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Interlocking spaces: A structural prototype inspired by Kigumi Architecture

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Abstract

This project is based on the results of a student workshop led by structural designer Prof. Jun Sato from Tokyo University together with a team of researchers based in Vienna. It represents an experimental investigation of spatial wooden structures that are based on the concept of Kigumi, the carpentry craft of interlocking joints in traditional Japanese Architecture. The resulting full scale demonstrator is first presented at the World Wood Day festival in March 2019 in Stübing, Austria.
Irregular architectural structures with varying densities that are characterized by a high level of geometrical and spatial complexity can be perceived as "natural" and thus represent comfortable environments (Sato, 2017). This workshop served as a case study of morphogenetic operations studying the relationship between material and space in timber construction. Wood as a solid material offers the potential of structures composed of crafted members joined without additional fasteners resulting in simplistic esthetics.
In traditional timber construction the principle of joinery emerges in a mutual relationship between material, craft and result (Zwerger, 2012). With computer aided design and manufacturing processes complex non-standard joinery can be considered and applied to complex geometrical configurations in contemporary and future contexts.
In physical models, working with a soft material (styrofoam), joint details as well as the design of an overall aggregation were developed following intuitive decisions based on structural performance, systematics and order. The model was digitized via 3d-scanning and translated into an axis model. In an iterative process the model was rationalized towards optimized manufacturing and assembly whilst balancing a recognizable systematic and the spatial complexity of the formation. Members were grouped and aligned into interlocking grid planes, the variation of angles was limited to a finite spectrum of angles and the overall form was optimized in a constraint based gravitational model.
The complex aggregation is defined by a simple underlying interlocking principle. Joints of two members oriented relatively vertical are locked by a third member that is oriented relatively horizontal. In addition to the vertical assembly logic parts situated higher up are resting on lower members constituting a self-stabilizing system which can be dismantled and reassembled. Structural analysis in Karamba for Grasshopper informed a refined configuration of lap joints adjusting the local profile overlap to minimize weakening of cross sections in joints with higher bending moments. Eventually the digital workflow was directed towards high precision manufacturing with an industrial CNC truss cutting machine.

The preliminary results of the ongoing research show potentials for experimental timber construction defined by an esthetics of craft, characterized by material homogeneity.
The intended goal is to develop structural models for architectural applications.

References

[1] J. Sato, *Transparent Structures as well as Environmental Filters*, Lecture Handout Vol.15, 2017

[2] K. Zwerger, *Wood and Wood Joints - Building Traditions in Europe, Japan and China*, Birkhäuser, 2012