JSS MAHAVIDYAPEETHA

JSS SCIENCE & TECHNOLOGY UNIVERSITY, MYSURU

SRI JAYACHAMARAJENDRA COLLEGE OF ENGINEERING, MYSURU

M.TECH PROGRAMME IN

BIOMEDICAL SIGNAL PROCESSING & INSTRUMENTATION

SCHEME I TO IV SEMESTER: 2017-2018

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SYLLABUS I TO IV SEMESTER: 2017-2018

DEPARTMENT OF INSTRUMENTATION TECHNOLOGY
Scheme of teaching and examination for M.TECH
(Biomedical Signal Processing & Instrumentation)

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DEPARTMENT OF INSTRUMENTATION TECHNOLOGY

Scheme of teaching and examination for M.TECH (Biomedical Signal Processing & Instrumentation)

SEMESTER	CREDITS
I	28.0
II	28.0
III	18.0
IV	26.0
TOTAL	100.0

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SRI JAYACHAMARAJENDRA COLLEGE OF ENGINEERING MYSORE

Scheme of teaching and examination for M.Tech (Biomedical Signal Processing & Instrumentation)

I SEMESTER

Sl No	Subject Code	Course Title	Teaching Department	CREDITS				Contact Hours	Marks			Exam Duration in hrs
			IT	L	T	P	TOTAL		CIE	SEE	Total	
1	BSI 110	Mathematics for Bioengineers	IT	4	0	1	5	6	50	50	100	03
2	BSI 120	Clinical Instrumentation-I	IT	4	0	1	5	6	50	50	100	03
3	BSI 130	Medical Imaging Systems	IT	4	0	1	5	6	50	50	100	03
4	BSI14X	Elective I	IT	4	0	1	5	6	50	50	100	03
5	BSI15X	Elective-II	IT	4	0/1	1/0	5	6	50	50	100	03
6	BSI 16L	Signal Processing Lab	IT	0	0	1.5	1.5	-	50	-	50	
7	BSI 17S	Seminar	IT	0	0	1.5	1.5	-	50	-	50	
				Total Credits			28		Total Marks		600	

Subject Code	ELECTIVE – I	L	T	P	TOTAL
BSI 141	Speech Signal Processing	4	0	1	5
BSI142	Statistical Signal Processing	4	0	1	5
BSI143	Embedded Systems Design	4	0	1	5

Subject Code	ELECTIVE – II	L	T	P	TOTAL
BSI 151	Pattern Recognition	4	0	1	5
BSI152	Biomechanics	4	1	0	5
BSI153	Biomaterials and Artificial organs	4	0	1	5

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Scheme of teaching and examination for M.Tech (Biomedical Signal Processing & Instrumentation)

II SEMESTER

Sl No	Subject Code	Course Title	Teaching Department	CREDITS				Contact Hours	Marks			Exam Duration in hrs
			IT	L	T	P	TOTAL		CIE	SEE	Total	
1	BSI 210	Advanced Biomedical Signal Processing	IT	4	0	1	5	6	50	50	100	03
2	BSI 220	Clinical Instrumentation-II	IT	4	0	1	5	6	50	50	100	03
3	BSI 230	Medical Image Analysis	IT	4	0	1	5	6	50	50	100	03
4	BSI 24X	Elective – III	IT	4	1	0	5	6	50	50	100	03
5	BSI 25X	Elective – IV	IT	4	0/1	1/0	5	6	50	50	100	03
6	BSI 26L	Medical Image Processing Lab	IT	0	0	1.5	1.5	-	50	-	50	
6	BSI 27S	Seminar	IT	0	0	1.5	1.5	-	50	-	50	
				Total Credits			28		Total Marks		600	

Subject Code	ELECTIVE – III	L	T	P	TOTAL
BSI 241	BIOMEMS and Nanotechnology	4	1	0	5
BSI 242	Medical devices regulations, Ethics and IPR	4	1	0	5
BSI 243	Lasers in Medicine	4	1	0	5

Subject Code	ELECTIVE – IV	L	T	P	TOTAL
BSI 251	Biometrics and Applications	4	0	1	5
BSI 252	Neural networks in Medicine	4	0	1	5
BSI 253	Rehabilitation Engineering	4	1	0	5

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Scheme of teaching and examination for M.Tech (Biomedical Signal Processing & Instrumentation)

III Semester

SL No	Subject Code	Course Title	Teaching Department	Credits				Contact Hours	Marks			Exam Duration in hrs
				L	T	P	Total		CIE	SEE	Total	
1	BSI31P	Practical Training In industry / Hospital Training	IT	0	0	4	4	---	100	---	100	---
2	BSI32P	Project Work (Phase-1)	IT	0	0	10	14	---	100	---	100	---
				Total Credits			18		Total Marks		200	---

IV Semester

SL No	Subject Code	Course Title	Teaching Department	Credits				Contact Hours	Marks			Exam Duration in hrs
				L	T	P	Total		CIE	SEE	Total	
2	BSI41P	Project Work (Phase-II)	IT	---	---	26	26	---	100	200	300	3
				Total Credits			26		Total Marks		300	---

Department Of Instrumentation Technology, SJCE, Mysuru

MATHEMATICS FOR BIOENGINEERS

Subject Code	**:**	**BSI 110**	**IA Marks**	**:**	**50**
Credits	**:**	**4 :0 :1**	**Exam hrs**	**:**	**03**
Total No.of Lecture Hrs	**:**	**52**	**Exam Marks**	**:**	**50**

Pre – requisite: Basic Mathematics

Course Objectives:

This course introduces concepts of matrices and matrix algebra, solving systems of linear equations, Present basic concepts of vector spaces, concepts of linear transformations and methods of computing using eigen values and eigenvectors.

Course Outcomes:

Students will be able to

1. Solve problems on Fourier series and transforms.
2. Solve and analyze the concepts on linear equations, vector equations matrix equation and factorization.
3. Analyze and solve vector spaces, bases, dimension, rank, eigenvlues and vectors and linear transformation.
4. Analyze and solve inner products, orthogonality, gram-Schmidt process, QR factorization, least squares problems.
5. Know and work on diagonalization of symmetric matrices, quadratic forms and SVD problems

Overview of Fourier analysis: Continuous & Discrete.

Linear Equations: System of linear equations, Row reduction and echelon forms, Vector equations, Matrix equations, Solution sets of linear systems; Applications of Linear systems, matrix operations;

inverse of a matrix, Matrix factorization, Applications to computer graphics.

12 Hrs

Vector Spaces: Vector spaces and subspaces; Linearly independent sets; bases, coordinate systems, dimension of a vector space; Rank, Change of basis Applications to difference equations.

10 Hrs

Linear Transformations: Linear transformations; eigen vectors and eigen values, characteristic equation, diagonalization, eigen vectors and linear transformation, Complex eigen values, Applications to differential equations. 10 Hrs

Orthogonality and Least Squares: Inner products, length and orthogonality, orthogonal sets, orthogonal projections; Gram-Schmidt process; QR-factorization; least-squares problems; Inner products spaces, Application to linear models, Application of inner product spaces. 10 Hrs

Symmetric Matrices and Quadratic Forms: Digitalization of symmetric matrices; quadratic forms; constrained optimization; singular value decomposition, Application to image processing and statistics. 10 Hrs

LIST OF EXPERIMENTS

Write program for following and verify with theoretical calculations:

1. Inverse of a matrix
2. Roots of characteristic equation
3. Rank & basis of matrix
4. QR factorization
5. Eigen values and eigen vector
6. Least squares

TEXT BOOK:

1. **Linear Algebra and its Applications**, David C. Lay, , 3rd Edition, Pearson Education (Asia) Pvt. Ltd, 2005.

REFERENCES:

1. **Linear Algebra and its Applications**, Gilbert Strang, 4thEdition, Thomson Learning Asia, 2007.
2. **Introductory Linear Algebra with Applications**, Bernard Kolman and David R. Hill, Pearson Education (Asia) Pvt. Ltd, 7th edition, 2003.
3. **Image Processing the Fundamaentals**, Maria Petrou/Costas Petrou 2nd Edition John Wiley.

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CLINICAL INSTRUMENTATION I

Subject Code	**:**	**BSI 120**	**IA Marks**	**:**	**50**
Credits	**:**	**4 : 0 :1**	**Exam hours**	**:**	**03**
Total No.of Lecture Hrs	**:**	**52**	**Exam Marks**	**:**	**50**

Pre – requisite: Electronic Instrumentation

Course Objective:

This course introduces to acquire the knowledge of the principle of operation and design of biomedical instruments; It gives the introductory idea about human physiology system which is very important with respect to design consideration. Describe and apply the signal amplification and processing that is common to many medical instruments. Summarize the origin of biopotentials and various bioelectric signals that are recorded routinely in modern clinical practice. Describe the basic mechanisms involved in the transduction process of biopotential electrodes and be able to discuss electrical characteristics of electrodes

Course outcomes:

Students will be able to:

1. Learn the genesis of various bio signals
2. Describe the cardiovascular system & ECG recording system

3. Describe the physiology of muscles and EMG acquisition
4. Explain the physiology, parts &disorders of brain and recording of EEG.
5. Analyze and evaluate the working of therapeutic equipments such as pacemakers and defibrillators.

