B.M.S. COLLEGE OF ENGINEERING, BENGALURU-19

(Autonomous College under VTU)

DEPARTMENT OF MEDICAL ELECTRONICS ENGINEERING

SCHEME & SYLLABUS

M.TECH PROGRAMME in

BIOMEDICAL SIGNAL PROCESSING and INSTRUMENTATION

I to IV SEMESTER

(Academic Year 2020 onwards)

B.M.S COLLEGE OF ENGINEERING, BENGALURU-19

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INSTITUTE VISION & MISSION

VISION

Promoting prosperity of mankind by augmenting human resource capital through Quality Technical Education & Training

MISSION

Accomplish excellence in the field of Technical Education through Education, Research and Service needs of society.

DEPARTMENT VISION & MISSION

VISION

To promote quality education in Medical Electronics Engineering for Health and well - being of humankind through teaching and research platforms.

MISSION

- To impart knowledge and skills necessary for professional development of graduates in Medical Electronics Engineering.
- To provide continuous up gradation of technical education with strong academic progression.
- To propagate creativity, responsibility, commitment and leadership qualities and exhibit professional ethics and values.

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PROGRAMME OUTCOMES

Program Outcome form a set of individually assessable outcomes that are the components indicative of the graduate's potential to acquire competence to practice at the appropriate level. The POs of the PG program are exemplars of the attributes expected of a graduate of an accredited program. The POs of the PG program of the NBA are as following:

PO1: An ability to independently carry out research /investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: Students should be able to demonstrate a degree of mastery over the area as per the program.

The mastery should beat a level higher than the requirements in the appropriate bachelor program

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I Semester

SCHEME

Course Code	Name of the Course	CREDITS			TOTAL CREDITS	CIE	SEE	TOTAL
		L	T	P				
20MLBIPCPE	Physiology for Biomedical Engineers	2	1	0	3	50	50	100
20MLBIPCBA	Biomedical Image Processing and Analysis	3	1	0	4	50	50	100
20MLBIPCBI	Bioelectricity and Instrumentation Techniques	3	0	0	3	50	50	100
20MLBIPCMD	Medical Device Development	3	0	1	4	50	50	100
20MLBIPERT	Real Time Bio Signal Processing	3	0	0	3	50	50	100
20MLBIPEES	Electrophysiological Signal Analysis							
20MLBIPEMP	Medical Prognostics	3	0	0	3	50	50	100
20ALLPICRM	Research Methodology and IPR	2	0	0	2	50	50	100
TOTAL		20	2	3	22	350	350	700

II Semester **SCHEME**

Course Code	Name of the Course	CREDITS			TOTAL CREDITS	CIE	SEE	TOTAL
		L	T	P				
20MLBIPCMI	Medical Imaging Techniques & systems	3	1	0	4	50	50	100
20MLBIPCBS	Biostatistics	3	0	1	4	50	50	100
20MLBIPCDT	Diagnostic and Therapeutic Instruments	3	0	1	4	50	50	100
20MLBIPENB	▪ Neuroimaging and Brain mapping	3	0	0	3	50	50	100
20MLBIPEPR	▪ Pattern Recognition and Neural Networks							
20MLBIPEES	▪ Embedded System Design for Biomedical Applications	3	0	0	3	50	50	100
20MLBIOEBE	Biomedical Ethics and Standards	4	0	0	4	50	50	100
20MLBINC01	Biosensors	-	-	-	-	-	-	-
TOTAL		16	1	5	22	300	300	600

III Semester **SCHEME**

Course Code	Name of the Course	CREDITS			TOTAL CREDI	CIE	SEE	TOTAL
		L	T	P				
20MLBIPEBC 20MLBIPEML	▪ Brain Computer Interface ▪ Machine Leaning in Biomedical applications	3	1	0	4	50	50	100
20MLBIPWP1	Project Phase – I	0	0	10	10	50	50	100
20MLBIPCIN	Internship	0	0	8	8	50	50	100
20MLBINC02	MOOC Course on BMSPI / Allied	--	--	--	-	--	--	--
TOTAL		3	1	18	22	150	150	300

IV Semester **SCHEME**

Course Code	Name of the Course	CREDITS			TOTAL CREDITS	CIE	SEE	TOTAL
		L	T	P				
20MLBIPCSR	Technical Seminar	2	0	0	2	50	50	100
20MLBIPWP2	Project Phase – II	0	0	20	20	50	50	100
TOTAL		3	1	18	22	100	100	200

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GENERAL GUIDELINES

Regular course (without lab): would be evaluated for 30 Marks as a part of Internal Assessment. Remaining 20 marks would be evaluated using alternative assessment tools. CIE for the theory courses would be 30+20=50 Marks. SEE will be conducted for 100 Marks and reduced to 50 Marks. The final marks would be CIE+SEE (50+50) 100 Marks.

Integrated course (with lab): would be evaluated for 30 Marks as a part of Internal Assessment. Laboratory Work would be evaluated for 20 Marks. All the experiments must be conducted and evaluated. The corresponding Lab reports must be prepared as part of the assessment. Total internal assessment (CIE) would be 30+20=50 Marks. SEE will be conducted for 100 Marks and reduced to 50 Marks. The final marks would be CIE+SEE (50+50) = 100 Marks.

Program Core/Elective with Tutorial: Assessment of additional knowledge would be evaluated for 20 Marks using only alternative assessment tools. Assessment would be part of core or elective course.

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SEMESTER – I -CORE SUBJECTS

Course Title	PHYSIOLOGY FOR BIOMEDICAL ENGINEERS	Course Code	18MLBIPCPE
Credits	3	L-T-P	2-1-0

CO1 apply basic concepts of physiology for engineering analysis of human physiological systems
CO2 translate the understanding of physiological functions into an engineering model.
CO3 analyze and comprehend the model as an engineering solution.

General Physiology: Cell, Cell junctions, Transport through cell membrane, Homeostasis, Acid base balance.

Respiratory System & Environmental Physiology: Physiological anatomy of respiratory tract, Pulmonary circulation, Mechanics of respiration, Pulmonary function tests, Ventilation, Exchange of respiratory gases, Transport of respiratory gases, Regulation of respiration, Artificial respiration.

Renal Physiology : Kidney, Nephron, Juxtaglomerular apparatus, Renal circulation, Urine formation, Concentration of urine, Acidification of urine, Renal function tests, Renal disorders, Micturition, Uroflow studies, Dialysis.

Cardiovascular System : Introduction to cardiovascular system, Properties of cardiac muscle, Cardiac cycle, Heart sounds, Cardiac murmurs, Electrocardiogram, Vector, Arrhythmia, Cardiac output, Regulation of heart rate, Hemodynamics, Arterial blood pressure, Hemorrhage.

GIS: GIS, Functions of stomach, pancreas, liver, intestine, function tests: endoscopies.
Nervous System-Introduction to nervous system, Neuron, Classification of nerve fibers, Properties of nerve fibers, Degeneration & regeneration of nerve fibers, Neuroglia, Receptors, Synapse, Neurotransmitters, Reflex activity, Physiology of pain, Hypothalamus, Electroencephalogram Physiology of sleep, Epilepsy, cerebrospinal fluid, Autonomic nervous system and ANS tests. Evoked potentials. Cerebral circulation and tests.

