ESE 564 — Artificial Intelligence for Robotics

Instructor: Jorge Mendez-Mendez

Spring 2025

1 Lecture

Mondays and Wednesdays, 3:30 pm – 4:50 pm, Frey Hall 222. Attendance is mandatory. During lectures, we will do an overview of the technical contents of the course, tie together the high-level motivation for the ideas we'll cover, and go over concepts in detail. We will additionally do exercises on the whiteboard.

2 Office hours

Tuesdays and Thursdays, 3:30 pm – 5:00 pm, Light Engineering Building, Room 145, or by appointment.

3 Course description

Artificial Intelligence (AI) is intelligence demonstrated by machines, unlike the natural intelligence displayed by humans and animals. Research in AI focuses on the development and analysis of algorithms that learn and perform intelligent behavior with minimal human intervention. This course aims to introduce students some basic techniques and algorithms in AI including probabilistic inference, planning and search, localization, tracking and control, and their applications to robotics. Pre-/Co-requisite: Probability and Random Processes, Linear Algebra, Feedback Control. Success in this course also requires some mathematical fluency with background in linear systems (e.g., ESE 502 or instructor approval) and programming experience (fluent in at least one programming language, e.g., Python and MATLAB). Spring, 3 credits, grading ABCF.

4 Lecture schedule

The following schedule is tentative and subject to change.

	Monday	Wednesday
Week 1	Jan 27 Introduction to robotics	Jan 29 Discrete planning as search (BFS, DFS)
Week 2	Feb 3 Optimal discrete planning (Dijkstra's algorithm)	Feb 5 Heuristic planning (A*)
Week 3	Feb 10 Kinematics – coordinate transforms	Feb 12 Kinematics – 3D rotations
Week 4	Feb 17 Kinematics – forward kinematics	Feb 19 Kinematics – inverse kinematics
Week 5	Feb 24 Geometric perception – cameras, point clouds, and registration	Feb 26 Geometric perception – partial views and outliners
Week 6	Mar 03 Motion planning – obstacles, graphs	Mar 05 Motion planning – discretized search, sampling-based planners, potential fields
Week 7	Mar 10 Control – error dynamics, stability, velocity control	Mar 12 **MIDTERM**
Week 8	Mar 17 **SPRING BREAK**	Mar 19 **SPRING BREAK**
Week 9	Mar 24 Control – torque control, force control, hybrid control	Mar 26 Deep RL – part 1
Week 10	Mar 31 Deep RL – part 2	Apr 02 Deep RL – part 3
Week 11	Apr 07 Deep RL – part 4	Apr 09 Behavior cloning – part 1
Week 12	Apr 14 Behavior cloning – part 2	Apr 16 Deep perception – object recognition and segmentation
Week 13	Apr 21 Deep perception – perceptual representations for manipulation	Apr 23 Task planning (STRIPS, PDDL) – part 1
Week 14	Apr 28 Task planning (STRIPS, PDDL) – part 2	Apr 30 Integrated task and motion planning – part 1
Week 15	May 05 Integrated task and motion planning – part 2	May 07 Hierarchical planning with LLMs

5 Recommended books

There is no unified "AI for robotics" textbook, so we will follow a variety of resources. Here is a collection of materials that I recommend obtaining.

- "Planning Algorithms," by Steven M. LaValle. Available at `https://lavalle.pl/planning/`. *Topics:* Discrete planning, optimal discrete planning, heuristic planning.
- "Robotic Systems (draft)," by Kris Hauser. Available at `https://motion.cs.illinois.edu/RoboticSystems/`. *Topics:* Kinematics.
- "Robotic Manipulation: Perception, Planning, and Control," by Russ Tedrake. Available at `http://manipulation.mit.edu`. *Topics:* Kinematics (primarily the notation), geometric perception, deep perception.
- "Modern Robotics: Mechanics, Planning, and Control," by Kevin M. Lynch and Frank C. Park. Available at `https://hades.mech.northwestern.edu/images/7/7f/MR.pdf`. *Topics:* motion planning, control
- "Reinforcement Learning: An Introduction," by Richard S. Sutton and Andrew G. Barto. Available at `http://incompleteideas.net/book/the-book-2nd.html`. *Topics:* Deep RL.

6 Grading

The following evaluations will take place throughout the semester:

- 15% quizzes: between 1 and 2 quizzes per week, at the end of class. I will keep only the top 75% of your grades (e.g., keep 15 out of 20 quizzes).
- 35% homework: approximately 10 homework assignments, roughly weekly. They will involve a mix of hand-written math and programming.
- 20% midterm: date 03/12/2025
- 30% final: date determined by the registrar's office. (Tentatively 05/19/2025; check `https://www.stonybrook.edu/commcms/registrar/registration/exams.php` for updates.)

Late days Homeworks turned in late will receive a penalty of 20% per day. The full 20% penalty is applied at midnight immediately after the deadline for each assignment. Each student will be granted three automatic 1-day extensions on homework assignments.

Collaboration policy Students are responsible for writing their own quizzes, assignments, and exams. For homework assignments, students are welcome (and encouraged) to discuss problems with one peer, **but each student must write their own assignment wrtieup and code individually**. The peer must be listed at the top of the writeup for each assignment.

7 Student Accessibility Support Center Statement

If you have a physical, psychological, medical, or learning disability that may impact your course work, please contact the Student Accessibility Support Center, Stony Brook Union Suite 107, (631) 632-6748, or at `sasc@stonybrook.edu`. They will determine with you what accommodations are necessary and appropriate. All information and documentation is confidential.

Students who require assistance during emergency evacuation are encouraged to discuss their needs with their professors and the Student Accessibility Support Center. For procedures and information go to the following website: `https://ehs.stonybrook.edu/programs/fire-safety/emergency-evacuation/evacuation-guide-disabilities` and search Fire Safety and Evacuation and Disabilities.

8 Academic Integrity Statement

Each student must pursue his or her academic goals honestly and be personally accountable for all submitted work. Representing another person's work as your own is always wrong. Faculty is required to report any suspected instances of academic dishonesty to the Academic Judiciary. Faculty in the Health Sciences Center (School of Health Technology & Management, Nursing, Social Welfare, Dental Medicine) and School of Medicine are required to follow their school-specific procedures. For more comprehensive information on academic integrity, including categories of academic dishonesty please refer to the academic judiciary website at `http://www.stonybrook.edu/commcms/academic_integrity/index.html`.

9 Critical Incident Management

Stony Brook University expects students to respect the rights, privileges, and property of other people. Faculty are required to report to the Office of Student Conduct and Community Standards any disruptive behavior that interrupts their ability to teach, compromises the safety of the learning environment, or inhibits students' ability to learn. Faculty in the HSC Schools and the School of Medicine are required to follow their school-specific procedures. Further information about most academic matters can be found in the Undergraduate Bulletin, the Undergraduate Class Schedule, and the Faculty-Employee Handbook.