UNSW SYDNEY

MTRN4231: Group Project and Presentation

1. Due Dates and Weighting

	Due Date	Weighting
Gateway 1 Report* - Outline Design	17:00 Monday Week 4	10%
Gateway 2 Report^ - Minimum Viable Product	17:00 Monday Week 8	10%
Final Demonstration and Presentation#	Lab session in Week 10	30%
Peer Evaluation (see Sections 4.1.2 and 4.3.4)	17:00 Monday Week 4 17:00 Friday Week 10	-

*Gateway 1 will be assessed in the lab session in Week 4.

^Gateway 2 will be assessed in the lab session in Week 8.

#**Note** the mark for the final demonstration will be scaled by the results of the peer assessment activity – see Section 4.3.4.

2. Purpose

In this assessment, you will have the opportunity to specify, design, build and present your own robotic functional robotic system using the UR5e robotic arms. This assessment aims to:

1. Give you experience using ROS2 in a 'real-world' application.
2. Give you the flexibility to work on a problem or use-case that interests you.
3. Give you experience in working with others in a team to reach a shared objective.
4. Give you the opportunity to apply the design tools and processes you have developed during your degree.
5. Practice engaging with stakeholders to develop and refine a problem specification.
6. Present work to stakeholders and field technical questions from them.

It is also a great opportunity to see what other groups can produce, and how different teams approach different tasks.

3. Description

You are to specify a problem or task to be completed by a robotic arm, developing detailed specifications and metrics for determining the successfulness of any solution to the problem. **These requirements should represent the opinion or view of a 'customer'**. (This term can be interpreted widely – it could be an artist, a stay-at-home dad or a beverage manufacturer, say.)

You are then to **design and implement a robotic system to complete this task**, ensuring you meet the technical requirements given in Section 3.1. You will use ROS2 for communicating with the UR5e robot arms and develop your own custom end-effector. You will work together as a team and use established design processes to design and test your system.

3.1. Technical Requirements

There are five key technologies/components that your robotic system *must* include and demonstrate:

CRICOS Provider Code 00098G

1. Computer vision
2. A custom-built end-effector
3. System visualisation
4. Closed-loop operation

Each of these will be discussed further below.

3.1.1. Computer vision

Your solution must use computer vision in some way. A fixed depth camera on the robotic platform will be provided, but you are not required to use this if you would rather use a camera fixed to the robotic arm, for example. Computer vision could be used for tasks such as object detection, system mapping, and feedback of end-effector state.

3.1.2. A custom-built end-effector

You must build a custom end-effector for the robot. Specifications and CAD files for the quick-release interface fitted to the end effector are available on Moodle. You will also be provided with one Arduino microcontroller and two metal-geared servos and the means to power them will be available on the robots. It is likely that you will want to 3D print at least part of your custom end-effector.

3.1.3. System visualisation

You must develop a visualisation of your solution. This visualisation must show the end effector and the robot arm, and how the arm interacts with the item(s) you are using. This visualisation must run in real-time during system operation, so that its correctness can be verified.

3.1.4. Closed-loop operation

The system must have some element of closed-loop control/adaptation.

As a simple example, consider a simple pick-and-place task. In this case, you could hard-code the positions of the item to be picked up, and the final location for the piece once it is picked up. This implementation does *not* include any closed-loop system. For this simple system, you might feedback by using computer vision to determine the location of a moveable drop-off zone, or using force-feedback on the end effector to ensure that the object has been successfully picked up.

Whatever you choose to include as your closed-loop system, it must be demonstrate-able during the final demonstration. Following on with the simple example above, if the drop-off location is moved, the robot must still be able to successfully complete the pick-and-place task.

3.2. Restrictions

There are key safety restrictions for your robotic implementation:

- The end effector of the robot must be kept away from the three safety planes of the robots (the tabletop, behind the table and the righthand side of the table).
- The implementation will be limited by the joint speed limits programmed into the UR5e – these will not be changed for the assessment
- The project must not involve throwing.

4. Assessment Formats

This assessment is broken down into three parts: two gateways and a final demonstration and presentation. The gateways are for *formative* feedback on your system design and specifications. They are chances to engage with the 'customer' (the lab demonstrators) to ensure your project meets the customer's requirements and shows mastery of the correct skills. The final demonstration and presentation allow you an opportunity to show your working system and present your detailed engineering work to your peers. It also provides them an opportunity to ask for more detail on your system.

