M-Tech Biomedical Instrumentation and Signal Processing

Revised Curriculum 2023

**Program Outcomes:**

<table>
<thead>
<tr>
<th>PO1</th>
<th>An ability to independently carry out research to solve practical problems</th>
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<tbody>
<tr>
<td>PO2</td>
<td>An ability to write and present a substantial technical report / document</td>
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<tr>
<td>PO3</td>
<td>An ability to demonstrate a degree of mastery over the area as per the specialization of the program</td>
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<tr>
<td>PO4</td>
<td>An ability to bridge the gap between research and social needs</td>
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**Program Educational Outcomes:**

<table>
<thead>
<tr>
<th>PEO1</th>
<th>An insight on the recent trends in biomedical instrumentation and signal processing and the impact of the domain in industry and academia</th>
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<tbody>
<tr>
<td>PEO2</td>
<td>Skills to build, apply and evaluate instrumentation, signal processing and data analytic techniques to solve healthcare problems</td>
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<tr>
<td>PEO3</td>
<td>Capacity to contribute to state-of-the-art research in the field of biomedical instrumentation, signal processing, data analytics, and machine learning</td>
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**Focus areas and teaching plan**

<table>
<thead>
<tr>
<th>Area of Focus</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
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</thead>
<tbody>
<tr>
<td><strong>Foundations of BME</strong></td>
<td>Foundation courses</td>
<td></td>
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<tr>
<td><strong>INSTRUMENTATION</strong></td>
<td>Electronic circuits + lab</td>
<td>Embedded systems + lab</td>
<td>Elective 1</td>
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<tr>
<td><strong>DATA PROCESSING</strong></td>
<td>Image processing +lab</td>
<td></td>
<td></td>
<td>Project phase I</td>
</tr>
<tr>
<td><strong>Signal</strong></td>
<td>Signal processing + lab</td>
<td>+ lab</td>
<td>Elective 3</td>
<td>Project phase II</td>
</tr>
<tr>
<td><strong>DATA SCIENCE</strong></td>
<td>Analytics</td>
<td>M/C learning + lab</td>
<td>Elective 2</td>
<td></td>
</tr>
</tbody>
</table>

The curriculum has been designed to reflect the program educational outcomes in three significant thrust areas: (a) Biomedical Instrumentation, (b) Biomedical data processing and (c) Biomedical data sciences.
Over the course of the first two semesters, foundation/subject core courses are offered to help the students transit from a basic to intermediate level of understanding/expertise in the areas.

- By the end of Semester-2, the elective courses will help the students fine-tune their understanding (of the thrust areas) to a relatively advanced level. This will get them ready to choose their specialization and project interests.
- The 3rd semester elective is meant mainly to help the students link their specialization with the project work and prepare a good feasible work plan for the last semester.
- At the end of the course and project work, a student should be competent in 2/3 of the thrust areas.

### Semester - 1

<table>
<thead>
<tr>
<th>Type</th>
<th>Course Name</th>
<th>Teaching Scheme (hours/week)</th>
<th>Credits</th>
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<td>Amrita Values Program*</td>
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*Non-credit Course

### Semester - 2

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<td>Embedded systems</td>
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**Total Course Credits: 68**

**ELECTIVES**

**Elective 1**

**Domain: Instrumentation**

<table>
<thead>
<tr>
<th>Type</th>
<th>Course Name</th>
<th>Teaching Scheme (hours/week)</th>
<th>Credits</th>
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<td>E</td>
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**Elective 2**

**Domain: Artificial intelligence/Data science**

<table>
<thead>
<tr>
<th>Type</th>
<th>Course Name</th>
<th>Teaching Scheme (hours/week)</th>
<th>Credits</th>
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<tbody>
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<td>E</td>
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<tr>
<td>E</td>
<td>Data Mining and Visualization Techniques</td>
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<td>E</td>
<td>IoT in Healthcare</td>
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</table>

**Elective 3**

**Domain: Signal Processing/ Artificial intelligence**

<table>
<thead>
<tr>
<th>Type</th>
<th>Course Name</th>
<th>Teaching Scheme (hours/week)</th>
<th>Credits</th>
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</thead>
</table>
Learning Objectives