Muscle Physiology: Classification of muscles, Structure of skeletal muscles, Properties of skeletal muscles, Changes during muscular contraction, Neuromuscular junction, Electromyogram & disorders of skeletal muscles Types of joint- Fibrous, Cartilaginous, Synovial, characteristics of synovial joints, shoulder joint, elbow joint, radioulnar joint, wrist joint, joints of hands and fingers, Hip joint, Knee joint, ankle joint, joints of foot and toes.

Physiology of Eye and Ear: Structure of the Eye, Visual process, Field of vision, Visual pathway, Pupillary reflexes, Color vision, Errors of refraction. ERG and EOG. Structure of ear, auditory defects.

Text Book:

1. Essentials of Medical Physiology, K Sembulingam & Prema Sembulingam (Jaypee Publications, 2004)

Reference Book:

1. "Concise Medical Physiology" Sujit K. Chaudhuri, 5thEd, New Central Book Agency

Course Title	BIOMEDICAL IMAGE PROCESSING AND ANALYSIS	Course Code	20MLBIPCBA
Credits	4	L-T-P	3-1-0

CO1: Apply the fundamental concepts of Image processing for Biomedical Image analysis.

CO2: Conduct experiments for medical image enhancement and segmentation.

CO3: Implement open ended experiments for medical image analysis and prepare technical document.

Basics of Medical Image processing- The Nature of Biomedical Images**,** Types of Medical Images Objectives of Biomedical Image Analysis, Computer aided Diagnosis, Fundamental steps in Digital Image Processing, image sensing and acquisition, digital image representation, Basic relationship between pixels, color models.

Image Enhancement- Spatial Domain image enhancement, basic gray level transformations, Histogram equalization, Smoothing spatial filters, Sharpening spatial filters, Image Enhancement in Frequency Domain- Smoothing frequency domain filters, sharpening frequency domain filters, homomorphic filtering, image restoration, a model of restoration process, restoration in presence of noise only, estimating degradation function, inverse filtering.

Detection of region of interest – detection of discontinuities , Thresholding, Otsu's algorithm for optimum thresholding, Detection of Isolated Points and Lines, Edge Detection, Region Growing, Splitting and merging of regions.

Analysis of shape and Texture - chain codes, signatures, boundary segment, skeletons, boundary descriptors, texture, gray level co-occurrence matrix.

Pattern Classification and Diagnostic Decision: Pattern Classification, Supervised Classification, Unsupervised Classification, statistical decision making, Nonparametric decision

making, Nearest neighbour classifiers clustering, partitional clustering, neural networks, measures of diagnostic accuracy reliability of features classifiers and decisions.

Text Book:

1. Digital Image Processing by Rafael C. Gonzalez & Richard E. Woods, Third Edition. Pearson Education Inc, 2012

2. Earl Gose, Richard Johnsonbaugh, "Pattern Recognition andImage Analysis", 1st Edition, Prentice Hall of India Private limited, 2009.

3. Biomedical Image Analysis, Rangaraj. M Rangayyan, CRC 2015

Reference Books:

1. Image Processing, Analysis and Machine -Vision by Milan Sonka,Vaclav Hlavac & Roger Boyle, Second Edition

2. Biomedical Image Analysis: Segmentation (Paperback)by Scott T. Acton, Nilanjan Ray Published by Morgan Claypool Publishers, United States (2009),ISBN 10: 1598290207

3. Handbook Of Medical Image Processing And Analysis by Isaac Bankman , Academic Press

WEB REFERENCE:
http://nptel.iitm.ac.in/courses/106108057

Course Title	Bioelectricity and Instrumentation Techniques	**Course Code**	20MLBIPCBI
Credits	**3**	**L-T-P**	**3-0-0**

CO1: Apply the comprehensive knowledge of science and electronic instrumentation techniques to comprehend bioelectricity generation and their measurements

CO2: Analyze the performance in the material selection and deployment of different types of electrode systems on human skin.

CO3: Design and Implement medical instrumentation systems based on ECG measurements and Pace makers.

Excitable Tissue and Bioelectric Signals: Bioimpedance and Biopermittivity, Bioelectricity, Dielectrics – Introduction, Basic Biomaterials, Tissue- Conductivity, Special Electrical Properties, Cell Polarization, Action Potential, The Neuron, Axon Transmission, Receptors

Geometrical Analysis: Volume Conductors, Sphere Sources, Ideal Three-Dimensional Models, Line Sources, Ideal Two-Dimensional Models, Signal Transfer, Finite Element Method – Concepts, Imaging, Electrical Impedance Tomography, Duality of Dielectric and Conductor Theory. Case study – ECG signal.

Electrodes: Electrode pair, metals, Contact Electrolytes, Skin Preparation, Electrode double layer, DC Potentials, No Current Flow, Basic Experiment with DC Current Flo, Faraday's Law of Electrolysis, Electrode Polarization, Multiple Electrode System, Electrode Terminology, Electrode design- overview.

Biomedical Sensors and Signal conditioning: Introduction, Biopotential amplifiers – Basic requirements, Interferences, Special circuits, Isolation Amplifier and Patient Safety, Surge Protection, Input Guarding, Dynamic Range and Recovery

Instrumentation in Implantable Cardiac Pacemakers: Introduction, Indications, Pulse Generators, Block diagram and functional elements of pace makers, Leads, Programmers and Ongoing Follow-Up, System Operation, Performance and Reliability, Future of Pacing Technology

TEXT BOOKS

1. Sverre Grimnes and Ørjan G Martinse, "Bioimpedance and Bioelectricity Basics" , Third Edition, Academic Press, Elsevier, 2015

2. Steven Schreiner Joseph D. Bronzino Donald R. Peterson," MEDICAL INSTRUMENTS AND DEVICES Principles and Practices", CRC Press, 2016

REFERENCE BOOKS

1. Plonsey, Robert, Barr, Roger C, "Bioelectricity

2. A Quantitative Approach", Springer, 2007

3. Tatsuo Togawa, Toshiyo Tamura and P. Åke O¨ berg, "Biomedical Sensors and Instruments", 2nd edition, CRC Press 2011

Online course

https://www.edx.org/learn/bioelectricity
https://www.classcentral.com/course/edx-introduction-to-bioelectricity-3921

E-Books

https://iopscience.iop.org/book/978-0-7503-1677-4/chapter/bk978-0-7503-1677-4ch3
https://www.sciencedirect.com/book/9780123740045/bioimpedance-and-bioelectricity-basics

Course Title	Medical Device Development	**Course Code**	20MLBIPCMD
Credits	**4**	**L-T-P**	**3-0-1**

CO1: Search, analyse and document clinical practice, engineering science and relevant literature in order to determine the need for further research and development in a chosen clinical area

CO2: Collect a range of data (both qualitative and quantitative) to analyse critically, reflect on and synthesize complex solutions to concepts and theories in a chosen topic

CO3: Ability to derive specifications and standards of a chosen device

CO4: Design a virtual device that helps to technologically address a clinical need in a team and document the same.

