CSE-4643-6643 AI Robotics (Fall 2024)

Jump to Today

CSE 4643/6643 - AI-Robotics

Tuesday – Thursday 3:30 – 4:45pm

MCCAIN 185

Instructor

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Office Hours

In-person: Tuesday and Wednesday, 2:15 pm - 3:15 pm in Butler Hall 314

Virtual: Tuesday 1:15pm - 2:15pm on WebEx

https://msstate.webex.com/meet/jdc1258

Links to an external site.

Other times by email appointment.

Course Description

Introduction to artificial intelligence methods for mobile robots. Focus on the theory and practice of robot sensing, localization, navigation, and intelligent task execution.

AI-Robotics encompasses all the topics needed to program an artificially intelligent robot for applications involving sensing, planning, control, and learning, operating under real-world uncertainty. This class will focus on these topics in a practical, programming-focused manner. This course provides part of a general education in computer science as well as a foundation for more advanced study of AI and Robotics.

Prerequisites

CSE 2383 (Data Structures and Analysis of Algorithms) or equivalent courses

Class Schedule

Date	Topic	Reading	Assignment
08/22	0a. Intro to Robotics	Jupyter notebook tutorial	

Links to an external site.

Google Colab Tutorial

Links to an external site.		Pre-class Survey

Links to an external site.

Links to an external site. Lab #0 released		
08/27	0b. Intro to ROS	Linux Tutorial

Links to an external site.

ROS Tutorial

Links to an external site.

ROS Courses

Links to an external site.

VirtualBox tutorial

Links to an external site.

VirtualBox tutorial (detailed)

Links to an external site.	Lab #1 released		
08/29	0c. Intro to ROS (continued)	Robot Motion Appendix E	
09/03	1a. Sensors and Actuators		In-class Turtlebot practice
09/05	1b. Sensor Data Fusion		
09/10	1c. 2D Perception		Lab #2 released.
09/12	1c. 2D Perception (continued)		In-class programming assignment #1
09/17	1c. 3D Perception		Lab #1 due.
09/19	1c. 3D Perception (continued)		
09/24	1d. Probability and Robotics	Probabilistic Robotics Chapter 1, 2.2, 2.3. Robot Motion Appendix I	**Quiz 1 due**
09/26	1e. Bayesian Filtering	Probabilistic Robotics Chapter 2.4	

10/01	1f. Kalman Filter	Probabilistic Robotics Chapter 3.1 - 3.3. Robot Motion Chapter 8 Extended Kalman Filter	
Links to an external site.			
10/03	1f. Kalman Filter (continued)		In-class programming assignment #2
10/08	1g. Particle Filter	Probabilistic Robotics Chapter 4.2	Lab #3 released
10/10	2a. Path Planning		
10/15	2a. Path Planning (continued)		Lab #2 due Quadruped robot proposal.
Links to an external site. (due Oct 17. selected teams will be notified by Oct 19)			
10/17	Fall break (MAVS Training Session Recording		
Links to an external site.)			Mid-semester Survey
Links to an external site.			
10/22	2a. Path Planning (continued)	Robot Motion Appendix H.1, H.2	Project Proposal

			due. Presentation signup sheet
Links to an external site.. In-class programming assignment #3			
10/24	2b. Motion Planning	Robot Motion Chapter 3	
10/29	2c. Randomized Planning	Robot Motion Chapter 7.1, 7.2	**Quiz 2 due**
10/31	3a. Potential Fields	Robot Motion Chapter 4	
11/05	3a. Potential Fields (continued)		Lab #4 released
11/07	3b. PID Control	Robot Motion Appendix J	
11/12	4b. Markov Decision Process	Probabilistic Robotics Chapter 15	Lab #3 due Interim Project Report due
11/14	4c. Reinforcement Learning		
11/19	4c. Reinforcement Learning (continued)		In-class programming assignment #4
11/21	5a. Robot Ethics and Cybersecurity		
11/26	Final Project Presentation #1.		**Quiz 3 due**

11/28	Thanksgiving	
12/03	Final Project Presentation #2	Lab #4 due
12/05	Reading Day	
12/11	Final Project Presentation #3 Wednesday 3:30pm - 6:30pm	Final Project Report due Peer Review Form

Links to an external site.

