CST474	COMPUTER VISION	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		PEC	2	1	0	3	2019

Preamble: Computer vision is a field of artificial intelligence (AI) that enables computers and systems to derive meaningful information from digital images, videos and other visual inputs. The curriculum covers the basics of image formation, key computer vision concepts, methods, techniques, pattern recognition, various problems in designing computer vision and object recognition systems. This course enables the learners to understand the fundamentals of computer vision and develop applications in computer vision.

Prerequisite: Nil

Course Outcomes: After the completion of the course, the student will be able to

CO1	Summarize basic concepts, terminology, theories, models and methods in the field of computer vision. **(Cognitive Knowledge Level: Understand)**
CO2	Explain basic methods of computer vision related to multi-scale representation, edge detection, detection of other primitives, stereo, motion and object recognition. **(Cognitive Knowledge Level: Understand)**
CO3	Describe principles of Segmentation, Motion Segmentation and Classification **(Cognitive Knowledge Level: Understand)**
CO4	Select appropriate object Tracking and detection methods for computer vision applications **(Cognitive Knowledge Level: Understand).**
CO5	Implement a computer vision system for a specific problem **(Cognitive Knowledge Level: Apply)**

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓		✓									✓
CO2	✓		✓									✓
CO3	✓		✓									✓

CO4	✓		✓									✓
CO5	✓	✓	✓	✓	✓							✓

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Lifelong learning

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination Marks (%)**
	Test 1 (%)	**Test 2 (%)**	
Remember	**30**	**30**	**30**
Understand	**50**	**50**	**50**
Apply	**20**	**20**	**20**
Analyze			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3

Continuous Internal Evaluation Pattern:

Attendance **10 marks**

Continuous Assessment Tests(Average of Internal Tests1&2) **25 marks**

Continuous Assessment Assignment **15 marks**

Internal Examination Pattern

Each of the two internal examinations has to be conducted out of 50 marks. First series test shall be preferably conducted after completing the first half of the syllabus and the second series test shall be preferably conducted after completing remaining part of the syllabus. There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly completed module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly completed module), each with 7 marks. Out of the 7 questions, a student should answer any5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 full questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

Syllabus

Module – 1 (Image Formation and Filtering)

Geometric Camera Models - Pinhole perspective, Intrinsic and Extrinsic Parameters, Geometric Camera Calibration. Linear Filters- Linear Filters and Convolution, Shift Invariant Linear Systems. Filters as Templates - Normalized Correlation and Finding Patterns.

Module - 2(Local Image Features and Stereo Vision)

Image Gradients - Computing the Image Gradient, Gradient Based Edge and Corner Detection. Stereopsis- Binocular Camera Geometry, Epipolar Constraint, Binocular Reconstruction, Local Methods for Binocular Fusion, Global Methods for Binocular Fusion.

Module - 3 (Segmentation)

Segmentation - Background subtraction, Interactive segmentation, Forming image regions. Segmentation by clustering - Watershed Algorithm. Motion Segmentation by Parameter Estimation- Optical Flow and Motion, Flow Models, Motion Segmentation with Layers.

Module- 4 (Classification and Tracking)

Classification - Classification Basics, Two-class and Multiclass classifiers, Error, Overfitting and Regularization, Cross Validation, Classifying Images of Single Objects.
Tracking - Tracking Basics, Simple Tracking Strategies, Tracking by detection, Tracking Linear Dynamical models with Kalman filters.

Module - 5 (Finding Objects and other Applications)

Object detection - The Sliding Window Method. Object Recognition -Goals of Object Recognition System. Applications - Robot Navigation by stereo vision, Face detection, Face recognition, Activity Recognition, Tracking people.

Text Books

1. Forsyth, David, and Jean Ponce. Computer vision: A modern approach. Prentice hall, 2011.

Reference Books

1. Szeliski, Richard, Computer vision: algorithms and applications. Springer Science & Business Media, 2010.
2. Medioni, Gerard, Emerging topics in computer vision. and Sing Bing Kang. Prentice Hall PTR, 2004.
3. Trucco, Emanuele, and Alessandro Verri, Introductory techniques for 3-D computer vision. Vol. 201. Englewood Cliffs: Prentice Hall, 1998.
4. Faugeras, Olivier, and Olivier Autor Faugeras, Three-dimensional computer vision: a geometric viewpoint. MIT press, 1993.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the relationship between coordinates involved in a pinhole camera imaging setup.
2. Explain the basic principle behind geometric camera calibration**.**
3. Describe how linear filters can be used for smoothing digital images.
4. How does normalised correlation help in matching patterns in images?

Course Outcome 2 (CO2):

1. Describe edge detection methods for computer vision.
2. List any five applications of object recognition.
3. Explain how the epipolar constraint simplifies the correspondence search between two stereo images.
4. List and explain the different methods used for binocular fusion.
5. Explain the different corner detection methods.

Course Outcome 3 (CO3):

1. Explain the principle of background subtraction.
2. Describe the watershed algorithm for image segmentation.
3. What is meant by optical flow? How can it be utilized for segmenting images?
4. Describe motion segmentation with layers.
5. What is overfitting in the context of classification?
6. Explain the principle behind classification of single images.

