The University Senate of Michigan Technological University

Proposal 29-26

Proposal to Establish a Graduate Certificate in Robotics Engineering

Basic Program Information

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Program/Degree type: Certificate

Program Title: Graduate Certificate in Robotics Engineering

Planned Implementation Date: Fall 2026

Program location/modality: Face to Face

Target student population: New and Current students (Robotics Engineering, Electrical Engineering, Computer Engineering, Mechanical Engineering, Computer Science, Applied Computing).

General description and characteristics of program

The Department of Electrical and Computer Engineering within the College of Engineering (CoE) proposes the establishment of a Graduate Certificate in Robotics Engineering. *The Graduate Certificate program is a building block to the new Master of Science in Robotics Engineering* and serves as a natural progression from the BSc program in Robotics Engineering, which was established in 2020 (see proposal 25-20). The Graduate Certificate builds on the BSc program to prepare graduates for technical leadership roles in the robotics industry and for advanced research in robotics. The addition of this Graduate Certificate fills a gap in Michigan Tech's program offerings that currently exists between electrical, computer, and robotics engineering, as well as mechanical engineering, computer science program, data science, electrical engineering technology, and mechanical engineering technology offerings. Robotics engineering involves the application of these disciplines to the design and development of automated systems across diverse sectors, including manufacturing, healthcare, autonomous vehicles, agriculture, logistics, aerospace, and service industries. The Graduate Certificate in Robotics Engineering will address the growing demand for advanced expertise in designing, developing, and deploying intelligent robotic systems across a variety of

sectors. A 9-credit certificate in Robotics Engineering prepares graduates for diverse opportunities across industries such as manufacturing, healthcare, agriculture, aerospace, and defense. With the rapid growth of automation, there is an increasing demand for skilled professionals

Rationale

The certificate in Robotics Engineering, as one of the credentials in the Department of Electrical and Computer Engineering is proposed for these reasons:

1. To appeal to student interest since currently enrolled undergraduates in Robotics Engineering would have a path for graduate studies in robotics.
2. To strengthen ties with the growing robotics industry as the use of robotics is increasing, driving the need for advanced programs in Robotics Engineering. Globally, robot installations are expected to grow.
3. To support faculty research through a graduate program in Robotics Engineering that will attract and retain robotics faculty, and to enable them to perform the most advanced research.
4. To allow enrollment from other programs as the interdisciplinary nature of the program will allow enrollment of students from Mechanical Engineering, Computer Science, Mechanical Engineering Technology, and Electrical Engineering Technology.

Related programs: within MTU and at other institutions

This program is marginally related to Michigan Tech Graduate Certificate in Industrial Robotics currently housed by the Applied Computing division in the College of Computing. There are, however, notable differences in these two certificates. The Industrial Robotics offers an understanding of the application of robotics systems in an industrial or manufacturing setting. It is an application and hands-on oriented program with focus on industrial robot arms and manipulators. The certificate in Industrial Robotics is designed to develop skills and competencies in operating, programming, and troubleshooting FANUC industrial robots and configuring and setting up the robotic vision systems commonly used to enhance industrial processes.

The Graduate Certificate in Robotics Engineering, on the other hand, focuses on autonomous robotic systems that can operate independently, perceiving their environment, making decisions, and performing tasks without constant human control. Autonomous robotic systems use sensors and artificial intelligence to navigate, adapt, and achieve goals in dynamic environments, from self-driving cars and warehouse robots to drones and robotic surgery systems. Key aspects include real-time data processing, decision-making, and adaptation. The Graduate Certificate in Robotics Engineering answers the question of how we interface robots with other systems, in a congruent manner, using the language of the associated engineering disciplines of mechanical engineering, computer engineering, and electrical engineering. Applications areas include healthcare, transportation, manufacturing and logistics, and public safety.

Projected Enrollment

Projected enrollment is 10-20 students in Year 1, growing to 20-30 by Year 4. Enrollment in the BSc in Robotics Engineering program has grown steadily since its inception, increasing from 33 students in Fall 2021 to 70 in Fall 2022, 87 in Fall 2023, and 103 in Fall 2024. Similar growth is expected at the graduate level with enrollment from domestic and international students.

Specialized Accreditation Requirements

Not Applicable.

Professional Licensure Requirements

Not Applicable.

Curriculum Details

Learning Goal

- **Learning Goal:** Students will apply fundamental principles of robotics engineering to the design, analysis, and implementation of robotic systems that address real-world engineering challenges. Achievement of the learning goal and outcomes will be assessed using multiple direct measures, including:
    - Coursework assessments, such as homework assignments, projects, laboratories, and exams in required core courses.
    - Project-based evaluations, where students demonstrate system-level design, integration, and analysis skills.
    - Capstone project assessment evaluated using a standardized rubric addressing technical rigor, system functionality, analysis, documentation, and presentation.
    - Written technical reports and presentations, used to assess communication and professional practice.

Indirect assessment methods (e.g., student feedback, exit surveys) may be used to supplement direct assessment and inform continuous improvement.

Assessment Plan

The ECE graduate program committee will monitor and evaluate the enrollment and student performance of the new program on an annual basis. Learning goals are tied to milestones in the Master program. The learning goal for the Graduate Certificate corresponds to the successful completion of coursework. Performance indicators and rubrics have been developed and are currently used by our programs.

Curriculum Design

This is a new graduate certificate to be offered in conjunction with the MSc in Robotics engineering, requiring 9 credits.

