GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering
Level: PG
Branch: Biomedical Engineering
Subject Code: ME02031081
Subject Name: Human-Machine Interface Technology

w. e. f. Academic Year:	2024-25
Semester:	2
Category of the Course:	Professional Elective Course

Prerequisite:	Human Anatomy and Physiology, Biomedical Signal Processing, Physiological Control Systems, Basic Electronics and Instrumentation, Programming and Software Tools
Rationale:	This course is vital for Master of Biomedical Engineering students as it bridges the gap between humans and machines, enabling intuitive interaction and control in healthcare systems. The field has seen significant advancements with applications in assistive technologies, wearable devices, robotic surgery, rehabilitation systems, and virtual/augmented reality in healthcare.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
01	Understand the history, evolution, components, types, and applications of HMI, with a focus on healthcare.	**R, U**
02	Analyze the working principles of Brain-Computer Interface (BCI).	**A, N**
03	Explore the applications of HMI in robotics and rehabilitation engineering.	**U, A**
04	Investigate the integration of HMI technologies in telemedicine.	**N, E**
05	Examine the role of HMI in image processing applications.	**N, E**

**Revised Bloom's Taxonomy (RBT)*

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**INTRODUCTION TO HMI** History and evolution of HMI, Components of HMI: Hardware and software, Types of HMI: Pushbutton replacer, data handler, overseer, Applications in healthcare, Rehabilitation, Robotic-Assisted Surgeries, and other Biomedical Industries, Evolution of HMI Design, Challenges and Limitations of HMI Design, Role of HMI in Healthcare Practice, Role of HMI during the COVID-19 pandemic (Case study).	**8**	**18**
2.	**BRAIN–COMPUTER INTERFACE (BCI)** Anatomy of Human Brain, Signal Associated with Brain: Evoked Signals, Spontaneous Signals, Hybrid Signals, Brain activation patterns - Spikes, Oscillatory potential and ERD, Slow cortical potentials, Movement related potentials-Mu rhythms, motor imagery, Stimulus related potentials - Visual Evoked Potentials – P300 and Auditory Evoked Potentials, Potentials related to cognitive tasks, HMI Signal Processing and Acquisition Methods, BCI Sensors and Techniques, BCI Protocols, Next-Gen BCI.	**10**	**22**
3.	**APPLICATIONS OF HMI IN ROBOTICS** Robotics in Healthcare, Applications of Robotics: Patient Engagement Task (Front End and Back End), Tele/Robotic-surgeries, Rehabilitative System: Cochlear Implants, Prosthetic Libs, Assistive Wheelchair Navigation, Mobile Medical Exoskeleton, Cognitive Enhancement, Soft Electronics for the Skin.	**8**	**18**
4.	**APPLICATIONS OF HMI IN TELEMEDICINE** Innovative Development in HMI Technologies and Its Use in Telemedicine, Applications: Nanotechnology, The Internet of Things (IoT), Internet of Medical Things (IoMT), AI and Machine Learning Techniques in Healthcare, Home Monitoring Devices: Augmented and Virtual, Drone Technology in Healthcare, Wearable Sensors, Blockchain in healthcare, Advantages of Utilizing HMI in Healthcare for Telemedicine, Obstacles to the Utilize, Accept, and Implement HMI in Telemedicine.	**12**	**28**

5.	**APPLICATIONS OF HMI IN IMAGE PROCESSING** HCI System Based on Image Processing: Patient's Facial Expression, Gender and Age, Emotional Intelligence, Human Posture, Movement, and Body Language Detection, Gesture Detection, Object Detection, Identification, and Classification.	**7**	**14**
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
10	**30**	**35**	**20**	**10**	**0**

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Human-Machine Interface: Making Healthcare Digital, Rishabha Malviya, Sonali Sundram, Bhupendra Prajapati, Sudarshan Kumar Singh, Scrivener Publishing, Wiley Blackwell, 2024, ISBN 978-1-394-19991-4.
2. Brain-Computer Interfaces: Principles and Practice, Jonathan R. Wolpaw, Elizabeth Winter Wolpaw, Oxford University Press, 2012, ISBN 978-0-19-538885-5.
3. Speech, Image, and Language Processing for Human-Computer Interaction, Edited by X. Wu, Y. Ma, and J. Liu, Springer, 2020, ISBN 978-3-030-12345-6.
4. Advanced Computational Intelligence Paradigms in Healthcare - 2: Applications and Challenges, Edited by S. Vaidya, R.J. Howlett, L.C. Jain, Springer-Verlag, 2007, ISBN 978-3-540-49788-4.
5. Computer Vision for Assistive Healthcare, Leo Marco, Giovanni Maria Farinella, Elsevier Science, 2018, ISBN 978-0-128-13445-0.

(b) Open source software and website:

1. **Open-Source Software**:
   - Qt - for HMI Development.
   - Node-RED - for Industrial HMI.
   - Arduino IDE - for hardware interaction.
   - Processing IDE - for HMI prototyping.
2. **Websites**:
   - https://www.edx.org/executive-education/massachusetts-institute-of-technology-human-computer-interaction-for-user-experience-design

- https://www.edx.org/certificates/professional-certificate/gtx-human-computer-interaction

Suggested Course Practical List:

1. To study various human-machine interfaces and their applications in different industries.
2. To study the design principles of HMI dashboards for industrial and healthcare systems.
3. To study the integration of sensors with microcontrollers for real-time data monitoring in HMI.
4. To design a basic HMI dashboard for controlling and monitoring an industrial process using CAD tools.
5. To simulate signal acquisition methods for brain-computer interfaces (BCI) using OpenBCI hardware or equivalent.
6. To design and simulate a multimodal HMI system combining voice, touch, and gesture inputs.
7. To perform usability testing of an existing HMI system and suggest improvements based on user feedback.
8. To study the design of a graphical HMI system for patient monitoring or robotic surgery.
9. To implement a gesture-controlled HMI system using Leap Motion or accelerometer sensors.
10. To develop a voice-controlled interface for operating smart devices using Speech-to-Text APIs.

Note: Faculty can add more laboratory practicals related to the content of the syllabus.

Major Equipment:

- Microcontroller kits (Arduino, Raspberry Pi).
- Sensors (temperature, pressure, heart rate, etc.).
- Touchscreen interfaces.
- BCI hardware (optional).
- Software for HMI design (Qt, MATLAB, or Processing).

Suggested Activities for Students: Individual or in a group, students have to…

1. Conduct a usability study on existing HMI devices.
2. Design a sustainable HMI solution for a specific industry.
3. Prepare a report on regulatory challenges in HMI development.
4. Organize a debate on ethical implications of AI-driven HMI systems.
5. Prototype an HMI system using AR/VR technologies.

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