

BME6138: ROBOTICS IN MINIMALLY INVASIVE HEALTHCARE

Effective Term

Semester A 2025/26

Part I Course Overview

Course Title

Robotics in Minimally Invasive Healthcare

Subject Code

BME - Biomedical Engineering

Course Number

6138

Academic Unit

Biomedical Engineering (BME)

College/School

College of Biomedicine (BD)

Course Duration

One Semester

Credit Units

3

Level

P5, P6 - Postgraduate Degree

Medium of Instruction

English

Medium of Assessment

English

Prerequisites

Nil

Precursors

Nil

Equivalent Courses

BME8138 Robotics in Minimally Invasive Healthcare

Exclusive Courses

Nil

Part II Course Details

Abstract

There is a growing demand for minimally invasive or even non-invasive diagnostics and therapeutics in modern healthcare. The application of robotics in healthcare brings benefits to the patients by ameliorating suffering and expediting recovery. **This course will cover the history and the state-of-the-art of the development and deployment of robotic systems in minimally invasive healthcare.** This course will teach the concepts, working principles, constraints, and open challenges in this field. Representative robotic systems will be analysed and compared from the perspectives of human involvement (from teleoperation to AI-powered autonomy), versatility (from disease-specific to general purpose), accessibility (from expensive dedicated systems to low-cost mobile modules) and size scale (from interacting with whole body to interacting with single cells). A library of topics to discuss include da Vinci surgical systems, robotic catheters and endoscopes swallowable capsules lab/organ-on-a-chip devices, AI in healthcare micro/nanorobots, etc.

Course Intended Learning Outcomes (CILOs)

| CILOs | Weighting (if app.) | DEC-A1 | DEC-A2 | DEC-A3 |
|-------|---|--------|--------|--------|
| 1 | Describe the basic concepts and goals of the robotic systems in minimally invasive healthcare. | | x | |
| 2 | Explain the design considerations working principles and applications of representative robotic systems in minimally invasive diagnostics and therapeutics. | x | x | |
| 3 | Interpret the application of AI and machine learning in robotic medical systems. Discuss the cooperation between the software (e.g., AI) and the hardware (e.g., da Vinci). | x | x | |
| 4 | Identify the open challenges and evaluate the candidate solutions. | x | x | x |
| 5 | Apply the system-level integration and candidate strategies to propose a novel robotic healthcare system to address problems derived from real-world challenges. | x | x | x |

A1: Attitude

Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

A2: Ability

Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to real-life problems.

A3: Accomplishments

Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

Learning and Teaching Activities (LTAs)

| LTAs | | Brief Description | CILO No. | Hours/week (if applicable) |
|------|---------|--|---------------|----------------------------|
| 1 | Lecture | Explain the concepts, working principles, designs, and analytical methods related with the robotic systems for minimally invasive healthcare and discuss representative robotic systems. | 1, 2, 3, 4, 5 | 3 hrs/week |

Assessment Tasks / Activities (ATs)

| ATs | CILO No. | Weighting (%) | Remarks ("- for nil entry) | Allow Use of GenAI? | |
|-----|---|---------------|----------------------------|------------------------------|-----|
| 1 | Homework | 1, 2, 3, 4 | 10 | - | No |
| 2 | Quizzes | 1, 2, 3, 4 | 10 | - | No |
| 3 | Presentations/ projects | 4, 5 | 15 | Promote teamwork | Yes |
| 4 | Attendance and performance in classroom | 1, 2, 3, 4 | 5 | Promote interactive learning | Yes |

Continuous Assessment (%)

40

Examination (%)

60

Examination Duration (Hours)

2

Minimum Continuous Assessment Passing Requirement (%)

30

Minimum Examination Passing Requirement (%)

30

Assessment Rubrics (AR)**Assessment Task**

Homework (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

Ability to interpret the basic concepts and methodology of robotic systems for minimally invasive healthcare.

Excellent

(A+, A, A-) High

Good

(B+, B, B-) Significant

Fair

(C+, C, C-) Moderate

Marginal

(D) Basic

Failure

(F) Below marginal level

Assessment Task

Quizzes (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

Ability to understand and analyse the concepts, working principles, and constraints of robotic systems for minimally invasive healthcare.

Excellent

(A+, A, A-) High

Good

(B+, B, B-) Significant

Fair

(C+, C, C-) Moderate

Marginal

(D) Basic

Failure

(F) Below marginal level

Assessment Task

Presentations/ projects (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

Ability to apply the system-level integration of different strategies to propose novel robotic systems to address problems derived from the real-world healthcare challenges.

