Natural Form(s): Design and fabrication of a medium scale demonstrator composed of naturally grown forked branches

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Abstract

The structural system of trees responds to multiple forces forming a complex configuration of structural members, resulting in an optimized form, with forking branches acting as optimized joints (Mattheck, 1998).
Based on concepts previously presented (Allner and Kroehnert, 2018), this paper expands the research with a design and fabrication process of an experimental spatial framework. A digitized set of hornbeam branches is utilized as components in a synthetic formation. This is a project in the tradition of architectural research attempting to utilize wood in its natural form (Mollica and Self, 2016). It also explores how design control becomes relative to the constraints introduced by the available inventory, determining a dynamic design process in which constraints and design goals are negotiated in a feedback system.
Adapting the structural logic of natural trees to architectural applications, originally cantilevering branches are reassembled to form closed loops constituting a cellular framework with improved structural integrity and general bracing. For the purpose of this paper, the demonstrator represents a case study of a regular lattice of tetrahedron cells.
The workflow starts with a collection of 3d scan models of the physical branch parts, which are translated into simplified centerline models in an automated process. Using algorithmic methods, a set of idealized branches, averaging the geometric characteristics of the scanned models, are first composed into a modular aggregation. This is evaluated to determine its structural performance. Subsequently, each element is replaced by one of the real parts from the catalogue. The position of these elements is selected according to their cross sections, placing thicker elements in areas with higher local stress/utilization.
Replacing idealized modular elements with actual specimen, each with a unique form, generates discontinuities in the original grid. These are compensated by translating the aggregation topology into a constraint-based model in Kangaroo, which is relaxed, modifying the grid geometry to allow the overlapping of each branch ending to the next one. Finally, the 3D scanned mesh models are mapped to the locations of their respective axis model. The resulting aggregated model is further refined and processed towards robotic fabrication.

The realization of this demonstrator serves as proof of concept and as a vehicle to physically test modes of engagement and inhabitation, exploring the structural and architectural potential of a spatial framework defined by the material logic of wood.

References

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