Group 1

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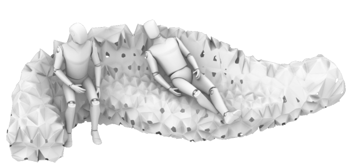
NOI

CONCEPT

With the increasing stagnation of work life and heightened social isolation, there has been an increasing need for urban furniture that encourages connection, playfulness and activity. ‘Noi’, meaning ‘us’ in italian, is a network of electronic Voronoi urban furniture with an integrated sensor-actuator system to entertain and engage the public along the network of WaterBus stops in Rotterdam. The furniture aims to provide opportunities for rest and activity with elements of comfort, playfulness and exercise to challenge the sedentary lifestyles promoted by the contemporary built environment. The application of the three different scales of the voronoi logic (micro, meso, macro) informed the entire process.

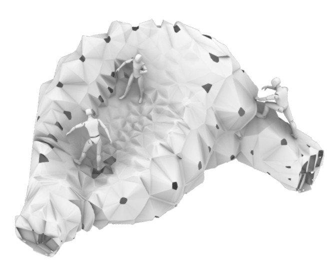
The project primarily focuses on the Willemsplein WaterBus stop, identified as a particularly grey, static streetscape, neglected by forms of interactive design. Its location offers many opportunities for users interaction due to its location at the intersection amongst the Maritiem District, North, the Katendrecht and Kop van Zuid, South, famous for their contemporary architecture and het Park, West.

Noi comprises three unique urban furniture modules that can be combined together to create various arrangements. The shape of each module is inspired by the River Maas and reaches a maximum approximate size of 4x4m each, resulting from the assembly of 2 printing sessions. Each of the modules has been designed to promote various degrees of activity intensity. The ‘rest’ module (fig.1) promotes a soft rocking movement in a seating position. The ‘exercise’ module (fig. 2) provides opportunity to exercise on one side of the furniture, with a step up platform and sit up bench, and a standing / leaning section on the other. The ‘play’ module (fig. 3) promotes playfulness with a unique form to encourage climbing, using high porosity cells for handles.



1.

2.



3.

SYSTEM

LED lighting is incorporated to promote user engagement with the furniture by beautification. Although mostly non-illuminated, the bench lights up at high usage times of the evening and when someone interacts with it, light running along the primary horizontal axis of each component, mimicking the sinuous flow of water. Where the user sits, jumps or steps on the furniture, the lights will interact as if water, parting, splashing or rippling apart. For instance with the flow of lighting parting around the user. Via a magnetic interlocking system, the modules connect and inform one another about the new configuration, allowing the lights to look as if they are continuously flowing.

The sensor-actuator system allows a continuous feedback loop. Which informs possible improvements in the design of each component and notifies on the optimal number and typology of components at each WaterBus terminal. To achieve this, the furniture registers the activity, behaviour and moods of the users. The generated data will be processed to learn how much energy is produced by the user, which modules are more in use, how much engagement occurs amongst users, and what times are most popular for interaction to schedule the most efficient use of energy. A reward system will encourage users to engage with the furniture: the more data and energy the user produces, the more free tickets they win. In addition, the system increases public engagement through social media such as twitter.

MATERIALITY

The application of the voronoi logic to the structure allows integrity in material optimisation as variation in cell dimension and cell density allows changing degrees of stiffness and flexibility according to the type of interaction foreseen in different areas of each component.

