Image and Video Analytic Fundamentals

Code: CS32126CS	Course Type: Elective	Semester: I
Evolution Scheme (TA-MSE-ESE): 20-30-100	Total Marks: 150	L-T-P (Credits): 3-0-0 (3)

Pre-Requisites:

- Students should have basic knowledge of:
- Mathematics: Linear Algebra (matrices, vectors), Calculus (differentiation, integration), Probability and statistics (basic concepts)
- Signals and Systems: Sampling, convolution, Fourier Transform
- Programming: Basic programming in C/C++/Python
- Fundamentals of Digital Electronics (optional but helpful)

Course Objectives:

1. **To** provide fundamental understanding of digital image processing concepts, image formation, and visual perception.
2. **To** introduce spatial and frequency domain techniques for image enhancement and segmentation.
3. **To** develop knowledge of video processing fundamentals and motion estimation techniques.
4. To design and analyse video analytics systems for object detection and tracking.
5. To advanced computer vision techniques for motion understanding and real-world applications such as action recognition

Course Outcomes: At the end of the course, the student will be able to

CO-1	Understand fundamental concepts of digital image processing, image formation, and enhancement techniques.
CO-2	Apply spatial and frequency domain techniques for image enhancement and segmentation.
CO-3	Analyze video processing techniques and implement motion estimation algorithms.
CO-4	Design and evaluate video analytics systems for object detection, tracking, and motion understanding.
CO-5	Apply advanced computer vision techniques for real-world applications such as action recognition and video analysis

Course Articulation Matrix:

COs	PEO-1	PEO-2	PEO-3	PEO-4	PEO-5	PEO-6
CO-1	3	2	2	-	-	-
CO-2	3	3	2	1	1	1
CO-3	3	3	3	2	2	2
CO-4	3	3	2	2	3	3
CO-5	3	3	3	2	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit-1: Digital Image Fundamentals and Spatial Processing

Introduction: Introduction & Applications of Digital image processing, Elements of visual perception, Image sensing and acquisition, simple image formation, Image sampling and

Quantization, Representing digital pixels, Image quality, Introduction to colour image – RGB and HSI Models. Image enhancement in Spatial domain: Introduction to image enhancement, basic grey level transforms; Histogram: Histogram-processing equalization, Matching &colour histogram, Enhancement using arithmetic/logic operations, spatial filtering, Smoothing spatial filtering, Sharpening spatial filtering.

Unit-2: Image Enhancement and Segmentation Techniques

Image Enhancement: Spatial Domain methods: Histogram Processing, Fundamentals of Spatial Filtering, Smoothing Spatial filters, Sharpening Spatial filters; Frequency Domain methods: Basics of filtering in frequency domain, image smoothing, image sharpening, selective filtering Image; Segmentation: Segmentation fundaments concepts, Edge detection (point, line and Edge detection), Thresholding, region based segmentation.

Unit-3: Video Processing and Motion Estimation

Analog video fundamental, Digital Video fundamental, Time varying Image Formation models : 3D motion models, Geometric Image formation, Photometric Image formation, sampling of video signals, filtering operations 2-D; Motion Estimation: Optical flow, pixel based motion estimation, Block matching algorithm, Mesh based motion Estimation, global Motion Estimation, Region based motion estimation, multi resolution motion estimation; Video Coding: Waveform based coding, Block based transform coding, predictive coding, Application of motion estimation in video compression.

Unit-4: Video Analytics and Motion Understanding

Computer Vision: Challenges- Spatial Domain Processing – Frequency Domain Processing; Video Analytics: Background Modelling-Shadow Detection-Eigen Faces, Object Detection, Local Features; Mean Shift: Clustering; Tracking: Object Tracking using Active Contours, Kalman filters, particle filters, Bayesian filters, hidden Markov models, change detection and model based tracking; Motion Understanding: Motion estimation and Compensation, Motion Segmentation techniques, Thresholding for Change Detection, Estimation of Model parameters, Optical Flow Segmentation; Modified Hough Transform Method: Segmentation for Layered Video Representation, Bayesian Segmentation, Simultaneous Estimation and Segmentation, Action Recognition.

Learning Resources:

Text Books:

1. 1. Digital Image Processing – Rafael C. Gonzalez, Richard E. Woods, 4th Edition, Pearson, 2018
2. R. Szeliski,*Computer Vision: Algorithms and Applications,* 2nd ed., Springer, 2022.

Reference Books:

1. S. E. Umbaugh,*Digital Image Processing and Analysis: Human and Computer Vision Applications with CVIP Tools,* 3rd ed., CRC Press, 2018.
2. G. Bradski and A. Kaehler, *Learning OpenCV 4: Computer Vision with Python*, O'Reilly Media, 2020.