The instructor reserves the right to change the course calendar in order to facilitate instruction. Any such changes will be updated on Canvas and distributed to students via Announcements on Canvas or through the course email list. Additionally, all changes will be discussed in class.

Learning Objectives

The learning objectives for students in this course will be as follows: 1) identify the different types of robotic sensors and actuators 2) given a real-world problem, identify how robots could be used to solve it, and which sensors and actuators should be selected 3) implement and experimentally analyze a variety of artificial intelligence robotic algorithms related to sensing, planning, control, and learning 4) understand how robots can operate in uncertain and unknown environments 5) design and implement software necessary for a robot to complete a complex task

Textbooks

- Probabilistic Robotics - Sebastian Thrun, Wolfram Burgard, Dieter Fox (ebook available)

https://mitpress.mit.edu/books/probabilistic-robotics

Links to an external site.

- Principles of Robot Motion - Choset et al.

https://mitpress.mit.edu/books/principles-robot-motion

Links to an external site.

Additional online readings will be posted on the class schedule on a regular basis.

This course contains materials that are part of the Bulldog Bundle. The digital materials required for this course have been integrated with Canvas and can be found in the B&N First Day Course Materials link in your Canvas course. Please sign into Canvas to access your course and course materials. Students have the option to opt-out of the program each semester if it is not the most cost-efficient option. For the fall semester, students can visit https://www.msstate.edu/bulldogbundle to opt-out of the program between August 1st-August 24th.

In-class Programming Assignments

Four in-class Python programming assignments will be given throughout the semester and is an essential part of understanding the lecture materials. The assignment should be worked on during the corresponding class period (refer to the class schedule above) and submitted before the due date by the end of the day. Students are encouraged to bring their laptops and will have the opportunity to work together with classmates and ask questions. The grade for in-class programming assignments will be given based on participation. The in-class programming sessions will be recorded for the benefit of distance students; distance students also have the option of joining the live WebEx sessions to interact and ask questions. Deadlines for the in-class programming assignments are given in the schedule above.

1. Image processing
2. Kalman filter
3. Path planning
4. Reinforcement learning

Individual Lab Assignments

Four lab assignments in Python and ROS will be given throughout the semester and is an essential part of understanding the lecture materials. Lab assignments consist of multiple sections, some which should be completed by all students, and some which are to be completed only by graduate students (but may be attempted by undergraduate students for extra credit). The assignment should be submitted by the specified due date by the end of the day. Assignments will be graded and returned based on the schedule given above. Students are responsible for assignments turned in on time; even for days when the student has an excused absence.

Unless otherwise specified, assignments will be done individually and each student must hand in their own assignment. It is acceptable, however, for students to collaborate in figuring out solutions and helping each other understand the underlying concepts. When collaborating, the "whiteboard policy" is in effect: You may discuss assignments on a whiteboard, but, at the end of a discussion the whiteboard must be erased, and you must not transcribe or take with you anything that has been written on the board during your discussion. You must be able to reproduce the results solely on your own after any such discussion. Finally, you must report the names of the students you collaborated with on each assignment.

1. Intro to ROS
2. Point cloud obstacle detection
3. Path planning with A*
4. Potential fields

Final Group Project

The course project is an opportunity to explore some of the techniques covered in class and apply them to solve a robotics problem that is of interest. The project topic may be anything related to AI and robotics. Each final project group should consist of 3-5 students. Groups of 1-2 students may be allowed depending on the availability of time slots. Final project groups may consist of only on-campus students, only distance students, or a combination of on-campus students and distance students. As part of the project deliverables, each group will need to submit a project proposal, interim project report, final project report and make a final presentation.