Prerequisites: Practical knowledge of circuit design

Medtech Innovation: Introduction, the status of bio-innovation in India, DALY, MedTech Innovation, New medical device steps, Common Myths, Biodesign process, clinical immersion, need filtration, Need Specification document, case studies, Market Segmentation, Concept Generation and Selection, Perfint Maximo Example

Product Requirement: Classification of Medical Device (FDA/CE/CDSCO), Requirement Analysis: Functional, Safety, Usability, User interface, Clinical Workflow, Internal Interface, Working environment, Infrastructure, Safety, Adaptability, Availability, User training, Labelling, Operating cost, Disposable, Design Input, ISO 13485

Design Engineering: Clinical Workflow, Design for Manufacturing, Design for Serviceability, FMEA, Economy of Scale, Standards in Medtech, Safety and Risk Management, Case studies.

Human Factor Engineering: HE75, Common UI and UA issues, Economy of Scale, Product Requirements, Design engineering, Practical Development process, Importance of verification and review, Iterative development, Design and development plan, Design Output, Design Process, Design Verification, Design Validation, Design Review, Review versus verification versus validation, Design Transfer, Functional Block Diagram, High-Level Design, Signal flow path / Signal Characteristics

Project Management and sustainability: Activity Planning - Objectives, Defining Activities, Project Plan (Gantt Chart), Network Planning models -Critical path management (CPM), Precedence Network, Nodes, Activity network, Forward Pass, Backward Pass, Float, Critical Path and its importance

Sustainability: Need, external push towards sustainability, hospital role, barriers, making sustainable device, examples

TEXT BOOKS

1. Biodesign: The Process of Innovating Medical Technologies, by Paul Yock, Stefanos A. Zenios, and Todd J. Brinton, Cambridge University Press, 2nd edition, 2015
2. Inventing Medical Devices: A Perspective from India, by Jagdish Chaturvedi, Notion Press, 2017

REFERENCE BOOKS

The Medical Device R&D Handbook, by Theodore R. Kucklick, Second Edition, CRC Press, 2012

Online course

Pharmaceutical and Medical Device Innovations Coursera
Medical Technology and Evaluation Coursera
Regulatory requirements for medical devices including in vitro diagnostics in India (Version 2.0) - Course Swayam

eBooks:

http://ebiodesign.org/
https://generisgp.files.wordpress.com/2016/05/ebook-medical-device-developmentbest-practices.pdf

1st Semester PROGRAM ELECTIVES

Course Title	REAL TIME BIO-SIGNAL PROCESSING	Course Code	20MLBIPERT
Credits	3	L-T-P	3-0-0

CO1. Implement computationally efficient algorithms on the DSP platform for bio signals.
CO2. Analyze real-time filter structures for performance evaluation using modern tools.
CO3. Develop multirate signal processing algorithms for real-time bio signals as case study, and present a technical report on the same.

Real time Signals and Systems: Overview on Continuous and Discrete time signals and Systems. Properties, Fourier analysis of discrete time signals and continuous time signals. Real time Convolutions (linear and circular) Real time correlations. Linear filtering aspects of convolutions. Case studies on 1-D and 2-D implementation.

Real time Digital Filters: Exposition on Filter designs structures. Real-Time FIR Digital Filters. Real-Time IIR Digital Filters, Real time Lattice structures and its implementation issues. Real time Transforms and its Algorithms: Real-Time Fast Fourier Transform (1-D and 2-D cases),

Discrete Cosine Transform (1-D and 2-D cases) Walsh Hadamard Transforms Basics and algorithms.(1-D and 2-D Cases), Haar Transform (1-D & 2-D cases), Basic of Discrete Wavelet Transform (1-D and 2-D Cases).

Multi-rate filters: Basics principles of decimations and interpolation, Noble identities and its advantages. Quadrature mirror Structures and Poly-phase structures, rational Sample Rate converters.

Adaptive Filters: Basics optimum signal processing, Wiener filters adaptive structures. LMS algorithms and simple variations. RLS algorithms, Basic Kalman Filters with implementations.

Random processes: Types, Examples, Notion of stationarity and Ergodicity. White noise, filtering random processes, spectral factorization, ARMA, AR and MA Processes.

Text Books:

1. Modern Digital Signal Processing by Roberto Cristi, Cengage Learning, 2004
2. Joseph Yiu, The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors

Reference Book:

1. Digital Signal Processing and Applications with the OMAP - L138 experimenter, Wiley

E Books:

1. The Scientist and Engineer's Guide to Digital Signal Processing By Steven W. Smith, Ph.D.

MOOCS:

1. https://www.mooc-list.com/course/applied-digital-signal-processing

2. Sign up at http://www.coursera.org/course/dsp

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Course Title	ELECTROPHYSIOLOGICAL SIGNAL ANALYSIS	Course Code	20MLBIPEES
Credits	3	L-T-P	3-0-0

CO1: Apply the knowledge of electrophysiological signals (ECG & EEG) for analysis in medical diagnosis

CO2: Identify the signal characteristics in normal and ailment conditions

CO3: Analyze real world electrophysiological signal using modern tools and prepare research report

Basics of Cardiovascular Signal: The Physiological Basis of the Electrocardiogram: Cellular Processes that Underlie the ECG, The Physical Basis of Electrocardiography, The Normal Electrocardiogram, Introduction to Clinical Electrocardiography, Abnormal Patterns, The Normal Determinants of Heart Rate: The Autonomic Nervous System (Ectopy, Tachycardia, and Fibrillation), Conduction Blocks, Bradycardia, and Escape Rhythms, Cardiac Ischemia, Other Metabolic Disturbances, and Structural Abnormalities, A Basic Approach to ECG Analysis.

ECG Statistics, Noise, Artifacts, and Missing Data: Spectral and Cross-Spectral Analysis of the ECG, Extreme Low and High Frequency ECG, The Spectral Nature of Arrhythmias, Standard Clinical ECG Features, Non-stationarities in the ECG, Heart Rate Hysteresis, Arrhythmias, Arrhythmia Detection, Arrhythmia Classification from Beat Typing, Arrhythmia Classification from Power-Frequency Analysis, Arrhythmia Classification from Beat-to-Beat Statistics, Noise and Artifact in the ECG, Noise and Artifact Sources, Measuring Noise in the ECG, Heart Rate Variability, RR Interval Models, The Cardiovascular System, The DeBoer Model, Integral Pulse Frequency Modulation Model, Nonlinear Deterministic Models, RR Interval Models for Abnormal Rhythms, ECG Models, Pathophysiology Guided T-Wave Alternans Measurement,, ECG-Derived Respiratory Frequency Estimation, ST analysis

Basic of Neural Signal Acquisition and processing: Introduction to EEG signal, Neural Activities, Action Potentials, EEG Generation , Brain Rhythms, EEG Recording and

Measurement, Conventional Electrode Positioning , Conditioning the Signals, Abnormal EEG Patterns, Ageing , Mental Disorders, Dementia , Epileptic Seizure and Non-epileptic Attacks, Psychiatric Disorders. External Effects

Neural Signal Analysis: Fundamentals of EEG Signal Processing , EEG Signal modeling, Linear Models , Nonlinear Modeling, Generating EEG Signals Based on modeling the Neuronal Activities, Nonlinearity of the Medium, Non-stationary, Signal Segmentation, Signal Transforms and Joint Time–Frequency Analysis, Wavelet Transform, Ambiguity Function and the Wigner–Ville Distribution

Event-Related Potentials: Detection, Separation, Localization, and Classification of P300 Signals, Using ICA, Estimating Single Brain Potential Components by modeling ERP Waveforms, Source Tracking, Localization of the ERP, Time–Frequency Domain Analysis, Adaptive Filtering Approach.

