ROBOTICS AND AUTONOMOUS SYSTEMS

The Robotics and Autonomous Systems program targets students that want to engineer and build complex robotics systems that operate with various degrees of autonomy. Students will have the opportunity to learn the theory of and actually develop autonomous robotic systems in multiple domains including transportation systems, medical robotics, internet of things, smart cities, and industrial systems. The program emphasizes a holistic approach to robotics and autonomous systems including dynamics and control, perception and cognition, autonomous decision making, human-robot and robot-robot collaboration, policy and ethics.

Program Committee

David Silberberg, Program Co-Chair
Principal Professional Staff
JHU Applied Physics Laboratory

Louis L. Whitcomb, Program Co-Chair
Professor of Mechanical Engineering
Laboratory for Computational Sensing and Robotics
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- Robotics and Autonomous Systems, Master of Science (https://e-catalogue.jhu.edu/engineering/engineering-professionals/robotics-autonomous-systems/robotics-autonomous-systems-master-science/)

Courses

EN.665.645. Artificial Intelligence for Robotics. 3 Credits.
This course provides an in-depth exploration of artificial intelligence (AI) techniques applied to robotics. Students will gain a comprehensive understanding of the intersection between AI and robotics, covering topics such as perception, planning, control, learning algorithms including deep learning and generative models, and co-operation (swarms). Practical applications of AI in robotics will be emphasized, and students will have hands-on experience with implementing AI algorithms for robotic systems.

EN.665.681. Application of Sensing Systems. 3 Credits.
This course will cover the core concepts and applications of sensing systems. These include problem identification, communication, process control, types of sensors and how they work, sensor data collection techniques, data acquisition protocols, signal processing, system design (low power and mobile), machine learning, and applications including but not limited to smart health, gesture interaction, robotics, and automotive. The course is geared towards giving students direct experience in building sensing systems to act and respond (using machine learning) to information in the environment and solving programming and analytical challenges with data collected from multiple sensors. The course emphasizes an understanding of both data (using systems theory, probability, and simulation), algorithms (using synthetic and real data sets) and hardware (using IoT devices). The assignments weigh conceptual (assessments, readings, discussions, and projects) and practical (labs, problem sets) understanding equally. Prerequisites (AS.110.109 Calculus II, EN.605.206. Introduction to Programming Using Python, and some knowledge of databases and circuits)

EN.665.684. Capstone Robotic Systems Development. 3 Credits.
This course introduces the fundamentals of the Robot Operating System (ROS 2) for building and controlling robotic systems. Key concepts include ROS 2 architecture, communication between nodes, simulation, and software engineering best practices. Topics in ROS 2 architecture cover packages, nodes, topics, services, and actions. Communication topics explore the publisher-subscriber model, message types, and inter-process communication. Simulation topics cover Gazebo, RViz, and other visualization tools to test and visualize robot behaviors. Throughout the course, students will be exposed to the problem-solving skills needed for a career in software and robotics engineering. Through weekly exercises and a final project, students will gain practical experience developing, controlling, and simulating robots using ROS 2.
Prerequisite(s): Algorithms for Data Science EN.685.621, Mathematical Methods For Engineers EN.535.641, Introduction to Robotics EN.605.613, Kinematics & Dynamics of Robots EN.535.630

EN.665.713. Embodied Intelligence: Robotics in Unstructured Worlds. 3 Credits.
Embodied Intelligence is an advanced exploration of AI systems that perceive, act, and learn through direct interaction with the physical world. It combines machine learning, computer vision, robotics, and language technologies (NLP and Generative AI). Unlike traditional AI, which relies on abstract models and symbolic reasoning, this course focuses on intelligence as an emergent property of real-world interaction. By integrating perception, movement, and decision-making, embodied systems develop a richer understanding of their environments and execute tasks with greater adaptability. This course covers key principles of embodied AI, including multimodal sensory processing, behavior-driven intelligence enabled by ML, deep Learning and Generative AI, and robotics in unstructured environments. Students will explore the interplay between perception and action, studying techniques in vision-language navigation, embodied task completion, adaptive control, and learning from experience. Core topics include sensorimotor coordination, real-time decision-making, spatial reasoning, and the role of physical embodiment in shaping AI capabilities. Through hands-on projects, homework and critical discussions, students will gain a deep understanding of how AI systems, especially Generative AI [LLMs, Multi-modal Large Models (MLMs) and World Models (WMs)], can be designed to interact with the physical world. By the end of the course, students will be able to develop intelligent agents that integrate perception, action, and learning to operate effectively in dynamic, real-world settings.
Prerequisite(s): EN.705.643 – Deep Learning Developments with PyTorch

EN.665.723. Multi Robot Systems and Swarm Intelligence. 3 Credits.
This course explores the principles and practical applications of multi-robot systems (MRS) and swarm intelligence (SI), emphasizing the decentralized and autonomous behaviors that drive robotic collaboration. Students will investigate core algorithms inspired by natural systems—like ant colonies and bird flocks—to understand how distributed decision-making and self-organization emerge in robotics. Through simulations and hands-on projects, students will design, implement, and test algorithms for swarm behaviors such as exploration, foraging, and object transport. Key topics include decentralized control, distributed coordination, and autonomous system development, with a focus on environmental perception, self-awareness, and inter-robot communication. Students will gain experience with tools such as Python, ROS 2, and Gazebo, and will apply their knowledge in a capstone project that synthesizes course concepts. The curriculum also addresses the ethical, legal, and societal considerations of deploying robotic swarms in real-world scenarios, including autonomous vehicles, disaster response, and environmental monitoring. By the end of the course, students will be equipped with both the theoretical foundation and practical skills to analyze, design, and implement multi-robot and swarm intelligence systems.
Prerequisite(s): EN.665.645 Artificial Intelligence for Robotics or equivalent proficiency in ROS 2, Python, and Gazebo.

EN.665.801. Independent Study in Robotics & Autonomous Systems I. 3 Credits.
This course permits graduate students in robotics and autonomous systems to work with a faculty mentor to explore a topic in depth or conduct research in selected areas. Requirements for completion include submission of a significant paper or project. Prerequisite(s): Seven program-applicable graduate courses including the four core courses, at least one focus area courses, and two 700-level courses. Students must also have permission of a faculty mentor, the student’s academic advisor, and the program chair

EN.665.802. Independent Study in Robotics & Autonomous Systems II. 3 Credits.
Students wishing to take a second independent study in robotics and autonomous systems should sign up for this course. Prerequisite(s): EN.665.801 Independent Study in Robotics and Autonomous Systems I and permission of a faculty mentor, the student’s academic advisor, and the program chair.