Bioelectric Signals and Electrodes : Sources of biomedical signals, basic medical instrumentation system, PC based medical instruments, General constraints in design of medical instrumentation systems, origin of bioelectric signals, Electrocardiogram (ECG), Electroencephalogram (EEG), Electromyogram (EMG), Electrooculogram (EOG), Electroretinogram (ERG), Electrodes – Electrode-tissue interface, polarization, skin contact impedance, motion artifacts, Silver-Silver Chloride electrodes, , Electrical conductivity of electrode jellies and creams, microelectrodes

12Hrs

Cardiovascular System & ECG: 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 Recording. Electrodes for ECG, Electrocardiograph-block diagram, ECG leads, effects of artifacts, multi-channel, ECG machine, Vectorcardiograph, Phonocardiograph-origin of heart sounds, microphones and amplifiers for PCG 10 Hrs

Muscle Physiology & EMG : Classification of muscles, , Neuromuscular junction, Electromyogram & disorders of skeletal muscles: Electrodes of EMG, Pain relief though electrical stimulators, TENS, spinal cord simulator, Magnetic stimulation, introduction to FES.

10 Hrs

Nervous System & EEG: Introduction to nervous system, Neuron, Classification of nerve fibers, , Degeneration & regeneration of nerve fibers, Receptors, , Reflex activity, Electroencephalogram, Physiology of sleep, Electrodes for EEG, Electroencephalograph- block diagram, 10-20 electrode systems, computerized analysis of EEG, biofeedback instrumentation.

10 Hrs

Pacemakers & Defibrillator: Need for cardiac pacemaker, external pacemaker, implantable pacemakers-types, ventricular synchronous demand pacemaker, programmable pacemaker, power sources for implantable pacemakers. Need for defibrillator, DC defibrillator, automatic external defibrillator, implantable defibrillators 10 Hrs

LIST OF EXPERIMENTS:

1. ECG Simulation & arrhythmia analysis using Biokit
2. Real time ECG acquisition and analysis
3. EEG simulation using Biokit
4. Real time EEG acquisition and analysis
5. EMG simulation using Biokit
6. Real time EMG acquisition and analysis

TEXTBOOKS:

1. **Essentials of Medical Physiology,** K Sembulingam & Prema Sembulingam , Jaypee Publications, 2004
2. **Handbook of Biomedical Instrumentation"** R.S.Khandpur, 2nd Edition, Tata McGraw Hill, 2003

REFERENCES:

1. **Text Book Of Medical Physiology,** Guyton & Hall, Saunders/Elsevier, 11th edition
2. **Concise Medical Physiology**, Sujit K. Chaudhuri, 5th Edition, New Central Book Agency Pvt. Ltd.
3. **Biomedical Instrumentation and Measurement,** Leslie Cromwell, Fred J Weibell and Erich A. Pfeiffer, Prentice-Hall India Pvt. Ltd.
4. **Introduction to Biomedical Equipment Technology,** Joseph J. Carr and John M. Brown, 4th Edition

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MEDICAL IMAGING SYSTEMS

Subject Code	**:**	**BSI 130**	**IA Marks**	**:**	**50**
Credits	**:**	**4 : 0 : 1**	**Exam hours**	**:**	**03**
Total No.of Lecture Hrs	**:**	**52**	**Exam Marks**	**:**	**100**

Pre – requisite: Basic sciences, Human Physiology

Course Objective: To introduce the students to the principle behind different imaging modalities, image acquisition techniques and components required for acquisition.

Course Outcome:

Students will be able to

1. Express the importance of basic components and imaging techniques used in X-Ray imaging and CT machines.
2. Assess the characteristics of Ultrasound and working of different types of ultrasound imaging systems.
3. Explain the basics of MRI and MRI acquisition techniques.
4. Express the importance of basic components of RNI and Image acquisition techniques.
5. Describe the components, concepts and architecture of PACS.

X-Rays: Interaction between X-Rays and matter, Intensity of an X-Ray, Attenuation, X-Ray Generation and Generators, Beam Restrictors and Grids, Intensifying screens, fluorescent screens and Image intensifiers, X-Ray detectors, Conventional X-Ray radiography, Fluoroscopy, Angiography, Digital radiography, Dynamic Spatial Reconstructor, X-Ray image characteristics, Biological effects

of ionizing radiation. Advancements in X-Ray imaging. 10 Hrs

Computed Tomography: Conventional tomography, Computed tomography principle, Projection function, Generations of CT machines, Electron beam CT, Reconstruction algorithms, Helical CT. Advancements in CT imaging. 8 Hrs

Ultrasound Imaging: Acoustic propagation, Attenuation, Absorption and Scattering, Ultrasonic transducers, Arrays, A mode, B mode, M mode scanners, Tissue characterization, Color Doppler flow imaging, Echocardiography. Advancements in Ultrasound imaging. 8 Hrs

Magnetic Resonance Imaging: Angular momentum, Magnetic dipole moment, Magnetization, Larmor frequency, Rotating frame of reference, Free induction decay, Relaxation times, Pulse sequences, Block Diagram of a magnetic resonance imager, Slice selection, Frequency encoding, Phase encoding, Spin-Echo imaging, Gradient-Echo imaging, Imaging safety. Advancements in MR Imaging. 10 Hrs

Radionuclide Imaging: Interaction of nuclear particles and matter, Nuclear sources, Radionuclide generators, Nuclear radiation detectors, Rectilinear scanner, scintillation camera, SPECT, PET. Advancements in nuclear imaging. 8 Hrs

PACS: PACS Components, PACS Infrastructure Design Concept, A Generic PACS Workflow, Current PACS Architectures, PACS and Teleradiology, Enterprise PACS and ePR System with Image Distribution. 8 Hrs

LIST OF EXPERIMENTS:

1. Study the technical specifications of X-RAY machine and CT machine used in the hospitals, Scanning procedure and the related softwares.

2. Compute reconstruction of images using Back-Projection method either by taking original images or by creating phantom images (by placing circle and rectangle).
3. Study the technical specifications of Ultrasound machine and Echocardiography equipment used in the hospitals, Scanning procedure and the related softwares.
4. Study the technical specifications of MRI machines and Radionuclide imaging machines used in the hospitals, Scanning procedure and the related softwares.
5. Study and understand DICOM image format, its importance and methods of getting information from it.
6. Study the component and architecture of the PACS used in the hospitals.

TEXT BOOKS:

1. **Principles of Medical Imaging**, by Kirk shung, Academic Press.
2. **PACS and Imaging Informatics: Basic Principles and Applications**, 2nd Edition, H. K. Huang, December 2009, Wiley-Blackwell.
3. **Medical Imaging Signals and Systems,** by Jerry L Prince and Jonathan M Links, Pearson Prentice Hall Bioengineering.

REFERENCES:

1. **Handbook of Biomedical Instrumentation**, by Khandpur, Tata McGraw-Hill Publishing Company Ltd., Second edition, 2003.
2. **Fundamentals of medical Imaging**, by Zhong Hicho and Manbir singh, John Wiley.

Department Of Instrumentation Technology, SJCE, Mysuru

SPEECH SIGNAL PROCESSING

Subject Code	**:**	**BSI141**	**IA Marks**	**:**	**50**
Credits	**:**	**4 : 0 : 1**	**Exam hours**	**:**	**03**
Total No.of Lecture Hrs	**:**	**52**	**Exam Marks**	**:**	**100**

Prerequisites: Signal and systems and Digital signal processing

Course Objective: This course will introduce the digital models and processing of speech signals. By the end of the course, students will be familiar with speech analysis and synthesis, enhancement, recognition and also on speech processors.

Course Outcomes:

Students will be able to:

1. Explain the sources of speech production and develop Digital Models and Digital representation of speech signals.
2. Express the importance of basic concepts in digital signal processing
3. Apply Time domain, Fourier, LPC and Cepstrum analysis.
4. Explain compression, enhancement and synthesis of speech signals.
5. Describe the principles of speech and speaker recognition techniques, Hearing impairment and speech processors.

Digital Models for Speech Signals: Process of Speech Production, Classification of Phonemes, Digital models for Speech signals. 4 Hrs

Digital Representations Sampling speech signals, Review of the statistical model for speech, Instantaneous quantization, Adaptive quantization, General theory of differential quantization, Delta modulation, Differential PCM, Comparison of systems. 6 Hrs

Introduction to digital signal processing: Introduction, A digital signal processing system, discrete time sequences, linear time invariant systems, Fast Fourier Transform (FFT) and Inverse Fast Fourier Transform (IFFT), Digital FIR Filters, Decimation and Interpolation process. 10 Hrs

Time Domain Models for Speech Processing: Time dependent processing of speech, Short time Energy and average magnitude, Short time average zero crossing rate, Speech vs. silence discrimination using energy and zero crossing, Pitch period estimation using parallel processing approach, Short time autocorrelation function, Short time average magnitude difference function, Pitch period estimation using autocorrelation function. 4 Hrs

Short Time Fourier Analysis: Introduction, Definitions and properties, Fourier transform interpretation, Linear filtering interpretation, Sampling rates of X(ejw) in time and frequency, Filter bank summation method of short time synthesis, Cepstrum analysis, Mel-frequency cepstrum, Spectrogram and its applications. 3 Hrs

Linear predictive coding analysis: Basic principles of linear predictive analysis, Solution of LPC equations using autocorrelation method, covariance method, Lattice method Applications of LPC parameters. 5 Hrs

Speech Compression: Speech compression using LPC and DCT. 2 Hrs

Speech Enhancement: Principles of Speech enhancement, Evaluation of speech intelligibility, Speech enhancement algorithms: Spectral subtraction, Adaptive filtering: LMS and RLS algorithm.

