Serial Robotics Manipulators Courseware

"This courseware explains thoroughly various types of serial robotics manipulators, namely, 3-dof planar robots, 6-dof spatial robot with decoupled architecture as in FANUC or non-decoupled as in UR10e."

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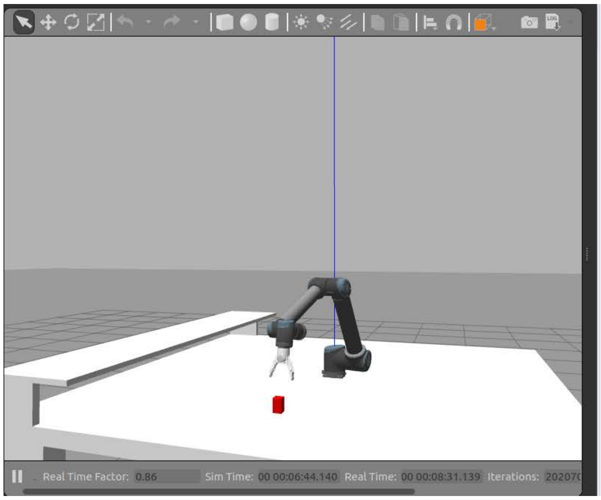
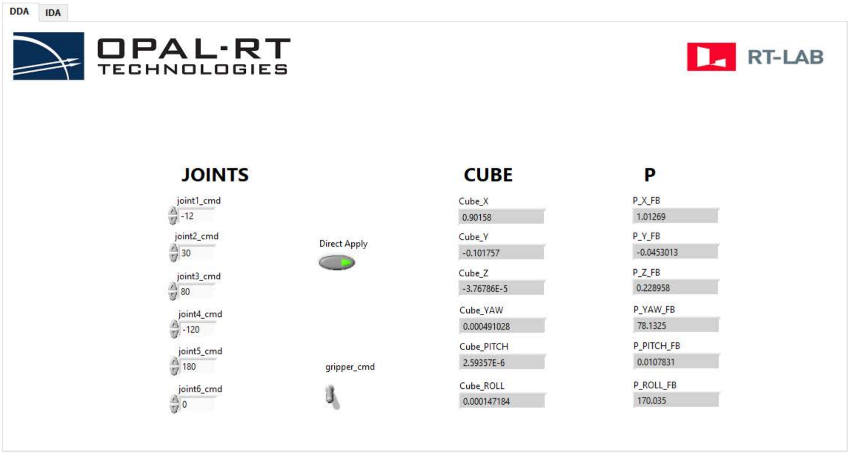
The courseware is intended to teach serial robotics manipulators to universities' students. Students grasp deep understanding of concepts such as: DH-Table, direct and inverse displacement analysis, decoupled and non-decoupled architectures, kineto-statics and Jacobian analysis, dynamics, trajectory generation and tracking, pick-and-place operation, open-loop and closed-loop joints control, linear and non-linear end-effector control, and force-based control.

