GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Technology
Level: UG
Branch: Robotics and Automation
Subject Code: BE05041051
Subject Name: Machine Vision

w.e.f.Academic Year:	2024-25
Semester:	5
Category of the Course:	Professional Elective Course - 2

Prerequisite:	Nil
Rationale:	The course Machine Vision is designed to provide fundamental and advanced knowledge of digital image processing, machine vision systems, image enhancement, restoration, segmentation, compression, and morphological operations used in modern automation and intelligent systems. The course enables students to understand image acquisition, processing, analysis, and interpretation techniques for multidisciplinary engineering applications. Machine vision and image processing technologies play a significant role in industrial automation, robotics, healthcare diagnostics, surveillance systems, agriculture, transportation, remote sensing, smart manufacturing, and quality inspection. This course helps students develop analytical and programming skills for solving real-world engineering problems using computer vision and image analysis techniques.

Course Objectives: This subject is designed to understand the various processing techniques to enhance the digital image for different applications. Applications of digital image processing in different fields are covered in this syllabus to make it a multidisciplinary course. Importance of digital image processing is revealed in the content such as image enhancement, restoration, filtering, etc**.**

Course Outcomes:

Sr.No.	CO statement	Marks% weightage
CO-1	Enhance digital image using various algorithms with the help of computer programming.	35
CO-2	Understand the role of image processing in different fields such as medical, engineering, space, biotechnology, ocean, agriculture, food industry, etc.	20
CO-3	Realize the significance of digital image processing in automation.	20
CO-4	Know the mathematical calculations of basic filters used in digital image enhancement.	25

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Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	PBL	Total no of hours per semester		ESE (E)	PA / CA (M)	PA/CA (I)	PBL(I)	ESE (V)	
45	0	30	15	90	4	70	30	20	30	50	200

**** Problem-Based Learning (PBL) aims to accommodate learning beyond syllabus as per clause 9.4 of NBA manual.***

Content:

Sr.No.	Content	Total Hrs
1	**Introduction:** Comparison with human visual system and perception level, digital image presentation, Definitions of digital image, Examples of the fields that use digital image processing, fundamental steps in image processing, components / elements of digital image processing systems, image acquisition, storage, processing, communication and display.	5
2	**Digital Image Fundamentals:** Elements of visual perception – brightness adaption and discrimination, light and electromagnetic spectrum, image sensing and acquisition, sampling and quantization, some basic relationships between pixels, connectivity, adjacency, distance measures, different types of image sensors, different types of file formats.	6
3	**Image Enhancement in Spatial Domain:** Point processing and mask processing, Basic gray level transformations, histogram processing, histogram equalization, histogram matching, local enhancement, histogram statistics, image subtraction, image averaging, basics of spatial filtering – smoothing, sharpening filters and order statistics filters.	10
4	**Image Enhancement in Frequency domain:** Introduction to Fourier Transform and frequency domain, The discrete Fourier Transforms – properties of 2-D Fourier Transform, smoothing frequency domain filters – ideal, butter worth, Gaussian low pass filters with additional examples of low pass filters, sharpening frequency domain filters – ideal, butter worth, Gaussian and Laplacian filters, unsharp masking, high boost filtering, homomorphic filtering, convolution and correlation, sampling, additional properties of 2-D Fourier transfer, Periodicity and need for padding.	9

5	**Image Restoration:** Model for image degradation/restoration, noise models – probability density functions of noise, periodic noise and estimation of noise parameters; periodic noise reduction by frequency domain filtering, Arithmetic mean filters, geometric mean filters, adaptive filters, Band pass and band reject filters.	**5**
6	**Image compression:** Fundamentals of image compression and types of redundancy, error free and lossy compression, variable length coding – Huffman coding, arithmetic coding, LZW coding, run length coding.	**5**
7	**Morphological Image Processing:** Basic concept, Dilation and Erosion process for binary and gray image with applications, Opening & Closing for binary and gray image with applications, Hit-or-Miss Transformation, Basic Morphological Algorithms, textural segmentation.	**5**
	TOTAL	**45**

Suggested Specification table with Marks(Theory):(ForB.E.only)

Distribution ofTheory Marks					
RLevel	ULevel	ALevel	NLevel	ELevel	CLevel
35%	20%	15%	15%	15%	0%

R: Remembrance; U: Understanding;A:Application,N:AnalyzeandE:EvaluateC:Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. Theactual distribution of marks in the question paper may vary slightly from above table.

