W. Huang, M. Williams, D. Luo, Y. Wu and Y. Lin (eds.), *Learning, Prototyping and Adapting, Short Paper Proceedings of the 23rd International Conference on Computer-Aided Architectural Design Research in Asia (CAADRIA) 2018*. 

# CUSTOMISED FLOATING NEIGHBOURHOODS

## *Design Interfaces for Non-experts and Designers to explore Emergent Floating Formations*

PETER BUŠ[1], LUKAS TREYER[2] and AYÇA TARTAR[3]
[1,2,3] *Chair of Information Architecture, Swiss Federal Institute of Technology ETH, Zürich, Switzerland*
*{bus, treyer, tartar}@arch.ethz.ch*

**Abstract.** Urban water spaces, lakes and rivers have played a key role in socio-economic and spatial development of cities throughout centuries. There is an increasing trend in creating floating neighbourhoods and spaces on water worldwide. Design of floating urban spaces is complex; it requires incorporation of advanced computational tools to ensure correct interpretation of environmental conditions to make proper design decisions. In this study, we focus on an investigation of possibilities of floating neighbourhoods to adapt according to rapid changes of environments and demands of their end-users to address deeper engaging of non-experts in the decision and design processes. In so doing, we proposed modular assemblies as a floating neighbourhood, designed and tested computationally using advanced modelling techniques to address potentials of floating systems to grow and create formations in waterfront cities. In this paper we tested 2 possible spatial developments of floating configurations in order to understand non-experts' preferences captured from an in-house developed computational model in comparison with designer's digital assembly strategies to deliver various emergent complex scenarios of urban development.

**Keywords.** Floating cities; on-site participation; participatory design; floating assemblies; emergent urban aggregations; modular design.

## 1. Introduction: design-computation approaches based on movable components in various scenarios or frameworks

Emergent behavior of components and aggregations capable to change their positions and configurations based on various conditions, dynamic forces, criteria and tendencies to join, assemble and aggregate with other objects is observable in many cases in nature and also in environments related to water. To understand and tackle this concept computationally, there are several computational strategies, e.g. already introduced by Pantazis and Gerber (2017) which simulated swarm fluctuations with physical mini robots to aggregate and create unpredictable formations of components. Similarly, Adréen et al. (2016) addressed principles for the robotic testbed with the ability of dynamic objects to move and assemble and manipulate with static objects. In so doing, his research explored complex large nests that create collective-driven emergent clouds of interacting objects in digital and physical world, based on rules of physics.

Very complex assemblies and aggregations of components can be achieved using the Wasp add-on for Rhino/Grasshopper interface, developed by Rossi and Tessmann (2017) bringing infinite possibilities of digital aggregations to grow which are based on simple rule-sets built by the designer.

If we concentrate on principles for floating urban environments more specifically, the aspects of aggregations for floating neighbourhoods have been tested and investigated in various urban scenarios at the AA EmTech platform. In particular, Limpiti et al. (2016) aimed for the integration of design processes to address wave energy reduction through the development of organisational logics of floating settlements; Campanile and Wuu (2017) generated an integral urban fabric through a programmatic definition in relation to the environment patterns for next 50 years; Aceytuno and Lim (2017) developed a series of wave breakers and wet-to-dry gradients; and Manousaki and Battisti (2017) established a catalogue of architectural forms and infrastructures for a landscape where water conditions have extreme variations throughout the day and the year according to the sea level rise.

## 2. Scope of the research study

The scope of this research study is an exploration of appropriate spatial aggregation possibilities of adaptive floating neighbourhoods according to non-experts' demands to position their floating objects in comparison with designers' intention to create complex floating formations. In particular, the research investigates and compares 2 cases of design-computation approaches to deliver design proposals of floating neighbourhoods. The first case is related to solutions taken from captured outcomes made by non-experts themselves, working with the developed online tool Hydro-scape. In the second stage, the state-of-the-art design assembly strategy of stochastic aggregation (Rossi and Tessmann, 2017) is customised and adapted according to designer's preferences using popular Rhino and Grasshopper interface. The comparison of these two methodologies for computationally generated urban scenarios serves as an initial overview for later design stages in the decision-making processes in respect to more liveable properties of urban water areas.