4.1. Gateway 1

4.1.1. Client Brief

The purpose of this Gateway is to engage with the 'customer' (the lab demonstrators). You will present your 'client brief' (project specification and success metrics) and your current outline design to the demonstrators. It will give them an opportunity to inspect your requirements and to provide *formative feedback* on your progress. The intention is to ensure you are producing a 'product' (robotic system) that meets the customer's requirements, and that you have a high-level design and a plan for developing this product.

You must submit your client brief to **Moodle** by **17:00 on Monday of Week 4**. Your client brief will be marked during a discussion with your lab demonstrator in your **Week 4 lab session** – it is expected that your whole team attends this discussion. The client brief must contain:

- A clear definition of the problem you intend to solve with the robot.
- An outline of the expected behaviour of the robot.
- Metrics for assessing the performance and success of the robot, e.g. repeatability, speed, accuracy, robustness.
- A draft design of the setup, including the required objects, your expected end-effector design and likely motion paths.
- A draft Gantt chart (or similar time plan) showing the tasks that need to be undertaken, the likely time required for the tasks, when the tasks will be undertaken, and who will undertake them.

The client brief should be **no more than 7 A4 pages** in length. See Section 5.1 for the marking rubric for Gateway 1.

4.1.2. Peer Evaluation

Peer evaluation (sometimes called "Team Evaluation" on Moodle) will be used to scale the Gateway 1 marks to produce an individual mark. Peer evaluation for the demonstration and presentation will be due at **17:00 on Monday of Week 4**.

➢ If you do not complete the peer assessment, you will be **penalised 10%** of the assignment mark (1% of the course mark). This is to ensure that all team members get constructive feedback.

There are three questions that make up the peer assessment:

1. **Relative quantity**: Each team member will rate the relative quantity of effort or contribution from each member of the team, including themselves, toward the preparation of the Gateway 1 submission.
2. **Relative quality**: Each team member will rate the relative quality of the work done by each member of the team, including themselves.
3. **Comments:** There will be two comments fields:
    i. A *compulsory* section asking for comments on your teammates – these will remain private.
    ii. An *optional* section asking for any public anonymous feedback you would like to give to your peers. Remember, you can provide positive as well as constructive feedback.

4.2. Gateway 2 – Minimum Viable Product

The purpose of this Gateway is a final check-in with the 'customer' before making the finishing touches to your implementation. It is expected that you have a final 'minimum viable product' (MVP) at this stage, and you will be expected to show this functioning prototype to the 'customer' (lab demonstrator) and a plan for the eventual completion of the system. The prototype may not be fully integrated yet, but it is expected that you will be able to show that your design will meet all of the technical requirements in Section 3.1. The demonstrators will provide *formative feedback* on your progress, discussing any elements of the design or the plan that need modification.

You must submit your final design report to Moodle by **17:00 on Monday of Week 8**. Your design and time plan will be marked during a discussion with your lab demonstrator in your **Week 8 lab session** - it is expected that your whole team attends this discussion. The design document must contain:

- The final system design, including how the system will meet the technical requirements and an overview of the ROS architecture.
- The final end-effector design, including wiring diagram.
- An updated Gantt chart (or similar time plan) showing the tasks that need to be undertaken, the likely time required for the tasks, when the tasks will be undertaken, and who will undertake them.

The final design document should be **no more than 10 A4 pages** in length. See section 5.2 for the marking rubric for Gateway 2.

4.3. Final Demonstration and Presentation

The final demonstrations and presentations will take place **during lab classes in Week 10**. The first 30 minutes of the lab will be allocated for teams to set up their robots and conduct any last-minute checks. After this, each group will present their work and demonstrate their robot to the rest of the class, adhering to the following time plan:

Component	Time (min)
Presentation	7
Demonstration	10
Questions	5

A random order for teams will be generated on the day. Within the total time allocated to each team, **each member of the team must speak for at least 2 minutes**.

The performance of each team will be judged by the other teams in the lab, the lab demonstrators and the course academics using the rubrics in Sections 5.3.1 and 5.3.2. The marks for this part of the course will be weighted by peer evaluation (see Section 4.3.4).

The best projects will be able to choose prizes from the **Prize Pool** detailed in Section 6.