5 Hrs

Speech Synthesis: Principles of Speech synthesis, Synthesis based on waveform coding, Synthesis based on analysis synthesis method, Synthesis based on speech production mechanism, Synthesis by rule, Text to speech conversion. 3 Hrs

Speech and Speaker Recognition: Principles of Speech recognition, Speech period detection, Spectral distance measures, Structure of word recognition systems, Dynamic time warping (DTW), Word recognition using phoneme units, Text dependent and Text independent speaker recognition systems. Hidden Morkov Model 3 Hrs

Hearing: Anatomy and physiology of the ear, Types of hearing impairments, Digital hearing aid, Cochlear implants. 2 Hrs

Speech Processor: TMS320C6713 Features, architecture and programming. Architecture and applications of SP0264. 5 Hrs

LIST OF EXPERIMENTS

1. Study of Non stationary nature, estimation of pitch and formants, wideband & narrow band spectrogram of speech signals using Prat and wavesurfer.
2. Study of short time energy, short time average magnitude, short time zero crossing rate and short time autocorrelation of speech signals using Matlab.
3. Study of LPC analysis and synthesis of speech signals using Matlab.
4. Study of Cepstrum analysis of speech signals using Matlab.
5. Study of LMS and RLS algorithms for speech enhancement using Matlab.
6. Study of DCT algorithm for speech compression using Matlab.

TEXT BOOKS:

1. **Digital Processing of Speech Signals**, L R Rabiner and R W Schafer, Pearson Education 2004.
2. **Digital Speech Processing, Synthesis and Recognition**, Sadoaki Furui, Second Edition, Mercel Dekker 2002.

3. **Digital hearing aids: A tutorial review,** Harry levitt, Journal of Rehabilitation research, Vol 24, N0-4, 1987
4. **Signal processing for Cochlear Prothesis: A Tutorial review ,** Philips C.Loizou, 1997, IEEE, Cochlear implants
5. **Designing with speech processing chips**, Ricardo Jimenez, Acaademic press, INC 1991.

REFERENCES:

1. **Introduction to Data Compression**, Khalid Sayood, Third Edition, Elsivier Publications.
2. **Digital Speech**, A M Kondoz, Second Edition, Wiley Publications

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STATISTICAL SIGNAL PROCESSING

Subject Code	**:**	**BSI142**	**IA Marks**	**:**	**50**
No of Lecture Hrs/Week	**:**	**4 : 0 : 1**	**Exam hours**	**:**	**03**
Total No.of Lecture Hrs	**:**	**52**	**Exam Marks**	**:**	**100**

Prerequisites: Signal and systems and Digital signal processing

Course Objective: This course will introduce the signal modeling and estimation theories. By the end of the course, students will be familiar with Signal modeling, spectral estimation & analysis, linear prediction, and adaptive algorithms.

Course Outcomes:

Students will be able to

1. Develop Signal modeling using Least Square Methods.
2. Determine spectral estimation and analysis of signals using Non parametric methods.
3. Determine spectral estimation and analysis of signals using parametric methods.
4. Explain basic concepts of forward and backward Linear prediction
5. Explain principles of LMS and RLS adaptive algorithms and Kalman filters

Digital Filter design using least-square method: Least Square error criterion in the design of Pole-zero filters, FIR least squares inverse filters. 10 Hrs

Spectral Estimation and Analysis - Non parametric methods: Periodogram, Bartlett and Welch modified periodogram, Blackman-Tukey Methods. 10 Hrs

Spectral estimation and analysis - Parametric methods: wide sense stationary random process, rational power spectra: Auto Regressive (AR) Process, Moving Average (MA) Process, ARMA Process, Relationship between the Filter Parameters and the auto correlation sequence.

10 Hrs

Forward and backward Linear Prediction: Forward Linear Prediction, Backward Linear Prediction, Relationship of an AR process to Linear Prediction: Yule–Walker Method, Levinson–Durbin Algorithm. 12 Hrs

Adaptive Algorithms to adjust coefficients of digital filters: Least Mean Square (LMS), Recursive Least Square (RLS) and Kalman Filter Algorithms. 10 Hrs

LIST OF EXPERIMENTS

1. Using MATLAB find the signal energy or power of the signals.
2. Plot correlograms using MATLAB.
3. Periodogram of a signal containing two Sinusoidal components corrupted

   with White noise using MATLAB.
4. Power Spectrum estimate of a random signal using Bartlett Method.
5. Power Spectrum estimate of a random signal using Welch Method.
6. Implementation of LMS algorithm for optimum filter coefficients.

TEXT BOOKS:

1. **Statistical signal processing and Modelling**, Monson H.Hayes, Wiley, 1996
2. **Fundamentals of stastical signal processing,** Estimation Theory, S.M.Kay, Prentice Hall, 1993.

REFERENCE BOOKS:

1. **Digital Signal Processing, Principles, Algorithms, and Applications,** Proakis, John G., Dimitris G. Manolakis, and D. Sharma:, Pearson Education, 2006.
2. **Digital Signal Processing a computer Based approach,** Mitra Sanjit.K, Tata McGraw-Hill,2001.
3. **Adaptive Signal Processing,** B. Widrow & S Stearns, PHI, 1985.
4. **Statistical and Adaptive Signal Processing,** Dimitris, Manolakis, McGraw Hill, 2000.

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EMBEDDED SYSTEMS DESIGN

Subject Code	**:**	**BSI 143**	**IA Marks**	**:**	**50**
Credits	**:**	**4 : 0 : 1**	**Exam hours**	**:**	**03**
Total No.of Lecture Hrs	**:**	**52**	**Exam Marks**	**:**	**100**

Pre – requisite: Logic design, Linear ICs, Microprocessor/Microcontroller.

Course Objective: To introduce the students to the concepts, technical aspects, interfacing methods and programming methods used in embedded system design

Course Outcome:

Students will be able to

1. Explain the basic concept of embedded system design and fundamentals of ARM processors.
2. Apply the ARM instructions for system development
3. Apply the THUMB instructions for system development.
4. Design systems by interfacing external and internal devices using LPC 2148 ARM processor.
5. Express the importance of real time programming and operating systems.
6. Develop systems by interfacing peripheral devices.

Concept of embedded system design: Internal Block Diagram, Components, classification, skills required. Embedded Memories ROM variants, RAM, Applications of embedded system, Examples of Embedded systems. 10 Hrs

ARM embedded systems fundamentals: The RISC design philosophy, The ARM design philosophy, Registers, current program status register, pipeline, exceptions, interrupts and vector table. 6 Hrs

Introduction to ARM instruction Set: Data Processing Instructions, Branch Instructions, Load Store Instructions, Software Interrupt Instruction, Program Status Register Instructions, and Conditional Execution. 8 Hrs

Introduction to the THUMB Instruction set: Thumb register Usage, Data Processing Instructions, Single register Load –store Instructions, Multiple register Load Store Instructions, Stack Instructions, and Software Interrupt Instruction. 7 Hrs

Interfacing concepts using LPC 2148: Design of system using GPIO's, Timers, ADC, DAC and UART. 10 Hrs

Software Design

Real time programming Languages, operating systems. Programming concepts and embedded programming in C, Scheduling algorithms such as Round Robin, Round Robin with interrupts, priority, pre-emptive, function queue-scheduling architecture, Real time OS architecture, and selection. 11 Hrs

LIST OF EXPERIMENTS:

1. LPC2148 Assembly language programming using Arithmetic operations.
2. LPC2148 Assembly language programming using Logical operation and code conversion.
3. LPC2148 C language programming for interfacing input devices.
4. LPC2148 C language programming for interfacing output devices.
5. LPC2148 C language programming for internal Timer operations.

6. LPC2148 C language programming for internal DAC and ADC operations.

TEXT BOOKS:

1. Embedded Microcomputer systems: Real time interfacing,Valvano, J.W, Brooks/Cole, 2000
2. ARM system Developers Guide, Andrew N.Sloss, Elsevier, 2008

REFERENCE BOOKS:

1.LPC 2148 User Manual

2.Embedded System, Architecture, Programming and Design, Raj Kamal, TMH 2003.

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PATTERN RECOGNITION

Subject Code	**:**	**BSI 151**	**IA Marks**	**:**	**50**
Credits	**:**	**4 : 0 : 1**	**Exam hours**	**:**	**03**
Total No.of Lecture Hrs	**:**	**52**	**Exam Marks**	**:**	**100**

Course Objectives: To provide the basics of statistical techniques commonly used in pattern recognition systems and to introduce parametric, nonparametric decision making algorithms of pattern recognition systems and to provide knowledge clustering and artificial neural network for pattern recognition systems.

