NANYANG TECHNOLOGICAL UNIVERSITY

Robotics Research Centre

Intelligent Perception and Dexterous Manipulation for Fine Robotic Assembly

Project Motivation & Objectives

Fine assembly tasks (e.g. in the electronics, shoes, food industries) are still out of the reach of today's industrial robots. The main challenges lie in the unstructured environments, the soft/fragile materials of the parts to be assembled and the difficulty in controlling contact interactions.

This project aims at tackling these challenges in order to make robots capable of handling those fine assembly tasks in industrial contexts.

Researchers will evaluate the manipulation capabilities of the robotic system obtained at the end of the project on the task of autonomously assembling an IKEA chair.

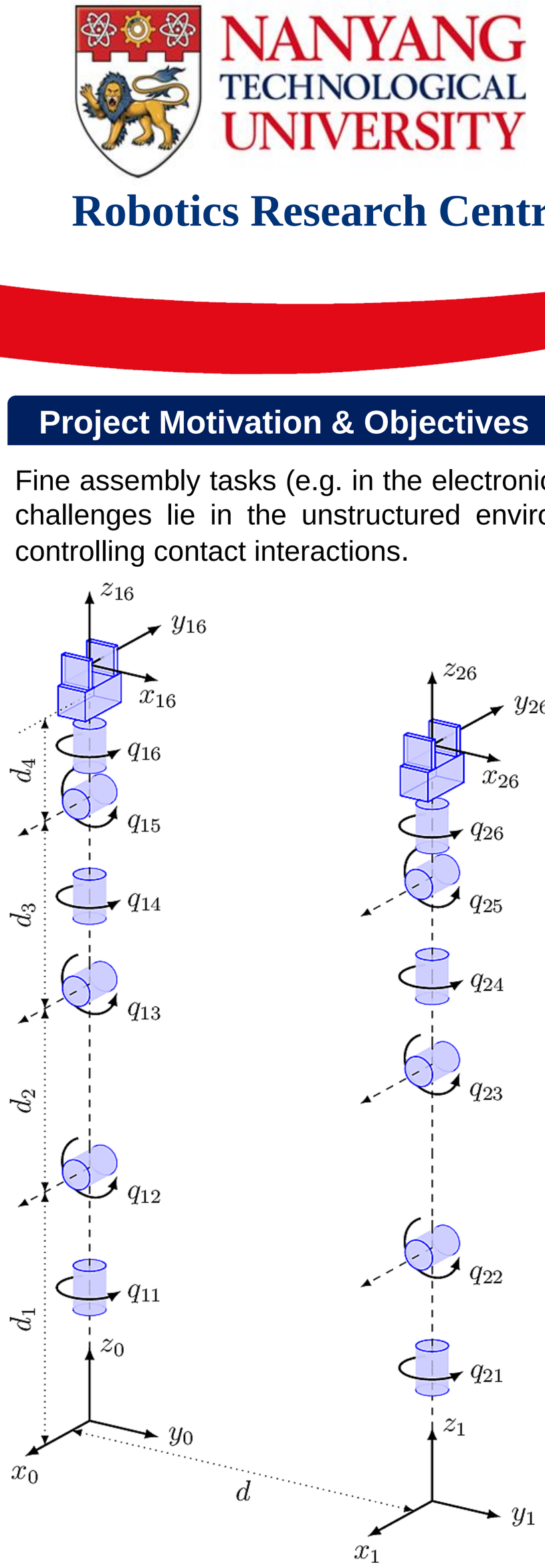


Figure 1. *Kinematic diagram of the bimanual setup. The distance between robots has been optimized to maximize the joint and intersection workspaces.*

Methodology

Researchers will integrate 3D perception with force/torque sensing: F/T sensor placed at the robot end effector can detect contacts, and via the robot kinematics, give information about the position and orientation of the contact points. 3D perception gives a rough description of the environment and guides the exploration while contact interactions refine environment description to a level suitable for fine manipulation.

Results

Researchers have developed a hardware and software framework tailored for robotic assembly. The hardware comprises of an optical motion capture system and two industrial position-controlled manipulators, each equipped with a force/torque (F/T) sensor at the wrist and a parallel gripper. The two manipulators are necessary since most assembly tasks require two hands to complete. On the software side, issues arising from fine assembly have been addressed, such as reachable workspace optimization, external wrench compensation, and position-based force control.

