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Project Title: Adaptive visuo-motor models for robotic welding in uncertain construction environments

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Project Outline:

Robot manipulators have been successfully implemented in many manufacturing applications for more than five decades now. Their accurate operation is largely due to the fact that industrial settings are fixed, therefore, the required environment's model and robot trajectories can be exactly computed in advanced. Although this situation is fairly acceptable in industry, it has proven to be too restrictive for many field applications with highly uncertain conditions, such as in construction sites. The need to interact and work alongside humans further complicates the use of robots in these situations.

The aim of this project is to develop a new control methodology for robots to perform automatic welding tasks in unstructured construction environments. Note that traditional motion controller cannot be used for this situation as these approaches require a-priori knowledge of the task geometric model and are not robust to variabilities in the environment. To overcome these issues, we propose to develop a new method with the following features: (1) it will adaptively compute the kinematic relations between the manipulator, vision sensors, and the workpiece; (2) it will integrate visual measurements from multiple 3D sensors for reconstructing the workpiece/environment model in real-time; (3) it will visually extract the desired welding trajectory from human manual demonstrations; and (4) it will guide the welding trajectories along the workpiece using real-time visual feedback.

To implement this method, we will build a fully sensorised experimental platform composed of a serial robot manipulator for positioning the welding torch, a camera mounted on the robot's wrist for guiding the welding trajectory, and multiple external 3D cameras for structuring the environment and cross-calibrating the visuo-motor model.

Objectives:

- To develop a new adaptive algorithm for computing the visuo-motor model of a welding robotic system in real-time.
- To develop a method for computing the desired welding trajectory from multiple 3D visual measurements.
- To develop a visual servoing controller for performing welding tasks in unstructured environments.
- To build a robotic welding platform for experimentally evaluating the proposed theory.

Expected deliverables:

- An adaptive method to cross-calibrate multiple 3D vision sensors.
- An online algorithm to compute welding trajectory from multiple views.
- A vision-based controller to automatically perform welding tasks.