Course outcomes:

Students will be able to

1. Explain the basics of pattern recognition, feature extraction, design cycle and Bayesian theorem, statistical decision making
2. Design and evaluate Bayesian classification, algorithms, error rate of classifier, different methods, performance evaluation
3. Describe the non parametric decision making system, classification algorithms, design issues
4. Design and develop clustering algorithms, and its different types, hierarchical and Partitional clustering algorithms
5. Explain and interpret the basics of artificial neural networks, layers, algorithms

Introduction: Pattern recognition overview, typical pattern recognition system, patterns and feature extraction examples, classification, post processing, design cycles, training, supervised learning,

Statistical decision making, Bayes theorem, continuous densities, decision regions, multiple features, conditionally independent features **10Hrs**

Bayesian classifiers: decision boundaries, two dimensional examples, d-dimensional decision boundaries in matrix notation, examples Estimation of error rates: unequal costs of error, estimation of error rates, model based estimates, simple counting, fractional counting, characteristic curves, Confusion matrices, examples, estimating the composition of populations

12**Hrs**

Nonparametric decision making: Introduction, histograms, Kernel and Window estimators, nearest neighbor classification technique, nearest neighbor error rates, adaptive decision boundaries, algorithm, examples, adaptive discriminant functions, examples, and minimum squared error discriminate function, examples **10 Hrs**

Clustering: Introduction, Hierarchical clustering, agglomerative clustering algorithms, single linkage algorithm, complete linkage algorithm, average linkage algorithm, Wards method, examples, Partitional clustering, Forgy's algorithm, k-means algorithm, examples **10 Hrs**

Artificial neural networks: Introduction, nets without hidden layers, examples, sequential MSE algorithm, steepest descent method, examples, nets with hidden layers, examples, the back propagation algorithm, Hopfield nets, examples, storage and retrieval algorithms, Support vector machines, Risk minimization principles and the Concept of uniform Convergence, VC dimension, support vector machine algorithms **10 Hrs**

TEXT BOOK:

Pattern Recognition and Image Analysis, Earl Gose, Richard Johnsonbaugh, and Steve Jost, PHI, 2002

REFERENCES:

1. **Pattern Classification,** Richard O Duda, Peter E Hart and David G stork, John Wiley and sons, 2nd ed. 2001

2. **Neural Networks a comprehensive foundation,** Simon Haykin, second edition, PHI, 2008

LIST OF EXPERIMENTS

1. Write a program to perform Bayesian classification for a two feature sample space, when the class probability, mean and covariance are given.
2. Write a program to determine the optimal decision boundary between two simple bivariate normal classes when the features are independent in each class(assume equal covariance)
3. Write a program to compute the confusion matrix when the training set is provided
4. Write a program to find a decision boundary to classify samples using adaptive decision boundary algorithm
5. Write a program to perform the hierarchical clustering when the feature values of samples are provided
6. Write a program to perform Partitional clustering using Forgy's or K-means algorithm when the feature values of samples are provided

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BIOMECHANICS

Subject Code	**:**	**BSI 152**	**IA Marks**	**:**	**50**
Credits	**:**	**4 : 1 : 0**	**Exam hours**	**:**	**03**
Total No.of Lecture Hrs	**:**	**52**	**Exam Marks**	**:**	**100**

Course Objective: This course will introduce the knowledge of biomechanics. At the end of the course student will be able to know concepts related to joint structure, gait kinematic analysis and Rheology of blood.

Course Outcome:

Students will be able to:

1. Express the concepts related to joint structure.
2. Explain Gait cycle and joint motion.
3. Develop Kinetics and Kinematics of Poistures.
4. Explain blood flow in heart, lung, arteries and veins.
5. Apply Finite element analysis in Biomechanics.

Biomechanics Applications to Joint Structure and Function: Introduction to Kinematics;Displacement in space; Force vectors and gravity; Linear forces and concurrent forces; Kinetics of rotary and translatory forces; Classes of levers; Close chain force analysis.

6 Hrs

Constitutive Equations: Equations for Stress and Strain; Non-viscous fluids; Newtonian viscous fluids; Elastic solids; Visco-elasticity and its applications in biology. 6 Hrs

Joint Structure and Function: Properties of connective tissues; Human Joint design; Joint Function and changes in disease. 10 Hrs

Integrated Functions : Kinetics and Kinematics of Poistures; Static and Dynamic Poistures; Analysis of Standing, Sitting and Lying Poistures. 10 Hrs

Gait: Gait cycle and joint motion; Ground reaction forces; Trunk and upper extremity motion; internal and external forces, moments and conventions; Gait measurements and analysis. 5 Hrs

Force Platform and Kinematic Analysis: Design of force platforms, Integrating force and Kinematic data; linked segment, free-body analysis. 5 Hrs

Rheology of Blood: Blood flow in heart, Lung, Arteries and Veins. 5 Hrs

Finite Element Analysis in Biomechanics: Model creation, Solution, Validation of results and applications of FEA. 5 Hrs

TEXT BOOKS

1. **Joint Structure and Function, A Comprehensive Analysis,** Pamela K. Levangie and Cynthia C. Norkin, JAYPEE Publications, Fourth Edition, 2006.

2. **Biomechanics; Mechanical Properties of Living Tissues**,Y. C. Fung Springer Verlag, 1985.

REFERENCE BOOKS

3. **Biomechanics, Structures and Systems**, A. A. Biewener, Sports Publication

4. **Biomechanics of Human Motion**, T. McClurg, Anderson.

Department Of Instrumentation Technology, SJCE, Mysuru

BIOMATERIALS & ARTIFICIAL ORGANS

Subject Code	**:**	**BSI 153**	**IA Marks**	**:**	**50**
Credits	**:**	**4 :0 :1**	**Exam hours**	**:**	**03**
Total No.of Lecture Hrs	**:**	**52**	**Exam Marks**	**:**	**50**

Course Objective:

This course is designed to provide a general understanding of the multidisciplinary field of biomaterials. It introduces polymer and biology/biochemistry courses and will further extend the understanding about the interactions at the interface of material and biological systems. The advanced study of multiple material systems applications will also provide an expanded understanding of how disciplines are merging to provide solutions for society while reinforcing the concept of self learning. Also aims at introducing existing artificial organs, prostheses, and rehabilitation systems, focusing on their goals, working principles, and limitations.

Course outcomes:

Students will be able to

1. To describe the properties of the Bio-compatible materials
2. To know the different types of Biomaterials
3. Explain hard tissue replacement techniques & preservation techniques for biomaterials
4. Evaluate design techniques for ventricular assist device and prosthetic valves
5. To know the different artificial methods for replacement of functions of kidney, lungs& liver.

Biomaterials: Introduction to biomaterials, uses of biomaterials, biomaterials in organs &body systems, materials for use in the body, performance of biomaterials **Metallic Biomaterials:**

Introduction, Stainless steel, Cobalt-Chromium alloy, Titanium alloys, Titanium-Nickel alloys, Dental metals, Corrosion of metallic implants, Manufacturing of implants, **Ceramic Biomaterials:** Introduction, nonabsorbable/relatively bioinert bioceramics, biodegradable/resorbable ceramics, bioreactive, ceramics, deterioration of ceramics, bioceramic manufacturing techniques

10Hrs

Polymeric Biomaterials: Introduction, polymerization and basicstructure, polymers used as biomaterials, sterilization, surface modifications to for improving biocompatibility.**Composite Biomaterials:** Structure, bounds on properties, anisotropy of composites, particulate composites, fibrous composites, porous materials, biocompatibility.**Biodegradable Polymeric Biomaterials:** Introduction, Glycolide based biodegradable homopolymers polyesters, non-glycolidelinear aliphatic polyesters, aliphatic and aromatic olycarbonates,biodegradation properties of synthetic biodegradable polymers. 10Hrs

Tissue Derived Biomaterials: Structure and properties of collagen and collagen-rich tissues, biotechnology of collagen, design of resorbable collagen-based medical implants.**Hard Tissue Replacements:** Bone repair and joint implants-longbone repair and joint replacements, dental implants- effects of material selection, effects of surface properties, surface chemistry. **Preservation Techniques For Biomaterials:** Phase behavior, nonfreezing storage-hypothermic, freeze-thaw technology, freeze drying,vitrification. 10Hrs

Artificial Organs: Introduction: Substitutive medicine, outlook for organ replacement, design consideration, evaluation process. **Artificial Heart And Circulatory Assist Devices:** Engineering design, Engg design of artificial heart and circulatory assist devices, blood interfacing implants – introduction, total artificial hearts &ventricular assist devices, vascular prostheses, Non-blood interfacing implants for soft tissues- sutures and allied augmentation devices, percutaneous and skin implants, maxillofacial implants, eye and ear implants. **Cardiac Valve Prostheses:** Mechanical valves, tissue valves, current types of prostheses, tissue versus mechanical, engineering concernsand hemodynamic assessment of prosthetic heart valves, implications forthrombus deposition, durability,

current trends in valve design, vascular grafts-history, synthetic grafts, regional patency, thrombosis, neointimal hyperplasia, graft infections.

12Hrs

Artificial Lungs: Gas exchange systems, Cardiopulmonary bypass (heart-lung machine)-principle, block diagram and working, artificial lung versus natural lung. Liver functions, hepatic failure, liver support systems, general replacement of liver functions. **ARTIFICIAL PANCREAS:** Structure and functions of pancreas, endocrine pancreas and insulin secretion, diabetes, insulin, insulin therapy, insulin administration systems. Tracheal replacement devices, laryngeal replacement devices, artificial esophagus Artificial Skin: Vital functions of skin, current treatment of massive skin loss, design principles for permanent skin replacement. 10Hrs

LIST OF EXPERIMENTS:

Understand the construction & working of the following in hospital visit

1. Metallic biomaterial
2. Polymer biomaterial
3. Prosthetic valve
4. Prosthetic limbs
5. Heart lung machine
6. Insulin administration system

TEXT BOOKS:

1. **Biomedical Engineering Handbook-Volume 1,** J.D.Bronzino, 2nd Edition CRC Press / IEEE Press, 2000.

2. **Biomedical Engineering Handbook-Volume 2 ,** by J.D.Bronzino, 2nd Edition, CRC Press / IEEE Press, 2000.