Text Books:

1. Advanced Methods and Tools for ECG Data Analysis, Francisco Azuaje, Gari D. Clifford, and Patrick E. McSharry, ISBN-13: 978-1580539661,

2. EEG Signal Processing, Saied Sanei and J A Chambers, John Wiely and Sons Limited, 2007.

Reference Books:

1. Introduction to Electrophysilogical methods and instrumentation, Franclin Bretschneider and Jan R De Weille, ISBN 978-0-12-370588-4.

2. Computer Analysis of Electrophysiological Signals, John Dempster, 2. http://iitr.vlab.co.in/?sub=49&brch=267&sim=1305&cnt=1

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Course Title	Medical Prognostics	Course Code	20MLBIPEMP
Credits	3	L-T-P	3-0-0

CO1: Understand Immunological factors in disease
CO2: Learn to Analyze a Prognosis with Tree-based models
CO3: Able to learn Survival Models and Time with probability concepts
CO4: Learn about Hazard Functions and risk factors
CO5: Learn the concept of Evaluation of Survival Model.

Immunological factors in disease: Components of the Immune System, Mechanism of the Immune Response, Immune deficiency and Lymphoproliferative disorders, Types of Immune reaction and their relation to human disease, Suppression of immune reactions and their effects.
Medical Prognosis, Examples of Prognostic Tasks,Atrial fibrillation,Liver Disease Mortality, Risk of heart disease, Risk Score Computation ,Evaluating Prognostic Models, Concordant Pairs, Risk Ties, Permissible Pairs

Prognosis with Tree-based models: Decision trees for prognosis, Decision trees, Dividing the input space, Building a decision tree, How to fix over fitting, Survival Data, Different distributions, Missing Data example, Missing completely at random, Missing at random, Missing not at random, Imputation, Mean Imputation, Regression Imputation, Calculate Imputed Values.

Survival Models and Time: Survival models, Survival Function, Valid survival functions, Collecting Time Data, When a stroke is not observed, Heart Attack Data, Right censoring, Estimating the survival function, Died immediately, or never die, Somewhere in-between, Using censored data, Chain rule of conditional probability,
Deriving Survival. Calculating Probabilities from the Data, Comparing Estimates, Kaplan Meier Estimate

Hazard Functions: Hazard, Survival to hazard, Cumulative Hazard, Individualized Predictions, Relative risk, Ranking patients by risk, Individual vs. baseline hazard, Smoker vs. non-smoker,, Effect of age on hazard, Risk factor increase per unit increase in a variable, Risk Factor Increase or Decrease, Intro to Survival Trees, Survival tree, Nelson Aalen estimator, Comparing risks of patients, Mortality score,

Evaluation of Survival Model: Permissible and Non-Permissible Pairs, Possible Permissible Pairs, Example of Harrell's C-Index, Example of Concordant Pairs

Textbooks:
Roitt′s Essential Immunology (Essentials) by Peter J. Delves, Seamus J. Martin, et al. | 13 January 2017

Current Medical Diagnosis and Treatment 2008 Stephen J. McPhee, Maxine A. Papadakis, Lawrence M. Tierney

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Course Title	RESEARCH METHODOLOGY AND IPR	Course Code	20ALLPICRM
Credits	2	L-T-P	2-0-0

Unit 1:
Meaning and sources of research problem, , Objectives and Characteristics of research–Errors in selecting research problem, Research methods Vs Methodology - Types of research-Criteria of good research – Developing a research plan. **5 hrs.**

Unit 2:
Investigations of a research problem - Selecting the problem - Necessity of defining the problem–Data collections-analysis- Importance of literature review in defining a problem - Survey of literature - Necessary instrumentations. **5 hrs.**

Unit 3:
How to write paper-conference articles-poster preparation, thesis report writing, inclusion of references, journal reviewing process, journal selection process, filling about journal template, developing effective research proposal-plagiarism-research ethics. **5 hrs.**

Unit 4:
Nature of Intellectual property, IPRs- Invention and Creativity - Importance and Protection of Intellectual Property Rights (IPRs) –procedure for grant of patents and patenting under PCT-types of patents technological research and innovation- international cooperation on IP. **5 hrs.**

Unit 5:
A brief summary of :Patents-Copyrights-Trademarks, patent rights-licensing and transfer of technology patent databases-case studies on IPR-Geographical indications-new developments in IPR-protection of IPR rights. **6 hrs.**

Reference Books:
1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers
2. Kothari, C.R., 1990. Research Methodology: Methods and Techniques. New Age International. 418p.
3. Anderson, T. W., An Introduction to Multivariate Statistical Analysis, Wiley Eastern Pvt., Ltd., New Delhi

Course Outcomes (COs):
On Completion of the course, the students will be able to

CO1: Write and present a substantial technical report/document
CO2: Demonstrate a degree of mastery over the area of specialization

SEMESTER II -CORE SUBJECTS

Course Title	MEDICAL IMAGING TECHNIQUES AND SYSTEMS	Course Code	20MLBIPCMI
Credits	4	L-T-P	3-1-0

CO1: Think laterally and originally, conceptualize and solve engineering problems, identify potential issues in an imaging system considering public health and safety.

CO2: apply the appropriate techniques to transform images for better visualization and interpretation.

CO3: Extract information pertinent to unfamiliar problems through literature survey, apply appropriate research methodologies to design ,analyse and interpret data, Demonstrate higher order skill and view things in a broader perspective.

Introduction to Diagnostic Imaging Modalities: Basic Imaging Principles, Overview of the different modalities of diagnostic imaging, Axial, Coronal and Sagittal Views, Introduction to DICOM, Introduction to Image Viewing Software.

