



# GUJARAT TECHNOLOGICAL UNIVERSITY

**Program Name: Master of Engineering**

**Level: PG**

**Branch: Biomedical Engineering**

**Subject Code : ME02031021**

**Subject Name : Medical Image Analysis**

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

<b>Prerequisite:</b>	Medical imaging techniques, Fundamentals of Signal Processing/Signals & Systems, Fundamentals of Image Processing
<b>Rationale:</b>	The Medical Image Analysis syllabus is designed to provide students with comprehensive knowledge of imaging technologies and computational methods critical to modern healthcare. It covers foundational concepts like imaging physics, enhancement, segmentation, and feature extraction, enabling students to analyze and process medical images effectively. Practical case studies and advanced topics such as deep learning and image fusion connect theoretical learning to real-world applications in diagnostics and treatment. By integrating ethical considerations and emerging trends like augmented reality, the syllabus ensures readiness for both academic research and industry roles, addressing the growing demand for skilled professionals in AI-driven medical imaging.

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**Course Outcome:**

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
01	Understand the Fundamentals of Medical Imaging and Image Processing	U
02	Apply Techniques to Detect Regions of Interest in Medical Images	A
03	Apply and Analyze Shapes, Textures, and Patterns in Medical Images	N
04	Design and Implement Diagnostic Decision Systems Using Pattern Classification	E
05	Evaluate various Advanced Techniques in Medical Image Analysis	E

*\*Revised Bloom's Taxonomy (RBT)*

**Teaching and Examination Scheme:**

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



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## Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	<p><b>Introduction to Medical Imaging &amp; Image Processing:</b> <b>Medical Imaging:</b> Fundamental concept and physics of various Imaging Modalities – X-Ray, Computed Tomography, Magnetic Resonance Imaging, Ultrasound Imaging, Positron Emission Tomography, Single Photon Emission Computed Tomography, Thermal Imaging, Nuclear Medicine Imaging</p> <p><b>Image Processing:</b> Types of Medical Images, Types of Image format and Color model, Sampling and Quantization in Image, Histogram of Image and Histogram Processing, CLAHE, Various Image Enhancement techniques, Image Pre-processing/processing using various filters, Morphological operations</p> <p>Difficulties in Image Acquisition and Analysis, Objectives of Biomedical Image Analysis</p>	8	15
2.	<p><b>Detection of Region of Interest:</b> Thresholding and Binarization, Detection of Isolated Points and Lines, Edge detection, Segmentation and region growing, Detection of Objects of known geometry, Methods for improving contour of estimation of region of interest</p> <p><b>Application/Case Studies:</b> Detection of Spinal Canal, Detection of Breast boundary from mammogram, Fuzzy set based region growing for detection of breast cancer</p>	8	20
3.	<p><b>Analysis of Shape, Textures and Oriented Patterns:</b> <b>Shape:</b> Representation of Shapes and Contours, Shape Factors, Fourier Descriptors, Fractional Concavity, Analysis of Spicularity <b>Texture:</b> Texture in Biomedical Images, Models for the Generation of Texture, Statistical Analysis of Texture, Law's of Measures of Texture Energy, Fractal Analysis, Fourier domain Analysis of Texture, Segmentation and Structural Analysis of Texture <b>Pattern:</b> Oriented Patterns in Images, Measures of Directional Distribution, Directional Filtering, Gabor Filtering, Directional Analysis via Multiscale Edge Detection, Hough Radon Transform Analysis</p> <p><b>Application/Case Studies:</b> Shape analysis of Calcifications, Shape analysis of Breast Masses/Tumours, Analysis of Breast Masses Using</p>	14	30



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	Texture and Gradient Measures, Analysis of Ligament Healing, Detection of Breast Tumours using pattern,		
4.	<b>Pattern Classification and Diagnostic Decision:</b> Supervised and Unsupervised pattern Classification, Probabilistic Models and Statistical Decision, Logistic Regression, Neural Networks and Training and Test steps, Measures of Diagnostic Accuracy Application/Case Studies: Image Enhancement for Breast Cancer Screening, Classification of Breast Masses and Tumors via Shape Analysis, Content based Retrieval and Analysis of Breast Masses	8	20
5.	<b>Advanced Techniques in Medical Image Analysis:</b> Deep learning in medical image analysis: Basics of Convolutional Neural Networks (CNNs), U-Net architecture for image segmentation, Pre-trained models: VGG, ResNet, and Transfer learning, Ethical concerns and challenges in AI-driven diagnosis Image Fusion: Image fusion concept, Need of Image Fusion, Types of Image Fusion methods, Application of Image Fusion in medical imaging and classification Virtual reality (VR) and augmented reality (AR) in medical imaging	7	15
<b>Total</b>		<b>45</b>	<b>100</b>

### Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	U Level	A Level	N Level	E Level	C Level
0	15	20	30	35	0

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

### References/Suggested Learning Resources:

#### (a) Books:

1. Biomedical Image Analysis by Rangaraj M. Rangayyan, Edition 1st, Published 2004.
2. Thomas M. Deserno (Ed.), Biomedical Image Processing, Springer, 2011, ISBN: 978-3-642-15815-4.
3. Isaac N. Bankman (Ed.), Handbook of Medical Imaging: Processing and Analysis, Academic Press, 2008, ISBN: 978-0123739049.

#### (b) Open source software and website:

1. Python
2. ImageJ
3. Various Image repository for Image dataset i.e. Kaggle, NIH, ATLAS, SpinWeb etc.



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4. [https://onlinecourses.nptel.ac.in/noc22\\_bt34/preview](https://onlinecourses.nptel.ac.in/noc22_bt34/preview)
5. <https://archive.nptel.ac.in/noc/courses/noc20/SEM1/noc20-ee40/>

## **Suggested Course Practical List:**

1. To comprehend the basic physics and principles behind X-ray, CT, MRI, Ultrasound, PET, and other medical imaging modalities.
2. To apply histogram processing and CLAHE (Contrast Limited Adaptive Histogram Equalization) techniques for improving image contrast.
3. To explore and apply filtering techniques (Gaussian, Median, Bilateral) for noise reduction and preprocessing of medical images. To use morphological transformations (e.g., dilation, erosion, opening, closing) to enhance features in binary medical images.
4. To implement thresholding and binarization techniques for detecting and isolating regions of interest in medical images.
5. To explore edge detection algorithms (Sobel, Canny, Laplacian) for boundary detection in medical imaging applications.
6. To compute shape factors and Fourier descriptors to quantify the shapes of anatomical structures.
7. To use statistical methods (e.g., Gray Level Co-occurrence Matrix) and Laws' measures for texture analysis in medical imaging.
8. To apply Gabor filtering and Radon transform for detecting and analyzing oriented patterns in medical images.
9. To train and test classification models (e.g., Logistic Regression, Neural Networks) for diagnosing medical conditions.
10. To design a system for content-based image retrieval and diagnostic decision-making using medical image datasets.
11. To implement a U-Net architecture for the segmentation of medical images, such as brain tumors in MRI scans.
12. To fuse multi-modal images (e.g., CT and PET) for enhancing diagnostic accuracy in medical imaging.

**List of Laboratory/Learning Resources Required:** MATLAB/Python, AI workstation with graphic card

## **Suggested Activities for Students:**

1. Image Fusion for Enhanced Medical Imaging-Combine multiple imaging modalities to create a more comprehensive medical image.
2. Image Classification using various methods

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