REFERENCE BOOK:

1. **Handbook of Biomedical Instrumentation -** by R.S.Khandpur, 2nd Edition, Tata McGraw Hill, 2003

Department Of Instrumentation Technology, SJCE, Mysuru

SIGNAL PROCESSING LAB

Sub code : BSI16L **Credit Pattern : 0:0:1.5**

Total Hours : 39 Hrs **Contact Hours : 03/Week**

Prerequisites: Signal and systems, Digital signal processing and DSP Architecture

Course Objective: This course will introduce DSP algorithm implementation using Matlab and on TMS320C6713 processor. By the end of the course, students will be familiar with Convolution, FFT, Filter programs, interpolation and decimation programs using MATLAB and assembly, C, real time C programs on TMS320C6713.

Course Outcome:

Students will be able to:

1. Develop Matlab convolution, correlation and FFT programs.
2. Develop Matlab programs to implement FIR filters, IIR filters, interpolation and decimation process.
3. Implement DSP algorithms using assembly language programs on TMS320C6713.
4. Implement DSP algorithms using C programs on TMS320C6713.
5. Implement DSP algorithms using real time C programs on TMS320C6713.

LIST OF EXPERIMENTS:

Using MATLAB:

1. Study of Sampling Theorem.
2. Study of convolution of series and parallel system and properties of linear time invariant system.

3. Study of implementation of correlation and correlation coefficients
4. Study of FFT and its inverse.
5. Study of FIR filters using window method: Low pass, High pass, Band pass and Band reject.
6. Study of IIR Butterworth and Chebyshev low pass filters
7. Study of interpolation and decimation process.

Using TMS320C6713 processor:

8. Study of convolution & filters implementation on 6713 using fixed point and floating point instructions.
9. Study of implementation of convolution, correlation, FIR filters, IIR filters, and FFT on 6713 using C programs.
10. Study of implementation of FIR filters using codec of 6713.

Text books:

Modern digital signal processing: V.Udayashankara, PHI, Third Edition, 2012.

Department Of Instrumentation Technology, SJCE, Mysuru

ADVANCED BIOMEDICAL SIGNAL PROCESSING

Subject Code	**:**	**BSI210**	**IA Marks**	**:**	**50**
No of Lecture Hrs/Week	**:**	**4 : 0 : 1**	**Exam hours**	**:**	**03**
Total No.of Lecture Hrs	**:**	**52**	**Exam Marks**	**:**	**100**

Prerequisites: Digital signal processing

Course Objective: This course will introduce the fundamentals of human physiological signal its characteristics, morphology, signal modeling. By the end of the course, the students will be able to write algorithms to detect events, data reduction and signal estimation using modeling techniques and for noise reduction in bio-signals.

Course Outcomes:

Students will be able to

1. Explain the sources of biomedical signals, their characteristics and understand the basic association with human physiology.
2. Apply the knowledge of signal processing to analyze the various events and waveform complexities, compression techniques and clinical applications of ECG signal.
3. Explain the basics of neurological signal; the EEG signal using Parametric and nonparametric spectral analysis technique.
4. Apply the knowledge of different noise cancellation techniques to different biosignals.

5. Explain the basics of EMG and have a knowledge of its analysis techniques.

Introduction - Biomedical Signal Processing: Objectives , Basics of Bioelectrical Signals, Signal Acquisition and Analysis, Performance Evaluation. The Electrocardiogram – Electrical Activity of the Heart- A Brief Background, Heart Rhythms, Heartbeat Morphologies, Noise and Artifacts, Clinical Application. 08 Hrs

ECG Signal Processing, Baseline Wander, Powerline Interference (50/60 Hz), Muscle Noise Filtering, QRS Detection, Wave Delineation, Data Compression. 10 Hrs

Heart Rate Variability - Acquisition and RR Interval Conditioning, Time Domain Measures, Heart Rhythm Representations, Spectral Analysis of Heart Rate Variability, Clustering of Beat Morphologies 06 Hrs

The Electroencephalogram –Electrical Activity –a brief description, EEG Signal Processing, Modeling the EEG Signal, Artifacts in the EEG, Nonparametric Spectral Analysis. 10 Hrs

Model-based Spectral Analysis, EEG Segmentation, Joint Time-Frequency Analysis, **Evoked Potentials**- Evoked Potential Modalities. 06 Hrs

Noise elimination techniques- Noise Characteristics, Noise Reduction by Ensemble Averaging, Noise Reduction by Linear Filtering, Single-Trial Analysis Using Basic Functions, Adaptive Analysis using basis functions, Wavelets. 06 Hrs

The Electromyogram: The Electrical Activity of Muscles, Amplitude Estimation in the Surface EMG, Spectral Analysis of the Surface EMG, Conduction Velocity Estimation, Modeling the intramuscular EMG, Intramuscular EMG Signal Decomposition. 06 Hrs

LABORATORY EXPERIMENTS:

1. Acquisition of biosignals like Electrocardiogram, Electromyogram , Electroencephalogram and storing them in a file.
2. Detection of QRS complex and heart rate measurement.
3. Signal Averaging to improve the SNR.
4. Design of Adaptive Noise Canceller for the removal of Interference and Noise in Bio signals
5. Data Compression Techniques: lossy compression : an example, lossless compression: an example,and wavelets.
6. Modeling of Biosignals: AR modeling.

TEXT BOOKS:

1. Sörnmo, "Bioelectrical Signal Processing in Cardiac & Neurological Applications", Elsevier ,2005.
2. Rangaraj M Rangayyan, "Biomedical Signal Analysis", Wiley 2002.

REFERENCES :

1. D.C.Reddy, "Biomedical Signal Processing: Principles and techniques" , Tata McGraw Hill, New Delhi, 2005
2. Willis J Tompkins, Biomedical Digital Signal Processing, Prentice Hall, 1993
3. Bruce, "Biomedical Signal Processing & Signal Modeling," Wiley, 2001
4. Semmlow, "Biosignal and Biomedical Image Processing", Marcel Dekker, 2004

Department Of Instrumentation Technology, SJCE, Mysuru

CLINICAL INSTRUMENTATION II

Subject Code	**:**	**BSI 220**	**IA Marks**	**:**	**50**
Credits	**:**	**4 :0 :1**	**Exam hours**	**:**	**03**
Total No.of Lecture Hrs	**:**	**52**	**Exam Marks**	**:**	**50**

Pre – requisite: Electronic Instrumentation

Course Objective: This course describe the principles of biomedical measurement systems, describe the various techniques of measuring blood flow and volume, describe the physiology of renal system and principles of haemodialysis and describe the working of telemetry and telemedicine systems.

Course outcomes:

Student will be able to:

1. Explain the mechanism of respiration and recording system
2. Access the function of renal system & artificial kidney,
3. Describe the principle and measuring methods of blood flow, oximetry and cardiac output.
4. Differentiate between direct and indirect blood pressure measurement
5. Analyze the principles of biomedical telemetry and telemedicine

Respiratory System: Physiological anatomy of respiratory tract, Pulmonary circulation, , Pulmonary function tests, Ventilation, Spirometry: Basic spirometer, wedge spirometer, ultrasonic spirometer. Pneumotachometers: Basics, Fleisch Venturi type, turbine type Pneumotachometers, Ventilators, types, classification, pressure-flow diagrams, modern ventilators, High frequency ventilators, Humidifiers, Nebulizers and Aspirators. 10 Hrs

Renal system : Kidney, Renal function tests, Renal Failure, Dialysis and Artificial Kidney, Dialyzers, Membranes for Haemodialysis, Haemosialysis machine. Lithotripters-Modern lithotripter system, Extra- corporeal shock- wave therapy

10 Hrs

Circulatory system: Introduction, properties of blood, composition of blood, Functions of blood, Hemoglobin and Iron metabolism, blood volume. Oximetry- In-vitro & in-vivo, ear oximetry, pulse oximetry, skin reflectance oximeters, intravascular oximeter. Electromagnetic blood flowmeter-principle, square wave electromagnetic flowmeter, Doppler shift ultrasonic flowmeter, flow measurement by Doppler imaging, NMR & Laser Doppler flowmeter, Cardiac output measurement-Indicator & dye dilution technique, impedance method, ultrasound method.

10 Hrs

Patient Monitoring Systems: Cardiac monitor, bedside patient monitoring system, measurement of heart rate-average and instantaneous heart rate meters, measurement of pulse rate, Blood pressure measurement: Direct method, indirect method-automatic pressure measurement using Korotkoff's method, differential auscultatory technique, oscillometric method, ultrasonic Doppler shift method, arrhythmia monitor, exercise stress testing-treadmill test & bicycle test,

10 Hrs

Biomedical Telemetry and Telemedicine: Wireless Telemetry, Single channel telemetry systems, ECG telemetry system, temperature telemetry system, Multichannel wireless telemetry systems, ,Multipatient telemetry, Implantable telemetry system, Telemedicine: Telemedicine applications, Essential parameters for telemedicine, Telemedicine technology, video conferencing, Digital communication systems, Telemedicine using mobile communication, use of internet resources for telemedicine, introduction to Bluetooth and Zigbee. 12 Hrs

LIST OF EXPERIMENTS:

1. Blood pressure recording
2. Recording of Heart sounds using phonocardiogram
3. Design of Instrumentation amplifier with different gains using opamp
4. Design of high gain amplifiers with offset nulling
5. Design of Band pass filter to cancel the low frequency and high frequency noises
6. Design of real time data acquisition system for ECG using discrete components & opamp.

