Automated Nailing in Off-site Mass Timber Construction: Toward Robotic Assembly Solutions

Paolo Pancho[1], Second Mauricio Arredondo[2], and Rafiq Ahmad[1,2]
[1] Smart and Sustainable Manufacturing Systems Laboratory (SMART Lab), Department of Mechanical Engineering, University of Alberta, 9211 116 Street NW, Edmonton, Canada
Email: rafiq1@ualberta.ca

INTRODUCTION

Mass timber is increasingly used in sustainable construction, yet its fabrication still relies on repetitive and labour-intensive tasks such as nailing and material handling. To address these challenges, robotic approaches have been explored in timber assembly. Arredondo-Soto et al. [1] introduced a multi-tool end-effector for integrated picking and nailing, while Cisneros González et al. [2] investigated robotic cell design and simulation for cross-laminated timber operations.

Building on these advances, this study presents a prototype robotic cell for automated nailing and pick-and-place operations. The system integrates a KUKA KR250 robot with a multi-tool setup and is experimentally validated on representative stud layouts. A visual programming interface supports program generation, enabling efficient trajectory definition. This case study highlights the potential of reconfigurable robotic solutions for off-site timber fabrication.

MATERIALS AND METHODS

The prototype cell employs a KUKA KR250 industrial robot integrated with a multi-tool that combines a nail gun and grippers. For accurate task execution, three coordinate systems were defined: the robot base as the global reference, the worktable frame for material positioning, and the tool center point (TCP) associated with the nail gun. To evaluate the cell, stud assemblies with defined dimensions and spacing were arranged on the worktable. A visual interface was developed to input these parameters and generate the corresponding robot code through inverse kinematics. The program included both joint trajectories and tool activation commands, allowing the robot to execute the nailing sequence automatically. The overall process, from parameter definition to program generation, is illustrated in Fig. 1.

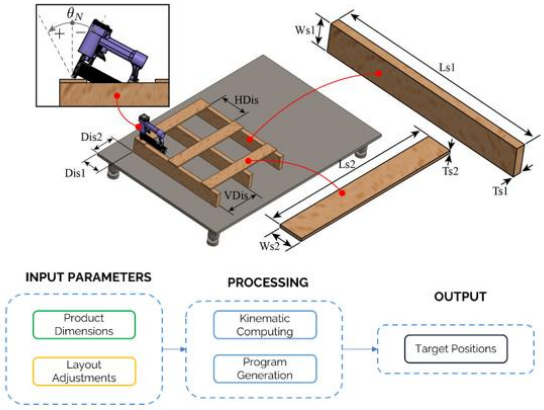

Fig. 1 Workflow of the automated nailing process.

RESULTS AND DISCUSSION

The prototype was experimentally tested on a six-stud configuration, consisting of three base studs and three top studs, with nailing points automatically determined at their intersections. The generated KRL code was executed successfully on the robot, and the nail gun operated reliably within the defined inclination range of –20° to +20°. As illustrated in Fig. 3, the experimental setup demonstrates the capability to vary the tool orientation: (a) nailing with a +20° inclination, (b) nailing with a –20° inclination, and (c) execution of the nailing process on the assembled stud configuration.

The assembly process was completed successfully, with minor deviations observed due to the manual placement of the studs on the worktable. These results confirm the effectiveness of the system in translating configuration parameters into robotic actions, reducing programming effort and improving repeatability.

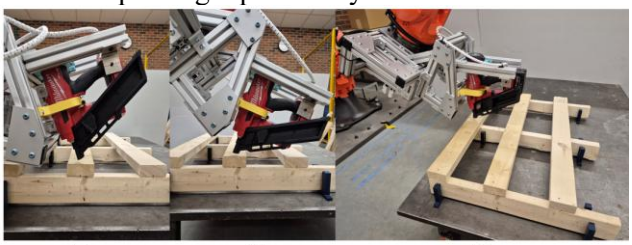

Fig. 2 Experimental nailing process: (a) +20° inclination, (b) –20° inclination, and (c) execution on stud assembly.

CONCLUSIONS

This study presented a prototype robotic approach for automated nailing in off-site mass timber construction. The system demonstrated the ability to generate and execute robot programs that performed nailing operations on representative stud assemblies, including variable tool inclinations. The experiments confirmed that such automation can reduce programming effort and improve repeatability compared to manual operations. Future developments will focus on integrating sensing and reconfiguration capabilities to compensate for positional deviations and ensure robust performance under real construction conditions.

REFERENCES

[1] Arredondo-Soto M et al. Proc 42nd ISARC: 34–41, 2025.
[2] Cisneros González J.J et al. Transforming Construction with Off-site Methods and Technologies: 1–8, 2024.