Course	ENR503 Machine Vision, Learning and Applications	Semester	Monsoon Semester 2024
Faculty Name(s)	Keyur Joshi	Contact	keyur.joshi@ahduni.edu.in
School	SEAS	Credits	3
GER Category:	Not Applicable	Teaching Pedagogy Enable:YES	P/NP Course: Can not be taken as P/NP

Schedule

Section 1	09:30 am to 11:00 am	Sat	01-08-24 to 26-11-24
	11:00 am to 12:30 pm	Sat	01-08-24 to 26-11-24

Prerequisite	MAT100 Calculus and Differential Equations/MAT100 Multivariate Calculus OR Understanding of basic programming, calculus, differential equations, statistics and mathematical concepts. Student has to explain how he/she is qualified to pursue the course in case if the prerequisite criteria are not met and must receive approval from instructor before registering the course.
Antirequisite	Not Applicable
Corequisite	Not Applicable

Course Description	This course covers three major topics: 1) Machine Vision, 2) Machine Learning and 3) related applications. A brief introduction to the first two topics will be provided to the students, while third topic could serve as a connecting bridge between theoretical and practical aspects. Nowadays, Machine learning is a buzz word that has the potential of changing lifestyle of many humans. The course is multidisciplinary and offered university wide so that a student from any engineering branch can enroll. For more details please visit the session plan.
Course Objectives	• Become familiar with the terminology of machine vision, computer vision, machine learning and artificial intelligence. • Study operation of each components of the machine vision system. • Study various machine learning algorithms and techniques. • Grasp knowledge from already available running applications and implement the similar logic for newer applications. • Develop skills in the area of vision and artificial learning, usually useful in industries.
Learning Outcomes	Upon completion of this course, student will be able to • Describe the terms such as Machine Vision, Computer Vision, Machine Learning and Artificial Intelligence. • Differentiate between the available components of the Machine Vision for a given application and available approaches of machine learning. • Illustrate the use of each components of a machine vision system in general along with the ability to make a prediction if there is some change in specifications from the client side. • Calculate the parameters that govern operation of the components. • Analyze the data with the help of machine learning algorithms, after the data acquisition. • Design and assemble a basic machine vision system with the selected machine learning approach to make intelligent system and meet the given requirements. • Compare the available techniques for the learning to predict and recommend some of them for a given application.
Pedagogy	This course will be taught 3 hours in a week, comprising of two 1.5 hour sessions. There will be hands-on session with camera and NI Vision Builder. An in-course project has been introduced first time where students would get the practical aspects of the course by performing the various activities.
Expectation From Students	The students must be prepared to work on a group project and learn by their experience. They must have desire to learn about the course and they are expected to 1) reflect and ponder on the topics covered in the class on the same day and make notes on how it can be useful to them and 2) go deeper to find a solution to their problem, if required. Apart from that, they must respect the other member in the group as well as others.

Assessment/Evaluation	• Mid-Semester Examination:
	  ◦ Online Exam - 15%
	• End Semester Examination:
	  ◦ Online Exam - 15%
	• Other Components:
	  ◦ Project - 50%
	  ◦ One slide presentation - 10%
	  ◦ Attendance and CP - 10%

Attendance Policy	As per Ahmedabad University Policy. Attendance is required, there are marks for that.
Project / Assignment Details	**Project (50% weightage):** In 12th session (near the in-semester examination), students must select the topic and work in their allocated group towards completion of the course project. The project must be completed and submitted a week before the 27th session which is allocated for project sharing and evaluation. *Duration for the project is 7 weeks for a group of students.*
Course Material	Reference Book • Computer and Machine Vision Theory, Algorithms, Practicalities, E.R. Davies, 4 Edition, Academic Press, • Machine Vision Handbook, B.G. Batchelor, Springer, • Foundations of Machine Learning, M. Mohri, A Rostamizadeh and A. Talwalkar, 2 Edition, The MIT Press, • Optics, Eugene Hecht, 5 Edition, Pearson, • Pattern Recognition and Machine Learning, C. Bishop, Springer, Other Course Material • 1. Robotics, Vision, and Control by Peter Corke; Second edition, 2018, Springer (Selected topics) 2. Reinforcement Learning: An Introduction by Sutton, R.S., and Barto A.G., 2020, MIT Press, (Selected topics) There is no textbook, as the course is multidisciplinary. Use lecture notes instead. Other course material: Books or research papers related to the subject. ,

Additional Information	**One slide literature review (10% weightage):** The 13th session is reserved for presenting a single slide literature review that would cover at least five research papers (conference and journal) in the selected project topic by a group of students. The references can be listed in another slide just in case if one needs to access the paper.