TEXTBOOKS:

1. **Essentials of Medical Physiology,** K Sembulingam & Prema Sembulingam , Jaypee Publications, 2004
2. **Handbook of Biomedical Instrumentation,** R.S.Khandpur, 2nd Edition, Tata McGraw Hill, 2003

REFERENCES:

1. **Text Book Of Medical Physiology,** Guyton & Hall, Saunders/Elsevier, 11th edition
2. **Concise Medical Physiology**, Sujit K. Chaudhuri, 5th Edition, New Central Book Agency Pvt. Ltd.
3. **Biomedical Instrumentation and Measurement**, Leslie Cromwell, Fred J Weibell and Erich A. Pfeiffer, Prentice-Hall India Pvt. Ltd.
4. **Introduction to Biomedical Equipment Technology,** Joseph J. Carr and John M. Brown, 4th Edition,

Department Of Instrumentation Technology, SJCE, Mysuru

MEDICAL IMAGE ANALYSIS

Subject Code	**:**	**BSI 230**	**IA Marks**	**:**	**50**
Credits	**:**	**4 : 0 : 1**	**Exam hours**	**:**	**03**
Total No.of Lecture Hrs	**:**	**52**	**Exam Marks**	**:**	**100**

Pre-requisite: Knowledge of image processing.

Course Objective: This course will introduce the knowledge of medical images, their characteristics and types of artifacts. At the end of the course student will be able to write algorithms for image quality improvement, image segmentation and for removal of artifacts.

Course Outcomes

Students will be able to

1. Explain the concepts related to medical images, image quality and information content.
2. Have the knowledge of characterization and removal of artifacts and noise in images.
3. Describe and interpret the techniques aimed toward the improvement of the quality or the desired features in images.
4. Have the knowledge of approaches for the segmentation and extraction of area of interest in images.
5. Express the importance of the methods to characterize the oriented patterns in images.

Introduction: Nature of biomedical images, objectives of biomedical image analysis, computer aided diagnosis. 04 Hrs

Image Quality and Information Content: Difficulties in image acquisition and analysis, Characterization of image quality, Digitization of images, Optical density, Dynamic range, Contrast, Histogram, Entropy, Blur and spread functions, Resolution, The Fourier transform and spectral content, Modulation transfer function, Signal-to-noise ratio, Error based measures, Application: Image sharpness and acutance. 06 Hrs

Removal of Artifacts: Characterization of Artifacts,Synchronized or Multiframe Averaging, Space-domain Local-statistics-based Filters, Frequency-domain Filters, Matrix Representation of Image Processing, Optimal Filtering, Adaptive Filters, Comparative Analysis of Filters for Noise Removal, Application: Multiframe Averaging in Confocal Microscopy, Noise Reduction in Nuclear Medicine Imaging. 08 Hrs

Image Enhancement: Digital Subtraction Angiography, Dual-energy and Energy-subtraction X-ray Imaging, Temporal Subtraction, Gray-scale Transforms, Histogram Transformation, Convolution Mask Operators, High-frequency Emphasis, Homomorphic Filtering for Enhancement, Adaptive Contrast Enhancement, Objective Assessment of Contrast Enhancement, Application: Contrast enhancement of Mammograms. 10 Hrs

Detection of Regions of Interest: Thresholding and Binarization, Detection of Isolated Points and Lines, Edge Detection, Segmentation and Region Growing, Fuzzy-set-based Region Growing to Detect Breast Tumors, Detection of objects of known Geometry, Methods for the Improvement of Contour or Region Estimates, Application: Detection of the spinal canal.

Analysis of Shape: Representation of Shapes and Contours, Shape Factors,Fourier Descriptors, Fractional Concavity, Analysis of Spicularity, Application: Shape Analysis of Calcifications, Shape Analysis of Breast Masses and Tumors.

Analysis of Texture: Texture in Biomedical Images, Models for the Generation of Texture, Statistical Analysis of Texture, Laws' Measures of Texture Energy, Fractal Analysis, Fourier-domain Analysis of Texture, Segmentation and Structural Analysis of Texture. 14 Hrs

Analysis of Oriented patterns: Oriented Patterns in Images, Measures of Directional Distribution, Directional Filtering, Gabor Filters, Directional Analysis via Multiscale Edge Detection, Hough-Radon Transform Analysis, Application: Analysis of Ligament Healing, Detection of breast tumors. 10 Hrs

LIST OF EXPERIMENTS:

1. Compute the Fourier spectra of some biomedical images with various objects and features of different size, shape and orientation characteristics. Explain the relationships between the spatial and frequency-domain characteristics of the images and their spectra.
2. From the collection of the images select two images: one with strong edges of the objects or features present in the image and other with smooth edges and features.

   Prepare several noisy versions of the images by adding Gaussian noise and salt and pepper noise at various levels. Filter the noisy images using

   (i) the median filter with different neighborhoods.

   (ii) The 3x3 mean filter with the condition that the filter is applied only if the difference between the pixel being processed and the average of its 8-connected neighbors is less than a threshold. Try different thresholds and study the effect.

   Compare the results in terms of noise removal, MSE.

3. Select two underexposed images from your collection. Apply histogram equalization, gamma adjustment and linear gray level mapping transforms to the images.

   Compare the results in terms of the enhancement of the visibilty of details, loss of details at the high or low ends of the gray scale and overall visual quality.

   Plot the histigrams of the resulting images and compare them with the histograms of the original images. Comment on the differences.

4. Synthesize a digital image with rectangles, triangles and circles of various sizes. Compute the shape factors for each object.

   Study the variation in the shape factors from one category of shapes to another in your test image.

5. Consider the images with random texture, oriented texture and ordered texture. Derive the histograms of the images. Compute the variance, the entropy, the skewness and kurtosis of the histograms.

   Write a program to estimate the fractal dimension of an image and relate to the nature of the texture observed in the image.

6. Prepare a test image with the segments of different directions, lengths and widths with overlap. Apply Gabor filters at a few different scales and angles. Evaluate the results in terms of

   (i) The lengths of the extracted components

   (ii) The widths of the extracted components.

Discuss the limitations of the methods and the artifacts in the results.

TEXT BOOKS

1. **Biomedical Image Analysis,** Rangaraj M Rangayyan, CRC Press.
2. **Medical Image Analysis Methods,** edited by Lena Costaridou, CRC Taylor and Francis.

REFERENCES

1. **Handbook of Medical Image Processing and Analysis,** edited by Isaac N Bankman, Second edition, Academic Press.
2. **Advanced Biomedical Image Analysis,** Mark A Haidekker, Wiley Publications.

Department Of Instrumentation Technology, SJCE, Mysuru

BIOMEMS AND NANOTECHNOLOGY

Subject Code	**:**	**BSI 241**	**IA Marks**	**:**	**50**
Credits	**:**	**4 :1 :0**	**Exam hours**	**:**	**03**
Total No.of Lecture Hours	**:**	**52**	**Exam Marks**	**:**	**50**

Prerequisites: Basic knowledge of VLSI fabrication and transducer principles

Course Objective: To introduce the concepts of Micro and smart systems, micromachining techniques, and basic concepts of nanotechnology. By the end of the course, students will be familiar with various biomedical applications of MEMS.

Course outcomes

Students will be able to

1. Differentiate micro systems and MEMS, identify the elements of a microsystem, express the principle and operation of microsensors and microactuators
2. Explain the micromachining techniques
3. Know the importance and requirement for scaling during miniaturization
4. Describe the basics of BioMEMS, understand working of a few BioMEMS devices.

5. Explain the basics of Nano technology and nano devices

Introduction to MEMS: Overview and working of MEMS & Microsystems, Microsystems design and fabrication, Scaling laws in Miniaturization, Materials for MEMS and Microsystems, Micro manufacturing, LIGA process, Microsystems Design, CAD packages for Microsystems.

12 Hrs

Introduction to BioMEMS: What is BioMEMS?, Biomedical Applications, Biocompatibility, Reliability Considerations, Regulatory Considerations, Education 05 Hrs

Microactuators and Drug Delivery: Introduction, Activation Methods, Microactuators for Microfluidics, Equivalent Circuit Representation, Drug Delivery. 05 Hrs

Micro-Total-Analysis Systems (μTAS): Lab-on-a-Chip, Capillary Electrophoresis Arrays (CEA),Cell, Molecule, and Particle Handling, Surface Modification, Microspheres, Cell-Based Bioassay Systems. 10 Hrs

Genomics and DNA Microarrays : Introduction to Genomics, Polymerase Chain Reaction (PCR), Gene Expression Profiling, DNA Lab-on-a-Chip Devices, DNA Microarrays, Pharmacogenomics.

06 Hrs

Proteomics and Protein Microarrays: Introduction to Proteomics, Mass Spectrometry, Protein Lab-on-a-Chip(LOC) Devices, Protein Microarrays, Bioinformatics. 06Hrs

Emerging BioMEMS Technologies: Introduction, Minimally Invasive Surgery, Point-of-Care Clinical Diagnosis, Cardiovascular Diabetes, Endoscopy, Neurosciences, Oncology, Ophthalmology, Dermabrasion, Tissue Engineering, Cell-Based Biosensors, Homeland Security

06 Hrs

Introduction to nano technology 02 Hr

TEXT BOOKS:

1. **Fundamentals of BioMEMS and Medical Microdevices,** Steven Saliterman, SPIE Press, 2006
2. **MEMS and Microsystems,** Design & Manufacture, Tai Ran Hsu, , TMH2002.
3. **MEMS Introduction & Fundamentals,** Mohammed had-el-hak, , CRC Press.
4. **Nanoscience and Nanotechnology,** Harisingh Nalwa, American Scientific Publishers.