Course Outcome 4 (CO4):

1. Explain 'Mean Shift Algorithm' to track an object using matching.

2. Describe an algorithm to track a moving object (dynamic object).

3. Explain the sliding window method for object detection.

4. Assume that we have the dynamics

$$x_i \sim N(d_i x_{i-1}, \sigma_{d_i}^2)$$

$$y_i \sim N(m_i x_i, \sigma_{m_i}^2)$$

a. $P(x_i|x_{i-1})$ is a normal density with mean $d_i x_{i-1}$ and variance $\sigma_{d_i}^2$. Whatis$(x_{i-1}|x_i)$?

b. Show how to obtain a representation of $P(x_i|y_{i+1}, \ldots, y_N)$ usinga KalmanFilter.

Course Outcome 5(CO5):

1. Explain how to implement a computer vision system.
2. Illustrate a computer vision system with the help of a neat diagram.
3. Discuss the components of a computer vision system for object recognition.
4. Explain how activity recognition can be done using computer vision.
5. Illustrate a face recognition system with the help of a diagram.

Assignment Questions

6. Implement a voxel-based approach to visual hull construction.
7. Implement a computer vision system for object recognition.

Model Question Paper

QP CODE:

Reg No: _____

Name: _____ **PAGES : 3**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CST474

Course Name: COMPUTER VISION

Max.Marks:100 **Duration: 3 Hours**

PART A

Answer All Questions. Each Question Carries 3 Marks

1. State three properties of shift invariant linear systems.
2. Explain the term normalized correlation.
3. What is image rectification? Mention its significance?
4. Illustrate epipolar geometry and showepipolar lines and epipoles.
5. Explain the term flow model.
6. How does background subtraction help in segmenting an image?
7. What is a Kalman filter? Give its applications.
8. State any three simple tracking strategies.
9. State the goals of an object recognition system.
10. Explain the task of face recognition. **(10x3=30)**

Part B

(Answer any one question from each module. Each question carries 14 Marks)

11. (a) Demonstrate the relationship between a point in the world coordinate frame and its corresponding image point using camera parameters. **(9)**

    (b) Show that convolving a function with a δ function simply reproduces the original function. **(5)**

OR

12. (a) What is linear filtering? Explain two applications of linear filtering to image processing. **(7)**

    (b) Explain an application of normalised correlation to find patterns. **(7)**

13. (a) Show that smoothing an image and then computing the gradient is same as convolving an image with the derivative of a smoothing function. **(5)**

    (b) State the epipolar constraint and derive its representations using the Essential matrix and the Fundamental matrix. **(9)**

OR

14. (a) Explain the algorithm for computing edges using gradients. **(9)**

    (b) Define binocular fusion. Explain two local methods for binocular fusion. **(5)**

15. (a) Discuss the different interactive segmentation approaches. **(7)**

    (b) What is meant by optical flow? How can it be utilized for segmenting images? **(7)**

OR

16. (a) Explain the Watershed algorithm. **(7)**

    (b) How can we perform motion segmentation by parameter estimation? **(7)**

17. (a) Explain tracking algorithm using Kalman filtering. **(7)**

    (b) Illustrate the tracking by detection algorithm. **(7)**

OR

18. (a) Explain the various kinds of errors in classification and the relationship between them. **(7)**

    (b) What is overfitting and how does regularization help to minimise it? **(7)**

19. (a) Explain human activity recognition with appearance features. **(7)**

(b) Describe the Sliding window method for detecting objects in images. **(7)**

OR

20. (a) Explain the principle of detecting faces in an image. **(7)**

(b) What are the various strategies for object recognition? **(7)**

Teaching Plan

No	Contents	No. of Lecture Hours (36hrs)
Module 1 Image Formation and Filtering (7)		
1.1	Geometric Camera model - Pinhole perspective	1
1.2	Geometric Camera model - Intrinsic Parameters	1
1.3	Geometric Camera model - Extrinsic Parameters	1
1.4	Geometric Camera Calibration – Linear Approach	1
1.5	Linear Filters and Convolution	1
1.6	Shift Invariant Linear Systems - Discrete convolution	1
1.7	Normalized Correlation and Finding patterns	1
Module 2 Local Image Features and Stereo Vision (8)		
2.1	Local Image Features - Computing the Image Gradient	1
2.2	Gradient Based Edge Detection	1
2.3	Gradient Based Corner Detection	1
2.4	Stereopsis - Binocular Camera Geometry and Epipolar Constraint	1
2.5	Essential Matrix and Fundamental Matrix	1
2.6	Binocular Reconstruction	1
2.7	Local Methods for Binocular Fusion	1
2.8	Global Methods for Binocular Fusion	1
Module 3 Segmentation (6)		

3.1	Segmentation basics	1
3.2	Applications - Background Subtraction, Interactive Segmentation	1
3.3	Forming Image Regions	1
3.4	Segmentation by clustering - The Watershed Algorithm	1
3.5	Motion Segmentation by Parameter Estimation - Optical Flow and Motion	1
3.6	Flow Models and Motion Segmentation with Layers	1
Module 4 Classification and Tracking (8)		
4.1	Classification Basics, Two-class and Multiclass classifier	1
4.2	Error, Overfitting and Regularization	1
4.3	Cross Validation, Classifying Images of Single Objects	1
4.4	Tracking Basics, Simple Tracking Strategies	1
4.5	Tracking by detection	1
4.6	Linear Dynamical models	1
4.7	The Kalman Filter background	1
4.8	Kalman filter algorithm	1
Module 5 Finding Objects and other Applications (7)		
5.1	Detecting Objects in Images- The Sliding Window Method	1
5.2	Object Recognition - Goals of Object Recognition System	1
5.3	Application of binocular stereo vision - Robot Navigation	1
5.4	Face detection	1
5.5	Face recognition	1
5.6	Activity recognition	1
5.7	Tracking people	1