

Amrita Vishwa Vidyapeetham
Amrita School of Computing, Amritapuri.
Department of Computer Science and Engineering

Course Plan

1. Course Information

Course code/Title: 25RA611 Computer Vision L-T-P-C: 2-0-3-3

Academic year and term: 2026-2027 Even Semester

Program/Batch/Semester: MTech. / 2025-2027 / Semester II

2. Course Mentors: Anjali T

3. Course Objectives

- To introduce the fundamentals of digital image formation, feature extraction, depth estimation, and image segmentation techniques...
- To enable students to analyze visual patterns using clustering and classification methods for computer vision applications. The application of convolutional neural networks and RNN for images and image sequences.

4. Course Outcomes

CO #	Outcome
CO1	Understand digital image formation and related processing.
CO2	Apply depth estimation using stereo views
CO3	Apply feature extraction techniques for detection of edges.
CO4	Perform image segmentation.
CO5	Analyze patterns using clustering and other means.

5. CO-PO Affinity Map

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	–	–	–	–	–	–	2
CO2	2	3	2	2	2	–	–	–	–	–	–	2
CO3	2	3	3	2	2	–	–	–	–	–	–	2
CO4	2	3	3	3	2	–	–	–	–	–	–	2
CO5	2	3	2	2	2	–	–	–	–	–	–	3

6. CO-PO Affinity Justification

CO	PO	Affinity	Justification
CO1	PO1	3	Builds strong foundational knowledge of digital image formation, image processing principles, and mathematical concepts used in computer vision.
CO1	PO2	2	Enables students to analyze basic image processing problems using appropriate computational techniques.
CO1	PO3	2	Supports the development of basic solution designs for low-level image processing tasks.
CO1	PO4	1	Provides limited exposure to investigation of image processing techniques through standard examples.
CO1	PO5	1	Introduces the use of modern tools such as OpenCV or MATLAB for image processing applications.
CO1	PO12	2	Encourages continuous learning in evolving computer vision methodologies.
CO2	PO1	2	Strengthens understanding of geometric principles and stereo vision concepts used in depth estimation.
CO2	PO2	3	Develops strong analytical skills for solving depth estimation and multi-view vision problems.
CO2	PO3	2	Supports the design of vision-based solutions for stereo and multi-camera systems.

CO2	PO4	2	Enables investigation and interpretation of depth estimation results using vision algorithms.
CO2	PO5	2	Promotes the application of modern vision tools and libraries for implementing stereo vision systems.
CO2	PO12	2	Motivates learners to keep pace with advancements in 3D vision and perception systems.
CO3	PO1	2	Reinforces theoretical knowledge of feature extraction and edge detection techniques.
CO3	PO2	3	Enables detailed analysis of image features for accurate detection and representation.
CO3	PO3	3	Supports the design and development of feature-based computer vision pipelines.
CO3	PO4	2	Facilitates experimental investigation of feature extraction methods on real image data.
CO3	PO5	2	Encourages effective use of vision toolkits for feature detection and description.
CO3	PO12	2	Supports lifelong learning in advanced feature representation techniques.
CO4	PO1	2	Enhances conceptual understanding of image segmentation and object detection algorithms.
CO4	PO2	3	Develops strong problem analysis skills for segmenting complex visual scenes.

CO4	PO3	3	Enables design of segmentation-based solutions for vision applications.
CO4	PO4	3	Encourages systematic investigation and evaluation of segmentation algorithms.
CO4	PO5	2	Promotes the use of modern computational tools for implementing segmentation techniques.
CO4	PO12	2	Encourages independent learning of advanced segmentation approaches.
CO5	PO1	2	Strengthens understanding of pattern analysis and statistical learning concepts.
CO5	PO2	3	Develops analytical skills for clustering and classification of visual patterns.
CO5	PO3	2	Supports the design of pattern recognition systems for vision applications.
CO5	PO4	2	Facilitates investigation and interpretation of clustering and classification results.
CO5	PO5	2	Encourages use of modern tools for implementing pattern analysis techniques.
CO5	PO12	3	Promotes lifelong learning and research orientation in computer vision and pattern analysis.

7. Syllabus

- **Digital** image formation and low-level processing

Overview and state-of-the-art, fundamentals of image formation, transformations (orthogonal, Euclidean, affine, projective), Fourier transform, convolution and filtering, image enhancement, restoration, and histogram processing.

- **Depth estimation and multi-camera views**

Perspective, binocular stereopsis, camera and epipolar geometry, homography, rectification, DLT, RANSAC, and 3-D reconstruction framework.

- **Feature extraction**

Edge detection (Canny, LOG, DOG), line detection (Hough Transform), corner detection (Harris, Hessian Affine), orientation histogram, SIFT, SURF, HOG, GLOH, scale-space analysis, image pyramids, Gaussian derivative filters, Gabor filters, and DWT.

- **Image segmentation**

Region growing, edge-based segmentation approaches, graph-cut, mean-shift, MRFs, texture segmentation, and object detection.

