ENEX13004 *Robotics and Autonomous Systems*
Term 1 - 2024

Profile information current as at 19/05/2024 05:22 am

General Information

Overview
This unit will introduce you to robotics and artificial intelligence in autonomous systems. You will learn the principles of robotic manipulators, mobile robots, robotic vision systems, forward kinematics, inverse kinematics of robotic manipulators, and programming. You will program industrial and mobile robots using Python programming language to model robotic systems mathematically, plan their path trajectories and predict and avoid collision with objects in the surrounding environment by fusing information from various sensors. The Robotic Operating System (ROS) is used with Gazebo robotic simulator to build and test various robotic applications. You are introduced to Linux operating system and will learn different ROS commands to test and troubleshoot real-world robotic systems. In addition, you will complete laboratory activities with real robots to strengthen your knowledge before completing a project in Gazebo simulated environment to solve a real-world problem. This unit supports the UN sustainable development goal 9- industry, innovation and infrastructure by discussing sustainable industrialisation using robotic applications.

Details
Career Level: *Undergraduate*
Unit Level: *Level 3*
Credit Points: *6*
Student Contribution Band: *8*
Fraction of Full-Time Student Load: *0.125*

Pre-requisites or Co-requisites
Prerequisites: ENEM12010 Engineering Dynamics AND MATH11219 Applied Calculus.
Important note: Students enrolled in a subsequent unit who failed their pre-requisite unit, should drop the subsequent unit before the census date or within 10 working days of Fail grade notification. Students who do not drop the unit in this timeframe cannot later drop the unit without academic and financial liability. See details in the Assessment Policy and Procedure (Higher Education Coursework).

Offerings For Term 1 - 2024
- Mackay
- Mixed Mode

Attendance Requirements
All on-campus students are expected to attend scheduled classes – in some units, these classes are identified as a mandatory (pass/fail) component and attendance is compulsory. International students, on a student visa, must maintain a full time study load and meet both attendance and academic progress requirements in each study period (satisfactory attendance for International students is defined as maintaining at least an 80% attendance record).

Residential Schools
This unit has a Compulsory Residential School for distance mode students and the details are:
Click here to see your Residential School Timetable.

Website
This unit has a website, within the Moodle system, which is available two weeks before the start of term. It is important that you visit your Moodle site throughout the term. Please visit Moodle for more information.

Class and Assessment Overview

Recommended Student Time Commitment

Each 6-credit Undergraduate unit at CQUniversity requires an overall time commitment of an average of 12.5 hours of study per week, making a total of 150 hours for the unit.

Class Timetable

Regional Campuses
Bundaberg, Cairns, Emerald, Gladstone, Mackay, Rockhampton, Townsville

Metropolitan Campuses
Adelaide, Brisbane, Melbourne, Perth, Sydney

Assessment Overview

1. **Written Assessment**
Weighting: 20%
2. **Written Assessment**
Weighting: 20%
3. **Practical and Written Assessment**
Weighting: 20%
4. **Project (applied)**
Weighting: 40%

Assessment Grading

This is a graded unit: your overall grade will be calculated from the marks or grades for each assessment task, based on the relative weightings shown in the table above. You must obtain an overall mark for the unit of at least 50%, or an overall grade of 'pass' in order to pass the unit. If any 'pass/fail' tasks are shown in the table above they must also be completed successfully ('pass' grade). You must also meet any minimum mark requirements specified for a particular assessment task, as detailed in the 'assessment task' section (note that in some instances, the minimum mark for a task may be greater than 50%). Consult the University's Grades and Results Policy for more details of interim results and final grades.

CQUniversity Policies

All University policies are available on the CQUniversity Policy site.
You may wish to view these policies:

- Grades and Results Policy
- Assessment Policy and Procedure (Higher Education Coursework)
- Review of Grade Procedure
- Student Academic Integrity Policy and Procedure
- Monitoring Academic Progress (MAP) Policy and Procedure – Domestic Students
- Monitoring Academic Progress (MAP) Policy and Procedure – International Students
- Student Refund and Credit Balance Policy and Procedure
- Student Feedback – Compliments and Complaints Policy and Procedure
- Information and Communications Technology Acceptable Use Policy and Procedure

This list is not an exhaustive list of all University policies. The full list of University policies are available on the CQUniversity Policy site.

Previous Student Feedback

Feedback, Recommendations and Responses

Every unit is reviewed for enhancement each year. At the most recent review, the following staff and student feedback items were identified and recommendations were made.