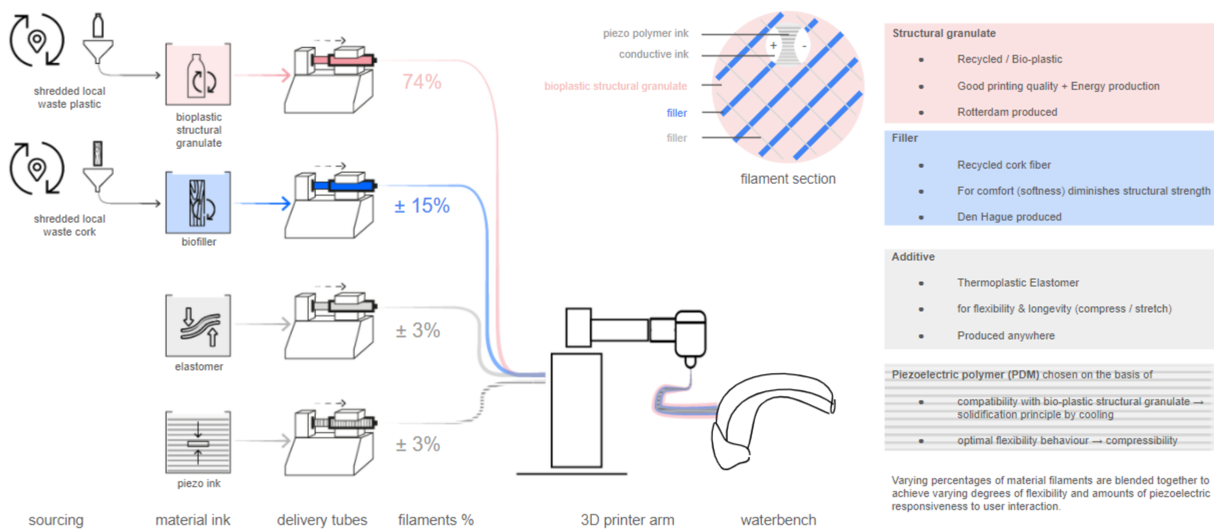
The sensor-actuator system is intrinsic to each bench component as they are manufactured with piezoelectric polymers integrated in the additive manufacturing filament (fig. 4). The piezoelectric enables each bench to react to compression, deformation and stretching by:

1. converting movement, impact and stress into electrical energy;
2. sensing and monitoring user-interaction, making the structure itself the sensor.

These principles informed a design that aims to encourage the user to such forms of interaction for greater data and energy production.

On the one hand, the interaction generates electric energy, allowing for only a small battery in each bench to store the user-generated energy and spread it during the day, especially in the evening when lighting is more compelling.

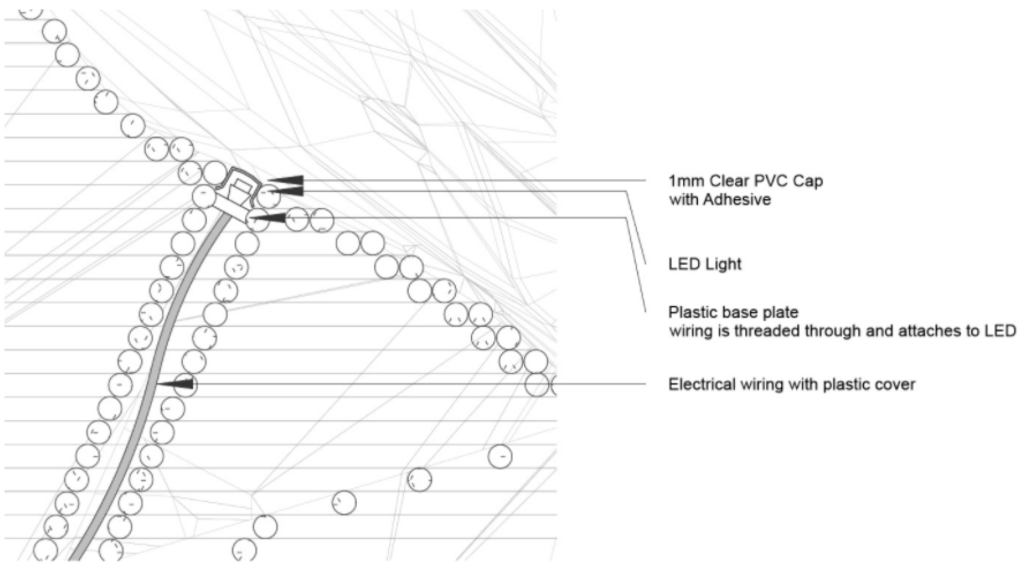
On the other hand, the pressure exercised by the users generates data sent via a repetiteur to two key actuators. Firstly, to the WaterBus affiliated app to inform users on ferry capacity and on the energy produced by each user interaction. Similarly, the app receives user feedback on the furniture network for possible future improvement. Secondly, to Rotterdam BigData Market to sell it to the City of Rotterdam to inform on points of interest for urban design along the River Maas. Indeed, Rotterdam BigData Market is deficient in data on UI with the river Maas infrastructure. Accordingly, the Waterbus company and the City of Rotterdam are identified as the two main investors in this project.



