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ACM Demo

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ACM Demo

Design-to-Robotic-Production for Circular Approaches in Architecture

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Design-to-Robotic-Production (D2RP) approaches developed in the Robotic Building lab at Technical University (TU) Delft link computational design to robotic production. They facilitate the development of process, energy, and material efficient approaches in architecture. When combined with circular wood approaches, they help reduce the ecological footprint left behind by construction processes, which is explored here as a workshop in collaboration with Amsterdam University of Applied Sciences (AUAS) as part of a project funded by the Dutch Research Council. The workshop introduced students to subtractive D2RP that was implemented on structurally optimized curvilinear components milled from circular i.e., reused wood. The workshop consisted of three parts:

<u>1. Computational design</u>: Which involved generating an initial geometry in relation to spatial experience and functions. This initial mesh was then structurally analyzed with respect to tension and compression forces (Fig. 1). This analysis was used to develop rationalized curve bundles in order to develop the material distribution strategy resulting in curvilinear beams. One fragment of these beams was selected to be prototyped using robotic fabrication.

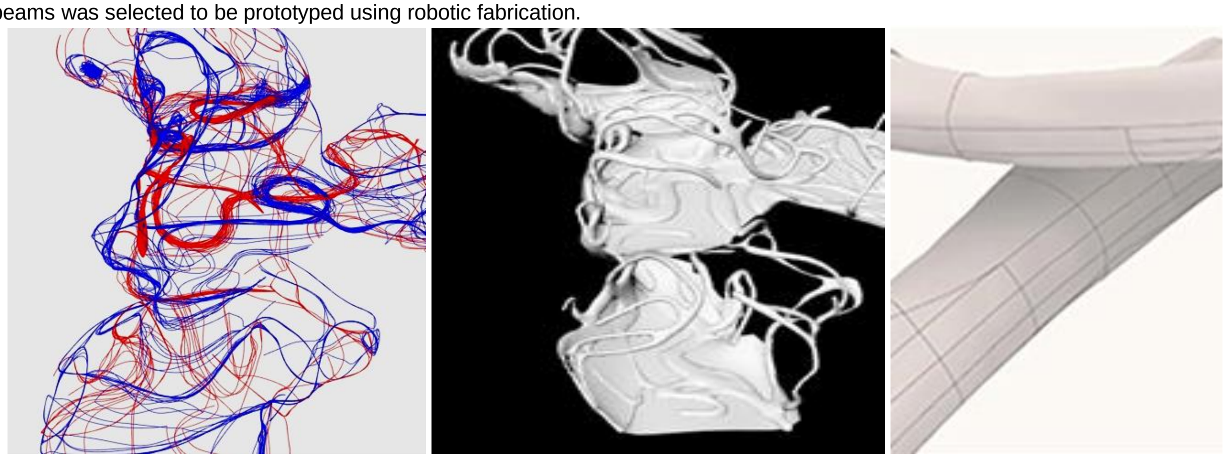

Figure 1: Computational design (left) and packing (right)

<u>2. Computational packing:</u> Before starting the Robotic fabrication, various packing strategies were conceptually tested within Rhino using geometry generated by 3D scanned information of the actual wooden pieces. Since the project aimed at reusing wood pieces each of them had unique sizes ranging from 350 to 1325 mm in length and average width and thickness of 100 and 30 mm respectively. Which resulted in a complex stacking logic. They were collected from a demolition project. The scanned pieces were positioned in a fully packed arrangement in Rhino using a packing algorithm that involved several steps: (i) The wooden beam is virtually divided into four longitudinal radial sections, which determined the direction of distribution of the wooden elements; (ii) The elements are grouped based on their thickness, with a tolerance of 1 mm; (iii) For any given section, the availability of wood from one thickness group is computationally compared with the geometry of the section. If the number of available beams fits the fragment efficiently, the wood pieces will be utilized for packing, otherwise discarded from this step and re-analyzed at a later stage. At any stage, the most efficient group of beams is utilized, which contributes to minimizing the amount of material necessary to be removed by milling as well as increasing the efficient use of available material. The final beam geometry is set relative to the geometry of the packed wood (Fig.1) with an offset to have a buffer that prevents accidental milling beyond the margins of the beam.

<u>3.Robotic fabrication:</u> The robotic milling process was implemented in steps (Fig. 2). (i). The packed wood geometry was placed on a support structure; (ii) The wood pieces were fixed on the support structure; (iii) The Tool Central Point (TCP) was calibrated in specific points as a reference to virtual points, in order to calibrate the virtual model to the physical world; (iv) milling path planning code was generated; (v) milling was executed.

The milling has revealed a colourful pattern resulting from combining various kinds of wood, which had aesthetic quality. The reuse of wood proved to be successful. In order to not waste material, the sawdust was saved for 3D printing with bio-polymers, which will be implemented in the next phase of the project.

Figure 2: Packing and robotic fabrication

Acknowledgements

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