ROBOTICS

ROBO513. ROBOT PROGRAMMING AND PERCEPTION. 3.0 Semester Hrs.

In this class students will learn the basics of integrated robot system programming and the design and use of algorithms for robot perception. Students will learn how to use the ROS robot middleware for the design of robot systems for perceiving and navigating the world; develop reinforcement learning based models for perception-informed autonomous navigation; and develop computational models for 3D robot perception and perceptual representation of human data.

Course Learning Outcomes

- 1. Explain the basic concepts in human-centered robotics
- 2. Model and analyze human behaviors for human-robot interaction applications
- 3. Recognize the cutting-edge human-centered robotics research and applications
- 4. Apply the learned knowledge to other fields

ROBO517. INTRODUCTION TO COMPUTER VISION. 3.0 Semester Hrs.

(I) Computer vision is the process of using computers to acquire images, transform images, and extract symbolic descriptions from images. This course provides an introduction to this field, covering topics in image formation, feature extraction, location estimation, and object recognition. Design ability and hands-on projects will be emphasized, using popular software tools. The course will be of interest both to those who want to learn more about the subject and to those who just want to use computer imaging techniques. 3 hours lecture; 3 semester hours. Prerequisite: Undergraduate level knowledge of linear algebra, statistics, and a programming language.

Course Learning Outcomes

- 1. Be able to analyze and predict the behavior of image formation, transformation, and recognition algorithms
- 2. Be able to design, develop, and evaluate algorithms for specific applications
- 3. Be able to use software tools to implement computer vision algorithms
- 4. Communicate (in oral and written form) methods and results to a technical audience

ROBO529. ESTIMATION THEORY AND KALMAN FILTERING. 3.0 Semester Hrs.

Estimation theory considers the extraction of useful information from raw sensor measurements in the presence of signal uncertainty. Common applications include navigation, localization and mapping, but applications can be found in all fields where measurements are used. Mathematic descriptions of random signals and the response of linear systems are presented. The discrete-time Kalman Filter is introduced, and conditions for optimality are described. Implementation issues, performance prediction, and filter divergence are discussed. Adaptive estimation and nonlinear estimation are also covered. Contemporary applications will be utilized throughout the course. Offered Spring semester of odd years. 1.5 hours lecture; 1.5 hours other; 3 semester hours.

Course Learning Outcomes

- Use Bayes' rule to calculate a statistical inference. Given a description of a stochastic process, calculate the joint and conditional probabilities for this process.
- Using the appropriate algorithm, calculate the probability distribution function for the state of a dynamic system with stochastic inputs.
- " Build a model of a dynamic system that includes a probabilistic description of uncertain inputs.
- Design and implement an algorithm to estimate the internal states of a linear system with input signals that are Gaussian stochastic processes.
- Design and implement an algorithm to estimate the internal states of general systems with general stochastic inputs.

ROBO534. ROBOT PLANNING AND MANIPULATION. 3.0 Semester Hrs.

An introduction to planning in the context of robotics covering symbolic and motion planning approaches. Symbolic computation, symbolic domains, and efficient algorithms for symbolic planning; Robot kinematics, configuration spaces, and algorithms for motion planning. Applications of planning will focus on manipulation problems using robot arms.

Course Learning Outcomes

- 1 - Implement algorithms for symbolic computation
- 2 - Construct symbolic planning domains for new scenarios
- 3 - Implement algorithms for symbolic planning via constraint-solving and heuristic search
- 4 - Implement algorithms for sampling-based motion planning
- 5 - Construct kinematic models of robot manipulators
- 6 - Analyze planning algorithms for key properties: correctness, completeness, optimality
- 7 - Evaluate the suitability of different planning approaches and apply appropriate algorithms to new planning scenarios
- 8 - Communicate implementations, analysis, and evaluation in written and oral form

ROBO535. ADVANCED MACHINE LEARNING. 3.0 Semester Hrs.
Machine learning is the study of computer algorithms that improve automatically through experience. Machine learning systems do not have to be programmed by humans to solve a problem; instead, they essentially program themselves based on examples of how they should behave, or based on trial and error experience trying to solve the problem. This course aims at provide students with an understanding of the capabilities of machine learning (especially for deep learning due to its state-of-the-art performance for predicting and understanding data), and the knowledge to formulate the real-world problem to solve it effectively by a combination of computational idea motivations, learning theories, mathematical and optimization backgrounds/tools.

