ETH zürich

Background Information

Semiramis, Tech Cluster Zug, 2021-2022

Core Innovations

Zurich, 23 November 2021

At the core of the new developing Tech Cluster in Zug will rise a 22.5 meters high architectural wooden structure designed and fabricated by Gramazio Kohler Research, ETH Zurich in collaboration with Müller Illien Landschaftsarchitekten and Timbatec. Semiramis, whose name is inspired by its living gardens and exclusive interaction with nature, is unique as it features a manifold of fruitful research and industrial collaborations from and outside ETH Zurich. Semiramis is pushing forward the latest innovations in design, using machine learning, interactive optimization, and robotic fabrication. Namely, the following four Core Innovations:

1) Designing with Machine Learning
Gramazio Kohler Research has designed Semiramis and its five characteristic pods with the help of a machine learning model, developed in collaboration with the Swiss Data Science Center. The bespoke autoencoder – a type of neural network – has been trained to map both the shape and spatial arrangement of the pods, as well as the resulting performance with respect to the sunshade, rain occlusion, and plantable surface. This design exploration method allows the architect to invert the conventional design process and to create newand unexpected geometries that fulfill the specific requested performance criteria, all at once. This circumvents the tedious task of manually tweaking the geometries to attain a particular performance and enables the designer to uniquely focus on the most creative steps and the inspection of the design space. The rich variety of designs provided can be explored in full-size and 3D rendered variants thanks to the infrastructure at Immersive Design Lab, ETH Zurich.

2) Interactive Multiobjective Design Tool
Thanks to the collaboration with the Computational Robotics Lab, ETH Zurich, the Gramazio Kohler Research team has employed a multiobjective optimization design tool, which is integrated into a 3D modelling software. Concretely, this allows the interactive control and adjustment of the complex geometry of the facetted pods consisting of various triangular and n-gonal pieces, keeping the individual

plates planar and respecting the possible range of their sizes while improving structural load capacity. By moving one single point within the geometry, the tool readapts the whole geometry, considering relevant fabrication parameters.

3) Collaborative Robotic Manufacturing
Each of the Semiramis pods is unique and exploits four robotic arms mounted on a gantry system to place the timber plates precisely at their individual target positions. The sensors mounted on each end-effector (outermost tip of the robot arm) allow for global high accuracy positioning. For this unprecedented and challenging multi-robot assembly process realized at the Robotic Fabrication Laboratory at ETH Zurich, Gramazio Kohler Research partnered with Intrinsic, the robotics software company at Alphabet. Intrinsic developed a robot motion and path planning solution that could be used with COMPAS FAB, an open-source digital fabrication framework developed at ETH Zurich. The fabrication process becomes thus a collaborative process between humans and robots, in which the robots execute the heavy lifting and precise positioning of the plates whilst the team cooperates with them on more dexterous tasks such as gluing. The cooperation during fabrication with ERNE, the general contractor, ensures that construction standards are met.

4) Fabrication and assembly
The aforementioned methods and research developments all contribute to the innovative digital fabrication of Semiramis since the assembly and fabrication constraints are integrated into the design parameters. Making use of four robots overcomes the need for customized, potentially wasteful, and temporary supports during the assembly process. The five timber pods are broken down into 14 segments to form easily transportable sub-assemblies. These consist of 16 to 56 timber plates connected by means of a novel joint sealing technology, which is the result of the decennial collaboration between Timbatec, ETH Zurich, and the Bern University of Applied Sciences in Biel. This process enables a rigid connection of larger timber plate edges via a butt joint bonding by injecting a special casting resin in the 3 mm wide gaps between the robotically placed plates. After being transported to Zug, the components will be assembled on-site.

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Credits

Gramazio Kohler Research, ETH Zurich

In cooperation with: Müller Illien Landschaftsarchitekten, Timbatec Timber Construction Engineers Switzerland

Client: Urban Assets Zug AG

General contractor: Erne AG Holzbau

Team: Matthias Kohler, Fabio Gramazio, Sarah Schneider, Matteo Pacher, Aleksandra Apolinarska, Pascal Bach, Gonzalo Casas, Philippe Fleischmann, Matthias Helmreich, Michael Lyrenmann, Beverly Lytle, Romana Rust

Industry partners: TS3 AG; Intrinsic

Selected experts: Computational Robotics Lab, ETH Zurich - Krispin Wandel, Bernhard Thomaszewsky, Roi Poranne, Stelian Coros; Swiss Data Science Center - Luis Salamanca, Fernando Perez-Cruz; Chair for Timber Structures, ETH Zurich.