

## AIPE3001 COMPUTER VISION AND IMAGE PROCESSING (3-0-0)

### Course Objectives:

- Understand the fundamentals of image formation, image representation, and image enhancement.
- Develop algorithms for processing digital images.
- Learn key concepts in computer vision such as feature extraction, segmentation, object detection, and recognition.
- Apply machine learning techniques to solve computer vision problems.
- Gain hands-on experience with real-time image and video processing applications.

### Module-I: (08 hours)

Introduction to Computer Vision and Basic Concepts of Image Formation:

Introduction and Goals of Computer Vision and Image Processing, Applications of computer vision and image processing.

Digital image fundamentals: image representation, sampling, quantization, Image types: binary, grayscale, colour, Human vision system and camera model.

Image Formation Concepts- Radiometry, Geometric Transformations, Geometric Camera Models, Camera Calibration, Image Formation in a Stereo Vision Setup, Image Reconstruction from a Series of Projections, Transformation: Orthogonal, Euclidean, Affine, Projective, etc.

### Module-II: (08 hours)

Image Processing Concepts:

Image Transforms, Image Enhancement, Image Filtering, Colour Image Processing- Point processing: contrast stretching, histogram equalization, Image Segmentation. Spatial filtering: smoothing and sharpening filters, Frequency domain processing (Fourier Transform basics), Noise models and filtering (mean, median, Gaussian filters), Image restoration techniques

### Module-III: (10 hours)

Image Descriptors and Features:

Texture Descriptors, Colour Features, Edges/Boundaries, Object Boundary and Shape Representations, Interest or Corner Point Detectors, Histogram of Oriented Gradients, Scale Invariant Feature Transform, Speeded up Robust Features, Saliency.

Feature Extraction: Importance of Features, Feature extraction techniques, Histogram of Oriented Gradient (HOG), Scale Invariant Feature Transform (SIFT), Background subtraction techniques, Image Matching, Principal Component Analysis (PCA), Image Segmentation Region Growing, Edge Based approaches to segmentation, Graph-Cut, Mean-Shift, MRFs, Texture Segmentation.

### Module-IV: (08 hours)

Object detection:

Pattern Analysis, Clustering: K-Means, K-Medoids, Mixture of Gaussians, Classification: Discriminant Function, Supervised, Un-supervised, Semi-supervised; Classifiers: Bayes, KNN, ANN models; Dimensionality Reduction: PCA, LDA, ICA; Non-parametric methods.

### Module-V: (06 hours)

Applications of Computer Vision:

Artificial Neural Network for Pattern Classification, Convolutional Neural Networks, Autoencoders, Gesture Recognition, Motion Estimation and Object Tracking, Programming Assignments.

**Course Outcomes (COs):**

After successful completion of this course, students will be able to:

- CO1: Explain the fundamental principles of image formation and enhancement techniques.
- CO2: Implement algorithms for filtering, edge detection, and color image processing.
- CO3: Extract useful features from images and videos using standard computer vision techniques.
- CO4: Design and evaluate object detection and classification models.
- CO5: Use modern libraries and tools such as OpenCV and deep learning frameworks for solving vision-based problems. Understand image structure, different image types, and foundational concepts of image processing and vision systems.

**Text Books:**

1. Forsyth & Ponce, "Computer Vision-A Modern Approach", Pearson Education.
2. M.K. Bhuyan, "Computer Vision and Image Processing: Fundamentals and Applications", CRC Press, USA, ISBN 9780815370840 - CAT# K338147.

**Reference Book:**

1. Richard Szeliski, "Computer Vision- Algorithms & Applications", Springer.