REFERENCES:

1. **Nano & MEMS,** Sergey Edward Lyshevski, , CRC press
2. **An Introduction to MEMS Engineering,** Nadim Maluf, Artech House Publishing.
3. **Nanotechnology in Biology & Medicine methods,** Taun-Vo-Dish, CRC press

Department Of Instrumentation Technology, SJCE, Mysuru

MEDICAL DEVICES REGULATIONS, ETHICS AND IPR

Subject Code : BSI 242		**IA Marks : 50**	
No of Lecture Hrs/Week	**: 04**	**Exam hours**	**: 03**
Total No.of Lecture Hours	**: 52**	**Exam Marks**	**: 50**

Course Objective: To introduce the concepts of medical devices regulations, basic rules of IPR regulations and Medical ethics.

Course outcomes

Students will be able to

1. Define a medical device and know the regulations and standards of Medical devices.
2. Explain the importance of medical devices directives.
3. Have the knowledge of the IPR Laws.
4. Know the basics of Industrial design.
5. Explain the importance of Medical ethics, device safety and risk management.

The medical device as an entity: What is a medical device?, Defining the device, The product definition process, Overview of quality function deployment, The QFD process, The business proposal.

Reliability: Definition, Quality Vs Reliability, Reliability Vs Unreliability, Types of Reliability,

Optimizing reliability, Reliability's effects on medical devices.Concept of Failure: Causes of Failure, Practical aspects of failure, Failure rates, Hardware failure, Software Failure, Failure due to human errors, Failures from customer's point of view.

Safety and Risk Management: Medical device safety and risk management, Effectiveness/performance of medical devices, Phases in the life span of a medical device,The risk management processes, Tools for risk estimation, Participants in ensuring the safety of medical devices, The role of each participant/stakeholder, Shared responsibility for medical device safety and performance 12 Hrs

Standards and Regulations Background Standards: What are standards? Voluntary and mandatory standards, Standards development process, Conformity assessment with standards, National and international standards systems, Identification of standards, Current trends in the use of standards in medical device regulations. The ISO 9000 Series of Standards, The ISO 14000 Series of Standards, EN 46001, The ISO 13485 Standard, ISO 9000-3, IEC 601-1-4.

The Medical Devices Directives: Definition of a medical device, The Medical Devices Directives process, Choosing the appropriate directive, Identifying the applicable essential

requirements, Identification of corresponding harmonized standards, Essential requirements, Classification of the device based on conformity, Medical Devices Directives, Active Implantable Medical Devices Directives, In-vitro Diagnostic Medical Devices Directives. 10 Hrs

Basic principles of IPR laws: History of IPR-GATT,WTO,WIPO & TRIPs, Role of IPR in Research & Development & Knowledge era, Concept of property, Marx's theory of property, Constitutional Aspects of Intellectual property, Different forms of IPR – copyright, trade mark, Industrial Designs, Layout designs of Integrated circuits, Patents, Geographical Indications, Traditional Knowledge, Plant varieties, Trade secrets Patent application procedure and drafting: Patent Drafting: Format, Provisional & Complete specifications. Scopes of inventions, description of invention, drawings, claims.

Filing requirements: Forms to be sent, Comparison of Patentability in different countries, filing mechanism-through individual patent office. PCT route & claiming priority from either route.

10 Hrs

Industrial Designs: Introduction, Justification, Subject matter of design law definition,Excluded subject matter Law relating to industrial design and registration in India, Infringement of design rights.Semiconductor & IC Layout Designs: semiconductor topography design rights.Infringement, Case studies. 10 Hrs

Medical Ethics: Theory, principles, rules and moral decisions, Belmont report, the principles of biomedical ethics: respect for autonomy, voluntariness information and informed consent, competency, nonmaleficence, the rule of the double effect, befecience, paternalism, justice, Examples.

10 Hrs

TEXT BOOKS:

1**. Reliable Design of Medical Devices,** Second Edition by Richard Fries, CRC Press, 2006

2. **Medical Device Quality Assurance and Regulatory Compliance,** Richard C Fries, CRC Press, 1998

3. **Intellectual Property Rights,** Prabuddgha Ganguli, TMH Publishing Co. Ltd. 2001

REFERENCES:

1. **World Intellectual Property Organizations (WIPO) Handbook/ Notes**

2. **Medical device regulations**, global overview and guiding principles Michael Cheng, World Health Organization

3. **Product Safety in the European Union Gábor Czitán**, Attila Gutassy, Ralf Wilde, TÜV Rheinland

Akadémia, 2008

4. **Principles of biomedical ethics,** D.H. Lawerance, Chapter 2, Jones & Bartlet publishers

5. **Intellectual Property Law Handbook,** Dr. B. L. Wadhera, Universal Law Publishing Co. Ltd.,

Department Of Instrumentation Technology, SJCE, Mysuru

LASERS IN MEDICINE

Subject Code	**:**	**BSI 243**	**IA Marks**	**:**	**50**
No of Lecture Hrs/Week	**:**	**04**	**Exam hours**	**:**	**03**
Total No.of Lecture Hours	**:**	**52**	**Exam Marks**	**:**	**50**

Course Objective: This course will introduce the fundamentals of lasers and fiber optics, its types, medical applications in tissue diagnostics, Ophthalmology, Cardiology and Photodynamic Therapy.

Course Outcomes:

The students will be able to

1. Explain the importance of laser and fiber optics in medical field.
2. Apply the knowledge of lasers in tissue diagnostics.
3. Apply the knowledge of lasers in Ophthalmology diagnosis and therapy.
4. Apply the knowledge of lasers in Cardiovascular Applications and other surgical application in Cardiology.
5. Apply the knowledge of lasers in Photodynamic Therapy for cancer and tumor.

Basics of Lasers: Laser Principles, Laser Materials, Pump, Sources Resonators , Major Types of Lasers, Medical Lasers, Measuring Laser Power, Focusing Laser Energy Basics of Fiber Optics, Optical Materials The Future of Medical Lasers and Fiber Optics . 08 Hrs

Optical and Thermal Response of Tissue to Laser Radiation: Introduction, The Optical Response Of Tissue Thermal Response. 06 Hrs

Tissue Diagnostics Using Lasers: Introduction, Light Interaction with Tissue Spectroscopic Diagnostics of Malignant Tumors ,Spectroscopic Diagnostics of Atherosclerotic Plaque ,Light Scattering and Tissue Transillumination 06 Hrs

Therapeutic and Diagnostic Application of Lasers in Ophthalmology: Introduction, Basic Ocular Anatomy and Physiology, Transmission and Absorptive Properties of Ocular Tissues, Photothermal Laser Applications, Photodisruptive Laser Applications, Photochemical Laser Applications: Photoablation and Photodynamic Therapy ,Diagnostic Laser Applications. 10 Hrs

Cardiovascular Applications of Lasers: Introduction, Anatomy and Pathology Physics, Angioplasty Transmyocardial Laser Revascularization (TMLR), Other Surgical Applications of Lasers in Cardiology ,Aids to Welding: Tissue Solders. 06 Hrs

Lasers in Photodynamic Therapy: Introduction, Tissue Optical Properties, Photobleaching, and Light Delivery Systems, PHOTOFRIN PDT for Superficial Bladder Cancer, PHOTOFRIN PDT in the Treatment of Endobronchial Lung Cancer, PHOTOFRIN PDT in Gynecologic Malignancies , PHOTOFRIN PDT in Head and Neck Cancer, PHOTOFRIN PDT in Gastrointestinal Cancer, PHOTOFRIN PDT for Intraoperative Abdominal or Thoracic PDT, PHOTOFRIN for Intraoperative PDT in the Treatment of Intracranial Tumors, PHOTOFRIN PDT in the Treatment of Ocular Cancer, PHOTOFRIN PDT in the Treatment of Cutaneous and Subcutaneous Tumors, New Photosensitizers for PDT. 16 Hrs

TEXT BOOK:

1. **Lasers in Medicine**, Raymond W. Waynant (Editor), CRC press, Jan 2002

REFERENCE BOOKS:

1. **Laser principles and applications,** Wilson and Hawkes, , Prentice Hall of India, 7th Edition,1987, ISBN: 978-0135237052.
2. **Handbook of Laser Technology and Application,** Julian D.C. Jones Collin E. Webb (Editor),.
3. **Soft Lasers in Medical Practice**, Kapur, Raman, , Jaypee Bros, Medical Publishers.

Department Of Instrumentation Technology, SJCE, Mysuru

BIOMETRICS AND APPLICATIONS

Subject Code	**:**	**BSI 251**	**IA Marks**	**:**	**50**
Credits	**:**	**4 : 0 : 1**	**Exam hours**	**:**	**03**
Total No. of Lecture Hrs	**:**	**52**	**Exam Marks**	**:**	**100**

Course Objectives: This course concentrates on the unique advantages that biometrics brings to computer security, but also addresses challenging issues such as algorithms, recognition, and performance, as well as alternatives of passwords and smart cards. Students will gain knowledge in the building blocks of this field: security and privacy, and secure systems design. By the end of the course students will be able to evaluate and design security systems that include biometrics.

