Reflection paper
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Approach

I started off the year with an idea for a production technique using CNC milling, where origami inspired folding structures with the core advantage to provide a hinge function within the material itself were used to achieve both structure and envelope with a single material and technique. The hereby created shell will be implemented as pop-up urban activator for ‘difficult’ voids in the urban fabric of Rotterdam. Citizen initiatives from the surrounding neighborhood will be developed and housed in the shell, offering a physical platform for the launch of citizen initiatives. The research was dedicated to the development of a framework for the production method of the shell. Literature regarding folding structures and origami engineering were studied and combined into a set up for the foundation of the framework. This was used to test my hypothesis of the proposed production method. The framework derived from the research was very helpful for the further process of my project; it gave direction but did not exclude too many options. It laid the foundation for a range of possible approaches, which were further investigated in the design phase. The framework was extended further during the design phase. The citizen initiative platform was further developed in compliance with Citylab010, an online initiative of the municipality of Rotterdam, which funds neighborhood initiatives.

The ‘how’ and ‘why’

The how and the why of my project were a bit of a struggle in the beginning, as I started off with a technique rather than with a problem statement. A SWOT analysis of the proposed system pointed out a range of possible implementations which used the full potential of the system and from that a suitable problem statement was constructed, thereby tackling the ‘why’. The created origami shell will offer a physical platform, in collaboration with the online Citylab010 platform. Within the project, neighborhood initiatives are supported and developed with the help of Citylab010 and realized as start-ups within the shell. Therefore all functions housed in the shell are derived from these neighborhood initiatives, reflecting the neighborhood.

By using a framework for the development of the system or the ‘how’, the final implementation was made late in the process as all options had to be explored to get the full potential out of the proposed system. Every design solution or principle was tested for compliance and research for the further development and prove of concept continued during the design process in order to stay true to the proposed system. This however led to the situation where I started designing very late in the process as I was trying to finish the entire framework for the design tool. Designing with the proposed system helped in the form-finding process and highlighted some new possibilities, however also highlighted some technical difficulties. During the further development of the implementation of the shell, I reconsidered certain choices made in the process, I came to the conclusion that certain origami pattern would suit my needs for implementation better, than the one previous chosen. After this reconsideration the design process went a lot smoother, and the origami pattern helped in the form-finding process.

Parametric tools such as grasshopper were fundamental in understanding the kinematics of the system, it was used in the fold-finding process, discovering all the geometric possibilities of the pattern. It was also used to perform structural analysis on the resulting geometry, therefore understanding and proving the system. In order to understand the physical system better and to test a variety of options I bought a small CNC machine as my entire project revolves around the use of this technique. The tests led to a deeper understanding of the kinematic properties and structural capacities of the system.

Feedback

My tutors have always steered me to see the bigger picture of the project and the justification of the project. During the process I sometimes got caught up in the technical aspects of my project as my intention was to have a fully functional product in the end which was proven to work. However thereby occasionally losing the larger scope of the project and its architectural implementation out of sight. Feedback sessions with my tutors therefore really helped to set a path to follow and to get the full potential out of the project and have a suitable and strong implementation.

Things learned

During the process I learned that by just doing a lot could be learned that couldn't always have been thought off beforehand. When designing you come across new problems and possibilities. Therefore starting to design earlier in the process would have helped me. After the first P4, I reconsidered a lot of choices made in the process and came to the conclusion that some things needed to be adjusted. After these adjustments the project took a new positive turn.

Towards P5

After the P4 the models will be finished and supplemented. These models will show more details and a larger model of 1 part of the final design will be made. A second context model 1:100 will be added in order to show the variety of possibilities of the geometry of the shell in different contexts. Furthermore renders will be made and all drawings will be improved.

Relationship between research and design.

The research paper aimed to propose an approach for developing and manufacturing three-dimensional structures by folding of flat, thin- walled elements provided with a crease pattern, by integrating geometric, technological and structural aspects. Thereby developing a new foldable system, presenting an innovative configuration inspired by the principles of origami. The research was dedicated to the development of a framework for the production method for origami inspired folding structures using CNC milling, with the core advantage to provide a hinge function within the material itself in order to achieve both structure and envelope with a single material and technique.
The framework provided the basis for the selection of different options to compose the system. The necessity of the use of parametric tools like Grasshopper and it's plug-ins were highlighted in the research as it is interconnected with the form-finding process, the structural analysis of the design, the development of small scale prototypes and later the development of final full scale models.
By reviewing the development and analysis of multiple proposed folding structures, a framework for considerations in structural design was proposed. After the research paper small scale models were created in order to demonstrate the feasibility of folding structures using CNC milling and the principles of origami. By taking small sections of connections the method was tested for validation and provided deeper insight in its structural capacities. The parametric tool Grasshopper was fundamental in understanding the kinematics of the system, it was used in the fold-finding process, discovering all the geometric possibilities of the pattern. It was also used to perform structural analysis on the resulting geometry, therefore understanding and proving the system. And later used to translate this into models.

