INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal - 500 043, Hyderabad, Telangana

COURSE CONTENT

IMAGE PROCESSING AND APPLICATIONS								
Semester: ECE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
		L	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
AECD69	Open Elective	3	-	-	3	40	60	100
Contact Classes: 48	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 48**		
Prerequisite: Digital Image Processing								

I. COURSE OVERVIEW:

The course is intended to provide image processing fundamentals, representation, sampling, quantization, image acquisition and imaging geometry. Transform techniques including two dimensional Fourier transforms, Walsh, Hotelling, Haar and Slant transforms. Analyze image processing filters and techniques for the applications of enhancement, segmentation and compression. The concept of color image processing is discussed for application into real time image processing. A case study on Face recognition using image processing is introduced to understand the application of image processing in which principal component analysis technique is discussed.

II. COURSES OBJECTIVES:

The students will try to learn

- **I.** The fundamental concepts of digital image processing methods and techniques.
- **II.** The image enhancement, image segmentation and compression techniques in spatial and frequency domains.
- **III.** The algorithms to solve image processing problems to meet design specifications of various applications of image processing in industry, medicine and defense.
- **IV.** A case study on face recognition to understand how to apply image processing algorithms for real-time tasks.

III. COURSE OUTCOMES:

At the end of the course students should be able to:

- CO1 Outline the principles and terminology of digital image processing for describing the features of image.
- CO2 Demonstrate 2D Fourier transforms and its properties for frequency domain representation of the image and make use of various image transform techniques like Walsh, Hadamard, Slant, DCT and Haar transforms for analyzing images in transform domain.
- CO3 Construct image intensity transformations and spatial filtering for image enhancement and restoration in the spatial domain.
- CO4 Illustrate image degradation models, noise models for modeling of degradation function and distinguish the image restoration in the spatial and frequency domains to deal with different types of noise models for removing degradation from given image.
- CO5 Apply region-based, edge-based image segmentation and image coloring techniques for detection of objects in images.
- CO6 Apply the knowledge of the existing image processing algorithms to build face recognition system.

IV. COURSE CONTENT:

MODULE – I: IMAGE FORMATION AND ALIGNMENT (10)

Image basics: pixel, domain, size, resolution; Digital and physical correspondence, concept of image alignment; Motion models: rotation, translation, affine, scaling, shearing, matrix representation, low rank transforms, composition of transformations; Control-point based image alignment; MSSD/MSE based image alignment, concept of field of view; Image warping: forward and reverse, bilinear interpolation; Applications of image alignment: template matching, panorama generation.

MODULE – IV: IMAGE ENHANCEMENT (09)

Local/Adaptive Histogram equalization; Local spatial filters; Convolution and correlation operations: examples, properties, derivation of ; Correlation (template matching) and convolution (Linear time/space-invariant systems); Mean and median filtering; examples of linear and non-linear filters; Introduction to derivative filters in image processing; Derivative operators in 1D and 2D, and their properties; Laplacian-based sharpening filter, unsharp masking; Laplacian of Gaussians, Sobel filter; Separable convolution filters and their advantages; Bilateral filters and their advantages, cross-bilateral filters; Edge and Corner Detection; Hough Transform

MODULE - III: IMAGE SEGMENTATION AND RESTORATION (10)

Image Segmentation: as a clustering problem; KMeans algorithm and its limitations; Concept of gradient ascent; mode finding given a PDF; Concept of nonparametric probability density estimation using kernels (kernel density estimation); Mean shift algorithm; Fourier Analysis

Image Restoration: Introduction to blur models - spatially varying and spatially invariant blur, defocus blur; Blur models: defocus blur, motion blur, derivation of motion blur frequency response for in-plane constant velocity translational motion, interpretation of Fourier transform of a motion blurred image; Inverse filter: definition, limitations

Code blur camera (see code demo), flutter shutter camera - spread spectrum filtering; Concept of Wiener filter; Derivation of Wiener filter; Regularized restoration using gradient penalty terms; PCA for image denoising: algorithm description and sample outputs; Derivation of Wiener filter for PCA denoising

MODULE -IV: **IMAGE COMPRESSION AND COLOR IMAGE PROCESSING (09)**

Image Compression: lossless and lossy; Discrete cosine transform - definition and basic properties; 1D and 2D DCT - concept of Kronecker product of 1D DCT bases to yield a 2D DCT basis; Comparison between DCT and DFT: DCT computation using fft (see code), DCT energy compaction; DCT quantization matrix, quantization step in JPEG, derivation of quantization matrix; Huffman encoding and run length encoding in JPEG; Structure of Huffman encoder and decoder; Properties of Huffman encoding: optimality, prefix-free nature

JPEG for Color image compression, YCbCr color scheme; Typical JPEG artifacts; Video compression with MPEG: concept of residuals, motion compensation residuals and motion vectors; concept of I,P,B frames in MPEG; Color models: RGB, CMY(K), HSI, YCbCr, merits and demerits of hue; Human visual system: rods and cones; Discussion about hue and illumination models with specular, ambient and diffuse lights

MODULE –V: CASE STUDY – FACE RECOGNITION (09)

Face recognition, face detection, face verification, challenges in face recognition, concept of training and test phase of a face recognition system; Principal Component Analysis (PCA) algorithm; Clarification about Lagrange multipliers; Illumination invariance in face recognition: Removal of top three eigenfaces; Eigenvalue decay in eigenfaces derived from well-aligned face images; Choice of k in PCA; Person-specific eigenspaces; PCA for compression; Face recognition from other modalities.

V. TEXT BOOKS:

1. Rafael C. Gonzalez, Richard E. Woods, "Digital Image Processing", Pearson, 3rd Edition, 2008.
2. S. Jayaraman, S. Esakkirajan, T. Veerakumar, "Digital Image Processing", TMH, 3rd Edition, 2010.

VI. REFERENCE BOOKS:

1. Rafael, C. Gonzalez, Richard E woods, Stens L Eddings, "Digital Image Processing using MAT LAB", Tata McGraw Hill, 2nd Edition, 2010.
2. A.K. Jain, "Fundamentals of Digital Image Processing", PHI, 1st Edition, 1989.
3. Somka, Hlavac, Boyle, "Digital Image Processing and Computer Vision", Cengage Learning, 1st Edition, 2008.
4. Adrain Low, "Introductory Computer vision Imaging Techniques and Solutions", Tata McGraw-Hill, 2nd Edition,2008.
5. John C. Russ, J. Christian Russ, "Introduction to Image Processing & Analysis", CRC Press, 1st Edition, 2010.

VII. WEB REFERENCES:

1. https://imagingbook.com/
2. https://en.wikipedia.org/wiki/Digital_image_processing
3. http://www.tutorialspoint.com/dip/
4. http://www.imageprocessingplace.com
5. https://homepages.inf.ed.ac.uk/rbf/HIPR2/hipr_top.htm

VIII. E-TEXT BOOKS:

1. http://bookboon.com/en/communication-ebooks-zip
2. http://www.bloomsbury-international.com/images/ezone/ebook/writing-skills-pdf.pdf
3. https://americanenglish.state.gov/files/ae/resource_files/developing_writing.pdf

IX. MATERIALS ONLINE

1 Course template
2 Tutorial question bank
3 Tech talk topics
4 Open end experiments
5 Definitions and terminology
6 Assignments
7 Model question paper – I
8 Model question paper - II
9 Lecture notes
10 E-learning readiness videos (ELRV)
11 Power point presentation