Excellent

(A+, A, A-) High

Good

(B+, B, B-) Significant

Fair

(C+, C, C-) Moderate

Marginal

(D) Basic

Failure

(F) Below marginal level

Assessment Task

Attendance and performance in classroom (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

Active participation in interactive learning activities during lectures. Active engagement in classroom discussions.

Excellent

(A+, A, A-) High

Good

(B+, B, B-) Significant

Fair

(C+, C, C-) Moderate

Marginal

(D) Basic

Failure

(F) Below marginal level

Assessment Task

Examination (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

Ability to understand basic concepts, working principles, design methods and analysis skills related with robotic systems for minimally invasive healthcare.

Excellent

(A+, A, A-) High

Good

(B+, B, B-) Significant

Fair

(C+, C, C-) Moderate

Marginal

(D) Basic

Failure

(F) Below marginal level

Assessment Task

Homework (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

Ability to interpret the basic concepts and methodology of robotic systems for minimally invasive healthcare.

Excellent

(A+, A, A-) High

Good

(B+, B) Significant

Marginal

(B-, C+, C) Basic

Failure

(F) Below marginal level

Assessment Task

Quizzes (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

Ability to understand and analyse the concepts, working principles, and constraints of robotic systems for minimally invasive healthcare.

Excellent

(A+, A, A-) High

Good

(B+, B) Significant

Marginal

(B-, C+, C) Basic

Failure

(F) Below marginal level

Assessment Task

Presentations/projects (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

Ability to apply the system-level integration of different strategies to propose novel robotic systems to address problems derived from the real-world healthcare challenges.

Excellent

(A+, A, A-) High

Good

(B+, B) Significant

Marginal

(B-, C+, C) Basic

Failure

(F) Below marginal level

Assessment Task

Attendance and performance in classroom (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

Active participation in interactive learning activities during lectures. Active engagement in classroom discussions.

Excellent

(A+, A, A-) High

Good

(B+, B) Significant

Marginal

(B-, C+, C) Basic

Failure

(F) Below marginal level

Assessment Task

Examination (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

Ability to understand basic concepts, working principles, design methods and analysis skills related with robotic systems for minimally invasive healthcare.

Excellent

(A+, A, A-) High

Good

(B+, B) Significant

Marginal

(B-, C+, C) Basic

Failure

(F) Below marginal level

Part III Other Information

Keyword Syllabus

General keywords

- Medical robotics
- Robotic surgery and telesurgery
- AI in healthcare

Applications

- Targeted drug delivery
- Endoscopy
- Minimally invasive healthcare

Exemplary systems

- da Vinci surgical systems
- AI and machine learning
- Swallowable capsules
- Robotic catheters
- Micro/nano robotics

Reading List

Compulsory Readings

| | Title |
|---|--|
| 1 | M. Sitti, et al., Biomedical applications of untethered mobile milli/microrobots. <i>Proc. IEEE</i> 103, 205–224 (2015). |
| 2 | J. W. Martin, et al., Enabling the future of colonoscopy with intelligent and autonomous magnetic manipulation. <i>Nat. Mach. Intell.</i> 2, 595–606 (2020). |
| 3 | K. H. Yu, A. L. Beam, I. S. Kohane Artificial intelligence in healthcare. <i>Nat. Biomed. Eng.</i> 2, 719–731 (2018). |

Additional Readings

| | Title |
|---|--|
| 1 | L. Sliker, G. Ciuti, M. Rentschler, A. Menciassi, Magnetically driven medical devices: a review. <i>Expert Rev. Med. Devices</i> 12, 737–752 (2015). |
| 2 | S. J. Park, et al., New paradigm for tumor theranostic methodology using bacteria-based microrobot. <i>Sci. Rep.</i> 3, 3394 (2013). |
| 3 | S. Martel, Microrobotics in the vascular network: present status and next challenges. <i>J. Micro-Bio Robot.</i> 8, 41–52 (2013). |
| 4 | N. G. Hockstein, J. P. Nolan, B. W. O' Malley, Y. J. Woo, Robotic microlaryngeal surgery: A technical feasibility study using the daVinci Surgical Robot and an airway mannequin. <i>Laryngoscope</i> 115, 780–785 (2005). |
| 5 | Y. Wei, et al., A Review of Algorithm & Hardware Design for AI-Based Biomedical Applications. <i>IEEE Trans. Biomed. Circuits Syst.</i> 14, 145–163 (2020). |
| 6 | Y. H. Bae, K. Park, Targeted drug delivery to tumors: Myths, reality and possibility. <i>J. Control. Release</i> 153, 198–205 (2011). |
| 7 | A. Esteva, et al., Dermatologist-level classification of skin cancer with deep neural networks. <i>Nature</i> 542, 115–118 (2017). |