ECE 4/578: Intelligent Robotics I

Catalog Description

Basic problems of intelligent robotics. Hardware for Artificial Intelligence and Robotics. Formulation and reduction of problems. Tree search. Predicate calculus and resolution method. Methods of formulating and solving problems in logic programming. Fuzzy Logic. Logic programming and artificial intelligence in robot systems. Reasoning by analogy and induction. Associative processors. Also offered for graduate-level credit as ECE 578 and may be taken only once for credit.

Credit hours: 4

Goals

Students will have the ability to use programming and mathematics to formulate and solve problems in robotics. They will learn basic concepts of intelligent robotics and with accompanying laboratory assignments, they will be able to design, program and teach mobile robots, robot arms and humanoid robots.

Prerequisites

ECE 372

Course Coordinator and Committee

Garrison Greenwood (coordinator)
Marek Perkowski
Richard Tymerski

Textbooks

Thomas Braunl, "Embedded Robotics. Mobile Robot Design and Applications with Embedded Systems". Springer, ISBN-13: 978-3540705338, ISBN-10: 3540705333

Gary Bradski and Adrian Kaehler: "Learning OPENCV. Computer Vision with the OpenCV Library." O'Reilly, ISBN: 978-0-596-51613-0.

Saeed B. Niku: "Introduction to Robotics. Analysis, Systems, Applications." Wiley, ISBN : 978-0-470-60446-5

The class webpage includes extensive mandatory material, auxiliary material, examples of problems and examples of projects with project-related documentation of robots, software and tools.

Course Learning Outcomes

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

1. Understand basic concepts of design and programming of mobile robots and robot arms.
2. Design a working robot from commercially available components such as advanced mechanical kits, gears, servos, brackets, cameras, sensors and microcontrollers (such as Raspberry Pi or Arduino).
3. Write software to control the robot, including methods of Computational Intelligence, Machine Learning, kinematics and optimization.
4. Demonstrate and analyze behavior of a robot or group of robots.
5. Document their one-quarter project work in a comprehensive technical report that includes: software manual, user and troubleshooting manual, and theory background.

Topical Outline

- State Machines as controllers of robots.
- Simple hierarchical machines for control and natural language dialog. Behavior versus memory-based actions.
- Braitenberg Vehicles and Behavioral Robotics.
- Examples of mobile robots, robot arms and humanoid robots.
- Fuzzy Logic algebra, fuzzy sets, fuzzy controllers. Examples of using fuzzy logic and other types of logic for mobile robot control to avoid obstacles.
- Expert systems, rule based systems in robotics.
- Genetic Algorithms and Genetic Programming using simplified Lisp language.
- Fundamentals of Machine Learning. Supervised Learning and Decision Trees.
- Evolutionary design of a neural network.
- Interactive Genetic Algorithms for robot motion generation.
- Robot control languages based on regular expressions and probability.
- Simple robot sensors.
- Kinect and introduction to robot vision.
- Mechanical design of mobile robots and robot arms. Basic sensors. Servos, brackets, pulleys, gears.
- Motion generation.
- Mobile robot software, path planning and obstacle avoidance.
- Human-robot Interaction using vision algorithms.
- Teams of mobile robots controlled by ceiling cameras.
- Discussion of projects. Demonstration of robots and robot software produced by the class.

Course Structure

The class meets for two 90-minute lectures plus one two-hour laboratory each week during the term. The grade is based on class participation, weekly reports, final project report, oral presentations, homework assignments and two midterm exams, two hours each. Grading breakdown (i.e. percentage weight for each category) is given to the students at the first lecture and posted on webpage. There are additional meetings with Laboratory Assistant to design simple mobile robots and learn how to program them using ROS and microcontroller boards. The most important component of the final grade is the large project that is done in teams of 1 to 4 people, usually 2 or 3.

Laboratory experiments may become part of the final project. Each student team works group on two out of four experiments. Projects change from year to year and laboratory experiments are selected for each year.

1. Fuzzy logic for mobile robot obstacle avoidance, robot arm or humanoid head..
2. Genetic Algorithm for mobile robot.
3. Integration of mobile robot sensors and control.
4. Robot arm. Grasping and manipulation.

5. Humanoid robot head. Emotional gestures and speech.

Relevant Student Outcomes

The following program outcomes are supported by this course:

(1) An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
(2) An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
(3) An ability to communicate effectively with a range of audiences
(4) An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
(5) An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives

Prepared by Marek Perkowski

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