The possibilities of the floating objects to adapt, aggregate, be modified and to be customised according to various criteria are examined. The qualitative criteria of the comparison are as follows:

- **Adaptability** in three different levels: ability to aggregate with other modules, ability to re-create different formations, ability to adapt to different urban activities
- **Spatial complexity and formation**
- **Aesthetics**

## 3. Research goal

In so doing, the paper reveals the potential of participatory design and decision processes combined with designers' preferences in the early urban design phases in order to improve liveability in urban environments. The study is a part of a broader research agenda related to Responsive Cities, considering citizens' engagement in planning and decision-making processes leading to the Citizen Design Science (Mueller et al., 2018). To address and to support non-experts' engagement (representing e.g. citizens) in the design process and the adaptation of urban space according to their needs, the study proposes a customised floating spatial system, which can be modified and adapted directly by end-users in the form of in-house developed online tool. The proposed on-line assembly system is ready to react appropriately on non-experts' inputs and fully bottom-up.

## 4. Methodology

### 4.1. HYDRO-SCAPE TOOL FOR NON-EXPERTS

In the first stage, the research explores different aggregations of floating assemblies consisting of a set of simple pre-defined modules (Figure 1) which can be assembled, reassembled, and modified in different configurations, leading to a diverse number of more complex urban spatial variants (Figure 2). Water, as a key environmental and architectural feature of a given space, can serve as a medium for adaptability, flexibility and interaction with the system. By means of developed interactive on-line tool Hydro-scape (Buš et al., 2017), the initial modular configurations are proposed by the non-experts and captured in an accessible on-line design catalogue of proposals.

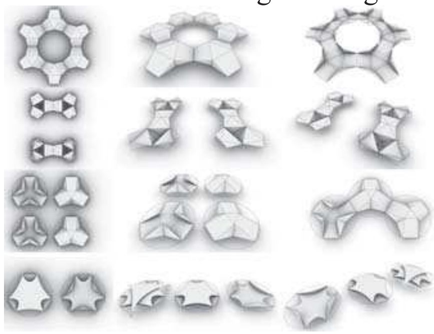

*Figure 1. The library of pre-defined modules for floating neighbourhood set by the designer.*

Harnessing a physics engine based on the Matter.js library (Brummitt, 2018) applied in the javascript language in HTML canvas as an accessible interface for non-experts, the framework delivers a variety of design solutions for possible urban configurations (Figure 3).

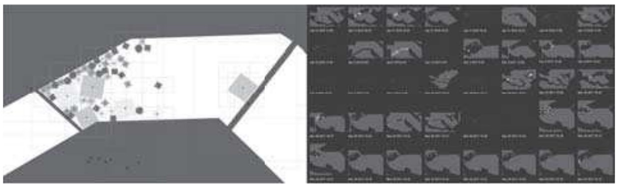

*Figure 2. The design interface of the Hydro-scape tool and a catalogue of design proposals provided by non-experts; the users can submit their design proposals into the catalogue.*

The Hydro-scape online tool allows the end-user to work with predefined modules in 2D space. The on-line form of user interaction is convenient as it is always accessible. The modules are affected by various forces and can create aggregations and cluster into unpredictable formations. This concept, based on the physics engine, deals with various internal and external forces, which can be modified and controlled in the user's interface. In so doing, the online users can deliver amount of design proposals stored in the catalogue accessed by the other non-experts and experts for further investigation.

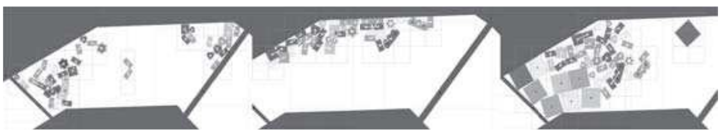

*Figure 3. Selected configurations taken from non-experts in the Hydro-scape tool catalogue.*

### 4.2. EXPERT'S INVESTIGATION OF AGGREGATION STRATEGIES

The second approach represents stochastic aggregation (Rossi and Tessmann, 2017) assembling the predefined modules into more complex formations by the specific rule-sets (Figure 4) to inform modules to form configurations.

The proposals of the formations are created by the designer who controls a way how the modules configure and aggregate. This strategy leads to more precise definitions of the layout while the non-experts' formations are more randomly designated.

