Introduction to MATLAB and its Application in Robotics

Quark Summer Technical Project, 2021

BITS Pilani, K.K. Birla Goa Campus

Logistics

- **Instructors:** Ashutosh Gupta, Pranav Goyal and Sanskar Jain
- **Duration:** 6 weeks
- **Discussion forum:** WhatsApp Groups

Course Description

Millions of engineers and scientists worldwide use MATLAB for a range of applications, in industry and academia, including deep learning and machine learning, signal processing and communications, image and video processing, control systems, test and measurement, computational finance, and computational biology.

MATLAB is also widely used in the field of Robotics for performing tasks such as

1. Model robotic systems down to the finest details such as sensor noise and motor vibration.
2. Simulate robotic systems with accurate kinematics, dynamics, and contact properties.
3. Design and optimize both high-level autonomy and low-level control.
4. Synthesize and analyze sensor data with a maintained library of algorithms.
5. Verify robot design or algorithm gradually, from simulation to hardware-in-the-loop (HIL) test.
6. Deploy algorithms to robots via ROS or directly to microcontrollers, FPGAs, PLCs, and GPUs.

Through this project, we will first cover the very basics of MATLAB and Simulink along with some of its very important toolboxes and implement a basic PID controller on it. After that, we will move to a more specific application in Robotics using Simscape Multibody, Stateflow, and Robotic System Toolbox. We will also look upon some basic concepts of Controls and Motion Planning. Finally using whatever we have learned, We will create a simulation of the Pick and Place arm in MATLAB.

Software Requirements

1. MATLAB and Simulink (Mathworks products) have free students' licenses for a few universities. If you are unable to download large files, you may use the online version of MATLAB, and Xcos instead of Simulink.
2. If your university/college does not have a free student's license available for Mathworks products, you can use alternative software like Scilab and Xcos.
3. Robotic System Toolbox provides tools and algorithms for designing, simulating, and testing manipulators, mobile robots, and humanoid robots,
4. Stateflow is a control logic tool used to model reactive systems via state machines and flow charts within a Simulink model.

Timeline

Weeks	Topics	Task Description
Week 1	Introduction to MATLAB and Simulink	Completing MATLAB Onramp and Simulink Onramp, writing a basic PID controller on MATLAB
Week 2	Simscape Multibody	Understanding basics of Simscape Multibody and using tools such Rigid Body and transforms and joints.
Week 3	Stateflow and RST	Starting with the Stateflow and using some tools from Robotic System Toolbox
Week 4	Joint Space Trajectories	Using RST to generate and simulate interpolated joint trajectories to move from an initial to a desired end-effector pose.

Week 5	Plan and Execute Collision-Free Trajectories	Planning closed-loop collision-free robot trajectories from an initial to a desired end-effector pose
Week 6	Finishing the Pick and Place Robotic Arm simulation	Setting up an end-to-end pick and place workflow for a robotic manipulator

Evaluation

A *Certificate of Completion* will be awarded to those who complete all weekly assignments and the final project. Moreover, the top 5-10 participants shall be awarded a *Certificate of Excellence*. Participants displaying considerable interest and aptitude in this course will also be considered for induction into the Electronics and Robotics Club.

Notes

1. Don't refrain from asking even the most basic doubts. We are all here to help you learn and enjoy this course.
2. Please don't try to cheat, since the skills and knowledge you learn here will be useful in some way or another.
3. Regular feedback forms would be circulated to gauge your thoughts about the course, the instructors, and your doubts.