Concentration in Robotics

Revision 2025-05-22

Description of the concentration

Robotics is a rapidly expanding field that combines mechanical design, sensing, actuation, and computations. Robotic systems are already transforming industries such as healthcare, manufacturing, and logistics, and have the potential to further improve productivity and quality of life in many areas of society. As an interdisciplinary field, robotics requires a diverse skill set, making it an exciting area of study for engineering students.

The Concentration in Robotics builds upon the fundamentals from the undergraduate engineering curriculum, and offers students the opportunity to focus on a specific subset of robotics. By pursuing this concentration, students will gain in-depth knowledge and skills in areas such as design, computation, perception, path planning, and real-time control, preparing them for careers in industry or research in one of the many areas encompassed by robotics.

The required course in the concentration offers a system-level view of a robotic system, while the additional classes provide students with a deep-dive into the fundamental building blocks of robotics. In addition to the required course, the concentration also includes a required experiential component, where students will apply what they have learned in a practical setting.

The 12-credit concentration is open to all undergraduate engineering students and will be noted on students' official transcripts. It is recommended that students interested in pursuing a Concentration in Robotics declare their concentration as early as possible in their degree program to facilitate course planning, but in no case later than May 1 of a student's junior year.

By pursuing a Concentration in Robotics, students will gain a valuable skill set that is highly sought after in today's job market, and prepare them to meet the current and future needs of society.

Concentration requirements

1. 12 credits plus experiential component
   a. **Required course**
      ENG ME 416 Introduction to Robotics
   b. **Two courses** from any of the list below:
      ENG ME 403★ Atmospheric Flight Mechanics and Control
      ENG ME 404★ Dynamics and Control of Mechanical Systems
      ENG EC 402★ Control Systems
      ENG BE 404★ Modern Control in Biomedical Engineering
      ENG EC 418 Reinforcement Learning
      ENG EC 444 Smart and Connected Systems
      ENG EC 518 Robot Learning
      ENG EC 520 Digital Image Processing and Communication
      ENG EC 535 Introduction to Embedded Systems
      ENG EC 545 Cyber-Physical Systems
      ENG ME 568 Soft Robotic Technologies
      ENG ME 570 Robot Motion Planning
      ENG ME 571 Medical Robotics

      ★Due to the overlap in the material covered in these classes, no more than one can be counted toward the concentration

2. **Experiential component**
   Students are required to complete a well-defined experiential component, which must be clearly related to robotics. The experiential component must be one among the following options:
   - Senior design project.
   - Laboratory research.
   - Internship.
   - Directed study.

   Successful completion of the experiential component requires **all** of the following:
   - Completion of the required course ENG ME 416 **prior** to the start of the experiential component.
   - A proposal delineating the scope of the experiential component must be approved by the Concentration Coordinator, and the Experiential Component Approval form must be submitted to the Undergraduate Records Office.
   - A written summary and a short presentation **after completion** experiential component**.** The summary and presentation must also be approved by the Concentration Coordinator.
   - For group projects, individuals must define and lead their own substantial efforts in the area of robotics.

   Please refer to the dedicated section for further details on the experiential component requirements.

Important Dates

For the deliverables, drafts should be submitted to the Concentration Coordinator for approval, and final versions to the ENG Records Office with a courtesy copy to the Concentration Coordinator.
Concentration declaration
    - May 1 Junior year.
- Experience – senior design
    - October 15: experiential proposal due.
    - April 1: draft deliverables due.
    - April 15: final deliverables due.
- Experience – summer internships
    - May 30: experiential proposal due. Proposal must be approved prior to starting internship.
    - Sept 15: draft deliverables due.
    - Sept 30: final deliverables due.
- Experience – Other, semester-based
    - Within 2 weeks of semester start: proposal due.
    - Within 2 weeks of completion of effort and before Dec 1/April 1: draft deliverables due.
    - Within 4 weeks of completion of effort and before Dec 15/April 15: final deliverables due.

For International Students

International students can use CPT in approved internships for the experience under the concentration. The process for approval is:

1. Declare concentration.
2. Complete ME 416 and identify internships opportunity.
3. Write and submit experiential proposal using provided template example.
4. Submit to ENG Undergraduate Records Office.
5. When approved, the ENG Undergraduate office will approve the Career Development Office application for internship.

