BME8138: 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
8138

Academic Unit
Biomedical Engineering (BME)

College/School
College of Biomedicine (BD)

Course Duration
One Semester

Credit Units
3

Level
R8 - Research Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
Nil

Precursors
Nil

Equivalent Courses
BME6138 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

Assessment Task
Problem-based learning (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 machine learning systems for minimally medical imaging.

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 algorithm-level integration of different machine learning to propose novel AI systems to address problems derived from the real-world medical imaging 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
Examination (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion
Ability to understand basic concepts, principles, design methods and analysis skills related with AI in medical imaging.

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
Problem-based learning (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

Ability to interpret the basic concepts and methodology of machine learning systems for minimally medical imaging.

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 algorithm-level integration of different machine learning to propose novel AI systems to address problems derived from the real-world medical imaging challenges.

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, principles, design methods and analysis skills related with AI in medical imaging.

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. Proc. IEEE 103, 205–224 (2015).
2	J. W. Martin, et al., Enabling the future of colonoscopy with intelligent and autonomous magnetic manipulation. Nat. Mach. Intell. 2, 595–606 (2020).
3	K. H. Yu, A. L. Beam, I. S. Kohane, Artificial intelligence in healthcare. Nat. Biomed. Eng. 2, 719–731 (2018).

Additional Readings

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