Robotics 41013: Lab Assignment 1

Weight: 20%.
Demo Due: Week 6 Lab Class – 15:00 Tuesday 28th April
Report Due: Week 6 – 21:59 Friday 1st May

Specific Tasks for this Robotics 41013 Assignment (Demo. specific)

1) Build a D&H model of two UR3s. Build simulated graphical models of the chosen robots, the parts to be assembled and the surrounding environment using Matlab and the Matlab robotics toolbox. Ensure the mounting location of the robot base can be easily modified.
2) On the submission day you will be given a specific mounting transform for each robot base, and for the demonstration you will need to be able to rapidly determine and demonstrate to your assessors/peers:
   a) the maximum reach of each arm (radius from top and side view);
   b) the approximate volume in m^3 that the entire arm may exist in (hint: consider the positions of each joint for a large, representative sample of joint positions) and;
   c) the updated location of proposed safety infrastructure given that mounting position.
3) The three parts must be put together as shown in Fig 1, i.e. housing top / bottom and the circuit board. The actual transform of the three parts will be given on the day of submission (for testing purposes you should set the locations to be random within some bounds). Assume that once the robot end-effector moves to the given part location it automatically and successfully grasps the part. You will need to demonstrate the following steps in the assembly:
   a) Determine a pose that can pick up each of the parts;
   b) Simulate the robot movement in a smooth joint-position controlled motion between the starting pose and the first two pickup tasks: pick up the top of the housing, and circuit board;
   c) Simulate moving the arms together so as to place the circuit board into the top of the housing;
   d) Determine a pose to grasp the bottom of the shell with the hand that was holding the circuit board;
   e) Simulate bringing the parts together, without colliding so as to complete the assembly;
   f) Determine a pose, and simulated path so as to drop the completely assembled part off into another box in front of the two robots.
4) Complete safety prerequisites before the demo day to unlock real robot use. Control one (or both) of the real UR3 robot's movements through the planned task trajectory via Matlab's ROS interface. Perquisites and evidence of real-world use (i.e. videos, early live demos) will still receive partial marks.

Extension Bonus Questions (Demo. specific):

You may wish to attempt these bonus questions for additional marks. These questions are challenging, and support is limited, but they will your demonstration impressive, your debugging easier, and enhance your understanding. Some questions are marked in the demonstration (D) and others in the report (R).

D1) Investigate Matlab's "GUIDE "to input a transform for the base of the arms, and the location of the three parts and the drop off location.
D2) Given a ROS '.bag' file of a real robot moving, playback the .bag file and demonstrate your simulated robot movements match the movements from the video of the real robot.
D3) Incorporate a sensor (e.g. camera, e-Stop, limit switch) via ROS that passes data into your Matlab system. You may like to use your SBC (e.g. Raspberry Pi) or an Arduino.
R1) Use Matlab's "profile" tool to investigate which functions consume most of the time. Reflect briefly (in the report) on alternative methods to improve computational efficiency.
R2) Determine and report on the optimal base location of the two robots so that the task can be completed, either by brute force or optimisation.
R3) Given the part models, select an appropriate gripper[1] and discuss with the use of diagrams the ideal way to grasp the objects.

[1] https://www.universal-robots.com/plus/end-effectors/#/01011111111111111111

Locations: Announced on the day

Robots

- Robot 1 Base = transl(-0.23,0.23,0) with any orientation.
- Robot 2 Base = transl(0.23,0.23,0) with any orientation.

Parts

Note: YOU MUST PROOVE THE TRUE TR OF END-EFFECTOR (i.e. fkine of q). Can use command window/gui/log

- Part 1 or 3 (top / bottom) = transl(-0.42,0.46,0) with any orientation
- Part 2 (Circuit board) = Student free to decide.
- Part 1 or 3 (top / bottom) = transl(0.42,0.46,0) with any orientation
- Location to combine parts = Student free to decide.
- Location to drop off parts = Student free to decide.

Marking Scheme:

The assignment is worth 20% of the subject. The assignment will be marked out of 100, attempting the extension bonus questions is encouraged but not compulsory, and the highest mark that can be received is still 100 (i.e. 20% for the subject).

General Task Description	Mark	When?
Given an end-effector pose determine a joint state	**7**	**Demo**
Move robot to required joint states and demonstrate that the joint states satisfy the given pose	**7**	
Demonstrate at least 1 Real or PolyScope simulated UR3 robot(s) completing above poses safely (COVID-19=Mark as "No attempt" and we'll scale marks up)	**7**	
Simulate parts and environment around the robot (must explain the purpose of everything)	**12**	
Simulated robot model: realistic (7) or simple shape (3) or stick (1)	**7**	
Display and log transforms and status during task completion	**5**	
Calculate and plot workspace radius & volume	**5**	
Incorporate and consider safety in your demonstration	**5**	
Incorporate and consider safety in your design, code and report	5	Report
Code aesthetics: Comments & neatness	5	
Code aesthetics: Compliance to code standard provided	5	
Code structure: mainly use classes (5) or functions (2) or scripts (0)	5	
Report on the design and reflect upon the process	10	
Effectively communicate the required task information	10	
Marking self and another demo (mark based on distance to mean)	5	
Total (55 in Demo & 45 in Report)	**100**	
Demo Bonus (3 marks each): (#1) GUI, (#2) Playback ROS bag, (#3) Incorporate sensor	9	**Demo**
Report Bonus (3 marks each): (#1) Profile tool analysis, (#2) Optimise base, (#3) Gripper	9	**Report**
Total Bonus (Bonus tasks worth 3 marks each (6 x 3))	**18**	
Total max marks = min(Total + Bonus,100)	**max = 100**	

Marking Instructions:

- **Below is the marking order. Timeslots are NOT guaranteed. Be ready from 3pm-6pm.**
- **Your assigned tutor will Private Message you a Zoom meeting link in Teams**
- **If you don't reply/join within 3min, we will move on to the next student and come back to you if we have time.**
- **All Zoom meetings are recorded for standardisation**
- **Demonstrate and show code for 10-15 minutes total including questions**
- **Submit code to UTSOnline after demo (https://online.uts.edu.au/webapps/assignment/uploadAssignment?content_id=_3780244_1&course_id=_42042_1&group_id=&mode=cpview):**
- **Stay in the Zoom call to mark the next student**
- **Mark yourself in your own time (before end of day)**

Demo Marking Google Form:

https://goo.gl/X6e3FB

Marking Order and Allocations

Gavin	*Sheila*	*Nuwan*	*Marc/Teresa/Jon*
12933572	12207231	98129594	12618272
12545428	12699070	12544425	97117269
99192282	97116242	12583567	12596793
12838138	12421133	98102534	12620136
12614943	12667731	12561460	11390097
13135518	13701937	13302233	12544300
12779714	12695882	99143152	12553638
13301902	12727069	12544932	12545012
12930893	98032562	13302245	12544944
12747150			97116533
			12584429
			12544831
			11980935
			13301460
			13393677
			12608889
			11378650
			12552117
			99132021
			12545606