Session Plan

NO.	TOPIC TITLE	TOPIC & SUBTOPIC DETAILS	READINGS,CASES,ETC.	ACTIVITIES	IMPORTANT DATES
0	Course overview	Introduction, topics, evaluation and project	course outline	Lecture	
1	Course overview	Introduction, topics, evaluation and project	course outline	Lecture	
2	Introduction to MV	Natural and artificial vision, concept of Machine vision and computer vision, Human and animal vision, comparision, color vision, standard and models	Section 1.1 & 1.3 of book 1, Section 1.1 to 1.6 of book 2, Section 2.1 to 2.3 of book 2 , Section 3.1 to 3.7 of book 2, section 4.1 to 4.6 of book 2	Lecture	
3	Light and Optics	Plane waves, refraction, reflection, transmittance, absorption, optical density, scattering, diffraction, diffusion, interference, and polarisation, Optical materials, Mirrors , filters, Mirrors for Machine Vision, mirror properties, examples, Types of light sources, lighting techniques, examples, Laser scanners introduction, lighting viewing methods	Section 2.7, 3.5, 4.3, 4.4, 4.6.3, 9.1 and 9.2 of book 4, Section 5.1 to 5.3 of book 2, Section 8.5, 8.6 of book 4, Section 5.5 to 5.12 of book 2, Section 9.1 to 9.4 of book 2	Lecture	
4	Lenses and Cameras	Lenses introduction, types, advantages and disadvantages, examples; Cameras introduction, images sensor CCD and CMOS, sensor performance measure, color imaging, calibration; Machine Vision camera types, characteristics and selection, lens mount and filters	Section 5.4 of book 2, sections 6.1 to 6.3 of book 2, Section 19.3 to 19.5 of book 1, Section 10.1 to 10.7 of book 2, Section 11.1 to 11.4 of book 2	Lecture	
5	Color and Image formation	Color temperature, color constancy, white balancing, color change due to absorption, dichromatic reflection, gamma, comparing color spaces, shadow removal, Perspective camera, camera calibration, Wide-Field of view Imaging, Unified imaging, Multi-camera arrays, Light-field cameras	Section 10.1 to 10.4, 11.1 to 11.5 of Peter Corke Book	Lecture	

6	Digital Image Processing-1	Obtaining an image, Image histograms, Monadic and diadic operations, Spatial operations, Mathematical morphology, and Shape changing; Image region and line features	Section 12.1 to 12.7, 13.1 to 13.2 of Peter Corke Book	Lecture	
7	Digital Image Processing-2	Image point features, feature correspondence, Geometry of multiple views, stereo vision, bundle adjustments, point clouds, structured light, and applications	Section 13.3, and 14.1 to 14.7 of Peter Corke Book	Lecture	
8	Basic MV techniques	Overview of MV techniques, One-slide presentation discussion	Section 14.1 to 14.6 of book 2, Section 10.1, 10.2, 10. 6 & 10.7 of book 1	Interactive session	
9	Application-1	Inspection of Bakery products using a color-based Machine Vision System	Research Paper: Journal of Food Quality 23, 39-50, 2000	Application introduction, paper reading, and Informal quiz session	
10	Application-2	A Machine Learning-Based Driving Assistance System for Lane and Drowsiness Monitoring	Chapter 10 of book: Machine Intelligence Computer vision and natural language processing	Application introduction, Paper reading, and terminology	
11	Vision Builder	Introduction to the software and tools, examples	Software manual	Software Demonstration	
12	Course Project Selection	Coin project demonstration, Detailed explanation of the project assessment, Selecting project topic	Coin project and its classification system	Interactive session	
13	Literature Evaluation	One slide presentation	Literature papers	Presentation by students	
14	Mid-semester examination	Mid-semester evalaution	Self-Preparation	Examination	

15	Introduction to Machine Learning	Overview, supervised learning, unsupervised learning, reinforcement learning and applications	Chapter 1 of book 3	Lecture	
16	Linear and logistic regression	Hypothesis testing, gradient descent for linear regression; Decision boundary, Cost function and multi-class regression	Section 11.1, 11.3 of book 3, and Section 3.1 of book 5; Section 4.3.2 of book 5	Lecture and tutorial	
17	Neural networks	Natural and artificial neural network, logic gates using nets, cost function, back propagation, examples	Section 13.10 of book 1, Section 5.1 of book 5, Section 13.11 of book 1, Section 5.2, 5.3 of book 5	Lecture and Matlab Demo	
18	Support vector machines	Introduction, large margin calculation for separable case, visualization	Section 7.1 of book 5, Section 5.1 and 5.2 of book 3	Lecture and Matlab Demo	
19	K-means clustering	Introduction, clustering, K means algorithm, selecting number of clusters	Section 13.7 and 13.8 of book 1, Section 9.1 of book 5	Lecture and Matlab Demo	
20	Dimensionality reduction	Data compression, Principal components analysis	Section 14.5 of book 1, Section 15.1 of book 3	Lecture and Matlab Demo	
21	Reinforcement learning	Overview: Introduction, components; Environment: environment interface, rewards, and included actions; Agents: critics and Q values, actors and critics, training with options	Chapter 1 of book: Reinforcement Learning: an introduction	Lecture and Matlab Demo	
22	Machine Learning Techniques	Train, validate and test distribution, bias and variance, precision and recall, balanced dataset, Evaluating a developed classifier, confusion matrix	Section 1.1 to 1.5 of book 6, Section 14.13 of book 1	Lecture and ML system demo	
23	Anamoly detection	Anamoly Detection (AD): Causes and Motivation, Approaches of detecting anomaly, single and multi-variate Gaussian distribution, AD example	Section 10.1, 10.3, 10.4 and 10.5 from book 7; MGD: Section 1.2.4 of book 5, Section 10.2 from book 7	Lecture and Matlab Demo	

24	Application-3	Automated Coin Recognition System	Research paper: International Journal of Computer Applications, 24(4), 2011	Lecture and exploration	
25	Application-4	Automatic gear sorting system based on monocular vision	Research paper: Digital Communications and Networks 1, 284–291, 2015	Lecture and exploration	
26	Application-5	Size-Sorting and measurement system of safety belt pin based on MV	Research paper: Applied Mechanics and Materials 741, 709-713, 2015	Lecture and exploration	
27	Project sharing session	Project presentation and feedback	Poster from project work	Interactive session	
28	Review and Reflection-Machine Vision	Revision and preparation	Previous lecture notes	Self-reading	
29	Review and Reflection-Machine Learning	Revision and preparation	Previous lecture notes	Self-reading	
30	End-semester examination	End-semester evaluation	Self-Preparation	Examination	