Robotics 41013: Lab Assignment 2

Total Subject Weight: 35%.

Group Size: 2-3 students (all members MUST contribute meaningfully)

Task	Who	Week	Date	Worth
Proposal	group	7	21:00 Sunday 24 September	2/35
Initial Peer Feedback Stage	individual	9	21:00 Friday 13 October	3/35
Short Promotion Video	group	11	21:00 Friday 27 October	5/35
Final System Demonstration	group	12	17:00 Friday 3 November	15/35
Final Video	group	12	21:00 Sunday 5 November	10/35
Final Peer Feedback	individual	Optional task: A week after the demo		$\times\ multiplier$

Background:

After your success in introducing the robot into their assembly of parts, your company, SafeCo, is looking to expand their product range. SafeCo wants to expand their business and are interested in investigating the possibility of selling small robot systems to customers for use in the home, office or workplace. Management wants your team to spend a few weeks investigating the application of a robot, including integrated safety. SafeCo has made available several[1] real desktop robot manipulators (including their models) for you to test your design on (see below). You need to choose and use one of these. Then model a second new industrial robot arm that is not in the Robotics Toolbox.

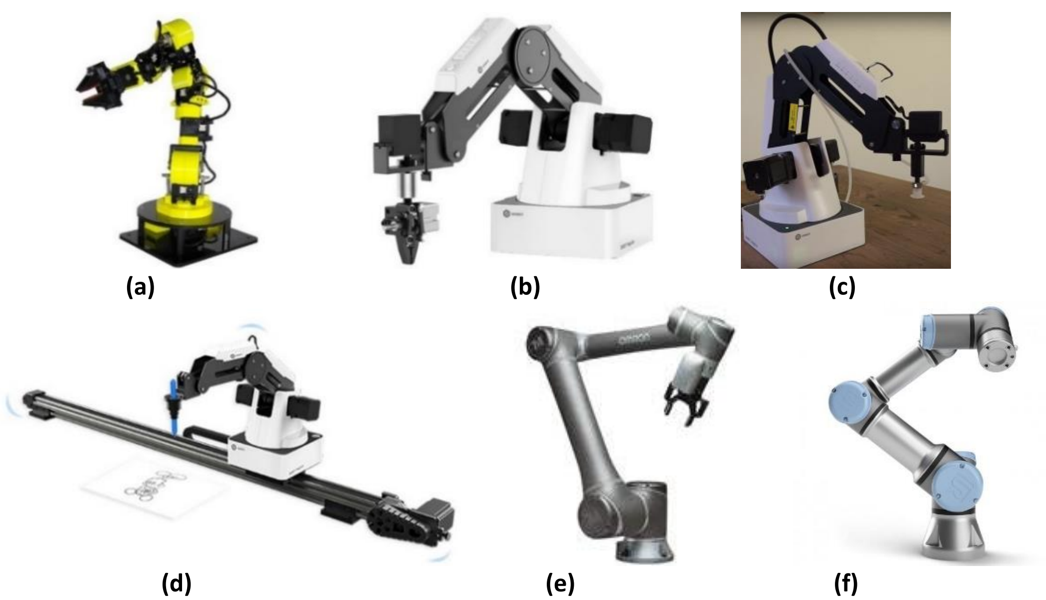

Fig 1. (a) Han's Cute (aka Cyton 300e) with pincer (claw) gripper, (b) Dobot Magician with pincer gripper, (c) Dobot Magician with suction cap gripper, (d) Dobot Linear rail, (e) Omron TM5, (f) Universal Robots UR3

[1] Drivers for the robots can be found in the Subject Resources page: https://canvas.uts.edu.au/courses/27375/pages/subject-resources?module_item_id=1290469

SafeCo Pick-and-Place Task:

SafeCo wants you to consider a plausible application for a pick-and-place robot that has a gripper. The application must be something outside of the traditional factory (e.g. home, kitchen, office, car, mine), and will involve the manipulation of (an) everyday object(s) in a novel way using at least 1 arm that is given and 1 new one that you create. There are likely to be collisions which your system must be able to detect and avoid. So, your group needs to model within your simulated environment (and/or include) at least 3 forms of safety (e.g. barriers and signage, active workspace sensing, collision detection / avoidance and planning), including a functioning e-stop (both in hardware using an Arduino (or similar) and simulated via a GUI), and avoid simulated robot collisions.

