Institute of Biomedical Engineering
UNIVERSITY OF TORONTO

Preliminary Syllabus / Course Outline

Robot Foundations & Programming for Biomedical Applications

BME1530H S - Winter 2025

Class Location	MN 3110 (UTM)
Class Time (Lecture/Practical)	Wed, 4:00 PM - 7:00 PM
Course Web Site	https://q.utoronto.ca/courses/372044
Instructor	Lueder Alexander Kahrs
Office Location	DH 3026
Office Hours	Wed, 3:00 PM - 4:00 PM
Telephone	(647)854-3626
E-mail Address	lueder.kahrs@utoronto.ca
Teaching Assistant	Nirmal Pol
Office Hour Location	MN 3110
Office Hours	Wed, 3:00 PM - 4:00 PM
E-mail Address	nirmal.pol@mail.utoronto.ca

Use Piazza through Quercus for all questions and discussions with the instructor, TA, and classmates! If there is an emergency, you can email the instructor by using your UofT address. Please include "BME1530" in the subject line, and your full name and UTORid in the body of the email.

Course Description

The global medical robot market is valued over $20 billion and is in the same ballpark as other robot market sizes (e.g. industrial, household). With a current annual growth rate of over 15%, medical robots will help to bridge lack of skilled professionals in the healthcare sector. Through this course, engineering students will be prepared interacting with robots and develop future innovations in biomedical robotics.

The course covers the foundations of robotics for biomedical engineering. Students will learn about applications that range from biomedical lab automation, robot-assisted surgery, mobile and service robots in hospitals, as well as further smart robot types for healthcare purposes. The practical component of the course will allow students to interact and program collaborative robots in UTM's Robot Teaching Lab.

Students will learn foundational concepts of robotics, i.e. forward and inverse kinematics, dynamics, trajectory generation, motion planning and execution for serial robots. Further on, they will learn to program robot motions in a preplanned, teleoperated and collaborative robot-style fashion. They will be familiarised with state-of-the-art methods like active constraints, admittance control, as well as coordinate system transformations through point-based and image-to-physical registration. In their course project, students have the chance to develop a robot application that is centered around their own research project, towards a lab automation task or hard- and software extensions ranging from designing dedicated endeffectors, integrating sensors, or developing AI-based control methods.

Learning Outcomes:

Upon completing this course through attending the lectures and completing the term test, assignments and robot projects, students will be able to:

- Use forward, velocity, and inverse kinematics to describe robot poses inside the workspace.
- Generate robot trajectories and plan robot motion.
- Follow robot safety rules.
- Perform hands-on interactions with a collaborative, serial robot.
- Implement programs to create robot motions (teleoperated and pre-planned).
- Demonstrate knowledge of various biomedical robot systems and its base methods.
- Design and implement a biomedical robot application.
- Document results of robot experiments.
- Collaborate with other students in jointly using same hardware.
- Learn about the trend in this research area and recent advancements.

Textbooks:

The following books are recommended as reading materials alongside the lecture materials:

[1] Bruno Siciliano, Oussama Khatib, “Handbook of Robotics”, Springer, 2016, https://doi-org.myaccess.library.utoronto.ca/10.1007/978-3-319-32552-1

[2] Mohammad Hossein Abedin Nasab, “Handbook of Robotic and Image-Guided Surgery”, Elsevier, 2019, http://myaccess.library.utoronto.ca/login?url= https://www.sciencedirect.com/book/9780128142455/handbook-of-robotic-and-image-guided-surgery

[3] Yao Guo , Giulio Dagnino , Guang-Zhong Yang, “Medical Robotics”, Springer, 2023, http://myaccess.library.utoronto.ca/login?url= https://link.springer.com/book/10.1007/978-981-99-7317-0

[4] Kevin M. Lynch, Frank C. Park, “Modern Robotics: Mechanics, Planning, and Control”, Cambridge University Press, 2017, https://hades.mech.northwestern.edu/index.php/Modern_Robotics

[5] Stênio de Cássio Zequi, Hongliang Ren, “Handbook of Robotic Surgery” Elsevier, 2024, https://www-sciencedirect-com.myaccess.library.utoronto.ca/book/9780443132711/handbook-of-robotic-surgery