Feedback from Unit coordinator's self reflection

Feedback

The present robotic simulation software employed for the final project demands substantial computational power, thereby constraining the project's complexity. Additionally, its resource-intensive nature poses challenges when running on students' computers.

Recommendation

Should explore and introduce an alternative lightweight robotic simulation software optimised for the hardware available on students' computers.

Unit Learning Outcomes

On successful completion of this unit, you will be able to:

1. Analyse robotic systems and manipulators by applying knowledge of kinematics and coordinate system transformation
2. Develop mathematical models to simulate robotic systems using the Robotic Operating System (ROS)
3. Program industrial robots using industry-standard programming software
4. Develop control systems for robotics sub-systems by extracting meaningful information from sensors using artificial intelligence techniques
5. Develop complete robotic solutions to solve real-life problems by combining theoretical knowledge and practical skills
6. Work individually and collaboratively in teams, communicate professionally by using robotic engineering terminology, symbols, and diagrams.

The Learning Outcomes for this unit are linked with the Engineers Australia Stage 1 Competency Standards for Professional Engineers in the areas of 1. Knowledge and Skill Base, 2. Engineering Application Ability and 3. Professional and Personal Attributes at the following levels:
Intermediate 1.5 Knowledge of engineering design practice and contextual factors impacting the engineering discipline. (LO: 5I) 2.4 Application of systematic approaches to the conduct and management of engineering projects. (LO: 5I) 3.1 Ethical conduct and professional accountability. (LO: 6I) 3.2 Effective oral and written communication in professional and lay domains. (LO: 6I) 3.3 Creative, innovative and pro-active demeanour. (LO: 5I) 3.4 Professional use and management of information. (LO: 5I) 3.6 Effective team membership and team leadership. (LO: 6I) Advanced 1.1 Comprehensive, theory-based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline. (LO: 1A) 1.2 Conceptual understanding of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline. (LO: 1A 2A) 1.3 In-depth understanding of specialist bodies of knowledge within the engineering discipline. (LO: 3A 4A 5A) 1.4 Discernment of knowledge development and research directions within the engineering discipline. (LO: 5A) 2.1 Application of established engineering methods to complex engineering problem solving. (LO: 1A 2A 3A 4I 5A) 2.2 Fluent application of engineering techniques, tools and resources. (LO: 2A 3A 4A 5A) 2.3 Application of systematic engineering synthesis and design processes. (LO: 3I 4I 5A)

Note: LO refers to the Learning Outcome number(s) which link to the competency and the levels: N – Introductory, I – Intermediate and A - Advanced. **Refer to the Engineering Undergraduate Course Moodle site for further information on the Engineers Australia's Stage 1 Competency Standard for Professional Engineers and course level mapping information** **https://moodle.cqu.edu.au/course/view.php?id=1511**

Alignment of Learning Outcomes, Assessment and Graduate Attributes

— N/A Level | • Introductory Level | • Intermediate Level | • Graduate Level | ∘ Professional Level | ∘ Advanced Level

Alignment of Assessment Tasks to Learning Outcomes

Assessment Tasks	Learning Outcomes					
	1	2	3	4	5	6
1 - Written Assessment - 20%	•	•				
2 - Written Assessment - 20%	•	•				
3 - Practical and Written Assessment - 20%			•	•		•
4 - Project (applied) - 40%			•	•	•	•

Alignment of Graduate Attributes to Learning Outcomes

Graduate Attributes	Learning Outcomes					
	1	2	3	4	5	6
1 - Communication						• (Intermediate)
2 - Problem Solving	• (Graduate)	• (Graduate)	• (Graduate)	• (Graduate)	• (Graduate)	
3 - Critical Thinking	• (Graduate)	• (Graduate)	• (Graduate)	• (Intermediate)	• (Graduate)	
4 - Information Literacy						
5 - Team Work					• (Intermediate)	• (Intermediate)
6 - Information Technology Competence	• (Intermediate)	• (Intermediate)	• (Intermediate)	• (Intermediate)	• (Graduate)	
7 - Cross Cultural Competence						
8 - Ethical practice					• (Intermediate)	• (Intermediate)
9 - Social Innovation						
10 - Aboriginal and Torres Strait Islander Cultures						

Textbooks and Resources

Textbooks

There are no required textbooks.

