. In this regard, two key strategies were investigated. *Firstly the strategy of creating integrated and interactive architecture and secondly the strategy of robotic production and assembly logic.* These two strategies will be discussed in paragraphs two and three.

Strategy 1, the bottom-up data-driven design process

Using data for the design is not new to us, but this project gave us the chance to reinterpret the way we use this data to further optimize our design. By using video footage of different activities we were able to map spatial requirements and movement typologies which could then inform the geometry of our model. To do this we used both real-time data and assumed values. The importance of data-driven design is discussed in the paper on Data-driven design to production and operation. In the research paper, we find how data-driven design can result in 4D simulations and design optimization and how simulations have a generative potential based on emergence (Bier, Knight, 2014, page 1).

One of the methods of generating data from real-time simulations and using it for emergent architecture was explained to us by Jeroen van Ameijde in his lecture on emergent constructions. His team used sensors to

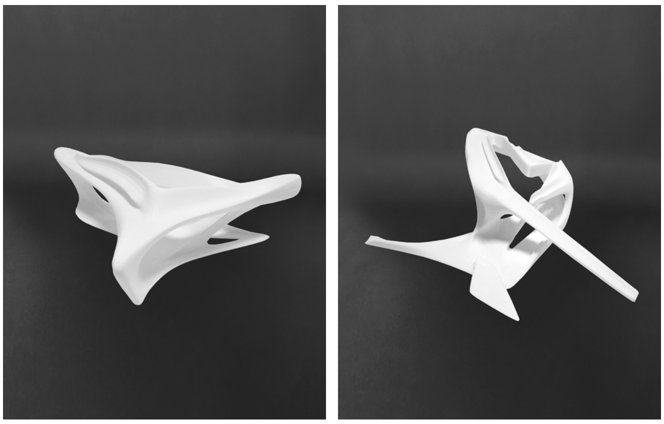

Figure 1 & 2: The initial macro model and the first transformation according to requirements of the activities.

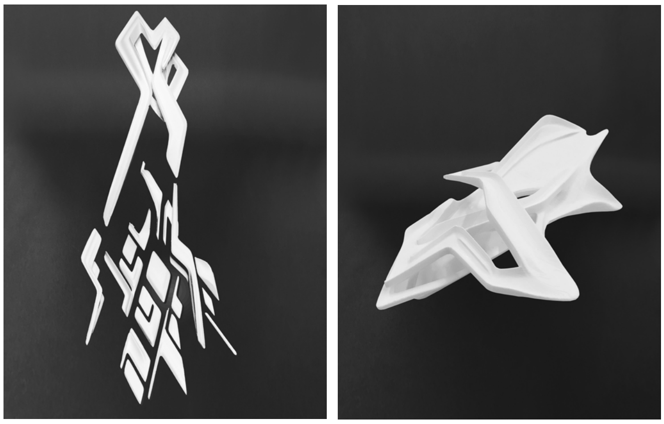

Figure 3 & 4: Showing the second iteration which was to expressive, extreme and therefore lost some qualities and the third iteration which was based on the strong points of all previous models.

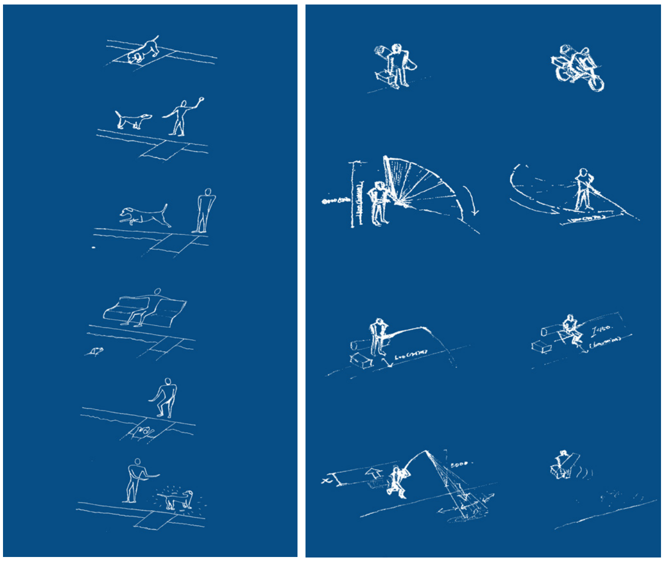

Figure 5 & 6: Showing how the data is translated into sketches which show the sequence of movement and spatial requirements.

gather data from real-time movement. This data was then used to specify paths on the location which were frequently used. Finally, his team used architectural elements to intervene in some points, resulting in emerging architecture (Ameijde, 2017).

