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Realization of Pick-and-Place Tasks for 7-DOF Franka Emika Robotic Manipulators

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Abstract

In industries, robotic manipulators often replace human works in challenging circumstances, such as hazardous workplace and heavy duties, and can improve efficiencies and performance due to fatigues caused by human workers. This work introduces how pick-and-place tasks are achieved by a 7-degree-of-freedom (7-DOF) Franka Emika robotic manipulator through the client-side C++ interface named Franka Control Interface (FCI). Concerning the real-time commands, the trajectory of an entire pick-and-place task can be considered as an iteration of numerous consecutive point-to-point motions. For each point-to-point motion, a joint position motion generator and a proportional and derivative (PD) controller are investigated. The inverse kinematics of FCI derives the joint positions of start and end locations from Cartesian poses. Then a proposed cubic polynomial trajectory planning generates a series of waypoints between the start and end locations. Finally, the decentralized PD controller sends real-time torque control signals to follow the desired trajectory. Based on the entire procedure, loading and unloading jobs in automated production lines of flexible assembly system can be completed.

Experimental results are extensively shown to demonstrate the effectiveness of the proposed method. Before presenting an entire pick-and-place task, a point-to-point motion has been firstly executed once to examine the performance of the designed motion generator. The second task is to place three parts aligned on a surface. The parts are three LEGO tires, and they are picked up and placed on the top surface of the white box. A human operator stands by on the left-hand side and passes the tires to the gripper for grasping, and the gripper places tires at the correct spot in sequence. The full video of entire pick-and-place task can be viewed at: https://www.youtube.com/watch?v=KI-G-9WTldM

The implement of this project is supported by theoretical knowledge, including the dynamics, inverse kinematics, trajectory planning, and control methodology of robotic manipulators. In future studies, a force control will be investigated for grasping heavy or delicate objects. An alternative task-space trajectory planning with optimization and intelligence will be investigated for a dynamic environment where collision/obstacle avoidance and optimal path are needed.