IT Resources

You will need access to the following IT resources:

- CQUniversity Student Email
- Internet
- Unit Website (Moodle)
- A computer with suitable hardware resources (8GB Memory, Intel core i5 and above CPU, Dedicated GPU is desired) and Windows(7 or later) with admin rights to install Virtual Box software.
- Microsoft Teams - camera and microphone
- Virtualbox (Version 7 or later)

Referencing Style

All submissions for this unit must use the referencing style: Harvard (author-date)
For further information, see the Assessment Tasks.

Teaching Contacts

Lasi Piyathilaka Unit Coordinator
l.piyathilaka@cqu.edu.au

Schedule

Week 1 - 04 Mar 2024

Module/Topic	Chapter	Events and Submissions/Topic
Introduction • Introduction to Robotics • Robotic Software Installation • Linux Basics • Introduction to Robotic Operating System (ROS)	• Moodle Week 1 Learning Resources	

Week 2 - 11 Mar 2024

Module/Topic	Chapter	Events and Submissions/Topic
Representing Position and Orientation • Robot Spatial Descriptions and Transformations • Robotic Simulation Environments • ROS Programming with Python • Robotic Coordinate Transformation	• Moodle Week 2 Learning Resources	

Week 3 - 18 Mar 2024

Module/Topic	Chapter	Events and Submissions/Topic
Robotic Manipulators • Robotic Manipulator Modeling • Forward Kinematics • Robotic Arm Simulation	• Moodle Week 3 Learning Resources	

Week 4 - 25 Mar 2024

Module/Topic	Chapter	Events and Submissions/Topic

Module/Topic	Chapter	Events and Submissions/Topic
Motion Planning • Inverse Kinematics (IK) of Robotic Manipulators • Programming with Inverse Kinematic Solvers • Manipulator Motion Planning	• Moodle Week 4 Learning Resources	**Written and Coding Assessment 1** Due: Week 4 Friday (29 Mar 2024) 11:45 pm AEST

Week 5 - 01 Apr 2024

Module/Topic	Chapter	Events and Submissions/Topic
Machine Learning in Robotics • Training Machine Learning Model for visual object detection	• Moodle Week 5 Learning Resources	

Vacation Week - 08 Apr 2024

Module/Topic	Chapter	Events and Submissions/Topic

Week 6 - 15 Apr 2024

Module/Topic	Chapter	Events and Submissions/Topic
Mobile Robots • Modelling • Kinematics	• Moodle Week 6 Learning Resources	

Week 7 - 22 Apr 2024

Module/Topic	Chapter	Events and Submissions/Topic
Robotic Perception • Robotic Sensors • Image Processing Techniques	• Moodle Week 7 Learning Resources	**Written and Coding Assessment 2** Due: Week 7 Friday (26 Apr 2024) 11:45 pm AEST

Week 8 - 29 Apr 2024

Module/Topic	Chapter	Events and Submissions/Topic
Robotic Localisation • Map building • Localisation algorithms	• Moodle Week 8 Learning Resources	Submit project methodology and code flowcharts with the role of each team member

Week 9 - 06 May 2024

Module/Topic	Chapter	Events and Submissions/Topic
Robotic Navigation • Path planning algorithms • Global Planner • Local Planner	• Moodle Week 9 Learning Resources	

Week 10 - 13 May 2024

Module/Topic	Chapter	Events and Submissions/Topic
Lab exercises		Residential School **Practical and Written assessment - Labs** Due: Week 10 Friday (17 May 2024) 11:45 pm AEST

Week 11 - 20 May 2024

Module/Topic	Chapter	Events and Submissions/Topic
Project Help		

Week 12 - 27 May 2024

Module/Topic	Chapter	Events and Submissions/Topic

Project demonstrations		Robotic Competition and Project Demonstration **Robotic Project** Due: Week 12 Friday (31 May 2024) 11:00 pm AEST

Review/Exam Week - 03 Jun 2024

Module/Topic	Chapter	Events and Submissions/Topic

Exam Week - 10 Jun 2024

Module/Topic	Chapter	Events and Submissions/Topic

Term Specific Information

This unit includes a mandatory residential school. Please refer to the timetable for dates and locations.