Our project did not get to the stage of 4D simulations because we could not use extensive research methods to collect large amounts of data, but we do see the possibilities of how to use data gathering methods to stimulate data-driven design and generate more optimal results in the near future. This way architectural design can focus more on user requirements in time and less on one particular outcome.

Strategy 2, creating integrated and interactive architecture

The second strategy involved thinking about integration of different aspects of the design so that the architectural concept, as well as the performance, would be enhanced. Integration of all these different aspects is mainly possible because of robotic production, which will be further discussed in paragraph three.

Integration in this part of the design process was mainly to shape and reshape based on deductive iteration and architectural intuition. The integration of design aspects became more interesting when we started thinking about integrating interactive architectural elements. The concept was to have some activities that generate energy which can be used for lighting during the nighttime. We wanted to do this by using an energy floor which converts vertical movement into electrical energy. The floor itself could stimulate movement by led-lights, patterns and sequences, thereby making it interactive.

This concept is in line with another lecture by Milica Pavlovic. She refers to interactive design as: "...the design of subjective and qualitative aspects of everything that is both digital and interactive, creating designs that are useful, desirable and acceptable" (Pavlovic, 2017). The design thereby becomes more than just an object in space, it becomes useful and acceptable. She continued her lecture at some point saying: "Digital technologies are employed to create new user experiences that enhance and extend the way people work, communicate and interact" (Pavlovic, 2017). Which means, in this case, the enhancement of certain activities like exercises and playing, thus resulting in healthier users.

Integrated interactive elements could also further amplify our design concept and stimulate certain movement, sequence of movement or activities. Integration posed more design problems than just the interactive elements. These other problems will now be discussed.

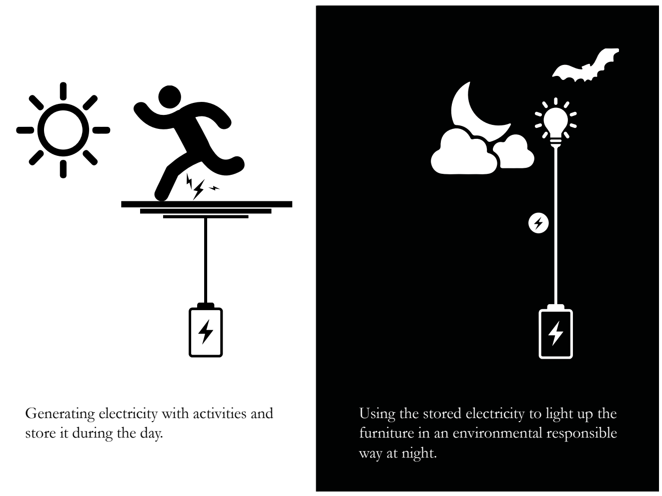

Figure 7: The concept of interactive architecture and how it will make our design sustainability.

Strategy 3, robotic production and assembly logic

Integration posed the most design problems but also a lot of opportunities if you consider methods of robotic production, which we did. A series of lectures, literature, work of other students and above all two intensive workshops made us look into methods of robotic production extensively. Being able to use (rapid) prototyping on different scales forced us to dive into computational design more then we anticipated, but the results were nonetheless interesting.

The first workshop we attended was about the micro scale and took place in Dessau, where we did a micro project to experiment with robotic production, and specific, the KUKA robotic arm. We translated a design concept into a parametric design and finally into the scripts for the KUKA robotic arm, which used a combination of milling and hot-wire cutting to create and 1:1 scale model of a specified component.

Figure 8: The result using the KUKA robotic production method of the Dessau institute of architecture.

The extent of this method was shown to us by Jelle Feringa in his lecture on "Exploring the Industrial Ramifications of Architectural Robotics" (Feringa, 2017). In this discourse, he showed other possibilities of using the KUKA robotic arm, for instance, to cut marble or to cut double curved surfaces.

Unfortunately, we began a new design once we were back in the Netherlands and therefore this model remained just an experiment.

The second workshop we participated in was about the meso scale and took place in Delft. This workshop was used to select a fragment from our macro model and cut it into smaller components, with the assembly logic in mind. During this workshop, we did rapid prototyping by using a 3D printer, which resulted in a 1:20 scale model of the fragment. In this model, we tested various joints which were parametrically designed. The result was not perfect, but it did give valuable insight into the further development of this componential assembly logic. We also developed some scripts for surface tectonics and looked into ways of integrating these patterns into the design. 3D printing was also used to create all the macro scale models.

By using these different methods some of the basic processes of robotic production have been investigated by our project group.

