UNSW Course Outline

ZEIT4161 Algorithms for Robotics and Autonomous Systems - 2024

Published on the 22 Feb 2024

General Course Information

Course Code : ZEIT4161
Year : 2024
Term : Semester 1
Teaching Period : Z1
Is a multi-term course? : No
Faculty : UNSW Canberra
Academic Unit : School of Engineering and Technology
Delivery Mode : In Person
Delivery Format : Standard
Delivery Location : UNSW Canberra at ADFA
Campus : UNSW Canberra
Study Level : Undergraduate
Units of Credit : 6

Useful Links

Handbook Class Timetable

Course Details & Outcomes

Course Description

This course will provide engineering, computer science and cyber security students with insight into some of the modern algorithms used in the field of robotics and autonomous systems (RAS). Students will first be exposed to simulation techniques used to test algorithms for RAS.

Topics covered will include methods for multi-robot coordination including formation control and swarming. Application of machine learning to robotics will be explored included reinforcement learning. The course will conclude with lectures on project validation and error analysis demonstrated through a student lab exercise.

Course Aims

This course aims to teach students how to apply and evaluate RAS algorithms, and give them the skills required to design algorithmic variants to solve specific problems. Algorithms for single and multi-agent systems will be covered, including learning, modelling, coordination and formation algorithms. Statistical methods for analysing the performance of algorithms will also be taught. Students will have the opportunity to work as individuals and in groups.

Course Learning Outcomes

Course Learning Outcomes	Engineers Australia - Engineering Technologist (Stage 1)
CLO1 : Apply a systematic approach to the design process of algorithms used for robotics and autonomous systems	• ET1.2 : Conceptual understanding of the, mathematics, numerical analysis, statistics, and computer and information sciences which underpin the technology domain
CLO2 : Conduct simulation, testing and validation of algorithms used in robotic and autonomous systems	• ET1.2 : Conceptual understanding of the, mathematics, numerical analysis, statistics, and computer and information sciences which underpin the technology domain
CLO3 : Implement multi-robot command and control schemes	• ET2.1 : Application of established engineering methods to broadly-defined problem solving within the technology domain
CLO4 : Apply machine learning concepts to the solution of engineering problems in autonomous systems	• ET3.6 : Effective team membership and team leadership

Course Learning Outcomes	Assessment Item
CLO1 : Apply a systematic approach to the design process of algorithms used for robotics and autonomous systems	• Introductory Assessment • Mid-term Test • Lab Assignment 1 • Lab Assignment 2 • Final Exam
CLO2 : Conduct simulation, testing and validation of algorithms used in robotic and autonomous systems	• Introductory Assessment • Mid-term Test • Lab Assignment 1 • Lab Assignment 2 • Final Exam
CLO3 : Implement multi-robot command and control schemes	• Lab Assignment 2 • Final Exam
CLO4 : Apply machine learning concepts to the solution of engineering problems in autonomous systems	• Mid-term Test • Final Exam

Learning and Teaching Technologies

Moodle - Learning Management System

Learning and Teaching in this course

Teaching Strategies

This course will use lectures, tutorials, and labs. New material will be presented in lectures. Tutorials will offer an opportunity for students to consolidate theoretical knowledge and undertake design exercises to support laboratory activities. Lab assignments will provide practical experience in implanting algorithms for RAS. In order to focus on learning algorithms we will use the simulator and commercially available robotics platforms, enabling students to use their prior knowledge in programming (e.g. Python).

Developing Graduate Capabilities

This course contributes to the following Engineers Australia Stage 1 Competencies for Engineers:

- 1.3. In-depth understanding of specialist bodies of knowledge within the engineering discipline
- 2.2. Fluent application of engineering techniques, tools and resources.
- 3.6. Effective team membership and team leadership.

The Learning Management System

Moodle is the Learning Management System used at UNSW Canberra. All courses have a Moodle site which will become available to students at least one week before the start of semester. Please find all help and documentation (including Blackboard Collaborate) at the Moodle Support page.

UNSW Moodle supports the following web browsers:

» Google Chrome 50+
» Safari 10+
** Internet Explorer is not recommended

** Addons and Toolbars can affect any browser's performance.

Operating systems recommended are:

Windows 7, 10, Mac OSX Sierra, iPad IOS10

For further details about system requirements click here.

Log in to Moodle here.

