Generating Reciprocal Structures with ABxM

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The project focuses on developing an agent-based modelling (ABM) system to design reciprocal structures using reclaimed timber stock. Reciprocal structures, known for their structural stability and minimal material use, are widely studied in architecture. The motivation for this project was to explore how ABM could be applied to sustainable design by maximizing the potential of non-standard, reclaimed timber. This aligns with environmental goals by reusing materials and reducing waste in construction. The project draws inspiration from previous work, like the *Lamella Flock* project, which uses a similar agent-based approach to generate dynamic, reciprocal geometries.

Methods and Approach

The project utilized ABM to simulate interactions between individual "agents" representing timber members. In this system, each timber member was paired with two agents, which were assigned custom data parameters, such as length, engagement distance, and docking status. These agents interacted based on four programmed behaviours: wandering, partner cohesion, attraction, and docking. Wandering allows agents to move through space, partner cohesion ensures coordinated movement between paired agents, attraction brings agents closer to facilitate docking, and the docking behaviour enables agents to connect, forming nodes within the structure.

The initial setup involved placing timber elements randomly in a Cartesian coordinate system, then applying the agent behaviours to create stable connections. Different node types were generated based on the number of members in each group: triangular nodes for three-member clusters and quadrilateral nodes for four-member clusters. This flexibility allowed the team to create varying node configurations based on timber availability, showcasing the adaptability of the ABM approach to irregular materials.

Results

The ABM system proved effective in generating reciprocal structures with reclaimed timber, achieving a balance between adaptability and structural integrity. Using the behaviours programmed into the agents, the project team successfully generated stable clusters that could be scaled to form larger geometries. The clustering results showed that nodes could be formed dynamically based on agent interactions, yielding triangular or quadrilateral formations as needed. Additionally, it was observed that adjusting the engagement distance parameter could help refine the structure, ensuring that angles between members remained optimal and avoiding overly wide or narrow connections that could compromise stability. The experiments demonstrated that ABM offers a viable method for working with reclaimed materials, allowing for design flexibility and efficient material use.

Conclusion and Future Directions

The project's initial success in modelling reciprocal structures with reclaimed timber highlights the potential of ABM in sustainable architectural design. One key improvement identified was in the data structure of agents; the current system has redundant information and an inefficient search algorithm for docking positions. Optimizing this by using direct access to endpoints and references to connected elements could streamline the modelling process and improve scalability. In the future, the team also plans to implement neighbour behaviours, such as those seen in the *Lamella Flock* project, to enable individual nodes to interact with their neighbour's. This would allow for the creation of larger, interconnected structures that maintain the properties of reciprocal geometries, further enhancing the system's architectural applications.