City University of Hong Kong
Course Syllabus

offered by
Department of Biomedical Engineering
with effect from Summer Term 2024

Part I Course Overview

Course Title:	Robotics in Minimally Invasive Healthcare
Course Code:	BME6138
Course Duration:	1 semester
Credit Units:	3 credits
Level:	P6
Proposed Area: *(for GE courses only)*	NA
Medium of Instruction:	English
Medium of Assessment:	English
Prerequisites : *(Course Code and Title)*	Nil
Precursors: *(Course Code and Title)*	Nil
Equivalent Courses: *(Course Code and Title)*	BME8138 Robotics in Minimally Invasive Healthcare
Exclusive Courses: *(Course Code and Title)*	Nil

Part II Course Details

1. 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.

2. Course Intended Learning Outcomes (CILOs)

(CILOs state what the student is expected to be able to do at the end of the course according to a given standard of performance.)

No.	CILOs	Weighting (if applicable)	Discovery-enriched curriculum related learning outcomes (please tick where appropriate)		
			A1	*A2*	*A3*
1.	**Describe** the basic concepts and goals of the robotic systems in minimally invasive healthcare.			✓	
2.	**Explain** the design considerations, working principles, and applications of representative robotic systems in minimally invasive diagnostics and therapeutics.		✓	✓	
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).		✓	✓	
4.	**Identify** the open challenges and **evaluate** the candidate solutions.		✓	✓	✓
5.	**Apply** the system-level integration and candidate strategies to **propose** a novel robotic healthcare system to address problems derived from real-world challenges.		✓	✓	✓
		N.A.			

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 self-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.

3. Teaching and Learning Activities (TLAs)

(TLAs designed to facilitate students' achievement of the CILOs.)

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

4. Assessment Tasks/Activities (ATs)

(ATs are designed to assess how well the students achieve the CILOs.)

Assessment Tasks/Activities	CILO No.					Weighting	Remarks
	1	2	3	4	5		
Continuous Assessment: 40%							
Homework	✓	✓	✓	✓		10%	
Quizzes	✓	✓	✓	✓		10%	
Presentations/projects				✓	✓	15%	Promote teamwork
Attendance and performance in classroom	✓	✓	✓	✓		5%	Promote interactive learning
Examination: 60%							
Examination	✓	✓	✓	✓	✓	60%	Duration: 2 hours
						100%	

For a student to pass the course, at least 30% of the maximum mark for both coursework and examination should be obtained.

5. Assessment Rubrics

(Grading of student achievements is based on student performance in assessment tasks/activities with the following rubrics.)

Applicable to students admitted in Semester A 2022/23 and thereafter

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B)	Marginal (B-, C+, C,)	Failure (F)
Homework	Ability to interpret the basic concepts and methodology of robotic systems for minimally invasive healthcare.	High	Significant	Basic	Below marginal level
Quizzes	Ability to understand and analyse the concepts, working principles, and constraints of robotic systems for minimally invasive healthcare.	High	Significant	Basic	Below marginal level
Presentations/projects	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.	High	Significant	Basic	Below marginal level
Attendance and performance in classroom	Active participation in interactive learning activities during lectures. Active engagement in classroom discussions.	High	Significant	Basic	Below marginal level
Examination	Ability to understand basic concepts, working principles, design methods and analysis skills related with robotic systems for minimally invasive healthcare.	High	Significant	Basic	Below marginal level

Applicable to students admitted before Semester A 2022/23

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B, B-)	Fair (C+, C, C-)	Marginal (D)	Failure (F)
Homework	Ability to interpret the basic concepts and methodology of robotic systems for minimally invasive healthcare.	High	Significant	Moderate	Basic	Below marginal level
Quizzes	Ability to understand and analyse the concepts, working principles, and constraints of robotic systems for minimally invasive healthcare.	High	Significant	Moderate	Basic	Below marginal level
Presentations/ projects	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.	High	Significant	Moderate	Basic	Below marginal level
Attendance and performance in classroom	Active participation in interactive learning activities during lectures. Active engagement in classroom discussions.	High	Significant	Moderate	Basic	Below marginal level
Examination	Ability to understand basic concepts, working principles, design methods and analysis skills related with robotic systems for minimally invasive healthcare.	High	Significant	Moderate	Basic	Below marginal level

Part III Other Information (more details can be provided separately in the teaching plan)

1. Keyword Syllabus

(An indication of the key topics of the course.)

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

2. Reading List

2.1 Compulsory Readings

(Compulsory readings can include books, book chapters, or journal/magazine articles. There are also collections of e-books, e-journals available from the CityU Library.)

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).

2.2 Additional Readings

(Additional references for students to learn to expand their knowledge about the subject.)

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).