LO1 To introduce the basic concepts of cell biology and biological systems
LO2 To impart knowledge on the functioning of various organs and systems
LO3 To enable the biological concepts to help in biomedical signal analysis

Course Outcomes

CO1 Ability to understand the anatomy, physiology, functions of various organs and disorders
CO2 Ability to apply the physiological concepts in modelling biomedical systems
CO3 Ability to analyse the functioning of various vital organs and systems

Course Contents

Circulatory system - Functional anatomy of the heart - Conducting system of the heart - Arterial and venous blood pressure. Gastrointestinal system - Gastric secretion - Pancreatic secretion - Renal physiology - Structure of kidney - Respiratory system - Mechanism of breathing - Regulation of respiration - Transport of gases - Hypoxia - Endocrinology - Endocrine glands - Hormones and their functions.

Textbooks


Learning Objectives

LO1 To define the term “Analytics” for healthcare
LO2 To be proficient with analytics tools for healthcare data preparation and analysis
**Course Outcomes**

CO1 Ability to understand the steps involved in the data mining process (e.g., pre-processing, classification, regression, clustering, and visualization) and apply them for analysis of healthcare data

CO2 Ability to describe different methods of predictive analytics and their applications in the healthcare domain

CO3 Ability to evaluate the data from diverse sources to create meaningful presentations

**Course Contents**

Getting to know your data – data pre-processing – exploring data – Probability and Uncertainty, Regression analysis – Mining patterns, associations, and correlations – classification and prediction, clustering, and outlier analysis.

The course will also include a practical component to implement theoretical concepts learnt via coding platforms such as Python and R.

**Textbooks**

1. Business Analytics: Data Analysis and Decision Making by Christian Albright and Wayne Winston
2. Data Mining Concepts and Techniques by Jiawei Han and Micheline Kamber

<table>
<thead>
<tr>
<th>Biomedical Instruments and Data Interpretation</th>
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<td>3-0-0-3</td>
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</table>

**Learning Objectives**

LO1 To familiarize with major signal and image acquisition modalities in healthcare

LO2 To understand instrumentation and signal characteristics associated with each modality

**Course Outcomes**

CO1 To get familiarized with
(a) biomedical signal acquisition modalities like ECG, EEG, EMG,
(b) biomedical imaging modalities like x-ray, MRI, CT and
(c) surgical and other analytic equipment.

CO2 Ability to read and interpret data from diverse modalities

**Course Contents**

Introduction to biomedical instruments and data – purpose – types – data characteristics – data acquisition and analysis.

Biomedical signals and their measurements – Biopotentials - Electrocardiogram (ECG), Electroencephalogram (EEG), Electromyography (EMG), Photoplethysmography (PPG).

Medical images and their measurements - X-ray, Magnetic Resonance Imaging (MRI), Computed Tomography (CT), PET, and SPECT, Ultrasonography.

Surgical Instruments, ENT, and Ophthalmic Instruments.

**Textbooks**
Learning Objectives

LO1 To familiarize with major signal and image acquisition modalities in healthcare
LO2 To understand instrumentation and signal characteristics associated with each modality

Course Outcomes

CO1 To get familiarized with (a) biomedical signal acquisition modalities like ECG, EEG, EMG, (2) biomedical imaging modalities like x-ray, MRI, CT and (3) surgical and other analytic equipment.
CO2 Ability to read and interpret data from diverse modalities

Course Contents

Imaging Modalities: Brief survey of major modalities for medical imaging: Ultrasound, X-ray, CT, MRI, PET, and SPECT.
Spatial domain filters - Frequency domain filters - Morphological image processing - Binary morphological operations and properties - Morphological algorithms - Medical Image Segmentation, Thresholding - Region growing - Region splitting and merging - Edge detection.
Reconstruction Techniques, Classification and Clustering, Examples of Image Classification for Diagnostic/Assistive Technologies, Case studies.