If you need further assistance with Moodle:

For enrolment and login issues please contact:
IT Service Centre
Email: itservicecentre@unsw.edu.au
Phone: (02) 9385-1333
International: +61 2 9385 1333

For all other Moodle issues please contact:
External TELT Support
Email: externalteltsupport@unsw.edu.au
Phone: (02) 9385-3331
International: +61 2 938 53331

Opening hours:
Monday – Friday 7:30am – 9:30 pm
Saturday & Sunday 8:30 am – 4:30pm

Other Professional Outcomes

Program Learning Outcomes:

- ***PLO2*** *appropriately select and apply the mathematical, statistical, programming and computational tools and techniques which underpin engineering.*
- ***PLO5*** *define, conduct experiments on and analyse complex, open-ended problems and apply appropriate methods for their solution.*
- ***PLO6*** *demonstrate proficiency in applying systematic engineering synthesis and design processes, and critically evaluating and effectively communicating the results and implications to all audiences.*
- ***PLO7*** *operate in collaborative environments, as a leader or member of interdisciplinary teams.*

Additional Course Information

This course assumes background knowledge in computer programming.

Study at UNSW Canberra

https://www.unsw.adfa.edu.au/study

Study at UNSW Canberra has lots of useful information regarding:

- Where to get help

- Administrative matters
- Getting your passwords set up
- How to log on to Moodle
- Accessing the Library and other areas.

Referencing Information:

In line with UNSW Canberra policy, undergraduate students must be instructed to use either the APA 7 or Chicago NB (notes and bibliography) referencing conventions.

In this course, students are required to reference following the APA 7 / Chicago NB referencing style. Information about referencing styles is available at: https://guides.lib.unsw.adfa.edu.au/c.php?g=472948&p=3246720

Additional Information as required

CRICOS Provider no. 00098G
The University of New South Wales Canberra.

Assessments

Assessment Structure

Assessment Item	Weight	Relevant Dates	Engineers Australia - Engineering Technologist (Stage 1)
Introductory Assessment Assessment Format: Individual	5%	Start Date: Not Applicable Due Date: Week 3: 11 March - 15 March	• ET1.6 : Understanding of the scope, principles, norms, accountabilities and bounds of sustainable engineering practice in the technology domain • ET2.3 : Application of systematic synthesis and design processes within the technology domain
Mid-term Test Assessment Format: Individual	10%	Start Date: Week 6 Due Date: Week 6: 01 April - 05 April	• ET1.2 : Conceptual understanding of the, mathematics, numerical analysis, statistics, and computer and information sciences which underpin the technology domain • ET3.2 : Effective oral and written communication in professional and lay domains
Lab Assignment 1 Assessment Format: Individual	25%	Start Date: Week 1 Due Date: Week 8: 29 April - 03 May	• ET1.2 : Conceptual understanding of the, mathematics, numerical analysis, statistics, and computer and information sciences which underpin the technology domain • ET1.6 : Understanding of the scope, principles, norms, accountabilities and bounds of sustainable engineering practice in the technology domain • ET2.3 : Application of systematic synthesis and design processes within the technology domain • ET3.5 : Orderly management of self, and professional conduct • ET3.4 : Professional use and management of information
Lab Assignment 2 Assessment	25%	Start Date: Week 9 Due Date: Week 13: 03 June	• ET1.2 : Conceptual understanding of the,

Format: Individual		- 07 June	mathematics, numerical analysis, statistics, and computer and information sciences which underpin the technology domain • ET1.6 : Understanding of the scope, principles, norms, accountabilities and bounds of sustainable engineering practice in the technology domain • ET2.3 : Application of systematic synthesis and design processes within the technology domain • ET3.4 : Professional use and management of information • ET3.6 : Effective team membership and team leadership
Final Exam Assessment Format: Individual	35%	Due Date: During the Exam Period (see Exam Schedule)	• ET1.2 : Conceptual understanding of the, mathematics, numerical analysis, statistics, and computer and information sciences which underpin the technology domain • ET2.3 : Application of systematic synthesis and design processes within the technology domain • ET3.2 : Effective oral and written communication in professional and lay domains

Assessment Details

Introductory Assessment

Assessment Overview

n/a

Course Learning Outcomes

- CLO1 : Apply a systematic approach to the design process of algorithms used for robotics and autonomous systems
- CLO2 : Conduct simulation, testing and validation of algorithms used in robotic and autonomous systems

Detailed Assessment Description

Written feedback will be provided individually, focusing on the progress of algorithm design, working with robots, and coding.

Assignment submission Turnitin type

Not Applicable

Mid-term Test

Assessment Overview

n/a

Course Learning Outcomes

- CLO1 : Apply a systematic approach to the design process of algorithms used for robotics and autonomous systems
- CLO2 : Conduct simulation, testing and validation of algorithms used in robotic and autonomous systems
- CLO4 : Apply machine learning concepts to the solution of engineering problems in autonomous systems

Detailed Assessment Description

This assessment is a Moodle test. It will be done during the Tutorial time of Week 6.