X-rays: Historical Overview, Fundamentals of X-rays, Electromagnetic Radiation, Interaction of X-rays with Matter, Intensity of an X-ray Beam, Attenuation and Factors affecting Attenuation, Generation of X-ray Radiation, X-Ray Generators, Filters, Beam Restrictors and Grids, X-ray Imaging Geometry, Film Radiography, Intensifying Screens and Image Intensifiers, Computed Radiography, Digital X-ray Detectors, X-ray Image Characteristics, Spatial Resolution, Noise and Contrast, Biological Effects of Ionizing Radiation, Units of Dose, Precautionary Measures while using X-rays, Fluoroscopy, Angiography, Digital Subtraction Angiography, Orthopantomography, Dual Energy X-ray Absorptiometry, Linear Accelerators,

Computed Tomography: Historical Overview, Conventional Tomography, Fundamentals of Computed Tomography, Generations of CT Machines from First to Seventh, Projection Function, Houns field Unit, Forward and Inverse Problems, Radon Transform, Sinogram, Algorithms for Image Reconstruction, Back Projection, Filtered Back Projection, Fourier Transform Methods, Fourier Slice Theorem, Algebraic Reconstruction Techniques, Parallel Beam Reconstruction, Fan Beam Reconstruction, Cone Beam Reconstruction, Helical CT, Maximum Intensity Projection Reconstruction, Volume Rendering, Artifacts in CT Images, Some Clinical Applications.

Ultrasound: Historical Overview, Fundamentals of Acoustic Propagation, Stress and Strain Relationships, Characteristic Impedance, Intensity, Radiation Force, Reflection, Refraction, Attenuation, Absorption, Scattering, Doppler Effect, Generation and Detection of Ultrasound, Piezoelectric Effect, Ultrasonic Transducers, Transducer Beam Characteristics, Beam Profiles,

Pulsed Ultrasound, Phased Arrays, Resolution – Axial and Lateral, Focussing of Ultrasound, Diagnostic Methods, Pulse Echo Systems, A-mode, B-mode, M-mode, C-mode, Ultrasound Image Characterization, Tissue Characterization, Colour Doppler Flow Imaging, Echocardiography, Biological Effects of Ultrasound, Ultrasound Safety, 3D Ultrasound, High Intensity Focussed Ultrasound (HIFU), Some Clinical Applications.

Nuclear Medicine: Historical Overview, Fundamentals of Radioactivity, Nuclear Activity and its Units, Half Life, Interaction of Nuclear Particles and Matter, Attenuation of Gamma Radiation, Radionuclides, Radiopharmaceuticals, Common Radioisotopes, Generation and Detection of Nuclear Emission, Radionuclide Generators, Cyclotrons, Nuclear Radiation Detectors, Rectilinear Scanners, Scintillation Camera, Single Photon Emission Computed Tomography (SPECT), Positron Emission Tomography (PET), PET-CT and PET-MR Systems, PET Image Reconstruction, Attenuation Correction, Characteristics of Images, Contrast and Noise, Nuclear Radiation Safety, Some Clinical Applications.

Magnetic Resonance Imaging: Historical Overview, Fundamentals of Nuclear Magnetic Resonance, Angular Momentum, Dipole Moment, Magnetization, Larmor Frequency, Rotating Frame of Reference, RF Magnetic Field, Free Induction Decay, Relaxation Times, Pulse Sequences, Generation and Detection of NMR Signal, Main Magnetic Field, Gradient Magnetic Fields, Superconducting Magnets, Transmitter, Receiver, Slice Selection, Frequency Encoding, Phase Encoding, Spin-Echo Imaging, Gradient-Echo Imaging, Biological Effects of Magnetic Fields, Imaging Safety, Introduction to Functional MRI, Diffusion Weighted Imaging, Introduction to Image Registration in Multi-modal imaging, Some Clinical Applications

Text book:

1. Kirk Shung, Michael Smith, Benjamin Tsui, Principles of Medical Imaging, Academic Press, 1992.
2. Khandpur

Reference Books:

1. Jerry Prince, Jonathan Links, Medical Imaging Signals and Systems, Pearson, 2008

2. edX MOOC Course, Principles of Biomedical Imaging, online course.

3. Internet Text References and Videos.

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Course Title	BIOSTATISTICS	Course Code	20MLBIPCBS
Credits	4	L-T-P	3-0-0

Pre Requisites: Engineering Mathematics
CO1: Analyze the role of biostatistics in public health or medical studies
CO2: Use descriptive tools to summarize and display data from a public health or medical studies
CO3: Identify the study designs and appropriate tests to perform hypothesis testing and interpret the outputs
CO4: Formulate and perform a descriptive and inferential analysis of a public health or other health sciences study using statistical Software and interpret the results.

Introduction to Biostatistics: Basic concepts, types of data, measurement and measurement scales, descriptive statistics, measure of central tendency, exploring data with tables and graph, measure of dispersion, bayes theorem, Probability distribution, Bernolli distribution, Binomial distribution, Poisson distribution, normal distribution, standard normal distribution, t-distribution, Central limit theorem, confidence intervals, and its significance.

Epidemiological concept: Study design types, randomized control trials, observational studies, prospective/retrospective study, cohort study, case-controlled study, cross-sectional study, determining sample size, Prevalence, incidence, and power of the study.

Hypothesis testing: Hypothesis, hypothesis testing, p-value, type 1, and type 2 errors, 95% confidence interval, selection of valid tests for hypothesis testing, factors to consider for valid tests

Univariate testing: Parametric testing: student's t-test, paired t-test, one way ANOVA, Non-parametric testing: Mann-Whitney test, Wilcoxon-signed rank test. Nominal- chi-square test, Fisher's exact test, Goodness-of-Fit and Contingency Tables

Regression and correlation: Linear regression, scatter plot, least-square line, Pearson's correlation, spearman's correlation, Kappa coefficient. Comparing a binary outcome between groups: Risk ratio, rates ratio, odds ratio

TEXT BOOKS

Biostatistics: A Foundation for Analysis in the Health Sciences, 11th Edition Wayne W. Daniel, Chad L. Cross, Wiley publishers, 2018.
Biostatistics with R: An Introduction to Statistics Through Biological Data by Babak Shahbaba, Springer, 2012

REFERENCE BOOKS

Biostatistics for the Biological and Health Sciences, 2nd edition by Marc M. Triola, Mario F. Triola, Jason Roy, Pearson publishers, 2017

Rosner B. Fundamentals of Biostatistics, 8th ed. Cengage Learning, Boston, MA, 2016

Online course
Introduction to Applied Biostatistics: Statistics for Medical Research edX
Introduction to Biostatistics - Course - Swayam

E-Books:
Biostatistics: New CD-ROM for self learning - WHO

Use of standard statistical software, such as R with EZR package, excel with data analysis package, etc would be learnt for all the above topics.

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Course Title	DIAGNOSTIC AND THERAPEUTIC INSTRUMENTS	Course Code	20MLBIPCDT
Credits	4	L-T-P	3-0-1

Course Outcomes

CO1: Apply knowledge of mathematics science and engineering fundamentals in designing, analyzing and/or working of biomedical circuits and instruments.

CO2: Analyse the health, safety, Environmental, legal and ethical issues while designing/working of a biomedical circuits and instruments.

CO3: Present in a group and document the findings or suggestions for the problems in the current techniques, modern tools and computing practice to improve technology in health care instruments.

UNIT I [08 Hours]

Physiological Transducers: Classification of transducers, performance characteristics of transducers. Pressure transducers, transducers for body temperature measurement,photoelectric transducers, optical fiber sensor, biosensor and smart sensor. Biomedical recorders and biofeedback instruments.Patient Monitoring Systems: System concepts, cardiac monitor, bedside patient monitoring system,central monitors, measurement of heart rate, measurement of pulse rate, blood pressure measurement, measurement of temperature, measurement of respiratory rate, catheterization laboratory instrumentation.