Image processing practical exercises:
1. Basic operations on images
2. Image enhancement using point operations
3. Image enhancement using spatial domain filters
4. Histogram processing of images
5. Image enhancement using frequency domain filters
6. Denoising of medical images
7. Medical image segmentation using edge and region-based methods
8. Extraction of shape and texture features from a medical image
9. Design of pattern classification system for biomedical images
10. Performance metrics in bioimages

Recommended Tools MATLAB, Python
Textbooks

4. Yoo, Terry S. Insight into Images: Principles and Practice for Segmentation, Registration and Image Analysis, CRC Press

<table>
<thead>
<tr>
<th>Bioinstrumentation</th>
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Learning Objectives

LO1 To understand the fundamental principles of electronics
LO2 To design, test and analyse biomedical circuits and signals

Course Outcomes

CO1 Apply knowledge of engineering and science to understand the principle of biomedical electronic circuits
CO2 Understand how to measure and fine-tune circuit performance to solve problems in the areas of biomedical signals

Course Contents


Textbooks


<table>
<thead>
<tr>
<th>Bioinstrumentation Lab</th>
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Learning Objectives

LO1 To develop exposure and knowledge on various circuit elements, principles, and operations.
LO2 To enable hands-on experience in the design and fabrication of electronic circuits

Course Outcomes

CO1 An ability to design and build electronic circuits for biomedical signal acquisition, as well as to analyse and interpret biomedical signals
CO2 Ability to Use National Instruments’ Multisim circuit modelling and analysis application software. CO3 Ability to use Digilent Analog Discovery Portable Circuit Design Kit (aka Portable Lab) to perform simple analog circuit experiments.

Course Contents

1. Network theorems, voltage, and current division.
2. Diode circuits
3. Passive filters
4. Transistor amplifiers
5. Active filters
6. Signal conditioning circuits
7. Medical signal acquisition circuits

Recommended Tools: NI-Multisim software for simulations, Digilent Analog Discovery kits and Wavefo rms software for hands-on circuit implementation.

References


Learning Objectives

LO1 To introduce characteristics of biomedical signals
LO2 To provide understanding of artifact removal in biomedical signals
LO3 To enhance knowledge in event detection and waveform analysis of biomedical signals
LO4 To provide insight on pattern classification in biomedical signals

Course Outcomes

CO1 Ability to understand concepts of signal processing
CO2 Ability to apply algorithms for signal processing
CO3 Ability to analyse biomedical signals and systems
CO4 Ability to evaluate biomedical signal processing systems

Course contents

Brief introduction to biomedical signals - Challenges in biomedical signal acquisition and analysis - Need for Computer Aided Diagnosis (CAD) - Sampling and reconstruction - Types of noise - Random noise - Structured noise - Physiological interference - Linear time-invariant filters - Time domain filters - Synchronized averaging - Moving average filters - Derivative based filters - Transform domain analysis of signals and systems - Discrete Fourier Transform (DFT) and its properties - Pole-zero plot - Time-frequency analysis - Short-Time Fourier Transform (STFT) - Wavelet Transform - Filter design - Butterworth filters - Notch and comb filters - Event detection - Analysis of waveshape and waveform complexity - Morphological analysis - Envelope extraction and analysis - Feature extraction - Receiver operating characteristics - Case studies - Removal of artifacts - QRS Detection
and classification of ectopic beats in ECG signals - Detection of epileptic seizures in EEG signals - Study of muscular contraction using parametric analysis of EMG signals

**Textbooks**

1. Rangayyan, Rangaraj M, Biomedical signal analysis, John Wiley & Sons, 2015

### Embedded systems

| Embedded systems | 3-0-3-4 |

**Learning Objectives**

- LO1 To introduce design concepts of embedded systems
- LO2 To provide insights on embedded C programming for configuring microcontroller and peripherals
- LO3 To enable development of embedded system models

**Course Outcomes**

- CO1 Ability to identify the features of microcontroller
- CO2 Ability to apply embedded C programming skills for configuring microcontroller peripherals
- CO3 Ability to analyse external peripheral interfacing with a microcontroller
- CO4 Ability to design and develop embedded systems using microcontroller

