Western Engineering

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
AISE 4470 – Intelligent Robotics

COURSE DESCRIPTION: This course presents an introduction into probabilistic approach to autonomous intelligent robotics. Theory and algorithms for probabilistic localization, mapping, autonomous motion planning, and motion control will be studied. During the course project, students will apply the learned methods and techniques to the design and simulation of algorithms for different autonomous robotics tasks.

ACADEMIC CALENDAR:
https://www.westerncalendar.uwo.ca/Courses.cfm?CourseAcadCalendarID=MAIN_031521_1&SelectedCalendar=Live&ArchiveID=

PRE OR COREQUISITES: Completion of 4th year of AISE program. Unless you have either the requisites for this course or special permission from your Dean to enroll in it, you will be removed from this course and it will be deleted from your record.

ANTIREQUISITES: N/A

CONTACT HOURS: 3 Lecture hours weekly

REQUIRED TEXT: N/A

RECOMMENDED TEXTS:

1. S. Thrun, W. Burgard, and D. Fox "Probabilistic Robotics," MIT Press, 2006. Cost: $90.00
2. R. Murphy, Introduction to AI Robotics, 2nd edition, 2019 Cost: $120.00

RECOMMENDED/ REQUIRED SOFTWARE: MATLAB/Simulink

COURSE MATERIALS: Lecture slides will be posted on course website.

UNITS: SI

COURSE TOPICS AND SPECIFIC LEARNING OUTCOMES: The following table summarizes the course learning outcomes along with CEAB GAIs where the GAIs in bold indicate ones to be measured and reported annually.

1. Introduction: Autonomous Robotic Tasks At the end of this section, students will be able to: a. Define and describe some basic autonomous intelligent robotics tasks
2. Mathematical Preliminaries: Review of Basic Probability Concepts At the end of this section, students will be able to: a. Define and explain basic probability notions including random variables, Gaussian probability distributions, and Bayes rule
3. Recursive State Estimation, Bayes Filters, Gaussian Filters (Kalman, EKF, UKF, IF, EIF) At the end of this section, students will be able to: a. Describe basic probabilistic laws that govern evolution of state and process of measurement in autonomous robotics b. Define and explain the Bayes filter algorithm c. Explain basic principles and implement Gaussian filter algorithms, including Kalman Filter (KF), Extended Kalman Filter (EKF), Unscented Kalman Filter (UKF), Information Filter (IF), and Extended Information Filter (EIF)
4. Nonparametric Filters (Histogram Filter, Particle Filter) At the end of this section, students will be able to: a. Explain basic principles and implement basic non-parametric filter algorithms, including Histogram Filter and Particle Filter
5. Probabilistic Models for Robot Motion and Perception At the end of this section, students will be able to: a. Explain principles and implement basic probabilistic models of robot motion, including velocity motion model and odometry motion model b. Explain basic principles and implement probabilistic beam models of range finders (such as ultrasonic and laser) c. Explain and implement probabilistic feature-based measurement models
6. Robot Localization Algorithms At the end of this section, students will be able to: a. Define robot localization problem b. Explain basic Markov localization algorithm c. Explain and implement Gaussian localization algorithms, including EKF and UKF d. Explain and implement non-parametric localization algorithms, including Grid and Monte-Carlo localization

7. Occupancy Grid Mapping

At the end of this section, students will be able to:

a. Formulate mapping problem
b. Explain and implement basic occupation grid mapping algorithm

8. Simultaneous Localization and Mapping (SLAM)

At the end of this section, students will be able to:

a. Formulate Simultaneous Localization and Mapping (SLAM) problem
b. Explain and implement Extended Kalman Filter (EKF) SLAM algorithm
c. Explain and implement the GraphSLAM algorithm

9. Value Iteration Algorithms and Applications to Robot Planning and Control

At the end of this section, students will be able to:

a. Drive an optimal control policy for a fully observable robotic system using Value Iteration algorithm

EVALUATION:

Name	Worth %	Assigned	Due Date
Project	50%		
Final Examination	50%		

Note that the dates listed above are **tentative** and may be adjusted if needed. Marks will be assigned on the basis of method of analysis and presentation, correctness of solution, clarity and neatness.

COURSE POLICIES: All work submitted must be of professional quality in the requested format. Material that is handed in dirty, illegible, disorganized, or in an unapproved format will be returned to the student for resubmission and the late submission penalty will take effect. An additional penalty of 10% may be deducted for poor grammar, incoherence, or lack of flow in the written reports.

COURSE PROJECT: There will be a course project related to design and simulation of algorithms for different autonomous robotics tasks. For the simulation component of the project, the use of Matlab®/Simulink® environment is recommended. The project consists of 5 (five) steps. Due dates will be announced in class. Project reports should be written individually. To obtain a passing grade in the course, a mark of 50% or more must be achieved on the project component. A project mark < 50% will result in a final course grade of 48% or less.

FINAL EXAMINATION: There will be 24-hour take-home final exam**. To obtain a passing grade in the course, a mark of 50% or more must be achieved on the final examination**. A final examination mark < 50% will result in a final course grade of 48% or less.

LATE SUBMISSION POLICY: Advise the instructor if you are having problems completing the assignment on time prior to the due date of the assignment and be prepared to submit an Academic Consideration Request and provide documentation if requested by the instructor. If you are granted an extension, establish a due date with the instructor. The approval of the Chair of your Department is not required if assignments are completed prior to the last day of classes. Extensions beyond the end of classes must have the consent of the instructor, the department Chair and the Associate Dean, Undergraduate Studies and documentation is mandatory.

Late submissions of project reports will be penalized by 5% of the available marks per day for late submission. Reports submitted more than 5 days late will not be accepted.

ATTENDANCE: Attendance is mandatory for all lectures.