UNIT II [08 Hours]

Oximeters: Oximetry, ear oximeter, pulse oximeter, skin reflectance oximeter andintravascular oximeter. Blood Flow Meters: Electromagnetic blood flow metersdifferent types, Ultrasonic blood flow meters, NMR blood flow meters and Laser Doppler blood flowmeters.Cardiac output measurements: Indicator dilution method, Dye dilution method,Thermal dilution techniques, Measurement of continuous cardiac output derived fromthe aortic pressure waveform, Impedance technique.Pulmonary Function Analyzer:Pulmonary function measurement, Spirometry,Pneumotachometer, Measurement ofvolume by Nitrogen washout technique.

UNIT III [08 Hours]

Blood Gas Analyzers: Acid-base balance, blood pH measurement, measurement of blood pCO2, intra-arterial blood gas monitoring, complete blood gas analyzer.Audiometer and Hearing Aids: Mechanism of hearing, measurement of sound,basicaudiometer, pure-tone audiometer, speech

audiometer, audiometer system,Bekesyevoked response audiometer system, calibration of audiometer and hearing aids.

UNIT IV [08 Hours]

Cardiac Pacemakers and Defibrillators: Need for cardiac pacemaker, External pacemaker, Implantable pacemaker, Types of Implantable pacemakers and recent developments. Programmable pacemaker, Rate-responsive pacemakers, pacing system Analysers,Need for Defibrillator, Dc defibrillators, Implantable Defibrillators, Defibrillator analysers.

UNIT V [07 Hours]

Instruments of Surgery: Principles of surgical diathermy, surgical diathermy Machine, Safety aspects in electro- surgical units, surgical diathermy Analyzer.Automated drug delivery Systems: Infusion pumps, components of drug infusion systems andimplantable infusion systems.Patient Safety: Electric shock hazards, Leakage currents, safety codes and analyzer.Ethical issues in the design of Biomedical Instruments.

Text Books:

1. Handbook of Biomedical Instrumentation – by R.S.Khandpur, 2 Edition, Tata McGraw Hill, 2003
2. Leslie Cromwell, Fred J. Weibell, Eric A. Pfeiffer, Biomedical Instrumentation and Measurements, PHI Publicatios.

Reference Books

1. J. G. Webster, Biomedical Instrumentation, John Wiley and Sons, Hoboken, NJ,2004.
2. Biomedical Instrumentation by Dr.M. Arumugam-Second Edition- 1994

E-Books:

1. http://www.ebook3000.com/Introduction-to-Biomedical-Instrumentation--TheTechnology-of-Patient-Care_51854.html
2. Barbara Christe, Introduction to Biomedical Instrumentation: The Technology of Patient Care, Cambridge University Press | 2009 | ISBN: 0521515122

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2nd Semester PROGRAM ELECTIVES

Course Title	NEUROIMAGING AND BRAIN MAPPING	Course Code	18MLBIPENB
Credits	4	L-T-P	3-0-1

CO1: Have a neuroanatomical knowledge, in-depth knowledge of the technological bases of each neuroimaging technique and have a good knowledge of the relative advantages and disadvantages of each technique, based on their strengths and limitations.

CO2: have comprehensive understanding of each stage of pre-processing neuroimaging data , image analysis and able to draw appropriate inferences based on the image analysis employed.

CO3: will learn how to conduct various aspects of image analysis through hands-on experience with analyses packages and execute a open ended project, present and document the same.

Introduction to Neuroimaging and Brain Mapping Terminology: Review of Neuroanatomy. The Physics of Neuroimaging (invasive and non-invasive, structural vs.
functional, digital data representation).The Normal Brain, The Developing Brain, Matured Brain, Aging Brain Diseases: Depression, Schizophrenia, Autism, Bipolar disorder, Neurodegeneration and dementia(AD), Epilepsy, Multiple Sclerosis, Methamphetamine, Foetal Alcohol Syndrome, Head
Trauma, Tumours.

Neuroimaging Techniques: Functional and structural neuroimaging methodology of neuroimaging techniques of MRI, fMRI, PET and EEG/ERP, highlighting their relative strengths and limitations.

Image processing and Analysis : Pre-processing of neuroimaging data , Diffusion Weighted Imaging, Image Segmentation and Registration, Image Smoothing and MARM. Functional Data Analysis. Low-rank Representation.

Data Analysis: Analysis of neuroimaging data using varied designs, such as blocked, event-related and mixed designs. Image analysis through hands-on experience with analyses packages. Prediction Models. Imaging Genetics. Big Data Integration. statistics on neuroimaging data.

Cognitive Psychology for Clinical Neuroscience: Introduction to cognitive psychology , theoretical developments in a wide selection of areas of cognition, cognitive models ,examples of computational models, role played by behavioural experiments in establishing and testing models of cognition. Neuroimaging applications in : language, memory, attention, face recognition, cross-modal processing, sleep, emotion and social cognition, neural bases of cognition, emotion, social cognition and behaviour.

BOOK:

1. Handbook of Functional Neuroimaging of Cognition, 2nd edition. Edited by Roberto Cabeza and Alan

   Kingstone.

2. Statistical Parametric Mapping: The Analysis of Functional Brain Images

3. edited by William D. Penny, Karl J. Friston, John T. Ashburner, Stefan J. Kiebel, Thomas E. Nichols

4. Neuroradiology: The Requisites (Requisites in Radiology) 4th Edition

5. by Rohini Nadgir MD (Author), David M. Yousem MD MBA (Author)

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Course Title	PATTERN RECOGNITION AND NEURAL NETWORKS	Course Code	20MLBIPEPR
Credits	3	L-T-P	3-0-0

CO1: Understand the concepts of pattern recognition

CO2: Analyze the neural network concepts

CO3: Apply the theorems for biomedical applications

Unit 1
Introduction: Applications of pattern recognition, statistical decision theory, image processing and analysis, Probability: Introduction, Probability of events, random variables, joint distribution & densities, moments of random variables, estimation of parameters from samples, minimizing risk estimators.

Unit 2
Statistical decision making: Introduction, Bayes theorem, multiple feature, conditionally independent feature, decision foundries, unequal costs of error, estimation of error rates the living one out technique characteristics curves estimating the composition of populations

Unit 3
Nonparametric Decision Making: Introduction, Histogram, Kernel & Window Estimators, Nearest Neighbour Classification Techniques, Adaptive Decision Boundaries, Adaptive.
Clustering: Introduction, Hierarchical Clustering and Partitional Clustering

Unit 4
Introduction: Biological Neuron – Artificial Neural Model - Types of activation functions – Architecture: Feedforward and Feedback, Convex Sets, Convex Hull and Linear Separability, Non-Linear Separable Problem. XOR Problem, Multilayer Networks. Learning: Learning Algorithms, Error correction and Gradient Descent Rules, Learning objective of TLNs, Perceptron Learning Algorithm, Perceptron Convergence Theorem

Unit 5:
Supervised Learning: Perceptron learning and Non Separable sets, α-Least Mean Square Learning, MSE Error surface, Steepest Descent Search, μ-LMS approximate to gradient descent, Application of LMS to Noise Cancelling, Multi-layered Network Architecture, Backpropagation Learning Algorithm, Practical consideration of BP algorithm.