4.3.1. Presentation

The presentation should be used to:

- Outline the problem statement: What are the ‘customer’ requirements for the system/process?
- Outline your design solution: How have you designed your system to solve the problem or undertake the process?
- Spotlight technical achievements: This is your chance to show off any parts of the project you are particularly proud of, or which are innovative and exciting.
- Show that you meet the technical requirements in Section 3.1.

You should aim for each member of the team to speak for a roughly equal amount of time. The presentations will be marked together with the Q&A session using the rubric in Section 5.3.1.

Time limits will be strictly upheld – your presentation will be stopped at 7 minutes.

4.3.2. Demonstration

You will be given 10 minutes to demonstrate the operation of your robot system. You should demonstrate that your system meets all the technical requirements in Section 3.1, and show that it meets your customer’s requirements. This is also a good opportunity to show off your robot:

- What are the interesting/novel approaches that you used?

- What is new or different about the end effector that you have designed and built?
- Show off how robust your implementation is.

How you use your 10 minutes, and what you do with that time, is up to you. The marking rubric for the demonstration is in Section 5.3.2.

4.3.3. Questions

Questions will follow the demonstration. They will provide an opportunity for fellow students, lab demonstrators and academic staff to ask for clarification or to quiz your team on the technical detail of your implementation. This will be marked together with the presentation according to the rubric in Section 5.3.1.

4.3.4. Peer Evaluation

Peer assessment (sometimes called "Team Evaluation" on Moodle) will be used to scale the demonstration and presentation marks to produce an individual mark. Peer evaluation for the demonstration and presentation will be due at **17:00 on Friday of Week 11**. This peer evaluation will be undertaken at the same time as the peer evaluation for the team portfolio.

- If you do not complete the peer assessment, you will be **penalised 10%** of the assignment mark (3% of the course mark). This is to ensure that all team members get constructive feedback.

There are three questions that make up the peer assessment:

1. **Relative quantity**: Each team member will rate the relative quantity of effort or contribution from each member of the team, including themselves, toward the preparation of the Gateway 1 submission.
2. **Relative quality**: Each team member will rate the relative quality of the work done by each member of the team, including themselves.
3. **Comments:** There will be two comments fields:
   i. A *compulsory* section asking for comments on your teammates – these will remain private.
   ii. An *optional* section asking for any public anonymous feedback you would like to give to your peers. Remember, you can provide positive as well as constructive feedback.

5. Draft Marking Rubrics

5.1. Gateway 1: Outline Design

Area of Assessment	Unsatisfactory	Satisfactory	Excellent
Problem Specification and Customer Requirements	The report lacks a clear problem specification and customer requirements. The chosen problem is not well-defined or lacks clarity.	The report includes a problem specification and customer requirements, but they are not fully developed or may have some room for improvement.	The report provides a well-defined problem specification and comprehensive customer requirements. The chosen problem is clearly articulated, and the requirements demonstrate thorough consideration.
Depth of Understanding (During Lab Discussion)	The team demonstrates a limited understanding of the problem and its intricacies during the lab discussion. Their responses are superficial and lack depth.	The team shows a satisfactory understanding of the problem and its intricacies during the lab discussion. Their responses provide some depth of understanding.	The team exhibits an excellent understanding of the problem and its intricacies during the lab discussion. Their responses are insightful and showcase a deep understanding of the topic, the challenges involved and the limitations of their approach.
Reasonableness of Solution	The solution given in the report lacks a reasonable approach to solving the problem. The chosen solution is impractical, overly complex, or does not align well with the problem statement.	The solution given in the report demonstrates a reasonably practical approach to solving the problem. The chosen solution has some elements of practicality and alignment with the problem statement.	The solution given in the report showcases a highly reasonable and practical approach to solving the problem. The chosen solution is well-designed, feasible, and aligns very well with the problem statement.
Gantt Chart/Time Plan	The Gantt chart or time plan is poorly defined, lacking key tasks, timelines, or responsible team members.	The Gantt chart or time plan is partially developed, with some key tasks, timelines, and responsible team members identified.	The Gantt chart or time plan is well-defined and comprehensive, outlining key tasks, timelines, and responsible team members effectively.
Success Metrics	The report lacks a well-defined set of metrics for assessing the success of the robotic system.	The report includes a set of metrics for assessing the success of the robotic system, but they may not be fully comprehensive or lack clarity in how they will be measured.	The report presents a well-defined set of measurable metrics for assessing the success of the robotic system.