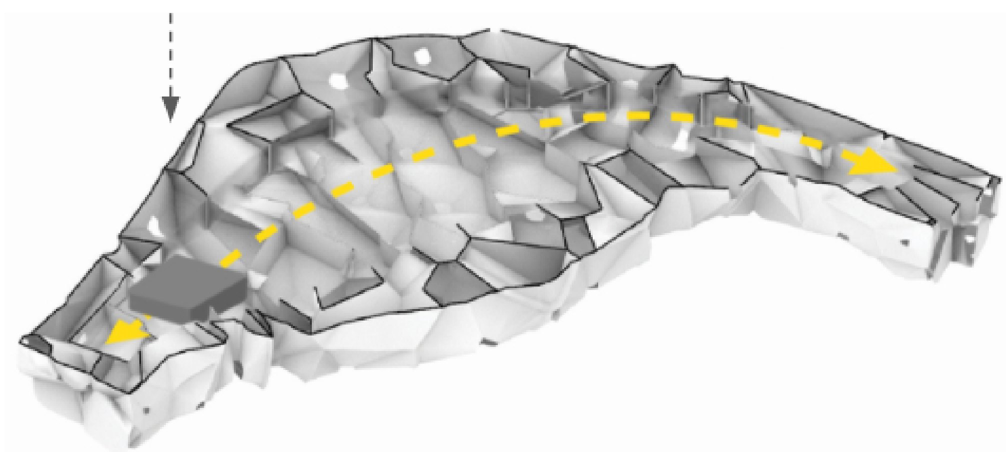
4.

CONSTRUCTION

First, the furniture is printed in components in order to ease post-production integration of the lights and battery. Second, L.E.D. spot lights are weaved through the structure (fig. 5). The lights run along the base of the module and branch into the meso components of the structure. The led bulb is then weaved into the canals between the micro voronoi cells. Finally a cap is put on the led bulb. Third, the battery is added into the final component (fig. 6). Finally, large pad magnets are integrated at the end of the modules in order to connect them (fig.7). Between the panels, at the vertex of the cell, are sensors to transmit information about the lighting configurations.


1mm Clear PVC Cap
with Adhesive
LED Light
Plastic base plate
wiring is threaded through and attaches to LED
Electrical wiring with plastic cover

5.



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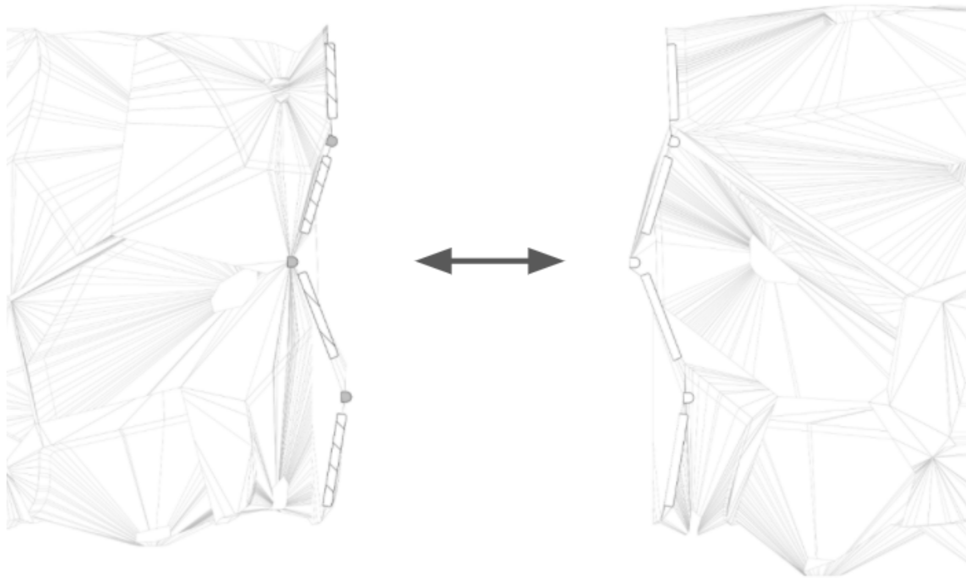


7.

The announced construction method was developed as a result of research into additive-manufacturing processes. Indeed, the restrictions of in-person interaction and access to the modelling hall at TU-Delft compromised our ability to test the physical modelling of the structure.