**Course Contents**


Embedded programming practical exercises:

1. General purpose input output configuration and programming
2. LCD and keypad interfacing
3. Universal asynchronous receiver and transmitter (UART) configuration and programming
4. Analog to digital conversion (ADC) peripheral configuration and programming
5. Timer configuration and programming
6. PWM generation and motor speed control

**Recommended Tools:** STM32CubeMX, Keil µVision

**Textbooks**
Learning Outcomes

LO1 To introduce different machine learning paradigms
LO2 To provide understanding of machine learning algorithms to be used on a given dataset for regression/classification problems.

Course Outcomes

CO1 Ability to conduct data analysis and data visualization
CO2 apply the complete ML pipeline in real-world dataset - Analyse datasets, decide pre-processing steps, visualize data, apply ML models, and infer the meaning based on different performance metrics.

Course contents

Role of learning in intelligent behaviour, general structure of a learning system; learning from example; concept learning, Introduction to machine learning and machine learning applications, Supervised learning, linear regression, polynomial regression, logistic regression, multivariate methods, dimensionality reduction, Support Vector Machine, clustering. Neural networks, multilayer perceptron, local models, assessing and comparing ML models. MLOps - introduction to converting ML models from test bench to production (saving, loading, using trained models).

Machine Learning practical exercises:

1. Design and implementation of a Bayes classifier for two-class and multi-class classification
2. Design and implementation of an MLP based Artificial Neural Network Model for classification or regression
3. Design and implementation of a deep learning classifier model using transfer learning
4. Design and implementation of a simple DAG Network for deep learning
5. Design and implementation of clustering algorithms
6. Determining the Bipartiteness of a graph using search algorithms

Recommended Tools: MATLAB, Python

Textbooks

Learning Objectives

LO1 To enhance practical knowledge in biomedical signal analysis
LO2 To provide hands-on experience in filtering of biomedical signals

Course Outcomes

CO1 An ability to apply algorithms for signal processing
CO2 Ability to analyse biomedical signals and systems
CO3 Ability to evaluate biomedical signal acquisition and processing systems

Course Contents

1. Digital signal processing - Basic operations
2. Time domain filtering
3. Discrete Fourier Transform (DFT)
4. Frequency domain filtering
5. Artifact removal in bio-signals
6. Waveform analysis and feature extraction from bio-signals
7. Pattern classification in bio-signals

Recommended Tools: MATLAB, Python

References


Research Methodology

<table>
<thead>
<tr>
<th>Learning Objectives</th>
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</thead>
<tbody>
<tr>
<td>LO1 To enable defining and formulating research approaches towards obtaining solutions to practical problems</td>
</tr>
<tr>
<td>LO2 To facilitate development of scientific oral and written communication skills</td>
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<tr>
<td>LO3 To comprehend the concepts behind adhering to scientific ethics and values</td>
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</table>

<table>
<thead>
<tr>
<th>Course Outcomes</th>
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</thead>
<tbody>
<tr>
<td>CO1 Ability to understand some basic concepts of research and its methodologies</td>
</tr>
<tr>
<td>CO2 Ability to define and apply appropriate parameters and research problems</td>
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<tr>
<td>CO3 Ability to develop skills to draft a research paper</td>
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<tr>
<td>CO4 Ability to analyse and comprehend the ethical practices in conducting research and dissemination of results in different forms</td>
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</table>

<table>
<thead>
<tr>
<th>Course contents</th>
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</thead>
<tbody>
<tr>
<td>Meaning of research - Types of research - Research process - Problem definition - Objectives of research - Research questions - Research design - Approaches to research - Quantitative vs. qualitative</td>
</tr>
</tbody>
</table>
Learning Objectives

LO1 To introduce the fundamentals of wearable sensor technology
LO2 To impart knowledge on electronics in wearable system design
LO3 To enable knowledge development on principles of energy harvesting
LO4 To provide insight to assistive technologies in wearable system