Assignment submission Turnitin type

This is not a Turnitin assignment

Lab Assignment 1

Assessment Overview

Single Agent Algorithms

Course Learning Outcomes

- CLO1 : Apply a systematic approach to the design process of algorithms used for robotics and autonomous systems
- CLO2 : Conduct simulation, testing and validation of algorithms used in robotic and autonomous systems

Detailed Assessment Description

The instruction on this assessment is provided in Moodle. You need to provide your codes with a report. There will be a demonstration during the week 8 lab.

Assignment submission Turnitin type

This is not a Turnitin assignment

Lab Assignment 2

Assessment Overview

Multi-agent algorithms

Course Learning Outcomes

- CLO1 : Apply a systematic approach to the design process of algorithms used for robotics and autonomous systems
- CLO2 : Conduct simulation, testing and validation of algorithms used in robotic and autonomous systems
- CLO3 : Implement multi-robot command and control schemes

Detailed Assessment Description

The instruction on this assessment is provided in Moodle. This can be done individually or in a group. You need to provide your codes with a report. There will be a demonstration during the week 13 lab.

Assignment submission Turnitin type

This is not a Turnitin assignment

Final Exam

Assessment Overview

n/a

Course Learning Outcomes

- CLO1 : Apply a systematic approach to the design process of algorithms used for robotics and autonomous systems
- CLO2 : Conduct simulation, testing and validation of algorithms used in robotic and autonomous systems
- CLO3 : Implement multi-robot command and control schemes
- CLO4 : Apply machine learning concepts to the solution of engineering problems in autonomous systems

Detailed Assessment Description

This will be a 2 hours exam of short answers, multiple-choice, and designs. Students must attain >50% in the final exam to pass the course.

Assignment submission Turnitin type

This is not a Turnitin assignment

Hurdle rules

Students must attain >50% in the final exam to pass the course.

General Assessment Information

Introductory Excercise is Due on Week 3 (15th of March), with 5% weight: Written individualised formative feedback will be provided to support learning.

Use of Generative AI in Assessments

The permitted generative AI tools in

Introductory exercise, mid-term text and final exam

NO ASSISTANCE

It is prohibited to use any software or service to search for or generate information or answers. If its use is detected, it will be regarded as serious academic misconduct and subject to the standard penalties, which may include 00FL, suspension and exclusion.

Lab assignments 1 and 2

PLANNING ASSISTANCE

As this assessment task involves some planning or creative processes, you are permitted to use software to generate initial ideas. However, you must develop or edit those ideas to such a significant extent that what is submitted is your own work, i.e. only occasional AI generated words or phrases may form part of your final submission. It is a good idea to keep copies of the initial prompts to show your lecturer if there is any uncertainty about the originality of your work. [Alternative wording: You are required to submit the original AI generated responses as set out below] (Consider what would be the minimum requirement for you to be satisfied of the originality of the submitted work, and the workload implications of any detailed examination as part of the marking).

If the outputs of generative AI such as ChatGPT form a part of your submission, it will be regarded as serious academic misconduct and subject to the standard penalties, which may include 00FL, suspension and exclusion.

Grading Basis

Standard

Requirements to pass course

All marks obtained for assessment items during the session are provisional. The final mark as published by the university following the assessment review group meeting is **the only official mark.**

- Students must attain >50% in the final exam to pass the course.
- Unless prior arrangement is made with the lecturer or a formal application for special consideration is submitted, a penalty of 5% of the total available mark for the assessment will apply for each day that an assessment item is late up to a maximum of 5 days (120 hours) after which an assessment can no longer be submitted and a grade of 0 will be applied.