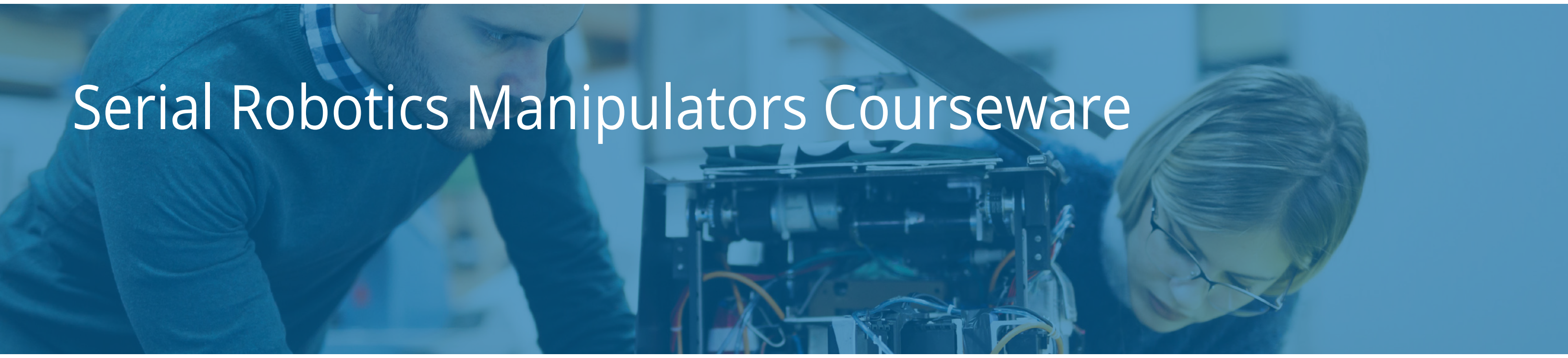
MAIN BENEFITS

- Covering thoroughly serial robotics manipulators concepts, step-by-step, via interactive exercises where students are in-the-loop interacting with the virtual robot and analyzing / controlling its motion.
- Reproducing digital twins of industrial robots FANUC LRMate 200iC and UR10e
- Comparison of the performance of various control schemes in real-time and instantaneous observation of the changes in the displays and robots motions.

INTERACTIVE PANEL







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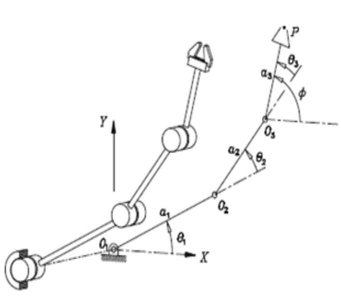
SERIAL ROBOTICS MANIPULATORS LEARNING OUTCOMES

3-dof planar horizontal robot: Construct DH-table. Do direct displacement analysis. Understand homogeneous transformations and apply them to the planar case, which drops down to two cartesian coordinates and one orientation angle. Understand the concept of non-decoupled architecture. Do inverse displacement analysis (IDA) while making benefit of the decoupled architecture. Control each joint separately to validate IDA. Understand kinetostatics and analyze Jacobian. Generate trajectory using interpolating polynomial and obtain position, speed, and acceleration references for pick-and-place operations. Implement end-effector (EE) open-loop control and validate results.

6-dof spatial decoupled manipulator – FANUC LRMate 200 iC: Repeat all the steps listed for horizontal planar robot while noticing that this is a spatial robot and apply the concept of decoupled manipulator in IDA for arm (first three revolute joints) and wrist (last three revolute joints). Control each joint separately to validate IDA and understand 3D rotations with quaternions. Switch to closed-loop EE control to understand the impact of gravity.

6-dof spatial non-decoupled manipulator – UR10e: Repeat the steps listed for FANUC while noticing that UR10e doesn't have decoupled architecture. Compute inverse displacement for this general case. Control each joint separately to validate IDA. Apply closed-loop EE control. Additionally, apply force-based control.

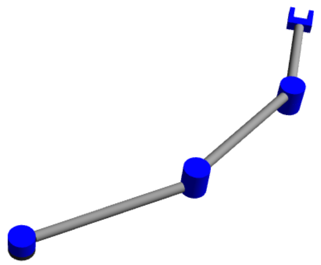
3-dof Planar Robot



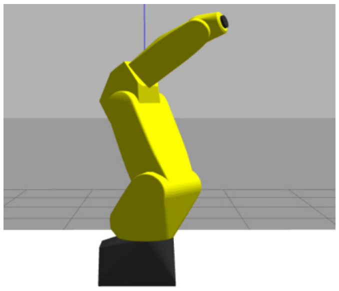
FANUC LRMate 200 iC

UR10e

Planar Robot's Digital Twin



FANUC's Digital Twin



UR10e's Digital Twin