Course Outcomes

CO1 Ability to understand the basics of wearable sensor system design
CO2 Ability to apply the IC technologies for bio sensing
CO3 Ability to analyse the energy and power consumption requirements in system design
CO4 Ability to evaluate the multi parameter measurements from wearable sensors

Course contents

Introduction to Wearable sensors - Attributes of wearables - Meta-wearable - Challenges and opportunities - Future of wearables - Social interpretation of Aesthetics - Case study - Google glass - Wearable haptics - Need for wearable haptic devices - Categories of wearable haptic and tactile display - Wearable Sensors - Chemical and Biochemical sensors - System design - Challenges in chemical biochemical sensing – Applications

Textbooks


Biosensors

3-0-0-3

Learning Objectives

LO1 To introduce the operation of biosensors
LO2 To provide understanding on characterization techniques of biosensors
LO3 To impart knowledge on Lab-on-a-Chip concepts

Course Outcomes

CO1 Ability to understand the working principles of biosensors
CO2 Ability to characterize optical and electrochemical sensors
CO3 Ability to analyse the response of biosensors

Course contents

Electrochemical biosensors - Construction and working of potentiometric - Amperometric and impedemetric sensors - Development and applications of piezoelectric sensors - Electrochemical
sensors for glucose - Vitamins - Cholesterol - Dopamine - Biochips and electrochemical microarrays - Lab-on-a-chip - Biosensing using nanomaterials - Biocompatibility of sensors - PCR Principles

Textbooks


Learning Objectives

LO1 To introduce the basics of MEMS
LO2 To provide understanding fabrication of BioMEMS
LO3 To impart knowledge on biomedical applications of MEMS

Course Outcomes

CO1 Ability to understand the operation of micro devices, micro systems, and their application
CO2 Ability to design the micro devices, micro systems using the MEMS fabrication process
CO3 Ability to analyse the optic MEMS applications in bioengineering
CO4 Ability to evaluate the performance of MEMS in diagnostic applications

Course contents

History of BioMEMS - overview of the different types of MEMS and microsystems, Smart systems and 3D architectures. Current state of the art and trends at the academic and industrial levels.
MEMS for biomedical sensing and diagnostic applications - MEMS for in vivo sensing - MEMS and Electrical Impedance Spectroscopy (EIS) for non-invasive measurement of cells - MEMS ultrasonic transducers for biomedical applications - BioMEMS for drug delivery applications - BioMEMS for drug delivery applications - Applications of MEMS technologies for minimally invasive medical procedures - Smart microgrippers for bioMEMS applications.
Optical bio-sensing applications - Colorimetric detection - Fluorescence detection - Luminescence detection - Bioluminescence detection - Chemiluminescence detection - Biochemiluminescence detection - Electrochemiluminescence detection.

Textbooks

Virtual Instrumentation

Learning Objectives

LO1 To provide knowledge of virtual instrumentation
LO2 To enable understanding of virtual signal processing tools
LO3 To introduce biomedical applications of virtual instrumentation

Course Outcomes

CO1 Ability to understand programming concepts for virtual instrumentation
CO2 Ability to analyse bio-signal processing algorithms using virtual instrumentation
CO3 Ability to develop virtual codes for biomedical applications

Course contents

Introduction to virtual instrumentation - Loops and structures - Arrays and clusters - Graphs and charts
File and string handling - Basics of data acquisition - Common communication buses using DAQ assistant - Real world DAQ and issues - Network and distributed systems.
Data handling techniques - Signal acquisition and sampling theorem - Effect of undersampling - Convolution - Designing an FIR and IIR filters - FFT analysis of periodic and aperiodic signals - Designing of low pass filter - High pass filter - Bandpass filter - Band reject filter - Notch filter and Comb filter.
Processing of ECG, EMG and EOG signals - Adaptive signal processing - Data compression techniques - AZTEC - TP - CORTES and KL transform.