Total Required Credits: [9 credits]

At least one course from the list below (up to 9 credits)

EE 5531: Introduction to Robotics (3 cr)

EE 5615: AI Engineering Applications (3 cr). Pre-Requisite(s): EE 3180

EE 5532: Sensing and Processing for Robotics (3 cr). Pre-Requisite(s): EE 5522

Elective Coursework (up to 6 credits) of the following (up to 3cr of 4000-level)

EE 4253: Real Time Signal Processing (3 cr) Pre-Requisite(s): EE 4252

EE 4615: AI Engineering Applications (3 cr) Pre-Requisite(s): EE 3180

EE 5XXX: Advanced Robotics (3 cr) Prerequisite: EE 3261 (or ME 4775 or equivalent)

EE 5522: Digital Image Processing (3 cr)

EE 5XXX: Machine Learning for Robotics (3 cr) Prerequisite: EE 4235 or EE 5522 (or equivalent)

CS 5861 - Artificial Intelligence Theory and Applications (3 cr)

CS 5821: Computational Intelligence – Theory and Applications (3 cr)

EE 5841/CS 5841: Machine Learning (3 cr)

ME 5190: Machine Learning for Engineering Applications (3 cr)

EE 5XXX900: Rehabilitation Robotics (3 cr) Prerequisite: EE 3261 (or ME 4775 or equivalent)

EE 5533: Neuromorphic Robotic Systems (3 cr)

EE 5XXX: Cyber-physical system cybersecurity (3 cr)

EE 5XXX: Probabilistic Graphic Models (SLAM)

CS 5740: Development Trusted Software (3 cr) Pre-Requisite(s): CS 4471

HF 4880: Usability Assessments (3 cr)

New Courses Description

The courses listed below are either currently under development or have already been developed and are scheduled to be offered in the upcoming academic year. For example, *Machine Learning for Robotics* will be offered in Fall 2026 under course number EE5900 (CRN 84631). All of the courses listed below are planned to be included in the course binder review process for the 2026–2027 academic year.

Course Title	cr	Description
EE 5xxx Machine Learning for Robotics	3	This course introduces machine learning methods for perception in robotics. Topics include image processing, convolutional neural networks, 3D perception, LiDAR and multi-modal fusion. Fall/Spring semesters. **Prerequisite**: EE 4235 or EE 5522 (or equivalent)
EE5xxx Cyber-Physical Systems Cybersecurity	3	Provides an advanced exploration of cybersecurity principles, vulnerabilities, and defense mechanisms in cyber-physical systems (CPS) that integrate computational intelligence with physical processes. Emphasis is placed on understanding how attacks on cyber components can impact physical operations and system safety in domains such as robotics, autonomous vehicles, smart grids, healthcare devices, and industrial automation Fall/Spring semesters. **Prerequisite**: Graduate students
EE5xxx Rehabilitation Robotics	3	Introduces the principles, technologies, and applications of robotics in rehabilitation and assistive systems. Students will explore how robotic devices can aid physical therapy, motor recovery, and functional assistance for individuals with neurological or physical impairments. Topics include human biomechanics and motor control, sensors and actuators for human–robot interaction, control strategies for assistive devices, wearable exoskeletons, prosthetics, and neurorehabilitation systems. Emphasis is placed on system integration, user-centered design, safety, and clinical considerations in the deployment of rehabilitation robots. Fall/Spring semesters. **Prerequisite**: EE 3261 (or ME 4775 or equivalent)

EE5xxx Advanced Robotics	3	Introduces Rigid body models of robots, motion planning methods including sampling based, trajectory optimizations, state estimation algorithms including linear observers, Kalman filters, feedback control methods including PD, Impedance Control, optimization-based controllers, Differential Dynamic Programming, Lyapunov, and underactuation. Fall/Spring semesters **Prerequisite**: EE 3261 (or ME 4775 or equivalent)
EE5xxx Probabilistic Graphical Models	3	This course provides a unified probabilistic framework for perception, mapping, and localization in robotic systems. Students will learn to represent uncertainty, dependency, and structure using probabilistic graphical models, including Bayesian networks and factor graphs, and apply these models to state estimation, sensor fusion, and SLAM (Simultaneous Localization and Mapping). Fall/Spring semesters **Prerequisite**: EE 3180 (or EE5500)
EE5xxx Swarming Robotics	3	This course explores the principles of using simple robots to work together in a decentralized system, inspired by biological swarms like ants and bees. Course content includes decentralized control, coordination strategies, and emergent behavior. Students will learn to design, simulate, and test collective behaviors like formation control and task allocation, often using tools like Python and ROS 2. Fall/Spring semesters **Prerequisite**: EE 3261 (or ME 4775 or similar course)
EE5xxx Advanced Perception Systems	3	This course addresses the performance of perception systems at both the component and system levels. A primary focus is placed on assessing system robustness in degraded environments, particularly inclement weather. While all sensors relevant to autonomous vehicles are discussed, students will explore advanced techniques for filtering, processing, and evaluating data with an emphasis on radar, lidar, and camera systems (both visible and infrared). The course heavily utilizes unique field data collected in and around Michigan Tech. Fall/Spring semesters **Prerequisite**: None listed. Instructor approval.

Model Schedule

Semester	Course	Credits	Pre-reqs
Spring	EE 5531: Introduction to Robotics	3	
	EE 5532: Sensing and Processing for Robotics	3	
	EE 5615: AI Engineering Applications (sp)	3	EE 3180

Faculty Qualifications

The curriculum vitae of the faculty members is given at the ECE Faculty Listing.

Graduate Faculty serving this program will be the same as the existing MS and PhD degrees in the department of Electrical and Computer Engineering.

Resources Needed

Library and other learning resources needed

No additional library or learning resources are required.

Suitability of existing space, facilities, and equipment

The ECE Department at Michigan Technological University is well equipped with modern research laboratories. Since the department already offers a Master's degree in Electrical and Computer Engineering, no additional equipment is required to implement this proposal.

Program Costs

No additional resources are required. No new costs anticipated for this new graduate certificate program.