Image Processing

Course Title: Image Processing
Course No: CSC321
Nature of the Course: Theory + Lab
Semester: V

Full Marks: 60 + 20 + 20
Pass Marks: 24 + 8 + 8
Credit Hrs: 3

Course Description: This course covers the investigation, creation and manipulation of digital images by computer. The course consists of theoretical material introducing the mathematics of images and imaging. Topics include representation of two-dimensional data, time and frequency domain representations, filtering and enhancement, the Fourier transform, convolution, interpolation. The student will become familiar with Image Enhancement, Image Restoration, Image Compression, Morphological Image Processing, Image Segmentation, Representation and Description, and Object Recognition.

Course Objectives: The objective of this course is to make students able to:
➢ develop a theoretical foundation of Digital Image Processing concepts.
➢ provide mathematical foundations for digital manipulation of images; image acquisition; preprocessing; segmentation; Fourier domain processing; and compression.
➢ gain experience and practical techniques to write programs for digital manipulation of images; image acquisition; pre-processing; segmentation; Fourier domain processing; and compression.

Detail Syllabus:

Unit 1	Introduction	Teaching Hours (5)
Digital Image, A Simple Image Model	Definition of digital image, pixels, representation of digital image in spatial domain as well as in matrix form.	1 hr
Fundamental steps in Image Processing	Block diagram of fundamentals steps in digital image processing, application of digital image processing system, Elements of Digital Image Processing systems	1 hr
Element of visual perception	Structure of the Human, Image Formation in the Eye, Brightness Adaptation and Discrimination	1 hr
Sampling and Quantization	Basic Concepts in Sampling and Quantization, Representing Digital Images, Spatial and Gray-Level Resolution	1 hr
Some basic relationships like Neighbors	Neighbors of a Pixel, Adjacency, Connectivity, Regions, and Boundaries, Distance Measures between pixels	1 hr

Unit 2	Image Enhancement and Filter in Spatial Domain	Teaching Hours (8)
Basic Gray Level Transformations	Point operations, Contrast stretching, clipping and thresholding, digital negative, intensity level slicing, log transformation, power log transformation, bit plane slicing	2 hrs.
Histogram Processing	Unnormalized and Normalized Histogram, Histogram Equalization, Use of Histogram Statistics for Image Enhancement	1 hr
Spatial operations	Basics of Spatial Filtering, Linear filters, Spatial Low pass smoothing filters, Averaging, Weighted Averaging, Non-Linear filters, Median filter, Maximum and Minimum filters, High pass sharpening filters, High boost filter, high frequency emphasis filter, Gradient based filters, Robert Cross Gradient Operators, Prewitt filters, Sobel filters, Second Derivative filters, Laplacian filters	4 hrs.
Magnification	Magnification by replication and interpolation	1 hr
Unit 3	Image Enhancement in the Frequency Domain	Teaching Hours (8)
Introduction	Introduction to Fourier Transform and the frequency Domain, 1-D and 2-D Continuous Fourier transform, 1-D and 2-D Discrete Fourier transform	1 hr
Properties of Fourier Transform	Logarthmic, Separability, Translation, Periodicity, Implications of Periodicity and symmetry	1 hr
Smoothing Frequency Domain Filters	Ideal Low Pass Filter, Butterworth Low Pass Filter, Gaussian Low Pass Filter	1 hr
Sharpening Frequency Domain Filters	Ideal High Pass Filter, Butterworth High Pass Filter, Gaussian High Pass Filter, Laplacian Filter	1 hr
Fast Fourier Transform	Computing and Visualizing the 2D DFT (Time Complexity of DFT), Derivation of 1-D Fast Fourier Transform, Time Complexity of FFT, Concept of Convolution, Correlation and Padding.	2 hrs.
Other Image Transforms	Hadamard transform, Haar transform and Discrete Cosine transform	2 hrs.
Unit 4	Image Restoration and Compression	Teaching Hours (8)
Image Restoration	Introduction, Models for Image degradation and restoration process, Noise Models (Gaussian,	2 hrs.

