

COURSE OUTLINE

Computer Science/Information Systems 157 Robot Motion Planning

I. Catalog Statement

Computer Science/Information Systems 157 provides an introduction to the art and practice of programming mobile robots using modern programming language(s) such as C++, Java or Python. It uses the context of robot programming to develop skills in software development. Students gain experience specifying open-loop and feedback behaviors, handling RGB input video, range images, tactile sensing, and other robot sensors, and reasoning about the spatial context of navigation and localization tasks. The vast majority of the course experience consists of implementation of and experimentation with these skills through hands-on labs.

Total Lecture Units: 2.0

Total Laboratory Units: 1.0

Total Course Units: 3.0

Total Lecture Hours: 32.0

Total Laboratory Hours: 48.0

Total Laboratory Hours To Be Arranged: 0.0

Total Faculty Contact Hours: 80.0

Recommended preparation: CS/IS 135

II. Course Entry Expectations

Prior to enrolling in the course, the student should be able to:

- analyze a programming task in order to develop and communicate efficient algorithms to implement that task;
- recognize programming problems on a function-by-function basis and develop structured/procedural code based on this approach;
- demonstrate an understanding of object-oriented programming concepts and object-oriented design;
- design, code, and debug basic object-based programs;
- program in the C++ language including use of objects, pointers, and structures.

III. Course Exit Standards

Upon successful completion of the required coursework, the student will be able to:

- implement ground-platform and aerial platform robotic programming;
- write code that will enable a mobile robot handle navigations tasks successfully with the use of sensor data and motion;
- translate human tasks into code for mobile robotics.

IV. Course Content

Total Faculty Contact Hours = 80.0

A. Programming Robot Motions/Actuation (**Lecture 10 hours, Lab 15 Hours**)

1. Ground-platform programming
 - a. Differential-drive geometry and constraints
 - b. Arcade-style vs. individual-wheel control
2. Aerial platform programming
 - a. Strategies for stabilizing motions
 - b. Holonomic robot control
3. Control techniques
 - a. Open-loop control
 - b. Direct-feedback control (servoing)
 - c. State-machine control

B. Processing Sensor Data (**Lecture 10 hours, Lab 15 Hours**)

1. Infrared data (e.g. for line-following or single-range sensing)
2. Tactile (bump) sensing
3. RGB video data
 - a. Color spaces and color definitions
 - b. Region segmentation and image morphology
 - c. Statistical summaries: center of mass and bounding box
4. Range image data
 - a. 2d and 3d estimation of planar surface/wall geometry
 - b. Handling angles without a privileged coordinate system
 - c. 2d segmentation of 3d range data

C. Robotic Spatial Reasoning (**Lecture 12 hours, Lab 18 Hours**)

1. Designing robot tasks through purely reactive control
2. Using state machines to add context to robot tasks
3. Implementing navigation algorithms
 - a. Using human-specified destinations
 - b. Using sensor-specified destinations
 - c. Robust motion planning to handle environmental uncertainty
4. Implementing localization algorithms
 - a. Environment-specific localization
 - b. Monte Carlo techniques for localization

V. Methods of Instruction

The following methods of instruction may be used in the course:

- lecture and demonstration;
- instructor and peer analysis of student work;
- individual instructor-to-student assistance in the class.

VI. Out of Class Assignments

The following out of class assignments may be used in the course:

- individual and/or group project (e.g. develop and deploy software solutions to solve robot challenges).

VII. Methods of Evaluation

The following methods of evaluation may be used in the course:

- quizzes;
- midterm examinations;
- performance-based assessment of student-written programs;
- instructor evaluation of student portfolio work;
- final examination.

VIII. Textbook(s)

Siegwart, Roland, Illah, Nourbakhsh, and Davide Scaramuzza. *Introduction to Autonomous Mobile Robots*. 2nd ed. Cambridge: MIT P, 2011.

13th Grade Textbook Reading Level. ISBN-13: 978-0262015356.

IX. Student Learning Outcomes

Upon successful completion of the required coursework, the student will be able to:

- design and implement programs that solve algorithmic and robotic problems;
- compose software that will control a mobile robot to complete navigation tasks successfully, including the integration of sensing, sensor-data processing, and robot action;
- articulate and mitigate the challenges that distinguish robot programming both from the human performance of tasks and from programmatic solutions to non-robotic tasks.