DESIGN PROCESS

VORONOI MACRO SCALE

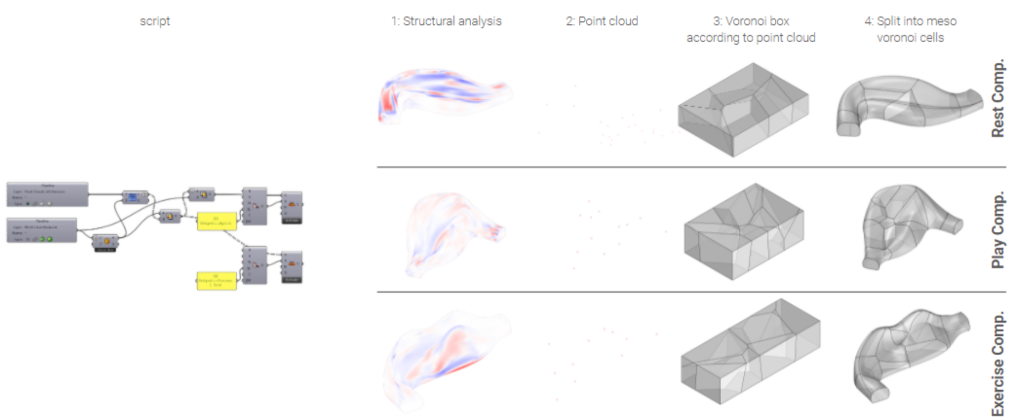
After identifying the site in which we wanted to place our design and deciding to link our network of urban furniture to the network of WaterBus stops, we discovered that the WaterBus company in 2018 initiated a strategy to produce zero carbon emissions. Accordingly, we identified our first design principle to also be as carbon neutral and self-reliant as possible in the operational phase of our urban furniture. Moreover, the precedent studies inspired our goal to mimic the form of the river.

SCRIPTING

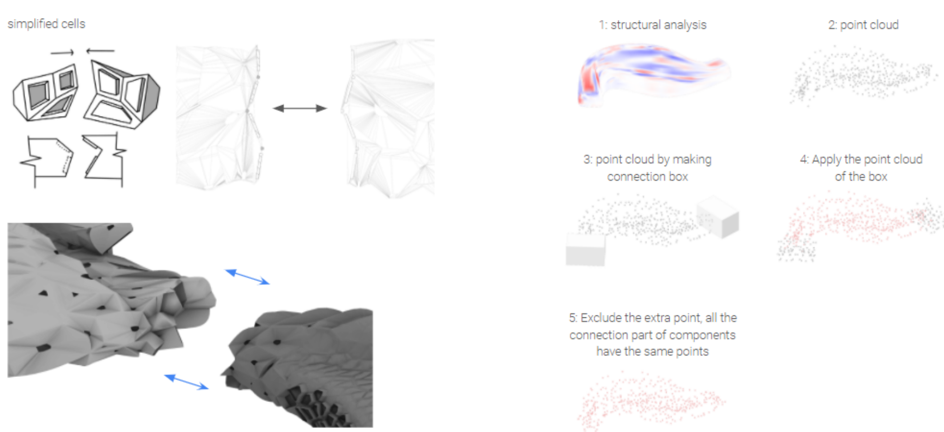
During the entire process we were also testing the structural, point cloud and voronoi script. Each furniture component first went through the structural analysis, and produced point clouds regarding the result of the analysis. After that, to achieve the voronoi in meso level, each furniture was subdivided into small components according to the structural analysis for the better construction and understanding of voronoi structure. Similar to the workflow of a normal component, the less dense point cloud was generated based on the structural analysis and then subdivided by the voronoi box according to the point cloud. Thus, it can allow interlock assembly and on-site composition as a smaller printing session.

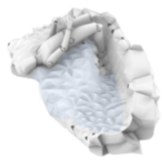
Moreover, for the voronoi in micro level, we came across a few complications during the scripting process. This is because our components are designed to connect with each other, and hence must extend beyond the existing point cloud. To accommodate this, a box was modelled at the end of each module in order to extend the point cloud. After that, an extra point cloud with the same density was added at the connection point of the furniture, and therefore each furniture can smoothly blend into the next.