	Rayleigh, Erlang, Exponential, Uniform and Impulse), Estimation of Noise Parameters	
Restoration Filters	Mean Filters: Arithmetic, Geometric, Harmonic and Contraharmonic Mean Filters Order Statistics Filters: Median, Min and Max, Midpoint and Alpha trimmed mean filters Band pass and Band Reject filters: Ideal, Butterworth and Gaussian Band pass and Band Reject filters	2 hrs.
Image Compression	Introduction, Definition of Compression Ratio, Relative Data Redundancy, Average Length of Code Redundancies in Image: Coding Redundancy (Huffman Coding), Interpixel Redundancy (Run Length Coding) and Psychovisual Redundancy (4-bit Improved Gray Scale Coding: IGS Coding Scheme)	2 hrs.
Image compression models:	Lossless and Lossy Predictive Model (Block Diagram and Explanation)	2 hrs.
Unit 5	**Introduction to Morphological Image Processing**	**Teaching Hours (2)**
Introduction	Logic Operations involving binary images, Introduction to Morphological Image Processing, Definition of Fit and Hit	1 hr
Morphological Operations	Dilation and Erosion, Opening and Closing	1 hr
Unit 6	**Image Segmentation**	**Teaching Hours (8)**
Introduction	Definition, Similarity and Discontinuity based techniques	1 hr
Discontinuity Based Techniques	Point Detection, Line Detection, Edge Detection using Gradient and Laplacian Filters, Mexican Hat Filters, Edge Linking and Boundary Detection, Hough Transform	3 hrs.
Similarity based techniques	Thresholding: Global, Local and Adaptive Region Based Segmentation: Region Growing Algorithm, Region Split and Merge Algorithm	4 hrs.
Unit 7	**Representations, Description and Recognition**	**Teaching Hours (5)**
Representation and Descriptions	Introduction to some descriptors: Chain codes, Signatures, Shape Numbers, Fourier Descriptors	2 hrs.

Recognition	Patterns and pattern classes, Decision-Theoretic Methods, Introduction to Neural Networks and Neural Network based Image Recognition	2 hrs.
Pattern Recognition	Overview of Pattern Recognition with block diagram	1 hr

Laboratory Works:

Students are required to develop programs in related topics using suitable programming languages such as MatLab or Python or other similar programming languages.

Text Books:

1. Rafael C. Gonzalez and Richard E. Woods, "Digital Image Processing", Pearson Edition, Latest Edition.

Reference Books:

1. I. Pitas, "Digital Image Processing Algorithms", Prentice Hall, Latest Edition.
2. A. K. Jain, "Fundamental of Digital Image processing", Prentice Hall of India Pvt. Ltd., Latest Edition.
3. K. Castlemann, "Digital image processing", Prentice Hall of India Pvt. Ltd., Latest Edition.
4. P. Monique and M. Dekker, "Fundamentals of Pattern recognition", Latest Edition.

Model Question

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Section A
Attempt any two questions. (2 × 10 = 20)
1. Differentiate between Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT). Explain the FFT algorithm for one-dimensional case. **[3+7=10]**

2. Given the following frequency table obtained from the histogram of a 16 X 16, 8 level image.

M	0	1	2	3	4	5	6	7
N_M	15	6	70	16	31	35	32	51

Where M = gray level and N_M = pixels having Mth gray level.
Construct Huffmann code for each gray level. Calculate the compression ratio and the relative data redundancy assuming if 3-bit code is used to code the gray level instead of Huffmann code. **[7+3 =10]**

3. What is an edge detection filter? Differentiate between the first derivative and second derivative filter? Derive the filter mask for laplacian filter and write the algorithm for its implementation. **[1+2+7=10]**

Section B
Attempt any eight questions. (8 × 5 = 40)
1. How many images of size 1024×768 with 256 gray levels can be stored in a 2048 MB storage space?
2. Write short notes on dilation and erosion.
3. Explain the contra-harmonic mean filters used in image restoration.
4. Explain the Bit plane slicing technique for image enhancement.
5. Explain how Hough transform is useful in line detection?
6. Describe in brief that how do you implement Gaussian High Pass Frequency domain filter for image smoothing in the frequency domain?
7. Explain lossy predictive coding in brief.
8. Explain the region growing technique for image segmentation.
9. Explain how can a neural network be applied in digital image processing with the help of a simple perceptron.