

ECE 4/579: Intelligent Robotics II

Catalog Description

Sensors. Computer vision hardware. Problems in image processing, vision, manipulation, and planning. Machines for image processing and computer vision. Morphological processors. Manufacturing inspection. Non-numeric computers. Path planning. Localization. Use of reasoning and learning. Applications in scheduling, planning, and assignment. Computer architectures for robotics. Integrated robotic systems for manufacturing. Architectures of comprehensive mobile robots. Robots in health care. System integration. Examples of application. Also offered for graduate-level credit as ECE 579 and may be taken only once for credit.

Credit hours: 4

Goals

Students will have the ability to use mathematics, programming and skills from ECE 478 to formulate and solve robot vision and learning problems. They will program, teach, integrate and analyze vision and sensor fusion algorithms for human-robot interaction and autonomous robot behavior. The emphasis is on robot vision, Machine Learning and integration of vision, learning and behavior for mobile and humanoid robots.

Prerequisites

ECE 478/578

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

George F. Luger, Artificial Intelligence: Structures and Strategies for Complex Problem Solving, Addison-Wesley, ISBN-13: 978-0321545893, ISBN-10: 0321545893

Learning Outcomes

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

1. Understand selected approaches to robot perception and robot learning.
2. Be able to use OpenCV software to analyze images and navigate robots. Obstacle avoidance.
3. Add vision and sensing system to one of robots used in this class: a mobile robot, an arm or a humanoid robot. Use and integrate robot control software with vision algorithms in Matlab or OpenCV.
4. Use Matlab, OpenCV or Orange system to write Machine Learning or search software used as part of the robot system with sensing, motion control and autonomous behavior.
5. Write a comprehensive report about their completed project. Describe robot programming that uses Matlab or OpenCV software for vision and Matlab or Orange for Machine Learning. Python or C++ used for integration. Analyze results, explain the theory and your original ideas used in the project. Some best projects are published.

Topical Outline

- Overview of Computer Vision and Image Processing for various applications.
- Morphological algebra: dilation, erosion, opening and closing. Hit-and-run operators. Applications.
- Thinning and Thickening.
- Blob algorithms.
- Finding shapes, encoding shapes.
- Convolution, filtering, image enhancement.
- Sobel, Canny and other filters. Applications to noise removal.
- Matlab for low-level image processing and robot vision.
- Basics of Machine Learning.
- Occam Razor versus Vapnik's statistical learning theory.
- Decision trees.
- Methodology to evaluate Machine Learning methods.
- Overfitting.
- Random Forests.
- Systems to induce rules.
- Ensembles, bagging and hybrid adaptive systems.
- Support Vector Machines and Support Vector Regression.
- Naïve Bayes and Bayes Networks.
- Principal Component Analysis.
- Integrated vision-learning systems in robotics.
- Tracking and grasping.
- Deep learning algorithm.
- Autonomous cars and robot soccer

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 discuss software and hardware issues of our 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. Graduate students play a leading role as team leaders and presenters.

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. Kinect based human gesture recognition to control a robot. Question-answering.
2. Robot theatre of small biped robots, animation, learning, control.
3. Humanoid robot head. Emotional gestures and speech. Vision based interaction with a human.
4. Robot soccer and mobile robots using ceiling camera.
5. Car safety with frontal camera, obstacle avoidance and fast safety feedback.
6. Music, dance and motion of humanoid robots.

Relevant Program 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 environment, establish goals, plan tasks, and meet objectives

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