

Robotics 41013: Lab Assignment 2



Total Subject Weight: 45%.

Proposal (group): Week 7 – 21:00 Friday 16 April

Initial Feedback Stage (individual): Week 9 Lab Class – 21:00 Monday 26 April

Short Promotion Video (group): Week 11 – 21:00 Friday 14 May

Final System Demonstration (group): Week 12 Lab Class – 18:00 Monday 17 May

Final Video (group): Week 12 – 21:00 Friday 21 May

Final Code Viva (individual): Sometime after week 12 demonstration. Bookings essential (via Airtable)

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 a desktop robot manipulator available for you to test your design on. We have the the robots below at UTS, so if you plan to use a real robot this is the extent. But you are not limited to this selection. You can propose (and simulate) another robot, although tutors reserve the right to discuss/veto proposed robots.

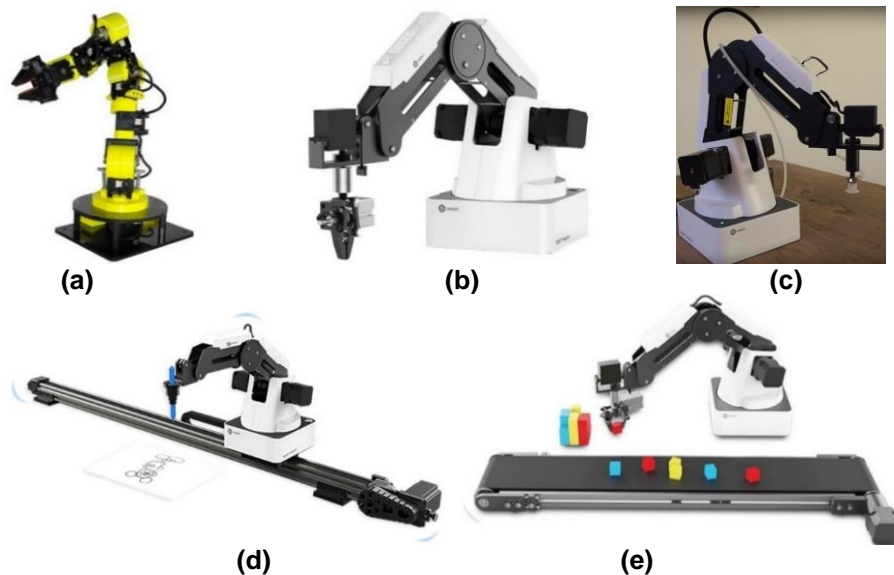


Fig 1. (a) Han's Cute¹ (previously Cyton 300e) with pincer (claw) gripper, (b) Dobot Magician² with pincer gripper, (c) Dobot Magician with suction cap gripper end effector, (d) Dobot Linear rail, (e) Dobot conveyor

¹ Hans Cute Robot: <https://www.hansrobot.net/products/detail-4.html>, In ROS: <http://wiki.ros.org/Robots/Hans-Cute>

² Dobot Magician User Manual: http://www.dobot.cc/downloadcenter/dobot-magician.html?sub_cat=73#sub-download

SafeCo Pick-and-Place Task:

SafeCo wants you to consider a plausible application for a pick-and-place robot which can have 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. There are likely to be possible collisions which your system must be able to detect and avoid. So, in order to pass this section, your group need 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). Also, sensor data, including at least a functioning E-stop (can be simulated via a GUI) and simulated collisions, and other sensors such as cameras or laser that can feed data into your system.

Overview Lab Assignment #2

| Due in Week | Milestone | Worth | Description |
|-------------|----------------------------|-----------|---|
| 7 | Proposal | 2% | Together with a partner, present/discuss your proposal with Gavin or Sheila. Then the team is to submit the following details via a Google Form ³ : <ul style="list-style-type: none">Names and students' numbers of group members,Team project title100-word description of the intended projectThe robot you intend to use and whyThe Code repository⁴ URL for your code (note if you make the project private, please invite tutors to join) |
| 9 | Initial Feedback Stage | 3% | <ul style="list-style-type: none">SWMS and Risk Assessment assuming the robot is real (even if it is only in simulation) (1st attempt is marked, but resubmits are required until adequate)Evidence of regular commits to repository to show progressSpark+ report on participation of other team member(s) |
| 11 | Short Promotion Video | 5% | <ul style="list-style-type: none">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. |
| 12 | Final Demo + Video | 40% + 25% | Final system demonstration (see detailed task breakdown) Final 3-minute video (see detailed task breakdown) |
| After demo | Final individual code viva | 25% | Each student will be examined closely on all the code in the repository 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 will be used in the viva (just the code). Students may request to be examined on only a portion of the code (which they wrote); however, their marks will be reduced accordingly. |

