Pokhara University
Faculty of Science and Technology

Course Code.: CMP 441
Course title:**Image Processing and Pattern Recognition (3-1-2)**
Nature of the course:Theory & Practice
Year, Semester:……
Level: Bachelor

Full marks: 100
Pass marks: 45
Time per period: 1 hour
Total periods: 45
Program: BE

1. Course Description

This course covers essential image processing and pattern recognition techniques, including image enhancement, segmentation, and feature extraction. Students will use these methods to tackle real-world problems in fields such as medical imaging and computer vision, blending theory with practical, hands-on projects.

2. General Objectives

- To familiarize students with key techniques in image processing and pattern recognition.
- To equip students with skills for practical application in real-world scenarios.
- To develop competence in solving complex problems using advanced image processing methods.

3. Contents in Detail

Specific Objectives	**Contents**
Understand the foundational concepts, applications, and basic techniques involved in digital image processing.	**Unit 1: Introduction to Digital Image Processing [4 hrs]** 1.1 Fundamental Steps and Elements of DIP 1.2 Applications Areas of DIP 1.3 Elements of Visual Perception, Sampling and Quantization 1.4 Image and its types (Color Image, grayscale Image) 1.5 Relationship between Pixels (Neighbors, Path, Connectivity, Adjacency, Distances).
Learn practical methods to enhance images using spatial domain techniques like gray-level transformations and spatial filters.	**Unit2: Image Enhancement in Spatial Domain [7 hrs]** 2.1. Gray Level Transformations 2.1.1. Point operations 2.1.2. Contrast stretching, 2.1.3. Thresholding, 2.1.4. Digital negative, 2.1.5. Intensity level slicing 2.1.6. Bit Plane Slicing 2.2.Histogram Modeling, Histogram equalization, Histogram

	matching 2.3. Enhancement Using Arithmetic and Logic Operations 2.4. Spatial Filters 2.5. Smoothening and Sharpening Spatial Filters 2.5.1. Averaging 2.5.2. Median filtering 2.5.3. Spatial Low Pass 2.5.4. High pass filtering 2.5.5. Magnification by replication and interpolation
Master frequency domain techniques for image enhancement using Fourier Transform and frequency filters.	**Unit 3: Image Enhancement in the Frequency Domain [6 hrs]** 3.1. Introduction to Fourier Transform, DFT, FFT 3.2. Computing and Visualizing the 2D DFT 3.3. Smoothing Frequency Domain Filters 3.4. Sharpening Frequency Domain Filters, 3.5. Other Image Transforms 3.5.1. Hadamard transform 3.5.2. Haar transform 3.5.3. Discrete Cosine transform
Develop skills in restoring degraded images by applying noise reduction techniques in spatial and frequency domains.	**Unit 4: Image Restoration [4 hrs]** 4.1. A model of The Image Degradation / Restoration Process, 4.2. Noise Models Restoration in the Presence of Noise-Only Spatial Filtering 4.3 Types of noise (White noise, salt & pepper noise, Impulse noise, Gaussian noise, Rayleigh noise) 4.4. Periodic Noise Reduction by Frequency Domain Filtering
Acquire knowledge of image compression techniques to efficiently reduce file sizes while maintaining quality.	**Unit 5:Image Compression and Coding [7 hours]** 5.1 Need of Compression 5.2 Lossy & Lossless Compression, Issues of Compression 5.3 A generic model of compression 5.4 Element of Information Theory (Self Information, Entropy) 5.5 Data Redundancy, Coding Redundancy 5.6 Types of compression techniques 5.6.1 Entropy Encoding 5.6.1.1 Run Length Encoding (Interpixel Redundancy) 5.6.1.2 Huffman Encoding (Coding Redundancy) 5.6.1.3 LZW coding 5.6.2 Transform Coding 5.6.2.3 Predictive Coding
Learn to segment images into meaningful regions using various edge detection and thresholding techniques. Understand object	**Unit 6: Image Analysis [9 hrs]** 6.1 Introduction to Image Analysis 6.2 Feature Extraction & Types of Features, Detection of Discontinuities,

representation using descriptors for effective shape analysis in images.	6.3 Segmentation: Discontinuities-based segmentation (Point detection, line detection, Edge detection) 6.4 Similarities-based segmentation 6.4 .1 Feature Thresholding 6.4.1.1 Amplitude Thresholding 6.4.1.2.Thresholding based upon histogram statistics 6.4.1.3. Multi-level Thresholding 6.4.1.4. Local & Global Thresholding 6.4.1.5. Optimum Thresholding 6.4.2 Region growing based segmentation: seeded and unseeded 6.4.3 Region splitting& Merging 6.5 Region Description & representation 6.5.1Crack code & chain code 6.5.2 Polygon Approximation 6.5.3 Signatures 6.5.4 Shape Numbers 6.5.5 Fourier Descriptors
Gain expertise in object recognition and classification using pattern recognition techniques. Master the fundamentals of pattern recognition, focusing on feature extraction and classification algorithms.	**Unit 7: Pattern Recognition & Artificial Neural Network in Pattern Recognition [8 hours]** 7.1 Image pattern and its recognition 7.2 General steps of Pattern recognition 7.3 Boundary Preprocessing, Boundary Feature Descriptors, Region Feature Descriptors 7.4 Feature extraction: PCA 7.5 Scale-Invariant Feature Transform (SIFT) 7.6 Patterns and Pattern Classes 7.7 Pattern Classification by Prototype Matching 7.8 Optimum (Bayes) Statistical Classifiers 7.9 Artificial Neural Network 7.9.1 Perceptron 7.9.2 Hopfield Network

Note: The figures in the parentheses indicate the approximate periods for the respective units.