Course Schedule

Teaching Week/Module	Activity Type	Content
Week 1 : 26 February - 1 March	Lecture	Introduction to Software Architectures (SA)
	Tut-Lab	• Tutorial: No Tut • Lab: No Lab
Week 2 : 4 March - 8 March	Lecture	Braitenberg Vehicles; Introduction to Python (SA)
	Tut-Lab	• Tutorial: Agent Architectures (KK) • Lab: Braitenberg; Python (SA/ED)
Week 3 : 11 March - 15 March	Lecture	Validation of Algorithms (SA)
	Tut-Lab	Introductory assignment feedback is due on the 15th of March. • Tutorial: Python (KK) • Lab: Data Collection (SA/ED)
Week 4 : 18 March - 22 March	Lecture	Environmental Sensing (SA)
	Tut-Lab	• Tutorial: Statistical Analysis and Visualisation (KK) • Lab: Work on Assignment 1 (SA/ED)
Week 5 : 25 March - 29 March	Lecture	Reinforcement Learning (SA)
	Tut-Lab	• Tutorial: Environmental Sensing (KK) • Lab: Work on Assignment 1 (SA/ED)
Week 6 : 1 April - 5 April	Lecture	Intro to Multi-Agent Systems (SA)
	Tut-Lab	• Tutorial: Test 1 (KK) • Lab: Work on Assignment 1 (SA/ED)
Week 7 : 22 April - 26 April	Other	No Lectures, Labs, and Tuts (ANZAC Day and Military Training Day)
Week 8 : 29 April - 3 May	Lecture	Swarm Intelligence 1 (SA)
	Tut-Lab	• Tutorial: RL (KK) • Lab: Assignment 1 Demonstration Due (SA/ED)
Week 9 : 6 May - 10 May	Lecture	Formation Control (SA)
	Tut-Lab	• Tutorial: Multi-Agent Systems - MAS (KK) • Lab: Multi-Agent Systems or Work on Assignment 2 (SA/ED)
Week 10 : 13 May - 17 May	Lecture	Introduction to VICON (SA)
	Tut-Lab	• Tutorial: VICON (KK) • Lab: VICON or Work on Assignment 2 (SA/ED)
Week 11 : 20 May - 24 May	Lecture	Swarm Intelligence 2 (SA)
	Tut-Lab	• Tutorial: Swarm Intelligence (KK) • Lab: Work on Assignment 2 (SA/ED)
Week 12 : 27 May - 31 May	Lecture	Introduction to Developmental Robotics (SA)
	Tut-Lab	• Tutorial: Developmental Robotics (KK) • Lab: Work on Assignment 2 (SA/ED)
Week 13 : 3 June - 7 June	Lecture	Ethics in RAS - AI (SA)
	Tut-Lab	• Tutorial: No Tut • Lab: Assignment 2 Demonstration Due (SA/ED)

Attendance Requirements

Students are strongly encouraged to attend all classes and review lecture recordings.

General Schedule Information

This is the proposed schedule of topics. The order of topics may change in response to need. We intend that all the lectures and Thursday labs be with Shadi Abpeikar (SA), all Wednesday labs be with Essam Debie (ED), and all the tutorials be with Kathryn Kasmarik (KK), unless any changes occur in response to a need.

Missed Classes:

- There are **no classes (Lectures, Labs, and Tutorials) in Week 7**, due to the **ANZAC Day public holiday and the military training day**.

Course Resources

Prescribed Resources

- Compulsory Equipment: *Sphero BOLT* robot (https://sphero.com.au/products/sphero-bolt). Available direct from Sphero, OR Modern Teaching Aids (https://www.teaching.com.au/) OR on Amazon.
- Compulsory Texts: Nil; Recom Readings: Will be advised progressively in lectures.
- Moodle is the Learning Management System used at UNSW Canberra. All courses have a Moodle site which will become available to students at least one week before the start of the semester. Please find all help and documentation (including Blackboard Collaborate) on the Moodle Support page. UNSW Moodle supports Google Chrome 50+ and Safari 10+. Internet Explorer is not recommended. Addons and Toolbars can affect any browser's performance.

Additional Costs

Academic Integrity and Plagiarism

UNSW has an ongoing commitment to fostering a culture of learning informed by academic integrity. All UNSW staff and students have a responsibility to adhere to this principle of academic integrity. All students are expected to adhere to UNSW's Student Code of Conduct https://www.unsw.edu.au/content/dam/pdfs/governance/policy/accessible/studentcode.pdf

Plagiarism undermines academic integrity and is not tolerated at UNSW. *It is defined as using the words or ideas of others and passing them off as your own, and* can take many forms, from deliberate cheating to accidental copying from a source without acknowledgement.

For more information, please refer to the following:

https://student.unsw.edu.au/plagiarism

Course Evaluation and Development

One of the key priorities in the 2025 Strategy for UNSW is a drive for academic excellence in education. One of the ways of determining how well UNSW is progressing towards this goal is by listening to our students. Students will be

asked to complete the myExperience survey towards the end of this course. Students can also

provide feedback during the semester via direct contact with the lecturer, the “On-going Student Feedback” link in Moodle, Student-Staff Liaison Committee meetings in schools, informal feedback conducted by staff, and focus groups. Student opinions do make a difference. Refer to the Moodle site for this course to see how the feedback from previous students has contributed to the course development.