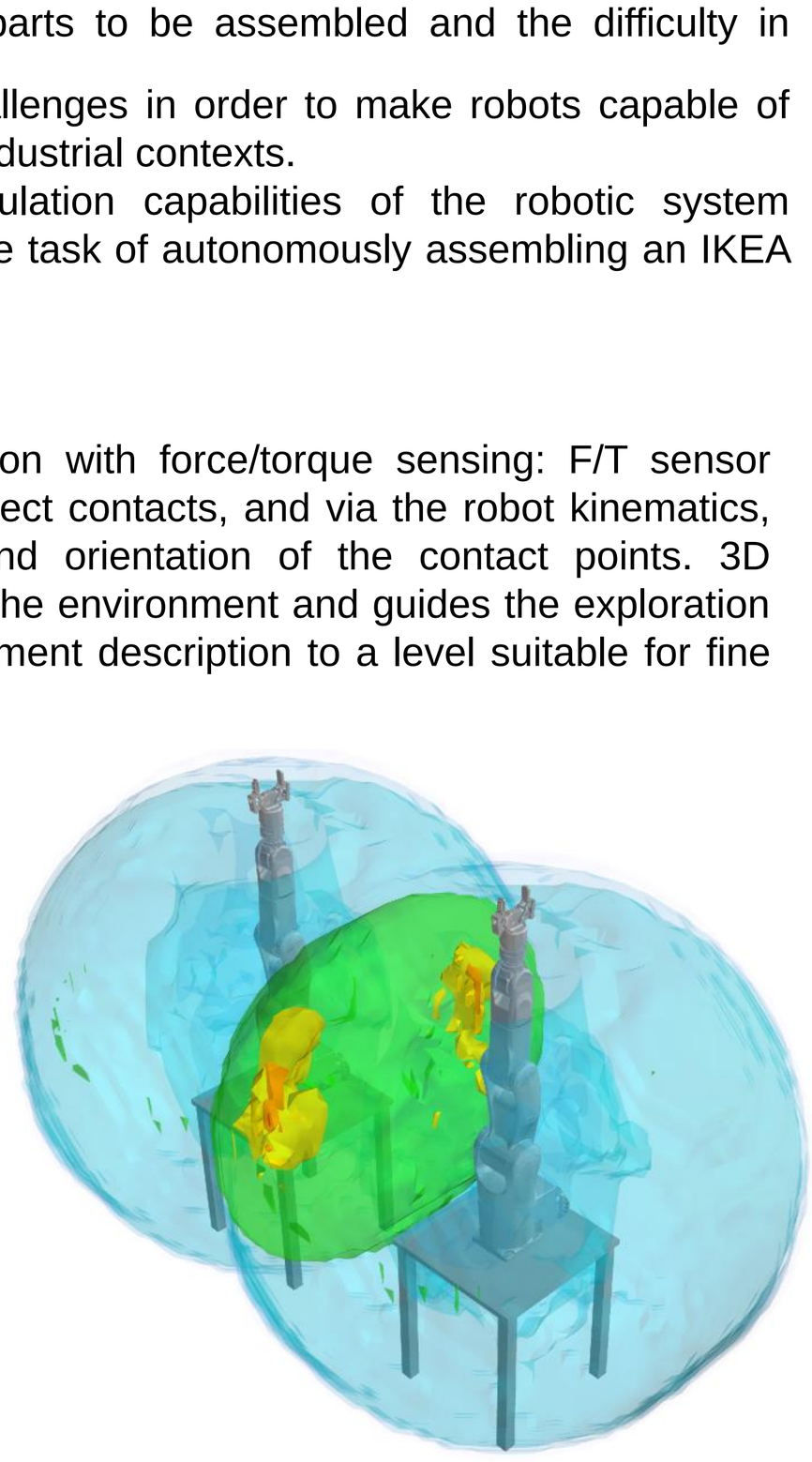
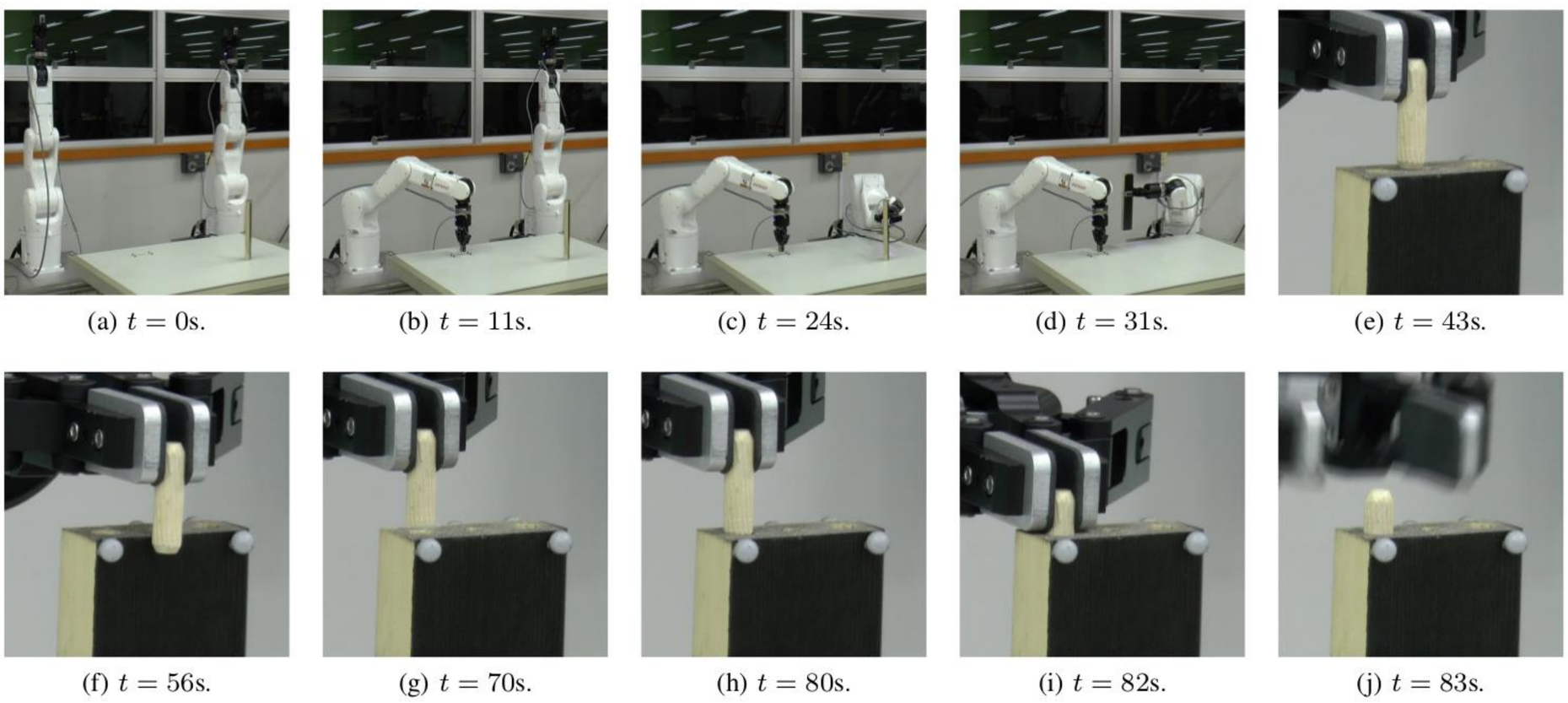


Figure 2. *Reachability of the bimanual setup. The workspace intersection shows the combined reachability of the two manipulators.*



(a) $t = 0$s. (b) $t = 11$s. (c) $t = 24$s. (d) $t = 31$s. (e) $t = 43$s.

(f) $t = 56$s. (g) $t = 70$s. (h) $t = 80$s. (i) $t = 82$s. (j) $t = 83$s.

Figure 3. *Snapshots of the bimanual pin insertion. The left arm performs the compliant grasping of the pin. Through force exploration, the left arm finds the edges of the stick and once the hole is found, the left arm inserts the pin.*

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