Course outcomes

Students will be able to

1. Express the importance of biometrics, operation of biometric systems, characteristics and performance of biometrics, forensic identification
2. Design and develop finger print recognition system, acquisition devices, segmentation algorithms, matching approaches, palm print sensing and recognition
3. Explain and interpret face recognition system, acquisition devices, algorithms, and ear biometric recognition system
4. Describe iris recognition system, acquisition devices, algorithms, encoding and matching, hand vascular pattern acquisition and recognition

5. Explain and interpret gait and hand biometric system, acquisition, processing algorithms, feature extraction and matching

Introduction to Biometrics : Biometrics as authentication scheme, operation of a biometric system, verification versus identification, performance of a biometric system, error and accuracy in biometric systems, applications of biometrics, biometric characteristics and types, forensic biometric traits, dental, voice, signature identification 10 Hrs

Fingerprint recognition: fingerprint sensing, acquisition devices, feature extraction, ridge orientation and frequency, segmentation, singularity detection, enhancement and binarization, minute extraction, matching approaches, palmprint features, finger print and palmprint recognition in forensics 10 Hrs

Face recognition: face recognition techniques, principal component analysis(PCA), eigenfaces, linear discriminant analysis(LDA) and fisherfaces, local face recognition and hybrid face recognition techniques, Ear as a biometric, approaches, PCA, force field transformation, acoustic ear recognition 10 Hrs

Iris recognition and vascular pattern recognition: typical iris recognition system, image acquisition, capturing devices, iris segmentation, segmentation using the integro-differential operator, segmentation using geodesic active contours, iris normalization, coordinate transformation, image enhancement, feature extraction, recognition, encoding and matching, performance evaluation, hand vascular pattern technology, operation, acquisition, feature extraction, pattern matching 10 Hrs

Gait and hand geometry: Gait recognition, segmentation of walking humans, detection and extraction algorithms, shadow removal, gait cycle detection, gait analysis for feature extraction, radon transform, gait recognition, hand geometry, image capture, processing steps, performance 10 Hrs

TEXT BOOK:

Hand Book of Biometrics: Anil K. Jain, Patrick Flynn, Arun A. Ross, Springer, 2008 (ISBN: 978-0-387-71040-2)

Signal and Image Processing for Biometrics: ed. Amine Nait-Ali and Regis Fournier, Wiley 2012, (ISBN: 978-1-84821-385-2)

References:

Guide to Biometrics, Ruud M. Bolle, Jonathan H. Connel, Sharath Pankanti, Nalini K Ratha, Andrew W Senior, Springer, 2009 (ISBN: 0387400893)

LIST OF EXPERIMENTS:

1. Write a program to develop a simple biometric system based on finger print features
2. Write a program to develop a simple biometric system based on face recognition features
3. Write a program to develop a simple biometric system based on iris features
4. Write a program to develop a simple biometric system based on hand geometry recognition and hand vascular patterns
5. Write a program to develop a simple biometric system based on gait

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NEURAL NETWORKS IN MEDICINE

Subject Code	**:**	**BSI 252**	**IA Marks**	**:**	**50**
Credits	**:**	**4 : 0 : 1**	**Exam hours**	**:**	**03**
Total No.of Lecture Hrs	**:**	**52**	**Exam Marks**	**:**	**100**

Course Objectives: The main objective of this course is to provide the student with the basic understanding of neural networks and related algorithms and Design the neural algorithm based applications

Course outcomes:

Students will be able to

1. Explain the basics of neural networks, supervised and unsupervised learning, performance evaluation
2. Design and develop single layer neural networks, multi layer networks, algorithms
3. Design and develop radial basis function, algorithms, design issues
4. Express the importance and develop support vector machines, algorithms, design issues
5. Explain the principal component analysis and applications of neural networks

Learning and Soft Computing: Examples, basic tools of soft computing, basic mathematics of soft computing, Differences between neural network and Biological neural network, Network Architecture, Artificial Intelligent, Learning process: Error correction Algorithm, Memory based Learning, Hebbian

Learning, Learning with Teacher, Learning without Teacher

10 Hrs

Single Layer Networks: Perception, Perceptron Convergence theorem, Realization of Basic logic gates using single layer Perceptron, Adaptive linear neuron (Adaline) and the LMS algorithm. Multilayer Perception: Error back propagation algorithm, generalized delta rule, XOR Problem, Practical Aspects of Error Back Propagation Algorithm. Problems

12 Hrs

Radial Basis Function Networks: supervised learning as **i**ll posed problems and regularization Technique, Stabilizers and Basis Functions, Generalized Radial Basis Function Networks, XOR problem 10 Hrs

Support Vector Machines: Risk minimization principles and the Concept of Uniform Convergence, VC dimension, Structural Risk Minimization, support vector machine algorithms

10 Hrs

Principal components Analysis: principles of self organization, principal component analysis, hebbian based, adaptive and kernel based PCA algorithms, self organizing maps, applications of neural networks 10 Hrs

REFERENCE BOOKS:

1. Neural networks: A Comprehensive Foundation, S.Haykin, Pearson Education (Asia) Pte. Ltd/Prentice Hall of India, 2003.
2. Neural Networks Fuzzy Logic, and Genetic Algorithms, S. Rajasekaran and G.A.Vijaylakshmi Pai. Prentice Hall of India.
3. Learning and soft computing, Vojislav Kecman, Pearson Education (Asia) Pte. Ltd. 2004.
4. Introduction to neural networks using Matlab 6.0, S.N. Sivanandam, S Sumathi, S.N.Deepa, Mc Graw Hill, 2005

LIST OF EXPERIMENTS:

1. Write a program to generate XOR function using McCulloch –Pitts neuron model network
2. Write a program for Heb net to classify two dimensional input patterns in bipolar
3. Write a program to demonstrate the perceptron learning law with its decision regions with suitable example
4. Write a program to implement back propagation network with suitable example(XOR function)
5. Write a program to develop a radial basis function network
6. Write a program to develop a neural network based on support vector machine algorithm

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REHABILITATION ENGINEERING

Subject Code	**:**	**BSI 253**	**IA Marks**	**:**	**50**
Credits	**:**	**4 : 1 : 0**	**Exam hours**	**:**	**03**
Total No.of Lecture Hrs	**:**	**52**	**Exam Marks**	**:**	**100**

Pre – requisite: Basics of Human physiology, Sensors and Digital Signal Processing.

Course Objective: To introduce the students to the different types of devices that can be used for assisting the people with different types of disability.

Course Outcome:

Students will be able to

1. Assess the importance of different types of Arm and Limb prosthesis
2. Interpret the concepts behind the design of devices used for assisting people with auditory and speech impairment.
3. Interpret the concepts behind the design of devices that can assist people with visual impairment.
4. Interpret the design and working of stimulating devices.
5. Express the importance of legal aspects related to rehabilitation device design and selection.

Prosthetic And Orthotic Devices: Hand and arm replacement, Different types of models for externally powered limb prosthetics, Lower limb, Upper limb orthotics, Material for prosthetic and orthotic devices, Mobility aids. 11 Hrs

Auditory And Speech Assist Devices: Types of deafness, Hearing aids, Application of DSP in hearing aids, Cochlear implants, Voice synthesizer, Speech trainer. 10 Hrs

Visual Aids: Ultra sonic and laser canes, Intra ocular lens, Braille Reader, Tactile devices for visually challenged, Text voice converter, screen readers. 10 Hrs

Medical Stimulator: Muscle and nerve stimulator, Location for Stimulation, Functional Electrical Stimulation, sensory Assist Devices, Design issues. 10 Hrs

Rehabilitation Medicine And Advocacy: Physiological aspects of Function recovery, Psychological aspects of Rehabilitation therapy, Legal aspect available in choosing the device and provision available in education, job and in day-to-day life. 11 Hrs

TEXT BOOK:

1. Rory A Cooper, An Introduction to Rehabilitation Engineering, CRC press, 2006

Department Of Instrumentation Technology, SJCE, Mysuru

MEDICAL IMAGE PROCESSING LAB

Sub code : BSI 26L **Credit Pattern : 0:0:1.5**

Total Hours : 39 Hrs **Contact Hours : 03/Week**

Prerequisites: Signal and systems, Digital signal processing and DSP Architecture

Course Objectives: This course will introduce the implementation of image processing algorithms using Matlab. By the end of the course, students will have the knowledge of implementation of algorithms to improve the quality of the image using filters and to segment the image.

Course Outcomes:

Student will be able to write the MATLAB program to

1. Convert the image files from one format to other format and also to study the concept of spatial resolution.
2. Plot the histogram and equalized histogram of an image.
3. Find the edges in an image using edge detection operators.
4. Improve the quality of the image with various enhancement methods.
5. Segment the area of interest from an image.

Note: All the programs should be executed using MATLAB.

1. List the image file formats that are supported by MATLAB and explain them.

   (i) Determine their type (binary, grayscale, true color or indexed color)

(ii) Determine their size (in terms of pixels)

2. Select a grayscale image. Write the image to files of type JPEG, PNG, BMP, binary and true color. What are the sizes of these files?

3. Experiment with reducing spatial resolution of some sample images. In each case note the point at which the image becomes unrecognizable and also experiment with reducing the quantization levels of the images.

4. Write a program to calculate the histogram of the gray values of an image without using built in command in MATLAB.

5. Consider an image segment of size 8x8 which has gray values in the range 0-19. Compute the gray level histogram and the mapping, that will equalize this histogram.

6. Apply Roberts, Prewitt, Sobel, Laplacian and Canny edge finding techniques to an image and study the performance of these techniques.

7. Create noisy versions of the images by adding Gaussian noise. Apply the ideal LPF and HPF, Butterworth LPF and HPF and Butterworth high emphasis filter to the images. Study the results in terms of edge enhancement or extraction, the effect of noise and the performance of the filters.

8. Select two images and enhance them using homomorphic filter.

9. Prepare a test image with a few straight lines of various slopes and positions. Apply the Hough transform for the detection of straight lines.

10. Consider an image. Decompose the image into bit planes and display the same.