ROBO550. MECHATRONICS. 3.0 Semester Hrs.
A course focusing on implementation aspects of mechatronic and control systems. Significant lab component involving embedded C programming on a mechatronics teaching platform, called a haptic paddle, a single degree-of-freedom force-feedback joystick.
Course Learning Outcomes

- 1. Become proficient in mechanical system modeling, system identification and simulations.
- 2. Develop an understanding of how control theory is applied and implemented in practice.
- 3. Learn fundamentals of and how to use semiconductor devices in mechatronic systems
- 4. Learn the basics of sensor and actuator theory, design, and application
- 5. Gain experience in embedded C programming for mechatronic systems
- 6. Gain experience in research article reading and technical presentations

ROBO565. ADVANCED ROBOT CONTROL. 3.0 Semester Hrs.
The goal of this course is to give the students an introduction to a fundamental working knowledge of the main techniques of intelligent learning-based control and their applications in robotics and autonomous systems. Specific topics include neural network based control, model predictive control, reinforcement learning based control, fuzzy logic control, and human-in-the-loop control.

ROBO567. THEORY AND DESIGN OF ADVANCED CONTROL SYSTEMS. 3.0 Semester Hrs.
This course will introduce and study the theory and design of multivariable and nonlinear control systems. Students will learn to design multivariable controllers that are both optimal and robust, using tools such as state space and transfer matrix models, nonlinear analysis, optimal estimator and controller design, and multi-loop controller synthesis. Offered Spring semester of even years. Prerequisite: EENG417.
Course Learning Outcomes

- 1. define control-oriented problem statements for real-world problems,
- 2. model, analyze, and design controllers and estimators for single-input, single-output (SISO) and multi-input, multi-output (MIMO) systems in time and frequency domains,
- 3. design optimal and robust controllers and estimators for these systems,
- 4. model, analyze, and design controllers for nonlinear systems,
- 5. explain the connection between state-space and transfer function representations of systems and the effects on controller design and analysis
- 6. model, analyze, and design feedback control systems using MATLAB and Simulink in both the time and frequency domains, and
- 7. understand and apply basic educational and learning theories and tools that will enhance your lifelong learning.

ROBO572. ROBOT ETHICS. 3.0 Semester Hrs.
(II) This course explores ethical issues arising in robotics and human-robot interaction through philosophical analysis, scientific experimentation, and algorithm design. Topics include case studies in lethal autonomous weapon systems, autonomous cars, and social robots, as well as higher-level concerns including economics, law, policy, and discrimination. Graduate enrollees will additionally participate in and report on the results of empirical and computational robot ethics research, with the goal of developing publishable works.
Course Learning Outcomes

- 1 - Understand the basic ethical theories, concepts, tools, and frameworks for analyzing the social and ethical ramifications of robotics
- 2 - Be able to critically examine the ethical significance of the use of robotics in daily and technical fields including human-robot interaction, medicine, relationship, military, etc.
- 3 - Develop a critical attitude toward the role of robotics in shaping human society including human perceptions and behaviors
- 4 - Be able to use the theories, concepts, tools, and frameworks learned from this class to critically examine emerging robot ethics issues in the society.
- 5 - Understand the tradeoffs underlying the design of autonomous moral agents.
- 6 - Conduct robot ethics research grounded in both human-subject experimentation and algorithm development.

ROBO576. HUMAN-ROBOT INTERACTION. 3.0 Semester Hrs.
Human-Robot Interaction is an interdisciplinary field at the intersection of Computer Science, Robotics, Psychology, and Human Factors, that seeks to answer a broad set of questions about robots designed to interact with humans (e.g., assistive robots, educational robots, and service robots), such as: (1) How does human interaction with robots differ from interaction with other people? (2) How does the appearance and behavior of a robot change how humans perceive, trust, and interact with that robot? And (3) How can we design and program robots that are natural, trustworthy, and effective? Accordingly, In this course, students will learn (1) how to design interactive robots, (2) the algorithmic foundations of interactive robots; and (3) how to evaluate interactive robots. To achieve these learning objectives, students will read and present key papers from the HRI literature, complete an individual final project tailored to their unique interests and skillsets, and complete a group project in which they will design, pilot, and evaluate novel HRI experiments, with in-class time expected to be split between lecture by the instructor, presentations by students, and either collaborative active learning activities or discussions with researchers in the field Prerequisite: Data Structures, Probability and Statistics or equivalent.
Course Learning Outcomes

- Understand the theoretical foundations and critical application domains of human-robot interaction.
- Employ design techniques to design interactive robots.
- Design human-subject experiments to evaluate interactive robots.
- Perform qualitative and quantitative analysis on the results of human-robot interaction experiments.

ROBO599. INDEPENDENT STUDY. 0.5-6 Semester Hr.
Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Variable credit: 0.5 to 6 credit hours. Repeatable for credit under different topics/experience and maximums vary by department. Contact the Department for credit limits toward the degree.

ROBO707. GRADUATE THESIS / DISSERTATION RESEARCH CREDIT. 1-15 Semester Hr.
Research credit hours required for completion of a Masters-level thesis or Doctoral dissertation. Research must be carried out under the direct supervision of the student's faculty advisor. Variable class and semester hours. Repeatable for credit.