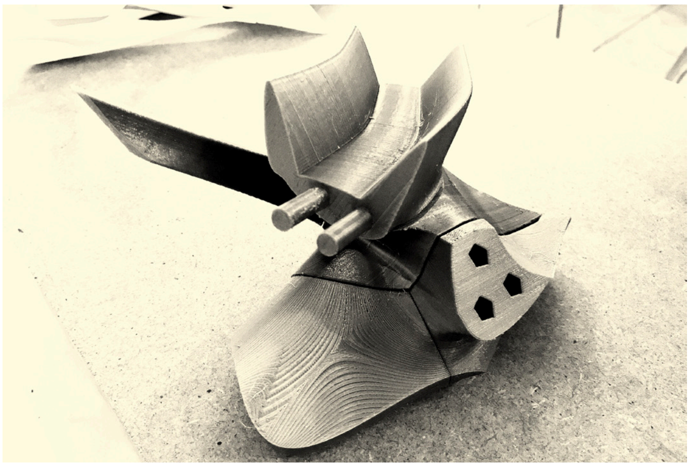

Figure 9: The result of rapid prototyping using the 3D printer during the Delft workshop.

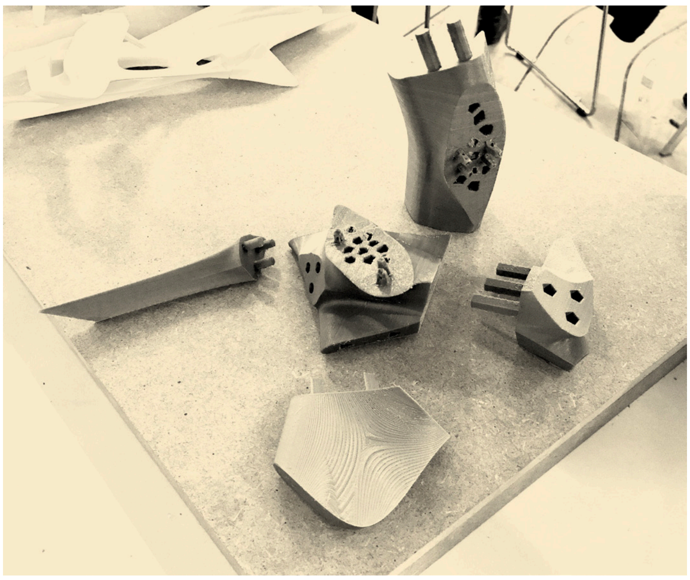

Figure 10: Image of the various components, showing a bit how the assembly logic was taken into consideration during the workshop.

Conclusion

A strong concept in combination with a lot of extensive research, design iterations, experiments and prototyping resulted in an informed and integrated urban furniture. With the combination of data-driven design, interactive elements, integration and robotic production we pushed the limits of our design and our own understanding of robotic architecture.

Although the design is mostly based on a bottom-up design process, the last few steps will try to further implement strategies for parametric design into robotic production and operation.

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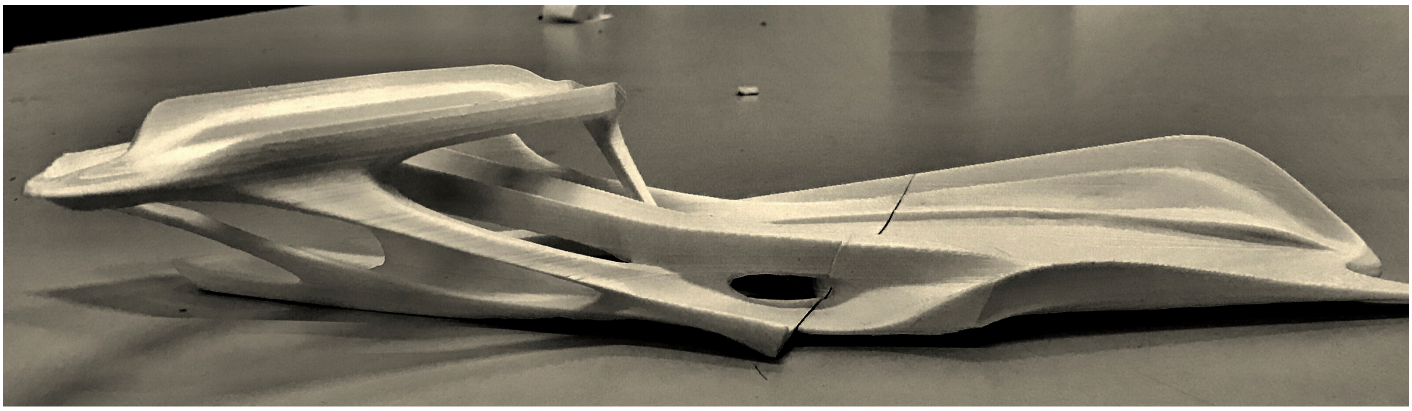

Figure 11: Image of the 3D printed macro scale using the Ultimaker 3. The model has been cut in multiple segments because of the limits of the bounding box.