Dual Arm Adaptation for Robotic Construction

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Project Type: Semester Project (Master Thesis) *Section:* *Microengineering*
Official Start Date: *Early Feb*
Submission of Final Report: *TBD*
Presentations at Group Meeting: *TBD*

Project Description:

This project studies dual-robot collaborative construction of self-supporting arches under geometric and physical uncertainty.

Robotic construction has the potential to automate building processes and improve efficiency. However, most existing systems rely on fully specified, fixed construction plans that assume precise knowledge of geometry and material properties. Assembly is typically position-based, with each element placed at a predefined location.

For certain structures, such as dry masonry, this paradigm is highly problematic. Small geometric and placement errors can accumulate over time, causing later construction stages to fail. Moreover, strict pre-planning restricts the use of natural or minimally processed materials, which are desirable for sustainability but inherently uncertain due to irregular geometry and poorly modeled contact conditions. As a result, pre-planned assembly sequences can easily become invalid.

In contrast, human builders work effectively with such materials by continuously adapting their actions based on visual perception and force feedback. Rather than strictly following a fixed plan, they adjust placement, apply stabilizing forces, and modify the construction strategy in response to the evolving structure.

This project seeks to transfer these human capabilities—vision-based understanding and force-aware interaction—to robotic construction. We focus on the dual-robot construction of stone arches, leveraging static force principles of arch stability and force-controlled multi-robot manipulation to enable safe and reliable assembly under uncertainty.

Figure 1. Robotic construction of stone masonry *Left: Masonry wall construction by CRCL. Right: Human Stone Art (https://www.youtubeeducation.com/watch?v=zoMuJ8AIS7g)*

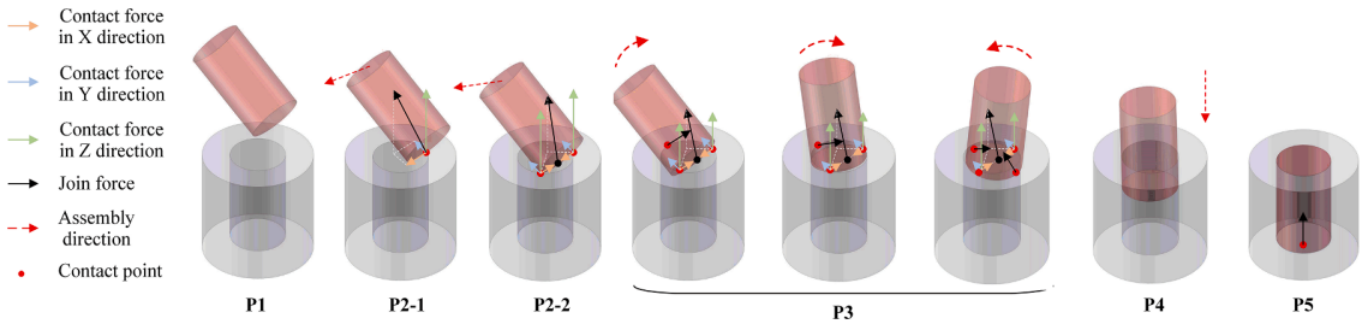

Figure 2. Force-guided wiggling motion strategy (ref: Assemble like human: A multi-level imitation model learning human perception-decision-operation skills for robot automatic assembly tasks)

The key tasks for the student include:

- **Literature review:** Reviewing relevant work on force-controlled manipulation.
- **Method implementation:** Implementing and testing existing proposed structural stability force-range solver and force-control methods provided by tutors, potentially propose new framework.
- **Experimental testing and evaluation:** Conducting experiments under varying uncertainty levels to evaluate stability, robustness, and construction success. Testing a wiggling planner based on multi-sensor feedback to achieve a more stable robot end-effector posture.
- **Performance assessment:** Analyzing experimental results, identifying failure cases, and comparing different strategies or baselines.

Through this process, the student will contribute to advancing robotic construction by enabling force-aware, adaptive dual-robot assembly under uncertainty.

Signatures:

Professors Scientific Assistants Student