Experiential Component Proposal Requirements

For the purpose of the experiential component in this concentration, a system will be considered a robot if it possesses the following three elements:

A. Embodiment: A robot needs to have a physical component (e.g., electromechanical system) that can move in a workspace to perform a task. This component might include the design of the embodiment.
B. Perception: A robot needs to be able to sense the environment and extract information relevant to the task.
C. Control or Planning: A robot needs to have some form of *intelligence* to turn information extracted from the environment into actions. This component can be model-based (e.g., traditional control) or data driven (e.g., based on machine learning).

Students are encouraged to think creatively about the requirements above. For instance, a wind turbine farm (embodiment) can be considered as a (very large) robot if there is a way to sense the incoming wind direction (sensing) and the turbines are adjusted in a coordinated fashion based on the data collected (control). The proposed experience does not need to consider all three aspects as once, and can instead focus on a specific part of the robot; however, the proposal should make clear how the proposed work fits in the larger system.

Proposal requirements

Proposals should be approved before the start of the experiential component. Students are highly encouraged to submit drafts of the proposal to the Concentration Coordinator at least two weeks prior to the deadline in order to allow for the incorporation of feedback and satisfaction of all the requirements.

Proposals must adhere to the following outline (use the bolded terms below as titles in your document):

1. **Heading:** "Concentration in Robotics Experiential Component Proposal" + Title + Your name & major + Name(s), affiliation(s) and email(s) of supervisor(s) + Name(s), major(s) and email(s) of team member(s) (for a group project) + Date
2. **Problem definition:** provide the context and problem definition. In particular
    a. Identify what is the robot used in the project; specifically, identify the three elements above: embodiment, perception, and control or planning. If the proposed work focuses on only one or two of the elements, explain how the other parts are considered.
    b. Identify what capability that will be added to the robot or the task for which it will be used to solve.

3. **Prior work:** Include a short description of the state of the art, such as four or five existing publications or patents that describe relevant algorithms or methods.
4. **Proposed work:** Describe the work you proposed to complete for the experiential component. The work does not need to be highly original, but make sure to discuss where it relies on existing work (see prior work section above), and where it differs. Include a sequence of proposed steps and a planned timeline (it might be a good idea to include a minimum goal and a stretch goal).
5. **Evaluation plan:** Provide performance metrics and criteria to decide what would be deemed success or failure.
6. Figures, tables, and bibliographic references: as appropriate.
7. **Student role:** Required only if the proposed work is part of a group project. Explain how your leading role in the proposed, robotics-related work illustrated above. If multiple students in the group are using the same project as a concentration experiential component, include a table with the names and the leading roles for each student; each student should be responsible for at least one area that has little overlap with the others.

The approval of the proposal will be performed by using the requirements above as a rubric.

Experiential Component Report and Presentation Requirements

Must be submitted and approved after completion of experience (form on website) no later than April 22 of senior year, and must include supervisor's approval via signature on the report.
Submit the following to engrec@bu.edu:

- A copy of the Experiential Component Proposal.
- Summary Approval Form (completed, signed & dated).
- PDF document of report with supervisor's signature (see below).
- PDF document of presentation slides (see below).
- Link to a self-recoded video of your presentation placed on your BU Google Drive (include link in PDF document of presentation slides).

Students are highly encouraged to submit drafts of the proposal to the Concentration Coordinator at least two weeks prior to the deadline in order to allow for the incorporation of feedback and satisfaction of all the requirements.

Report requirements

The report should be at least one page and at most four pages (excluding references), and must follow the same structure as the proposal (with description of the actual work instead of proposed work). The report must be formatted with 1-inch margins and a 12pt serif font (Times, Computer Modern or equivalent); all figures should have meaningful captions.
Please provide specific details on the work performed, highlighting the challenges you encountered and the implemented solutions. For the evaluation part, the report should include results of a simple simulation or real implementation that shows the three components of the robot (embodiment, perception, control or planning) working together. The report may include a section discussing areas for future improvement, but this should constitute no more than 10% of the final report. The approval of the report will be performed by using the requirements above as a rubric.

Presentation and video requirements

The presentation should contain at most 10 slides (excluding animations) and the video recording duration must be 5 minutes or less. The content of the presentation should follow the content of the report. It is highly encouraged to use videos to cover the evaluation component.