The syllabus of Machine Vision directly contributes to

SDG 3	Good health and well being through applications of medical imaging, disease detection, biomedical diagnostics, and healthcare monitoring systems.
SDG 4	By developing computational, analytical, and programming skills in digital image processing and intelligent automation technologies.
SDG 6	Clean water and Sanitation through image-based monitoring and analysis systems for water quality assessment and environmental observation.
SDG 7	Affordable and clean energy by enabling intelligent monitoring, inspection, and maintenance of renewable energy systems using machine vision techniques.
SDG 8	Decent work and Economic growth through industrial automation, smart inspection systems, defect detection, and productivity enhancement in manufacturing industries.
SDG9	Industry Innovation and Infrastructure by promoting smart manufacturing, robotics,

	autonomous systems, industrial quality control, and AI-enabled vision technologies.
SDG11	Sustainable cities through applications in intelligent transportation systems, traffic monitoring, surveillance, and smart city infrastructure.
SDG12	Responsible consumption by supporting automated quality inspection, reduction of manufacturing defects, efficient resource utilization, and waste minimization.
SDG13	Climate action through satellite image analysis, environmental monitoring, disaster assessment, and climate-related data interpretation.

Reference Books:

1	Refael C. Gonzalez and Richard E. Woods, Digital Image Processing, Addison-Wesley
2	Refael C. Gonzalez and Richard E. Woods Digital Image Processing Using MATLAB Addison-Wesley
3	Scott E Umbaugh, Computer Vision and Image Processing, Prentice-Hall International, Inc.
4	A.K. Jain, Fundamentals of Digital Image Processing, Prentice-Hall of India
5	Milan Sonka, Machine Vision and Image Processing
6	Castleman K.R. Digital Image Processing Prentice-Hall India

List of Experiments:

1	Learning and implementing basic MATLAB commands using script file
2	Make function file in MATLAB
3	Understanding different image classes
4	Use of arithmetic and logical operators on images
5	Zooming and shrinking of digital image
6	Carry out bit plane slicing
7	Blurring and sharpening the given image by spatial convolution method
8	Blurring and sharpening of image with built in command and perform scaling of the image
9	Performing negative, log, power-law and contrast stretching transformations on given image
10	Matching of the histogram of image with the specified one
11	Implementing 1-D and 2-D Discrete Fourier Transformation of given image

Major Equipment:

Nil

List of Open Source Software

Nil

List of learning website:

Supplementary learning Material:	
1	NPTEL and Coursera Resources

Pedagogy:

- Direct classroom teaching
- Audio Visual presentations/demonstrations
- Assignments/Quiz
- Continuous assessment
- Interactive methods
- Seminar/Poster Presentation
- Industrial/ Field visits
- Course Projects

List of suggested activities for Problem-based Learning (PBL):

Sr. No.	PBL category	Name of the activity	No. of hours	Evaluation Criteria
1.	Complex Problem-Solving targeting relevant SDGs / Mini Project	Mini Project	15h (need to be changed as per total PBL hours)	Based on the novelty of project, technical understanding, report quality and presentation
2.	Case Study Analysis / Seminar	Seminar	15h (need to be changed as per total PBL hours)	Based on the quality of report and presentation, technical understanding
3.	Micro project	Micro project	8h (need to be changed as per total PBL hours)	Based on the novelty of project, technical understanding, quality of report and demonstration
4.	Industry/Research laboratory visit	Industry/Research laboratory visit	Visit = 5h, Report preparation = 5h Total = 10h	Based on report submitted. Report should contain observations and calculations based on industry/ lab data.
5.	Video Based Learning	Technical video-based learning related to the subject	Duration of video =5h Report preparation = 5h Total = 10h	Report /presentation based on the video learning outcomes.
6.	Assignment / Technical Writing / Research Writing	Assignment writing. Numerical based assignment is preferable.	5 assignments of 4 h each Total = 20h	Based on the correctness of submitted assignment
7.	Group Discussion / Quiz / Simulation	Problem solving/Coding using C, C++,MATLAB, Python, SCILAB,modeling and	5 small coding-based assignment of 2h each Total = 10h	Based on the coding solution submitted.