5.2. Gateway 2: Minimum Viable Product

Area of Assessment	Unsatisfactory	Satisfactory	Excellent
Computer Vision	No evidence of a functioning computer vision system.	A computer vision system has been developed.	A working computer vision system has been demonstrated.
Custom-build End Effector	No custom-built end-effector.	An end-effector has been built.	The end-effector has been demonstrated in operation.
System Visualisation	No system visualisation developed.	A limited system visualisation using simplified representations or that does not dynamically update.	A fully functioning visualisation of the system has been demonstrated.
Closed-loop operation	No closed-loop operation developed.	Closed-loop system has been developed.	Closed-loop system has been developed and demonstrated.
Simplicity of Design	The design is overly complex and lacks consideration for simplicity, design for manufacture, and assembly.	The design shows some consideration for simplicity, but there is room for improvement in design for manufacture and assembly.	The design demonstrates a clear focus on simplicity, design for manufacture, and assembly, showing well-thought-out solutions.

5.3. Final Demonstration and Presentation

5.3.1. Presentation and Questions

Competency	Not Yet Competent	Competent	Proficient	Exceptional
Clarity and Engagement in Presentation	The presentation fails to effectively communicate the requirements and solution.	The presentation provides a basic overview of the requirements and solution.	The presentation effectively communicates the requirements and solution.	The presentation is clear, engaging, and effectively communicates the requirements and solution.
Adherence to Technical Requirements (3.1)	The presentation partially explains how the system meets the technical requirements.	The presentation provides a basic understanding of how the system meets the technical requirements.	The presentation demonstrates a clear understanding of how the system meets all the technical requirements.	The presentation accurately and comprehensively explains how the system meets each of the technical requirements.
Knowledge and Understanding	The team members demonstrate insufficient knowledge and understanding during their individual speaking segments.	The team members demonstrate satisfactory knowledge and understanding during their individual speaking segments.	The team members all demonstrate good knowledge and understanding during their individual speaking segments.	The team members all demonstrate in-depth knowledge and understanding during their individual speaking segments.
Team engagement	Only one team member presents.	One team member dominates the presentation.	Each team member contributes to the presentation.	Each team member significantly contributes to the presentation.
Quality of Answers to Questions	The questions are not adequately answered or are ignored.	The questions are answered adequately but may lack depth or clarity.	The questions are adequately answered with clear explanations.	The questions are thoughtfully answered with comprehensive explanations.

5.3.2. Demonstration

Competency	Not Yet Competent	Competent	Proficient	Exceptional
Performance of Robot	The robot performs inadequately or does not achieve the required functionalities.	The robot performs adequately, achieving the basic required functionalities.	The robot performs well, demonstrating the required functionalities effectively.	The robot performs flawlessly, showcasing advanced functionalities and precise execution.
Technical Knowledge	The team demonstrates a lack of understanding of the technical aspects while running through the demonstration.	The team demonstrates limited understanding of the technical aspects while running through the demonstration.	The team demonstrates good understanding of the technical aspects while running through the demonstration.	The team demonstrates excellent understanding of the technical aspects while running through the demonstration.
Complexity and Innovation	The team does not demonstrate complexity or innovation in their solution.	The team demonstrates elements of complexity or innovation in their solution.	The team demonstrates elements of both complexity and innovation in their solution.	The team demonstrates exceptional levels of complexity and innovation in their solution.
Group Involvement	One team member dominates the demonstration.	Each team member contributes to the demonstration.	Each team member contributes significantly to the demonstration.	Each team member contributes significantly to the demonstration, with smooth handovers between team members.
Adherence to Technical requirements (3.1)	The demonstration does not show how the system meets any of the technical requirements.	The demonstration shows how the system partially meets or meets some of the technical requirements.	The demonstration shows how the system meets most of the technical requirements.	The demonstration shows how the system meets or exceeds all the technical requirements.

6. Prizes!

There is a prize pool for winning teams to choose from. The two best-rated projects, as rated by the class, will get to choose from:

1. The chance to spend 5 days with the industrial robot (KUKA KR70) owned and operated by the Art & Design School
2. A tour of Reach Robotics in Glebe. The team will go on a tour of the facilities
3. Chocolate from Mitch