There is great potential for the design and creation of structures made by folding. The use of origami allows for rapidly complex folded plate structures with a great variety of forms and possible flat-foldability. By considering the proposed technique as starting point for a form-finding process, inspiration for both architectural structure and form design were given. During the design process I tried to keep the system as pure and 'simple' as possible, staying true to its foundation. The what and the why were constructed in such a way that the full potential of the proposed system was used. Every design solution or principle was tested for compliance and research for the further development and prove of concept continued during the design process in order to stay true to the proposed system. Research has been interwoven with the design process as the framework was developed during the entire process and design led to new insights for the framework and vice versa.

Relationship between your graduation (project) topic, the studio topic (if applicable), your master track (A,U,BT,LA,MBE), and your master programme (MSc AUBS).

I believe the concept of my project relates to the ideas behind the architectural engineering studio quite well, as starting from a technological fascination and innovation the goal is to create a fusion of architecture and technology within a complex social situation. Within the studio you are allowed a free choice of project as long as it stays true to the principles of the studio.

Throughout the process, my technological fascination sometimes led to a very in depth research into the system and its technological aspects and not always as much about the architectural experience and implementation. Therefore the architectural development took a slower path then I would have liked. However, my tutors always would help me see the larger picture, sometimes by taking a step back and exploring the possibilities and then testing these against compliance with my system in order to bring the design to a higher level.

Elaboration on research method and approach chosen by the student in relation to the graduation studio methodical line of inquiry, reflecting thereby upon the scientific relevance of the work.

The project started from a technical fascination and a suitable implementation had to be found which uses the full potential of the system. A methodological framework was formulated in the beginning, which was roughly followed during my graduation year. The first part of the research was literature study in order to explore the field and test and support my hypothesis using the available academic knowledge. From this literature study a framework for the development of my proposed system was created which was then used in a research by design process leading to the final design of the building. A SWOT analysis of the proposed system was used in order to find a suitable implementation which uses the full potential of the system. By conducting fold-finding studies to test if and which shape give the best solution to the problem, within the possible geometry of the uniform origami pattern. The findings where compared and the outcome provided a conceptual framework for the further design process. During the design phase of the graduation project, both the conceptual framework and the program of requirements combined into an integrated architectural design. Throughout the whole graduation process, case studies were looked into. My entire project stands on the academic/scientific foundation of the literature study and builds from this, using its principles.

Elaboration on the relationship between the graduation project and the wider social, professional and scientific framework, touching upon the transferability of the project results.

Despite the wide research and broad diversity on foldable shapes, applications are not very common in Architecture and Civil Engineering, due to difficulties with converting geometric models into built structures. When doing this, different parameters are considered and technological issues arise. Folding mechanisms involve complex kinematics, with simultaneous motion in all folds. Developing a manufacturing process based on folding techniques to produce the folded shape can therefore be a difficulty. Folding continuously transforms a flat surface into 3D space, meaning a folded shape is not a structure of itself, but rather a mechanism. In order to turn a folded surface into a structure, this mechanism has to be closed. Moreover, since rigid-Origami structures have mainly been studied in Academia, an industrial standardization for connections, joints and such doesn't exist. More important however, are issues related to the choice of material and thickness of the plates, which impede the possibility to flat fold the structure as discussed for instance in (Trautz, Kunstler, 2009; Tachi, 2009, cited in Lebée, 2015, p. 63). Multiple strategies for dealing with thick elements have been proposed, for example Tachi (2011), however the most promising method to overcome this difficulty is the double-line method of Hull and Tachi (2017). Deployable structures require lightweight materials, for ease of both transportation and manipulation and to enhance its structural properties. Several attempts have been developed, testing different materials such as concrete, cardboard and wood, as proposed by Robeller (2015). Origami shells are well suited for pop-up architecture, as these structures can be compactly stored and transported and can be quickly assembled into a material and structural efficient shell structure. These shells are well suited for housing neighborhood initiatives in order to function as an urban activator.

My aim is to add knowledge and contribute to the wider social, professional and scientific framework regarding foldable structures in combination with the proposed social setting, origami science, computational design, possible implementations of CNC milling and to provide a case study of an application of the above mentioned fields. My project both stands on the foundations laid down by some of the above mentioned researchers and adds knowledge in order to provide an application of a mostly theoretical research field.

Discuss the ethical issues and dilemmas you may have encountered in (i) doing the research, (ii, if applicable) elaborating the design and (iii) potential applications of the results in practice.

My project aims to revitalize depreciated or difficult spaces in the urban fabric in depreciated neighborhoods in the city of Rotterdam by creating a pop- and bottom-up temporary marketplace or platform where shopping, food, beverage, creativity, culture and neighborhood initiatives come together. The project aims to provide a physical platform to help develop and implement the neighborhood initiatives of the online platform Citylab010. The question rises how to allow for these aspects to integrate and support each other and how to get the neighborhood involved in the process. The neighborhood will be asked to help with the set-up of the shell structure and help design the positions of windows / the overall shape and segmentation of the shell within set design guidelines. By involving the neighborhood in the decision making of the overall design and helping it deploy, will create involvement from start to end. The created shell will offer a physical platform for the development and realization of their initiatives, therefore reflecting the neighborhood. The initiatives will be connected with matching commercial functions in order to be an enduring project which can revitalize the neighborhood for a longer period of time both economically and socially. Also cultural events from and for the surrounding neighborhood will be hosted in the outdoor theater.

References

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