Quizzes

Quizzes represent an opportunity for students to test their understanding and have some indication of their class standing by mid-semester. Quizzes will be open-book and administered through Canvas. The quizzes will consist of multiple-choice questions and will cover material given in the lecture slides, assigned readings, notes, lab assignments, guest lectures, and/or projects. Students may select any 30 minute period within the given one-week period on Canvas to attempt the Quiz.

Acknowledgements

The materials from this class rely on slides and assignments prepared by other instructors, especially Chris Archibald and Sayantani Dutta. Their work is gratefully acknowledged.

Grading

(Undergraduate section)

5% Class participation

10% In-class programming assignments

50% Individual lab assignments

20% Final group project:

- 5% Project proposal
- 5% Interim project report
- 10% Final project report and presentation

15% Quizzes

(Graduate section)

5% Class participation

10% In-class programming assignments

50% Individual lab assignments

20% Final group project:

- 5% Project proposal
- 5% Interim project report
- 10% Final project report and presentation

15% Quizzes

Grading Scale (undergraduate section):

A = 90 – 100 %

B = 80 – 89.9 %

C = 70 – 70.9 %

D = 60 – 69.9 %

F = Below 60 %

Grading Scale (Graduate section):

A = 90 – 100 %

B = 80 – 89.9 %

C = 70 – 70.9 %

D = 60 – 69.9 %

F = Below 60 %

Late assignments: Late assignments will lose 10% per day late (including weekend days), up to a maximum of 50% off.

Add/drop policy: See the Mississippi State University Add/Drop Policy
https://www.uaac.msstate.edu/faq/how-and-when-can-i-adddrop-class/

Attendance Policy: This section is a face-to-face instructional class. Students are expected to attend class regularly and to arrive on time. Although class attendance is mandatory, up to **two** absences are allowed during the semester. Sleeping in class, being late, or leaving early without prior notice may result in an unexcused absence. Each student is responsible for all material and administrative instructions given during the lecture period. Each unexcused absence will result in

one percentage point deducted from the participation grade. Please refer to Academic Operating Policy 12.09, regarding detailed attendance expectations and accommodations.

Distance Students

Video recordings will be provided for distance students to view the lecture sessions asynchronously. Distance students will need to complete labs and quizzes the same way as non-distance students, i.e., submitting them before the deadline via Canvas. Take-home quizzes will not use remote proctoring services such as Honorlock, but all the students must follow Mississippi State University Honor Code. Distance students are allowed to complete the group project presentation remotely. The Participation grade will be assigned based on active participation in posting relevant comments, questions, and answers about the lectures on Canvas Discussions. The in-class programming sessions will be recorded for the benefit of distance students; asynchronous distance students also have the option of joining the live WebEx sessions to follow along, interact and ask questions. In addition, virtual office hours will be held by the instructor every week to enable distance students to get help on their assignments and projects.

(Graduate Students only): Graduate students have the additional requirement that they need to complete at least **two** extra credit problems in total over the 4 individual lab assignments. These extra problems will be indicated in the instructions for each lab assignment and may include implementation of more challenging algorithms, as well as improvements in performance and runtime of existing algorithms. Failure to complete this requirement will result in 5% off the grade for individual lab assignments. This applies both to graduate students in the on-campus section and to graduate students in the distance section.

AI policy: In AI Robotics, students are encouraged to use Generative AI Tools such as ChatGPT to support their work. Students must give credit and cite any AI-generated material according to rules of documentation including in-text citations, quotations, and references. Students must also include the following statement in assignments to indicate use of a Generative AI Tool: "The author acknowledges the use of [Generative AI Tool Name] in the preparation of this assignment for [brainstorming, grammatical correction, citation, etc]."

University syllabus: The Mississippi State University Syllabus contains all policies and procedures that are applicable to every course on campus and online. The policies in the University Syllabus describe the official policies of the University and will take precedence over those found elsewhere. It is the student's responsibility to read and be familiar with every policy. The University Syllabus may be accessed at any time on the Provost website under Faculty and

Student Resources and at https://www.provost.msstate.edu/faculty-student-resources/university-syllabus