Using Real Hardware OR Simulation Only

All students enrolled in the F2F class need to incorporate a real robot into their demonstration. Only groups where **all** 3 students are officially enrolled in the online class are not expected to use a real robot. Using real robots is a rewarding learning experience. We will continue to bring the robots to the weekly class for supervised use. If you have done the lab inductions and safety prerequisites, you will be able to go to the lab unsupervised whenever there is space and time. There will also be special supervised lab sessions available on the Friday mornings of Weeks 11 and 12. Please note that we will only provide technical support for robots in Fig 1. If you happen to have access to a different robot at UTS (e.g., the Sawyer arm in the HRI lab in CB02.11), you are free to use and include that robot in your assignment. But please note that 41013 tutors probably are unable to support these robots.

Progress Tasks - "Journey before Destination"

Throughout the project's journey, there are several important progress tasks. First is the Week 7 Proposal Submission, a group task where teams discuss their project ideas with a lead tutor and submit project, team, robot and repository details via a Google Form. In Week 9, the Individual Initial Feedback Submission requires each team member to complete a SWMS and Risk Assessment, with everyone, including online students pretending they are using a real robot. Evidence of regular code repository commits are expected, along with a short Spark+ report on team member participation. Finally, in Week 11, a 1-minute group task involves creating a promotional video showcasing the system's purpose, features, and functioning, to be uploaded to YouTube and shared prior to the Week 12 demonstration. These progress tasks collectively monitor and steer the project's development.

Final Submission: Detailed Task Breakdown

Due: Week 12

System Demonstration

Build a simulated model of your chosen arm and environment (based on your chosen scenario).

On the submission day, separate to the videos (submitted the week before), each team needs to actively participate in an online demonstration of their system working both in simulation and, if applicable, on the real robot (students should present video evidence). The simulated system must:

1) Include 2 robot arms that interact. 1 should be an existing robot arm from the Robotics Toolbox and 1 needs to be a new one that you create. Thus, all groups need to model, in simulation, a commercial robot arm **other than** the ones in the Toolbox. There are many robots with different capabilities, so please propose one that is suitable for your application and discuss it with a tutor.
2) Include a MATLAB/Python graphical user interface (GUI) to interact with the system. The GUI should have advanced "teach" functionality that allows jogging the robot. It should include both individual joint movements (like the Toolbox's "teach") plus enable [x,y,z] Cartesian movements. A valid addition is to use a joystick or gamepad to augment and replace mouse GUI button presses.
3) Incorporate a functional estop (both simulated and real) that immediately stops operations. Disengaging the e-stop must not immediately resume the robot system but only *permit* resuming (meaning two actions are necessary to resume). For full marks, your system must be able to recover/resume after an e-stop event. Also, using uiwait, or similar busy "while" loop functionality, to pause everything will be penalised.
4) Place the system in a simulated environment that includes safety hardware (e.g., barriers, warning signs/lights/sirens), and if relevant this may be implemented on the real robot as well and augmented with active sensors (BONUS) where data or signals (other than the e-stop) are passed back to the main program.
5) Incorporate safety functionality:
    a) **To react to an asynchronous stop signal by a user.** The system will stop based upon an action from the user (e.g. simulated (or real) sensing of something/someone entering an unsafe zone).
    b) **To prevent collisions.** When a simulated object (that you make and control) is placed in the path of the robot, it will stop until there is no predicted collision or move to avoid the collision. Active collision avoidance will be marked higher than simply detecting a collision and stopping.
6) Ensure the team's MATLAB/Python code is available on a code repository for tutors to access and download. The code and your understanding will be closely scrutinised during the individual code viva. You are expected to still adhere to a particular code standard (either the one provided, or one chosen by your group).

Final Video

Create a 3-minute (i.e. **exactly** 180-second) professional video. Use real-world footage, simulations, images and diagrams of robot systems to assist in describing your project in detail. Videos should be:

1) interesting to watch (and you should be proud to share with your professional Engineering network later), but definitely not be an amalgamation of unrelated meme videos
2) demonstrate your learning from the subject to solve your novel task,
3) include details about the planning, control, safety, user interfaces, sensing in your system
4) give details of possible extensions, such as sensors, hardware, safety, other robots that would be applicable and to give your system more capabilities

Marking Scheme:

Criteria (task)	**Value**
Proposal Submission **(Due week 7)** (group task) Together with a partner, present/discuss your proposal with the lead tutors. Then the team is to submit the following details via a Google Form[2]: • Names and students' numbers of group members, • Team project title • 100-word description of the intended project • The robot you intend to use and why • The Code repository[3] URL for your code (note if your project is private, please invite tutors to join)	**2/35**
Initial Feedback Submission **(Due week 9)** (individual task) • SWMS and Risk Assessment assuming the robot is real (even if it is only in simulation) (1^{st} attempt is marked, but resubmits are required until adequate) • Evidence of regular commits to repository to show progress • Spark+ report on participation of other team member(s)	**3/35**
1-minute promotion video of your specific project **(Due week 11)** (group task) • Create a 1-minute (exactly 60-second) video promoting your system, include footage and details of the system's purpose, its features and the system working. • Upload to a sharing platform (preferably YouTube), then share the link on the discussion board to everyone.	**5/35**
System Demonstration (group task with the final Spark+ used to distribute these marks):	***15/35***
Demonstration of the new robot with an existing robot completing a specified task during an online (in class time) group presentation (10-15 minutes per group): Path plan between several poses and the final joint state given a unique and safe environment (developed by each group) and the simulated model. Use RMRC, collision avoidance and a GUI where appropriate. Creatively use a real robot that mimics and/or enhances the simulation and application.	*10*
Safety in Demo: (a) System reacts to user emergency stop action (1) GUI e-stop; (1) Hardware e-stop. (**Minus** marks if no e-stop). (b) Trajectory reacts to simulated sensor input (e.g. light curtain) (1) (c) Trajectory reacts to a forced simulated upcoming collision (1) (d) Design a simulated environment with a strategically placed models of appropriate safety equipment (1)	*5*
Final 3-minute video (group task with the final Spark+ used to distribute these marks)	***10/35***
Demonstrate development and learning to solve a problem with a novel robotic solution	*2*
Video has professional presentation and is interesting to watch	*2*
Includes details of 41013 Robotics learning outcomes such as robot modelling, planning and safety, and user interaction with the system.	*4*

[2] Google Form to submit group details of Robotics 41013 Lab Assignment #2 http://goo.gl/c5weiF

[3] There are many code repository options: e.g. Atlassian's BitBucket: http://bitbucket.org/ and Github https://github.com/

Robotics sensing: Ideas for applicable sensors that would (1) give the robot more capability; and (2) Improve the system's safety	*1*
Evidence-based future predictions for robotics in the given scenario	*1*
Final Group Member Peer Feedback Online via Spark+ (individual task) Individual multiplier used to distribute the Demo & Final Video group task marks amongst group members. This task is optional. Only needed if there is a need to distribute group marks in a non-uniform way.	× weight
<u>Total</u>	**<u>Out of 35</u>**
Bonus (1): Up to 2 bonus marks for incorporating additional hardware in your System Demonstration: e.g. for safety, collision detection, an end-effector.	+2/35
Bonus (2): Up to 2 bonus marks for having the system (real or simulated) react to **<u>real RGB-D sensor data</u>** in your System Demonstration. Require a combination of calibration, mapping, object recognition, image processing.	+2/35

The Final Individual Code Viva is a separate assignment based upon the code written in this assignment. Each student will be examined closely on <u>all the MATLAB/Python code in the repository</u> in a viva (i.e., interview). For full marks, assessors can ask any questions about the code, bugs found or additions to the code. No robots or simulations will be used in the viva (just the MATLAB/Python code). Students may request to be examined on only a portion of the code (which they wrote); however, their marks will be reduced accordingly.

FAQ

1. **I'm doing this subject in parallel with Sensor and Control. My group and I are doing a joint project for the two subjects. What are the expectations for 41013? What do I have to demo? Will I get marked on any of the ROS component?**

If you are doing this subject in parallel with Sensor and Control and are considering a joint project for the two subjects, then we will expect the following things for this subject:

- A simulated environment that includes your robots and all the other relevant components that you may have (light curtain, barriers, etc), in MATLAB/Python (similar to Assignment 1). For Python students, since Python is part of ROS ecosystem, please note that your primary simulated world must be in Swift (the simulator that comes with the Python robotics toolbox), **NOT** Gazebo.
- You are required to implement planning and controlling of your robots in MATLAB, i.e., you must use inverse kinematic and trajectory generation, as well as RMRC or visual servoing in MATLAB/Python robotics toolbox.
- You can use MoveIt, OpenCV, PCL or other similar ROS packages for other less important components but please note that they won't be marked or questioned in either the demo or your final viva, **except for hardware e-stop and the bonus RGB-D sensor question.**