Important note: Students are reminded that any feedback provided should be constructive and professional and that they are bound by the Student Code of Conduct Policy

https://www.gs.unsw.edu.au/policy/documents/studentcodepolicy.pdf

Staff Details

Position	Name	Email	Location	Phone	Availability	Equitable Learning Services Contact	Primary Contact
Convenor	Shadi Abpeikar		Building 21 Room 371		by appointment (just send me email to make a time)	Yes	Yes
	Kathryn Kasmarik		Building 15 Room 103	5114 5164	by appointment (just send me email to make a time)	Yes	No
Lab staff	Essam Debie				by appointment (just send me email to make a time)	No	No

Other Useful Information

Academic Information

Course Evaluation and Development

One of the key priorities in the 2025 Strategy for UNSW is a drive for academic excellence in education. One of the ways of determining how well UNSW is progressing towards this goal is by listening to our own students. Students will be asked to complete the myExperience survey towards the end of each course.

Students can also provide feedback during the semester via: direct contact with the lecturer, the “On-going Student Feedback” link in Moodle, Student-Staff Liaison Committee meetings in schools, informal feedback conducted by staff, and focus groups (where applicable). Student opinions really do make a difference. Refer to the Moodle site for your course to see how the feedback from previous students has contributed to the course development.

Important note: Students are reminded that any feedback provided should be constructive and

professional and that they are bound by the Student Code of Conduct.

https://www.gs.unsw.edu.au/policy/documents/studentcodepolicy.pdf

Equitable Learning Services (ELS)

Students living with neurodivergent, physical and/or mental health conditions or caring for someone with these conditions may be eligible for support through the Equitible Learning Services team. Equitable Learning Services is a free and confidential service that provides practical support to ensure your mental or physical health conditions do not adversely affect your studies.

Our team of dedicated **Equitable Learning Facilitators** (ELFs) are here to assist you through this process. We offer a number of services to make your education at UNSW easier and more equitable.

Further information about ELS for currently enrolled students can be found at: https://www.student.unsw.edu.au/equitable-learning

Academic Honesty and Plagarism

UNSW has an ongoing commitment to fostering a culture of learning informed by academic integrity. All UNSW staff and students have a responsibility to adhere to this principle of academic integrity. All students are expected to adhere to UNSW's Student Code of Conduct. Find relevant information at: Student Code of Conduct (unsw.edu.au)

Plagiarism undermines academic integrity and is not tolerated at UNSW. It is defined as using the words or ideas of others and passing them off as your own, and can take many forms, from deliberate cheating to accidental copying from a source without acknowledgement.

For more information, please refer to the following:

https://student.unsw.edu.au/plagiarism

Submission of Assessment Tasks

Special Consideration

Special Consideration is the process for assessing and addressing the impact on students of

short-term events, that are beyond the control of the student, and that affect performance in a specific assessment task or tasks.

Applications for Special Consideration will be accepted in the following circumstances only:

- Where academic work has been hampered to a substantial degree by illness or other cause;
- The circumstances are unexpected and beyond the student's control;
- The circumstances could not have reasonably been anticipated, avoided or guarded against by the student; and either:

(i) they occurred during a critical study period and was 3 consecutive days or more duration, or a total of 5 days within the critical study period; or

(ii) they prevented the ability to complete, attend or submit an assessment task for a specific date (e.g. final exam, in class test/quiz, in class presentation)

Applications for Special Consideration must be made as soon as practicable after the problem occurs and at the latest within three working days of the assessment or the period covered by the supporting documentation.

By sitting or submitting the assessment task the student is declaring that they are fit to do so and cannot later apply for Special Consideration (UNSW 'fit to sit or submit' requirement).

Sitting, accessing or submitting an assessment task on the scheduled assessment date, after applying for special consideration, renders the special consideration application void.

Find more information about special consideration at: https://www.student.unsw.edu.au/special/consideration/guide

Or apply for special consideration through your MyUNSW portal.

Late Submission of assessment tasks (other than examinations)

UNSW has a standard late submission penalty of:

- 5% per day,
- capped at five days (120 hours) from the assessment deadline, after which a student cannot submit an assessment, and
- no permitted variation.

Students are expected to manage their time to meet deadlines and to request extensions as

early as possible before the deadline.

Electronic submission of assessment

Except where the nature of an assessment task precludes its electronic submission, all assessments must be submitted to an electronic repository, approved by UNSW or the Faculty, for archiving and subsequent marking and analysis.

Release of final mark

All marks obtained for assessment items during the session are provisional. The final mark as published by the university following the assessment review group meeting is the only official mark.