Textbooks


Medical Robotics

Learning Objectives

LO1 To impart basic understanding of robotics
LO2 To enable understanding the design and control concepts of medical robots
LO3 To comprehend on the application of robotics in the field of healthcare

Course Outcomes

CO1 Ability to understand different types of Robotic Systems
CO2 Ability to apply the concepts of robotics for surgery
CO3 Ability to analyse the positioning and orientation of medical robots
CO4 Ability to design the kinematics model for a specified robotic system

Course contents

Introduction to robots - Robots as mechanical devices - Classification of robotic manipulators - Robotic systems - Accuracy and repeatability - Wrists and end-effectors - Mathematical modelling of robots - Symbolic representation of robots - The configuration space - The state space - The workspace common kinematic arrangements of manipulators - Forward kinematics - Inverse kinematics - Velocity kinematics.


Textbooks


Data Mining and Visualization Techniques

| 3-0-0-3 |

Learning Objectives

LO1 To introduce the concepts of pattern processing
LO2 To provide insights on different techniques of pattern processing - supervised and unsupervised
LO3 To provide knowledge on techniques of data visualization techniques

Course Outcomes

CO1 Ability to understand the basic concepts of data mining
CO2 Ability to apply data mining, clustering, classification, and data visualization techniques
CO3 Ability to analyse data using mining, clustering, and classification techniques
CO4 Ability to evaluate the effectiveness of various algorithms

Course contents

Challenges in data mining - Data pre-processing - An overview of data cleaning methods - Data integration - Data reduction and data transformation - Dimensionality reduction - Linear regression – Regularisation.

Data visualisation - Bar plots - Histogram - Box plots - Violin plots - Pairplots - Distplot - Scatter plots - Pie charts - Bubble plots - Regression plots - Quantile plots - Heatmaps - Plotting covariance matrices - Waffle chart - Word cloud - PCA - LDA - Manifold learning for data visualisation - t-SNE – UMAP.

Textbooks

1. Jiawei Han, Micheline Kamber, Jian Pei, Data Mining: Concepts and Techniques, Third Edition, Morgan Kaufmann Publishers (Elsevier), 2011.

Learning Objectives

LO1 To understand the concepts of Internet of Things
LO2 To provide exposure to the routing protocols used in medical IoT devices
LO3 To comprehend on applications of IoT in the field of healthcare

Course Outcomes

CO1 Ability to understand the basic architecture of an IoT device
CO2 Ability to apply big data analytics in Medical IoT devices
CO3 Ability to analyse mobility in location based IoT systems
CO4 Ability to evaluate the performance of IoT applications in healthcare

Course contents

Introduction to IoT - Physical design of IoT - Logical design of IoT - IoT enabling technologies - IoT levels and deployment templates - Cloud computing - Deployment models - Service models - Service management - Cloud security - Communication protocols - CoAP – MQTT.
IoT in Healthcare - Challenges in current healthcare systems - IoT healthcare services - Big data in IoT - Architecture of apache flume and spark - Wireless Body Area Networks (WBAN) Routing Protocols - Medium access control - Issues of WBAN.
Case Studies - Wearable sensor network for remote health monitoring - IoT based location aware smart healthcare framework - Analysis of recovery of mobility through inertial navigation techniques and virtual reality - Control and remote monitoring of muscle activity and simulation in the rehabilitation process.

Textbooks

Learning Objectives

LO1 To introduce concepts of Bio-inspired Computing and its applications
LO2 To provide insight on Artificial Neural Networks
LO3 To introduce Fuzzy logic and Fuzzy Systems
LO4 To provide knowledge on optimization algorithms

Course Outcomes

CO1 Ability to understand the principles of bio-inspired algorithms
CO2 Ability to apply bio-inspired techniques for pattern recognition and optimization tasks
CO3 Ability to analyse problems in medical applications using bio-inspired approaches
CO4 Ability to evaluate performance of optimization algorithms

Course contents


Textbooks


Learning Objectives

LO1 To provide basic concepts of multivariate signals
LO2 To impart knowledge on statistical analysis of multivariate time series data
LO3 To introduce time and spectral domain approaches for analysing multivariate biomedical data

Course Outcomes

CO1 Ability to understand the basics of multivariate signal processing
CO2 Ability to apply statistical analysis for multivariate time series data
CO3 Ability to analyse multi-domain features of Biomedical signals
CO4 Ability to evaluate performance of multivariate signal processing algorithms

Course contents

Concept of random variables - Stochastic processes - Relations among random variables - correlation, multiple correlation, and partial correlation - Univariate and multivariate Gaussian distributions - Univariate Time Series - Time domain approach - Frequency domain approach.