Assessment Tasks

1 Written and Coding Assessment 1

Assessment Type
Written Assessment

Task Description
This assessment will consist of problems with software implementation using the Robotic Operating System (ROS) and Python programming language. The students are expected to learn the basics of Python programming language and ROS framework in the first 2 weeks of the course. Interactive software tutorials will be provided using ROS to get hands-on experience, and the assessment items will be extensions of tutorials. Therefore, the students are required to complete interactive tutorials before attempting the assessment items. The assessment questions and criteria will be available on the Moodle course page. This assessment will test the student's understanding of coordinate system transformation, mathematical modelling of robotic manipulators and trajectory generation. The students are required to showcase their understanding by developing robotic models in ROS simulation environments and trajectory generation using the Python programming language. The final submission must include the scripts, the simulation outputs and the report. The report must include explanations for code outputs and simulation results.

Assessment Due Date
Week 4 Friday (29 Mar 2024) 11:45 pm AEST

Return Date to Students

Two weeks from submission

Weighting
20%

Minimum mark or grade
30%

Assessment Criteria
The following assessment requirements need to be fulfilled to obtain the full marks for this assessment.
1. Computer codes are properly commented and relevant coding practices are used
2. Developed mathematical models are accurate and output expected results
3. Computer code should not have any compilation errors
4. Software code output should match with the report and simulation results included in the submission
5. All working and assumptions must be shown

Referencing Style

- Harvard (author-date)

Submission
Online

Submission Instructions
One zip folder with the report, codes and simulation outputs. The software code needs to uploaded to the code repository.

Learning Outcomes Assessed

- Analyse robotic systems and manipulators by applying knowledge of kinematics and coordinate system transformation
- Develop mathematical models to simulate robotic systems using the Robotic Operating System (ROS)

2 Written and Coding Assessment 2

Assessment Type
Written Assessment

Task Description
For this assessment, students will be tested on their understanding of inverse kinematics and the application of using machine-learning model for object detection. They will also need to develop mathematical models for multi-link robotic manipulators and simulation models using the Robotic Operating System (ROS) framework. Additionally, students will be expected to create an image dataset and train the YOLO deep learning network for object detection. To complete this assignment, students will need to have a strong grasp of advanced ROS concepts. Weekly interactive tutorials will cover the necessary topics and provide code samples. Students must also prepare a report that includes code outputs, explanations, and simulation results. The final submission must include the scripts, simulation outputs, and report.

Assessment Due Date
Week 7 Friday (26 Apr 2024) 11:45 pm AEST

Return Date to Students

Two weeks from submission

Weighting
20%

Minimum mark or grade
30%

Assessment Criteria

The following assessment requirements need to be fulfilled to obtain the full marks for this assessment.
1. Computer codes are properly commented and relevant coding practices are used
2. Developed mathematical models are accurate and output expected results
3. Computer code should not have any compilation errors
4. Software code output should match with the report and simulation results included in the submission
5. All working and assumptions must be shown

Referencing Style

- Harvard (author-date)

Submission
Online

Submission Instructions
One zip folder with the report, codes and simulation outputs. The software code needs to uploaded to the code repository.

Learning Outcomes Assessed

- Analyse robotic systems and manipulators by applying knowledge of kinematics and coordinate system transformation
- Develop mathematical models to simulate robotic systems using the Robotic Operating System (ROS)

3 Practical and Written assessment - Labs

Assessment Type
Practical and Written Assessment

Task Description
This assessment covers computer lab sessions and practicals with robots and is distributed in four lab assessments (labs 1 to 4). You are required to use specific software and a simulation environment to complete each lab. Most of the labs can be run in the simulation environment. However, you need to attend the mandatory lab sessions that require robot

interaction.
The details of these labs/practicals will be available from the unit Moodle website. The lab and practicals are compulsory (you need to pass these to pass the unit). All students complete the labs at the compulsory residential school. The lab reports have to be submitted individually and no team report will be accepted.

Assessment Due Date
Week 10 Friday (17 May 2024) 11:45 pm AEST

Return Date to Students

Two weeks after each submission

Weighting
20%

Minimum mark or grade
Combined marks of Labs 1 to 4 need to be 50% or more to pass the unit.

Assessment Criteria
The following assessment requirements need to be fulfilled to obtain the full marks for this assessment.

1. Correct answers including plots and figures
2. Readability and flow of the code (should be neat, tidy, and legible)
3. Computer codes should be properly commented and formatted
4. Computer code should not have any compilation errors
5. Software code output should match with the report and simulation results included in the submission
6. All working and assumptions must be shown

Referencing Style

- Harvard (author-date)

Submission
Online

Submission Instructions
One folder including pdf (solutions, any handwritten data, code, and its output) and simulation outputs.