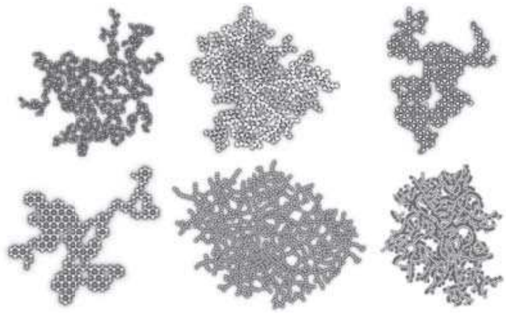

*Figure 4. The examples of stochastic aggregations out of the 3 pre-defined modules representing different urban activities (urban garden, public space, leisure).*

## 5. Discussion: comparison of computational frameworks

In this study, we compared two different computational approaches to form floating neighbourhoods out of predefined modules (Figure 5). It has been observed that web-based framework implementing physics engine is more difficult to control as the modules show uncontrolled and unpredictable behaviour of their positioning in the layout. Although the layouts are complex and adaptable by end users' direct interaction, they show less aesthetic properties. To use this framework with non-experts more appropriately, it is necessary to employ secondary rule-set for better and more precise aggregation formations. Using the on-line tool more deeply by professionals has not been investigated so far, but it is assumed the outcomes will have similar character as in the on-line catalogue.

*Figure 5. Visual comparison of two design-computational frameworks.*

In contrary, although the expert stochastic aggregation strategy leads to complex and unpredictable solutions, the layout is more aesthetic. However, as the formations are created automatically after a series of computational steps, there is no possibility to interact with the system directly via gestures using e.g. a touch device.

To conclude the study, for the non-expert design activities for floating neighbourhoods, the combination of stochastic aggregation strategies with direct users' interaction using the accessible and touchable web-based tool would be preferable. This will lead to citizen-oriented informed urban design for floating cities. The results will inform the experts' knowledge with citizens' preferences. The future research will continue in this direction.

## Acknowledgements

The research study has been conducted at the Chair of Information Architecture at the ETH in Zürich, using its own resources and infrastructure. We gratefully thank Dr. Johannes Mueller and Prof. Dr. Gerhard Schmitt (Future Cities Laboratory, SEC in Singapore) for their constant support in development of research ideas related to the Citizen Design Science.

## References

Aceytuno, M and Lim, S. J.: 2017, "Ecological urbanism". Available from: Emergent Technologies & Design-Urban and Ecological Systems <http://pr2017.aaschool.ac.uk/Urban-And-Ecological-Systems> (accessed 10 December 2017).

Andréen, D., Jenning, P., Napp, N. and Petersen, K.: 2016, Emergent structures assembled by large swarms of simple robots, Acadia16, Ann Arbor, 54-61.

Brummitt, L.: 2018, "Matter.js". Available from: GitHub Repository <https://github.com/liabru/matter-js/releases/tag/0.10.0> (accessed 3 January 2018).

Buš, P., Treyer, L., Tartar A. and Lu, H.: 2017, "Hydro-scape Floating City". Available from: Open design for citizens <https://www.ia.arch.ethz.ch/cds/floatingcity.html> (accessed 28 September 2017).

Campanile, C. and Wuu, S.-H.: 2017, "Environmental patterns". Available from: Emergent Technologies & Design-Urban and Ecological Systems <http://pr2017.aaschool.ac.uk/Urban-And-Ecological-Systems> (accessed 10 December 2017).

Limpiti, P., Song, Y., Tanhuanco, P. and Tseng, H-W.: 2016, "Adaptive floating settlement". Available from: Emergent Technologies & Design: Adaptive Floating Settlements <http://pr2016.aaschool.ac.uk/Adaptive-Floating-Settlements> (accessed 10 December 2017).

Manousaki, M. Ch. and Battisti, M.: 2017, "Above The Marshes". Available from: Emergent Technologies & Design-Urban and Ecological Systems <http://pr2017.aaschool.ac.uk/Urban-And-Ecological-Systems> (accessed 10 December 2017).

Mueller, J., Lu, H., Chirkin, A., Klein, B., Schmitt, G.: 2018, Citizen Design Science: A strategy for crowd-creative urban design, Cities A, 72(2018), 181–188.

Pantazis, E. and Gerber, D.: 2017, Emergent order through swarm fluctuations: A framework for exploring self-organizing structures using swarm robotics, eCAADe17, Rome, 75–84.

Rossi, A. and Tessmann, O.: 2017, Designing with digital materials: A computational framework for discrete assembly design, CAADRIA17, Suzhou, 37-42.