Data compression of EEG and ECG signals - EMG Source signal separation techniques - EEG signal separation and Pattern Classification - Correlation of Biomedical signals - Evaluating causal relations in biomedical systems - Case studies - ICA based analysis on neurological disorders using EEG - Deep learning-based arrhythmia classification using EEG.

Textbooks


Speech and Audio Processing

Learning Objectives

LO1 To introduce the concepts of signal processing with application to speech processing
LO2 To provide insights on feature extraction for speech coding, synthesis, and recognition
LO3 To enable understanding of deep learning applications to speech processing and health care

Course Outcomes

CO1 Ability to understand concepts of Speech signal processing
CO2 Ability to apply the concepts of signal processing to feature extraction of speech/audio signals
CO3 Ability to analyse and process speech data for speech coding, synthesis, and recognition
CO4 Ability to evaluate speech/audio processing techniques in healthcare applications

Course contents

Introduction to signal processing - FIR and IIR filters - DFT - FFT - Speech analysis overview - Modelling of speech production - Speech perception and models - Feature extraction for speech processing - Auditory system as a filter bank - Linear predictive coding - Spectrum - Cepstrum - Mel-frequency cepstral coefficients. Introduction to music synthesis - Music signal analysis - Source separation - Speech recognition - Synthesis and coding - Introduction to deep neural networks - Applications of deep learning techniques to speech processing - Applications of speech and audio processing in healthcare - Case studies - Dysarthria – Aphasia. Analysis of speech/audio - Experiment with speech
analysis and synthesis - Experiment with deep learning techniques for speech recognition - Analyse the speech signals of controls with dysarthria and aphasia.

Textbooks


Learning Objectives

LO1 To introduce the fundamentals of image formation
LO2 To provide understanding of segmentation techniques in vision-based applications
LO3 To impart knowledge on advanced concepts in image representation techniques
LO4 To provide insights on implementation of computer vision algorithms for biomedical applications

Course Outcomes

CO1 Ability to understand the fundamental concepts in computer vision
CO2 Ability to apply segmentation techniques and descriptors
CO3 Ability to analyse medical problems using computer vision techniques
CO4 Ability to evaluate performance of computer vision algorithms in biomedical applications

Course contents


Textbooks

Learning Objectives

LO1 To provide basic introduction to artificial intelligence and its role in biomedicine and healthcare
LO2 To introduce different concepts, methods, and potential intelligent systems in medicine

Course Outcomes

CO1 Ability to understand decision support systems
CO2 Ability to apply neural networks and deep neural networks for healthcare problems
CO3 Ability to apply time-series forecasting for healthcare applications

Course contents

Introduction of concepts, methods, and potential of intelligent systems in medicine: History and status quo, and decision support system. Application on any specific area of interest, Risk stratification, Data acquisition and pre-processing, Feature identification and extraction, Model selection and implementation, Model validation and evaluation with performance metrics, visualization and interpretability. Introduction to neural networks and applications in healthcare. Deep neural networks, Convolutional neural networks, ARIMA for time series forecasting, SHAP analysis for feature analysis and selection

Textbooks


Brain Computer Interfacing

Learning Objectives

LO1 To introduce the concepts of Brain Computer Interfacing (BCI)
LO2 To impart knowledge about the data acquisition methods used in BCI
LO3 To enhance the understanding on BCI signal Processing and parameter extraction
LO4 To enable the knowledge on classification of cognitive task from BCI parameters

Course Outcomes

CO1 Ability to understand the basic concepts of EEG and BCI
CO2 Ability to apply signal processing techniques in BCI
CO3 Ability to analyse human cognition using BCI parameters
CO4 Ability to evaluate machine learning methods in BCI applications

Course contents

Textbooks