Learning Outcomes Assessed

- Program industrial robots using industry-standard programming software
- Develop control systems for robotics sub-systems by extracting meaningful information from sensors using artificial intelligence techniques
- Work individually and collaboratively in teams, communicate professionally by using robotic engineering terminology, symbols, and diagrams.

4 Robotic Project

Assessment Type
Project (applied)

Task Description
In this project, students will be tasked with programming robotic systems to perform specific tasks within a simulated environment. The purpose of this project is to provide students with the opportunity to gain hands-on experience in programming and robotics. Each student will be awarded points for completing each task, and the final grade will be determined based on the total number of points earned. To ensure that each student fully understands the programming concepts and techniques involved, they are required to submit a project report that fully explains the software code used to solve each task.
The project work is expected to begin from week 5, giving students ample time to familiarise themselves with the software and hardware used in the project. During this time, students will work on the tasks assigned to them, and seek help from the teaching team.
The final project demonstration will take place in week 12, where students will showcase their completed projects. The project output must be demonstrated within the simulated environment, showing that the robotic systems are able to perform the tasks assigned to them. This demonstration will provide students with an opportunity to showcase the knowledge and skills they have acquired throughout the project.

Assessment Due Date
Week 12 Friday (31 May 2024) 11:00 pm AEST

Return Date to Students

Weighting
40%

Minimum mark or grade
50%

Assessment Criteria
The marks will be allocated as follows,
1. Project demonstrations (50%)

- Successfully completion of each task
- Explanation of how each task was solved
- Answering questions from the audience

2. Project report (50%)

- Well-structured project report with appropriate formatting
- Thorough code explanation in the report
- Project timeline and progress
- Critical analysis of the project's success and challenges
- Reflection on learning outcomes and areas for improvement.

Referencing Style

- Harvard (author-date)

Submission
Online

Submission Instructions
Project demonstration will be conducted online via Zoom, and the report should be submitted through Moodle

Learning Outcomes Assessed

- Program industrial robots using industry-standard programming software
- Develop control systems for robotics sub-systems by extracting meaningful information from sensors using artificial intelligence techniques
- Develop complete robotic solutions to solve real-life problems by combining theoretical knowledge and practical skills
- Work individually and collaboratively in teams, communicate professionally by using robotic engineering terminology, symbols, and diagrams.

Academic Integrity Statement

As a CQUniversity student you are expected to act honestly in all aspects of your academic work.

Any assessable work undertaken or submitted for review or assessment must be your own work. Assessable work is any type of work you do to meet the assessment requirements in the unit, including draft work submitted for review and feedback and final work to be assessed.

When you use the ideas, words or data of others in your assessment, you must thoroughly and clearly acknowledge the source of this information by using the correct referencing style for your unit. Using others' work without proper acknowledgement may be considered a form of intellectual dishonesty.

Participating honestly, respectfully, responsibly, and fairly in your university study ensures the CQUniversity qualification you earn will be valued as a true indication of your individual academic achievement and will continue to receive the respect and recognition it deserves.

As a student, you are responsible for reading and following CQUniversity's policies, including the **Student Academic Integrity Policy and Procedure**. This policy sets out CQUniversity's expectations of you to act with integrity, examples of academic integrity breaches to avoid, the processes used to address alleged breaches of academic integrity, and potential penalties.

What is a breach of academic integrity?
A breach of academic integrity includes but is not limited to plagiarism, self-plagiarism, collusion, cheating, contract cheating, and academic misconduct. The Student Academic Integrity Policy and Procedure defines what these terms mean and gives examples.

Why is academic integrity important?
A breach of academic integrity may result in one or more penalties, including suspension or even expulsion from the University. It can also have negative implications for student visas and future enrolment at CQUniversity or elsewhere. Students who engage in contract cheating also risk being blackmailed by contract cheating services.

Where can I get assistance?
For academic advice and guidance, the Academic Learning Centre (ALC) can support you in becoming confident in completing assessments with integrity and of high standard.

What can you do to act with integrity?

Be Honest
If your assessment task is done by someone else, it would be dishonest of you to claim it as your own

Seek Help
If you are not sure about how to cite or reference in essays, reports etc, then seek help from your lecturer, the library or the Academic Learning Centre (ALC)

Produce Original Work
Originality comes from your ability to read widely, think critically, and apply your gained knowledge to address a question or problem