Text Book:
1. Pattern recognition & image analysis (chapter 1 to Chapter 6) Earl Gose, Richard Johnson Baugh & Steve Jost, PHI.

2. Wiley-Interscience, 2001.Neural Networks A Classroom Approach– Satish Kumar, McGraw Hill Education (India) Pvt. Ltd, Second Edition

Reference Books:

1. Introduction to Artificial Neural Systems-J.M. Zurada, Jaico Publications 1994.
2. Artificial Neural Networks-B. Yegnanarayana, PHI, New Delhi 1998.
3. Richard O. Duda, Peter E. Hart, and David G.Stork: Pattern Classification, 2nd Edition,

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Course Title	EMBEDDED SYSTEM DESIGN FOR BIOMEDICAL APPLICATIONS	Course Code	20MLBIPEES
Credits	4	L-T-P	3-1-0

CO1: Analyze the functional and non-functional requirements of embedded systems and develop solutions for health care applications

CO2: Conceptualize and design embedded systems for optimal solutions considering issues related to safety, societal and environmental factors in the biomedical domain (PO2-2)

CO3 Extract information on concurrent problems through literature survey and analyze complex problems independentlyor in groups (PO1-2)

Embedded systems: Introduction, Characteristics, Classification, Generic architectures, Communication protocols, Overview of Real time operating systems, Medical applications with embedded software

Wireless medical systems: Introduction, Advances on Technologies for Implantable Bioelectronics, Lab on a Cellphone, A Wireless Intraoral Tongue–Computer Interface, Energy-Efficient Hierarchical Wireless Sensor Networks Based on Wake-Up Receiver Usage, Review of Signal processing for classification in wireless medical embedded systems

Algorithms and data processing : Framework for Biomedical Algorithm Design Cooperative Data Fusion for Advanced Monitoring and Assessment in Healthcare Infrastructures, Energy-Efficient High Data Rate Transmitter for Biomedical Applications

Power-Aware Scheduling Scheme for Medical Sensor SoC-Based WBAN Systems: Introduction, On-Time Power-Aware Scheduler, State transition models, Design, Typical power mode transition scenario, Structure of on-time power-aware scheduling system, Implementation details of implantable cardioverter-defibrillator (ICD) device and results

Case Studies: Embedded systems in a life supporting system, Embedded data logging platform for ECG and blood oxygenation monitoring, Real time monitoring systems, RTOS kernel in portable electrocardiograph, An Advanced Insulin Bolus Calculator for Type 1 Diabetes Combining Android and RTOS for medical devices, Embedded Software Quality Challenges in Medical Device Development

Text Books:-

1. Shibu K V: Introduction to Embedded Systems, Tata Mc Graw Hill, 2009
2. Wireless Medical Systems and Algorithms: Design and Applications, Pietro Salvo, Miguel Hernandez-Silveira, 2016, CRC Press
3. Tae-Ho Hwang et al. Sensors 2013, 13, 375-392

References:

1. Missomi Conti, Simone Orcioni et all, Lecture notes in electrical engineering Solutions on embedded systems, Springer science + business media BV 2011
2. Hassan Ghasemzadeh, Sarah Ostadabbas ,IEEE SENSORS JOURNAL, VOL. 13, NO.2, FEBRUARY 2013
3. Journal of Physics: Conference Series 332 (2011) 012006, IOP publishing
4. White papers: Embedded-computing.com, medsmagazine.com, mentor.com/embedded

E-book:
https://www.mdpi.com/books/pdfview/book/287

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OPEN ELECTIVE

Course Title	BIOMEDICAL ETHICS AND STANDARDS	Course Code	20MLBIOEBE
Credits	4	L-T-P	4-0-0

Course Outcomes:

The Student will be able to

1. Identify the scope of medical ethics
2. Illustrate the concepts of ethical theories and moral principles for the health professions
3. Explain the purpose of medical standards
4. Acquire knowledge about hospital accreditation standards
5. Summarize the importance of hospital safety standards
6. Recommend the suitable principles of medical equipment safety standards in hospitals

Introduction to Medical Ethics: Definition of Medical ethics, Scope of ethics in medicine, American medical Association code of ethics, CMA code of ethics- Fundamental Responsibilities, The Doctor and the Patient, The Doctor and the Profession, Professional Independence, The Doctor and Society.

Ethical Theories and Moral Principles: Theories-Deontology & Utilitarianism, Casuist theory, Virtue theory, The Right Theory. Principles Non- Maleficence, Beneficence, Autonomy, Veracity, Justice. Autonomy & Confidentiality issues in medical practice, Ethical Issues in biomedical research, Bioethical issues in Human Genetics & Reproductive Medicine

Medical Standards: Evolution of Medical Standards – IEEE 11073 - HL7 – DICOM – IRMA - LOINC – HIPPA –Electronics Patient Records – Healthcare Standard Organizations – JCAHO (Join

Commission on Accreditation of Healthcare Organization) - JCIA (Joint Commission International Accreditation) - Evidence Based Medicine - Bioethics.

Hospital Safety Standards: Hospital Accreditation Standards- overview Life Safety Standards- Protecting Occupants, Protecting the Hospital From Fire, Smoke, and Heat, Protecting Individuals From Fire and Smoke, Providing and Maintaining Fire Alarm Systems, Systems for Extinguishing Fires Environment of Care Standards-Minimizing EC Risks, Smoking Prohibitions, Managing Hazardous Material and Waste, Maintaining Fire Safety Equipment, Features, Testing, Maintaining, and Inspecting Medical Equipment.

Medical Equipment Safety Standards: General requirements for basic safety & essential performance of medical equipment. IEC 60601standards- Base Standard-general requirement of electrical medical devices, Collateral Standards EMC radiation protection &programmable medical device system, Particular Standards-type of medical device

Text Books:

1. JohnnaFisher, “Biomedical Ethics: A Canadian Focus.” Oxford University Press Canada 2009.

2. Ben Mepham,”Bioethics-—An Introduction for the biosciences”,Oxford, 2008.

3. Domiel A Vallero, “Biomedical Ethics for Engineers”, Elsevier Pub.1st edition, 2007.

Reference Books::

1. Joint Commission Accreditation Standards for Hospitals, 2nd edition 2003.

2. NilsHoppe and Jose Miola, “Medical law and Medical Ethics”, Cambridge University Press2014.

3. Robert M Veatch,” Basics of Bio Ethics”, Second Edition. Prentice- Hall,Inc, 2003

4. Physical Environment Online: A Guide to The Joint Commissions Safety Standards, HCPro, Inc.2010

5. Mohan Bansal, “Medical informatics”, Tata Mc Graw Hill Publishing Ltd, 2003.

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III SEMESTER PROGRAM ELECTIVES

Course Title	BRAIN COMPUTER INTERFACE	Course Code	20MLBIOEBC
Credits	4	L-T-P	3-1-0

Course outcomes

CO1. Apply the knowledge of mathematics science and engineering fundamentals to understand the Brain Organization, Anatomy, and Function.