4. Methods of Instruction

General instructional Techniques: Lectures, discussion, Projects, tutorials, lab, assignments, quizzes.

5. List of Tutorials

The following tutorial activities of 15 hours per group of maximum 24 students should be conducted to cover all the required contents of this course.The various tutorial activities that suit your course should cover all the content of the course to give students a space to engage more actively with the course content in the presence of the instructor/professor. The tutorials section will cover the following portion mentioned below:

S.N.	Tutorials
1	Students will explore the origins and applications of digital image processing, including key steps like image sampling, quantization, and system components. They will also study pixel relationships (connectivity, distance measures) and the influence of visual perception on processing techniques.
2	Practical techniques like gray-level transformations (point operations, contrast stretching, thresholding), histogram processing, and spatial filtering (smoothing, sharpening). Students learn to combine these methods for optimal image enhancement.
3	Introduced to frequency domain enhancement through Fourier Transform and 2D DFT. Tutorials focus on applying frequency filters, exploring transforms like Hadamard and DCT, and using FFT for efficient processing.
4	Restoring images by understanding degradation models and noise reduction techniques. Students learn spatial filtering and frequency domain methods to restore image quality from various types of noise.
5	Explore image compression, focusing on reducing file size via coding techniques (Huffman, run-length), and understanding lossless/lossy methods like predictive coding. Tutorials emphasize practical applications in compression.
6	Introduce students to binary image processing with operations like dilation, erosion, and logical operations. Students learn to apply these techniques for noise removal and shape analysis through practical exercises.
7	Segmentation techniques including edge detection, thresholding (global, adaptive), and region-based methods. Tutorials focus on practical exercises to segment images into meaningful regions.
8	Methods for representing objects using descriptors like chain codes and Fourier descriptors. Students gain practical experience in analyzing and describing object shapes within images.
9	Pattern recognition and classification through tutorials on decision-theoretic methods and an introduction to neural networks. Practical exercises focus on object identification and classification.
10	Feature extraction and classification techniques, allowing students to apply various algorithms for pattern recognition and object classification in image datasets.

6. Practical Works

1. Every topic of the course content should be included for the lab.
2. Individual or group project work to develop a web application could be assigned. This should cover most of the technologies included in the course content.

7. Evaluation system and Students' Responsibilities

Evaluation System

In addition to the formal exam(s) conducted by the Office of the Controller of Examination of Pokhara University, the internal evaluation of a student may consist of class attendance, class participation, quizzes, assignments, presentations, written exams, etc. The tabular presentation of the evaluation system is as follows.

External Evaluation	Marks	Internal Evaluation	Weight	Marks
Semester-End examination	50	Theory		30
		Assignments	15%	
		Attendance/Class Participation	15%	
		Project/Presentation	20%	
		Term exam	50%	
		Practical		20
		Lab Report/Project Report	20%	
		Attendance	20%	
		Practical Exam/Project work	40%	
		Viva	20%	
	50	Internal Final	100%	50
Full Marks 50+50 = 100				

Students' Responsibilities:
Each student must secure at least 45% marks in the internal evaluation with 80% attendance in the class to appear in the semester-end examination. Failing to obtain such score will be given NOT QUALIFIED (NQ) and the student will not be eligible to appear in the End-Term examinations. Students are advised to attend all the classes and complete all the assignments within the specified time period. If a student does not attend the class(es), it is his/her sole responsibility to cover the topic(s) taught during the period. If a student fails to attend a formal exam, quiz, test, etc. there won't be any provision for a re-exam.

8. Prescribed Books and References

Text Book:

Rafael C. Gonzalez and Richard E. Woods, "Digital Image Processing", Prentice Hall of India Pvt. Ltd., 2010.

References:

1. I. Pitas, "Digital Image Processing Algorithms", Prentice Hall, 2009.
2. A. K. Jain, “Fundamental of Digital Image processing”, Prentice Hall of India Pvt. Ltd., 2011.
3. K. Castlemann, “Digital image processing”, Prentice Hall of India Pvt. Ltd., 2010.
4. R. C. Gonzalez and P. Wintz, “Digital Image Processing”, Addison-Wesley Publishing, 2009.
5. P. Monique and M. Dekker, “Fundamentals of Pattern recognition”, 2007.
6. M. James, “Pattern recognition”, BSP professional books, 2008.