Finally, for the voronoi cells, we did some modification based on the needs of the usage and material. The extrusion and protrusion were adjusted through the script for people to sit and climb. Some of the cells were further modified to be denser or larger because of the structure by adjusting the parameters such as scale and fill in the grasshopper script. Therefore, through the scripting, the mirco voronoi cells can allow different uses and strengthen the structure.



Meso-scale voronoi sub-division of each individual component. Voronoi informs structural subdivision according to structural analysis.

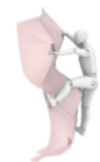




micro
stiffness &
user support

meso, semi-open w.
elastomer
for flexibility

meso, open
for structural
strength & lightness



macro,
semi-closed
for playfulness

DESIGN DEVELOPMENT

We then decided to design three furniture components with focus on three demographics: children, adults and the elderly that could be assembled in endless compositions. Thus, the challenge to develop the furniture so that one component flows into the next smoothly. This generated various aspects to resolve within a small span of furniture, taking many trial and errors to define the final shape.

The lighting was inspired by the adjacent river, with one of our primary design principles for the lights to move along the furniture like water. However, the question arose of how the furniture would get energy if we didn't want to produce any carbon emissions. From this question we began the investigation into 3D printing piezoelectric polymers in order to generate energy via user interaction. An important consideration for our design was the amount of energy able to be produced from the piezoelectric polymers. Therefore, we calculated the amount of energy produced by users interaction, continuously updating the calculations based on the new research we’d come across.

We also investigated the use of fibre optics or clear TPU in order to be able to print the furniture and lighting system. We discovered that the interactive element of the lighting would not be achievable with these materials. From this resolution we decided to design the furniture system with a series of channels at the macro, meso and micro level, for the lighting to weave through. This system also permits efficient construction and repairing.

One of the main issues that arose during the design process was how the furniture modules would connect, and how the lights would flow across the modules. From our research we developed a connection component inspired by modular lighting designs using magnets and sensors to connect the modules and lighting.

PIEZOELECTRIC POLYMER & BIG DATA

After integrating piezoelectric polymers we redesigned the furniture with a greater focus on activity in order to produce a greater amount of energy.

In order to design greater incentive to interact with the furniture we created a corresponding app that allowed users to see how much energy their activity has produced, and, after enough activity, earn a free ferry ride. The app would also show users the ferry's location and timetable. However, we felt we could do more with the already integrated piezoelectric sensors and computer. After discussions with Hamed Alavi we decided to look further into the idea of a feedback loop. We narrowed the choice of sensors according to the most useful responses that our furniture could generate. Another aspect we took into account was the feasibility of placement of interactive mechanisms such as Arduinos into the voronoi structure.

DISCUSSION

Reflecting upon our initial understanding of 3D printing and prototyping, we believe that we have learnt a lot through this design process. However, there are always more opportunities to improve and develop the design.

Throughout the design process we continuously strived to integrate the three scales of Voronoi. Although we sometimes struggled to achieve this, we felt that our final design thoroughly reflects the voronoi logic. Our greatest achievement was resolving the grasshopper script to reflect the three scale of voronoi, as our furniture comprises of three components which needed to smoothly integrate between one another. Therefore we had to modify the script to make the voronoi cells flow effortlessly between each of the components, echoing the pattern in the meso and macro scale. Future development of the technology integration and implementation in the design would also be beneficial, however there is limited knowledge and studies in 3D printing piezoelectric polymers. In time we may come to see many urban furniture solutions with this technology integration, however, studies in the field are still being conducted. Our group also had further inquiries into the 3D printing process and technology integration, and perhaps could have taken greater opportunity to discuss the 3D printing process with Vertico in order to develop a more practical design solution.

However, what remains a question is if this design will be used and if there is a great enough incentive to interact with the furniture in order to produce electricity? We aimed to create a dynamic design that promotes activity, but what if people would like to simply wait for the ferry? Although we have designed a corresponding app that allows people to earn a free ferry ride through exercise and activity, without visiting the site, there is no concrete knowledge that this will be sufficient. Without extensive activity the bench lighting might become obsolete. We aimed to address this issue with the integration of a feedback data loop. The data loop will inform the architect how many components are needed at each site, and which components are more popular at each site in order to accordingly arrange the components. Although this feature aims to permit continuous updates of the design, without sufficient prototyping there is also room for error and issues that we have not yet conceived.

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