³ Google Form to submit group details of Robotics 41013 Lab Assignment #2 <http://goo.gl/c5weiF>

⁴ There are many code repository options: e.g. Atlassian's BitBucket: <http://bitbucket.org/> and Github <https://github.com/>

Using Real Hardware OR Simulation Only

Prior to 2020, marks were allocated for using real robots in the labs. However, due to COVID, there needs to be the alternative to using real robots available to students. Therefore, if you and your partner are happy to come to UTS, you may choose the normal option and use the real Dobot Magician or Hans Cute. The labs will be available to book time slots throughout the rest of this session. Your marking criteria will expect you to use a real robot. However, if one or more of your team cannot come to UTS to use the real robot, that is fine. But in that case, you will need to choose to model, in simulation, any commercial robot arm other than the ones in the Toolbox, Dobot Magician, Hans Cute or UR3. There are many robots with different capabilities, so please propose one that is suitable for your application and discuss it with a tutor.

Extreme-Difficulty Option (should be a group of 3 and can use the UR3)

There is the option to take on the “Extreme-difficulty” option, and you should work in a group of 3 students and you may choose to use the UR3. This will require that you undertake one of the extended options that is expected to require significant and unassisted use of ROS:

- Mobile Manipulation (e.g. Dobot on a Turtlebot unstructured navigation, pick and manipulate),
- Multirobot Collaboration (e.g. gripper design/manufacture and two UR3 robots executing a handover or working together without direct communication). Sensor integration is a must for this task.
- Another highly challenging option that is negotiated with the tutors.

All students in a group of 3 need to clearly contribute. Please expect additional scrutiny to be given during the individual code Viva for all 3 members of the team if you choose this option.

Final Submission: Detailed Task Breakdown

Due: Week 12.

System Demonstration

Build a simulated model of your chosen arm and environment (based upon your 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 a Matlab 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 instead of GUI-based button presses.

- 2) Incorporate a functional estop (can be simulated or real) that immediately stops operations. Disengaging the estop 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.
- 3) 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 some signals are passed back to the main Matlab program.
- 4) 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.
 - c) To make the robot retreat from a simulated safety symbol using visual servoing and RMRC
- 5) Ensure the team's Matlab code is available on a code repository for tutors to access and download. The code and your understanding will be scrutinised during the individual code viva. You are expected to still adhere to the given code standard.

Video

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

- 1) interesting to watch (and you should be proud to share later),
- 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:

| <u>Criteria (task)</u> | <u>Weight (%)</u> |
|--|-------------------|
| Proposal Submission (Due week 7) (group task) | 2% |
| Initial Feedback Submission (Due week 9) (individual task) | 3% |
| 1-minute promotion video of your specific project (Due week 11) (group task) | 5% |
| System Demonstration (group task with the viva used to weight these marks): | 40% |
| Demonstration of the 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. Depending upon the robot, marks may be scaled to ignore the hardware portion, but only if the hardware is inaccessible due to university-approved reasons (e.g. travel restrictions). | 28% |
| Safety in Demo: (1) System reacts to user's emergency stop action (minus marks if no estop) (2) Trajectory reacts to simulated sensor input (e.g. light curtain) (3) Trajectory reacts to a forced simulated upcoming collision (4) Make the robot retreat from a simulated safety symbol using visual servoing and RMRC | 12% |
| Final 3-minute video (group task with the viva used to weight these marks) | 25% |
| Demonstrate development and learning to solve a problem with a novel robotic solution | 5% |
| Video has professional presentation and is interesting to watch | 5% |
| Includes details of 41013 Robotics learning outcomes such as robot modelling, planning and safety, and user interaction with the system. | 10% |
| Robotics sensing: Ideas for applicable sensors that would (1) give the robot more capability; and (2) Improve the system's safety | 3% |
| Evidence-based future predictions for robotics in the given scenario | 2% |
| Code Viva (individual task) | 25% |
| Total | 100% |
| Bonus (1): Up to 5% bonus marks for incorporating additional hardware in your System Demonstration: e.g. for safety, collision detection, an end-effector. | +5% |
| Bonus (2): Up to 5% bonus marks for having the system (real or simulated) react to real RGB-D sensor data in your System Demonstration. Require a combination of calibration, mapping, object recognition, image processing. | +5% |