CO2. Analyze and process the brain signals for artifact reduction.

CO3. Understand types of BCI, principles and its applications which are present state of art in the Neurosciences domain.

Introduction to BCI: Review of Basic Neuroscience, BCI concepts, Signal modalities in BCI – EEG based BCI/ Spike based BCI. Recording and Stimulating the Brain: Stimulating the Brain and Recording Signals from the Brain: Invasive Techniques & Noninvasive Techniques. Simultaneous Recording and Stimulation: Multi-electrode Arrays, Neurochip.

Signal Processing for BCI's: Spike Sorting, Frequency Domain Analysis: Fourier analysis, Discrete Fourier Transform (DFT), Fast Fourier Transform (FFT). Time Domain Analysis: Hjorth Parameters , Fractal Dimension, Autoregressive (AR) Modeling, Bayesian Filtering, Kalman Filtering. Principal Component Analysis (PCA) ,Independent Component Analysis (ICA) , Common Spatial Patterns (CSP). Artifact Reduction Techniques: Thresholding, Band-Stop and Notch Filtering, Linear Modeling, Principal Component Analysis (PCA), Independent Component Analysis (ICA).

Building a BCI: Major Types of BCIs: Brain Responses Useful for Building BCIs: Conditioned Responses, Population Activity, Imagined Motor and Cognitive Activity,

Stimulus-Evoked Activity. Invasive BCIs: Two Major Paradigms in Invasive Brain-Computer Interfacing: BCIs Based on Operant Conditioning, BCIs Based on Population Decoding.

Systems in BCI: Invasive - Cursor and Robotic Control Using a Multielectrode Array Implant, Cognitive BCIs in Humans, Long-Term Use of Invasive BCIs, Long-Term BCI Use and Formation of a Stable Cortical Representation, Long-Term Use of a Human BCI Implant Semi-Invasive BCIs: Electrocorticographic (ECoG) BCIs -ECoG BCIs in Animals, ECoG BCIs in Humans, BCIs Based on Peripheral Nerve Signals Nerve-Based BCIs, Targeted Muscle Innervation(TMR).
Non-Invasive BCIs: Oscillatory Potentials and ERD, Slow Cortical Potentials, Movement-Related Potentials, Stimulus Evoked Potentials; BCIs Based on Cognitive Tasks, Error Potentials in BCIs, Co-adaptive BCIs, And Hierarchical BCIs. fMRI, MEG, and fNIR. BCIs that Stimulate: Sensory R e s t o r a t i o n , Restoring Hearing: Cochlear Implants. Restoring Sight: Cortical and Retinal Implants, Motor Restoration, Deep Brain Stimulation (DBS), Sensory Augmentation. Spikes Based BCI and systems engineering in BCI - Neuro- stimulation

Applications of BCI: Medical - Sensory Restoration, Motor Restoration, Cognitive Restoration, Rehabilitation, Restoring Communication with Menus, Cursors, and Spellers, Brain- Controlled Wheelchairs. Nonmedical- Web Browsing and Navigating Virtual Worlds, High Throughput Image Search Lie Detection and Applications in Law. Estimating Cognitive Load, Education and Learning, Security, Identification, and Authentication. Ethics of Brain-Computer Interfacing: Medical, Health, and Safety Issues, Balancing Risks versus Benefits, Informed Consent, Abuse of BCI Technology, BCI Security and Privacy, Legal Issues, Moral and Social-Justice Issues.

TEXT BOOKS:

[1] RajeshP.N.Rao, Brain-ComputerInterfacing: AnIntroduction
(1Edition) Cambridge University Pres

[2] Brain-Computer Interfaces: Revolutionizing Human-Computer Interaction (The Frontiers Collection) Hardcover – (13 Dec 2010) by Bernhard Graimann (Editor), Brendan Z. Allison (Editor), GertPfurtscheller (Editor)

REFERENCE BOOKS:-

1. https://sccn.ucsd.edu/wiki/Introduction_To_Modern_Brain-Computer_Interface_Design
2. https://www.udemy.com/brain-computer-interface/

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Course Title	Machine Learning in Biomedical Applications	**Course Code**	20MLBIPEML
Credits	**4**	**L-T-P**	**3-1-0**

Course Outcomes:
CO1: Apply the knowledge of learning problems and models used in machine learning.
CO2: Identify and analyze the learning models to interpret the data.
CO3: Design, implement and demonstrate an open ended experiment for biomedical data using modern tool.

Introduction: Learning Problems, Designing Learning systems, Perspectives and Issues. Concept learning: Concept Learning, Version Spaces and Candidate Elimination Algorithm, Inductive bias. Decision Trees**:** Decision Tree learning, Representation, Algorithm, Heuristic Space Search.

Regression: Logistic Regression, Support Vector Machine, Kernel function and Kernel SVM Clustering: k-means, Adaptive hierarchical clustering, Gaussian mixture model.

Neural Networks: Neural Network Representation, Problems, Perceptron, Multilayer Networks and Back Propagation Algorithms. Genetic Algorithms: Hypothesis Space Search, Genetic Programming, Models of Evolution and Learning.

Bayesian Learning: Bayes Theorem, Concept Learning, Maximum Likelihood, Minimum Description Length Principle, Bayes Optimal Classifier, Gibbs Algorithm, Naïve Bayes Classifier, EM Algorithm.

Instant Based Learning: K-Nearest Neighbor Learning, Locally Weighted Regression, Radial Basis Functions, Case-Based Reasoning, Sequential Covering Algorithm. **Learning set of rules:** Learning Rule Sets, Learning First Order Rules, Learning Sets of First Order Rules, Induction as Inverted Deduction, Inverting Resolution.

TEXT BOOKS:

1. Tom M. Mitchell, “Machine Learning”, McGraw-Hill Education (INDIAN EDITION), 2013.

2. Ethem Alpaydin, “Introduction to Machine Learning”, 2nd Ed., PHI Learning Pvt. Ltd., 2013.

REFERENCE BOOKS:

1. T. Hastie, R. Tibshirani, J. H. Friedman, The Elements of Statistical Learning, Springer; 1st edition, 2001.

ONLINE COURSE LINKS:

1. https://www.coursera.org/learn/machine-learning.
2. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-867-machine-learning-fall-2006/syllabus/#Calendar.
3. https://onlinecourses.nptel.ac.in/noc18_cs40/

E-BOOK:

1. Andreas C. Müller & Sarah Guido, Introduction to Machine learning with Python- A Guide for Data Scientists, Published by O'Reilly Media, Inc., 1005 Gravenstein Highway North, Sebastopol, CA 95472.

2. Ethem Alpaydin, "Introduction to Machine Learning", 2nd Ed., PHI Learning Pvt. Ltd., 2013.