		Analysis software or any other software		
8.	Video Based Learning	Self-learning online course	Minimum duration of the course should be 10h	Examination based assessment at the end of course. Based on the certificate produced.
9.	Complex Problem-Solving targeting relevant SDGs / Mini Project	Identification and solution of Complex problem	Maximum 2 problems. Study of the problem and solution finding, Total =10h	Based on the depth of the solution submitted.
10.	Video Based Learning	Videos on Industrial safety/Disaster Management aspects based on subject	Duration of video = 5h Report preparation = 5h Total = 10h	Based on quiz/report submitted
11.	Research Paper Review / Analysis	Technical paper reading and summarization of research papers based on relevant subject	5 research papers = 20h	Summarize research paper and evaluation critical parameters
12.	Poster/Chart/PowerPoint presentation	Poster/chart/power point preparation on technical topics	Duration = 6h	Based on poster/chart preparation and presentation skills
13.	Industry/Research laboratory visit	Industrial exposure for 2-3 days to observe and provide tentative solutions on society/environment/health /sustainability/any other issue	Duration = 15h for industrial exposure Problem identification and tentative solution = 10h Total = 20h	Based on evaluation of critical problems and solutions
14.	Group Discussion / Quiz / Simulation	Group Discussion on emerging/trending technical topics based on subject	Duration = 1h – 3hper topic	Based on performance in group discussion, technical depth, knowledge etc.
15.	Case Study Analysis / Seminar	Real world case studies-based learning	Duration of data collection/study = 5h Report preparation = 5h Total = 10h	Based on in-depth study, technical depth, data collected, fact finding, etc.
16.	Group Discussion / Quiz / Simulation	Application/Software development	Duration = 10h	Depending on the complexity of the Application/Software
17.	Assignment / Technical Writing / Research Writing	Research paper publication	Duration = 10h	Based on submission of proof of publication
18.	Micro project	Upgradation/Reverse	Duration 10h	Based on the

		engineering studies of existing equipment of the laboratory		performance of the equipment
19.	Industry/Research laboratory visit	Expert lecture/session	Duration 3h For attending the lecture/session– 2h and for report writing 1h	Based on the proof of attendance and report submitted
20.	Video Based Learning	Annotated Video Explanation of Concept/Problem	10h (Preparation + Recording + Submission)	Based on accuracy of explanation, clarity, and presentation style.
21.	Assignment / Technical Writing / Research Writing	Patent Search and Innovation Gap Identification	10h (Search + Report)	Based on number of relevant patents analyzed and identification of innovation scope.
22.	Assignment / Technical Writing / Research Writing	Preparation of a report on Indian Standard(s)	10h (study of Indian Standard(s) + report	Based on report quality and understanding of the relevant Indian Standard(s).

Note:

1. In alignment with Outcome-Based Education (OBE) and NBA accreditation requirements, the subject **Quality and Reliability Engineeringcompulsorilyincorporates Micro Project and 5 marks as PBL activities for PEC and Seminar and Mini Project for PCC.**
   These activities are incorporated as integral Project-Based Learning (PBL) components. These activities are designed to foster experiential learning, encourage innovation, and strengthen problem-solving skills by engaging students in practical applications of power converter design, simulation, and analysis. The inclusion of PBL ensures that learners develop higher-order cognitive abilities mapped to Bloom's taxonomy, while simultaneously enhancing teamwork, communication, and research competencies essential for professional engineering practice.
2. The hours allocated to specific activities should be proportionate to the total no. of PBL hours and marks.
3. All the suggested activity should be related to the subject.
4. The number of hours is suggestive. Faculty can sub-divide the number of hours based on the activity. However, total number of hours is fixed.
5. Rubrics for the evaluation can be prepared by the faculty.
6. Subject teacher can add the relevant activities other than those listed above, with the consent of head of the department and DQAC.

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