- **Pattern analysis**

Clustering (K-Means, K-Medoids, Mixture of Gaussians) and classification (discriminant function, supervised, unsupervised, semi-supervised)

Suggested Lab Sessions:

- Usage of OpenCV / MATLAB / Equivalent for the implementation of the course topics.
- Develop computer vision-based applications in robotic systems.

Text Books

- ② Richard Szeliski, "Computer Vision: Algorithms and Applications", Springer-Verlag London Limited, 2011.
- ② D. A. Forsyth, J. Ponce, "Computer Vision: A Modern Approach", Pearson Education, 2003.
- ② Gonzalez, Woods and Eddins, "Digital Image Processing using MATLAB", Prentice Hall, 2004.

9. Evaluation Policy

Sl. No.	Exam	CO Coverage	Weightage%
1	Midterm	CO1, CO2	30
2	Assignment	CO3, CO4	10
3	Lab sheets	CO1, CO2, CO3, CO4, CO5	20
4	End Semester Exam	CO1, CO2, CO3, CO4, CO5	40
	Total		100

Lab Sessions

Week	Experiment / Lab Activity	Description
Week 1	Image acquisition and preprocessing	Reading, displaying, grayscale conversion, resizing, and normalization of images using OpenCV / MATLAB
Week 2	Image transformations and filtering	Spatial filtering, convolution, smoothing, sharpening, and frequency-domain processing (Fourier Transform)
Week 3	Histogram processing and image enhancement	Histogram equalization, contrast stretching, and image restoration techniques
Week 4	Edge detection techniques	Implementation and comparison of Sobel, Prewitt, Canny, LOG, and DOG edge detectors
Week 5	Feature extraction and description	Detection of corners and features using Harris, SIFT, SURF, HOG, and scale-space techniques
Week 6	Depth estimation using stereo vision	Camera calibration, epipolar geometry, disparity map generation, and depth computation

Week 7	Image segmentation techniques	Region growing, edge-based segmentation, graph-cut, mean-shift, and texture-based segmentation
Week 8	Object detection and recognition	Feature-based object detection using classical computer vision methods
Week 9	Pattern analysis and clustering	Implementation of clustering techniques such as K-Means and Mixture of Gaussians for image analysis
Week 10	Mini project / Case study	Development of a computer vision-based application relevant to robotic systems

10. Direct Assessment Tools

Sl. No	Direct Assessment Tools	Weightage (%)	Max Exam Marks	CO1	CO2	CO3	CO4	CO5
1	Midterm Exam	30	50	✓	✓			
2	Assignment	10	10			✓	✓	
3	Lab sheets	20	20	✓	✓	✓	✓	✓
4	End Semester Exam	40	100	✓	✓	✓	✓	✓

11. CO Attainment Levels

Attainment Level	Target %
High	≥ 70
Medium	≥ 50
Low	< 50

12. Course Delivery Plan

Unit 1					
Week 1	Overview and state-of-the-art, fundamentals of image formation	To introduce basic concepts of image formation and computer vision	CO1	PO1, PO2	PSO1
Week 2	Image transformations: orthogonal, Euclidean, affine, projective	To understand geometric transformations used in image processing	CO1	PO1, PO2	PSO1
Week 3	Fourier transform, convolution and filtering	To analyze frequency and spatial domain image processing techniques	CO1	PO1, PO2	PSO1
Week 4	Image enhancement, restoration, histogram processing	To apply enhancement and restoration techniques for image improvement	CO1	PO1, PO2, PO3	PSO1
Unit 2					
Week 5	Perspective projection, binocular stereopsis, camera geometry	To understand camera models and stereo vision principles	CO2	PO1, PO2	PSO1
Week 6	Epipolar geometry, homography, rectification, DLT, RANSAC	To analyze multi-camera geometry and 3-D reconstruction methods	CO2	PO1, PO2, PO4	PSO1
Week 7	Edge detection: Canny, LOG, DOG; Line detection: Hough Transform	To study edge and line feature extraction techniques	CO3	PO1, PO2	PSO1
Week 8	Corner detection (Harris, Hessian), SIFT, SURF, HOG, GLOH	To understand local feature descriptors and representations	CO3	PO1, PO2, PO3	PSO1
Unit 3					
Week 9	Scale-space analysis, image pyramids, Gaussian derivatives, Gabor filters, DWT	To analyze multi-scale and frequency-based feature representations	CO3	PO1, PO2	PSO1
Week 10	Image segmentation: region growing, edge-based methods, graph-cut, mean-shift, MRFs	To apply segmentation techniques for object separation	CO4	PO1, PO2, PO3	PSO1
Week 11	Pattern analysis: clustering (K-Means, K-Medoids, MoG), classification methods	To analyze visual patterns using clustering and classification techniques	CO5	PO1, PO2, PO3	PSO1

13. Faculty Information with Signature

Faculty Name	Class	Signature
Anjali T	S2 Mtech Robotics	