SOMAIYA VIDYAVIHAR UNIVERSITY

K J Somaiya College of Engineering

Syllabus
Honour Programme in
AI, Computer Vision, and Robotics

(Programme commenced from AY 2024-25)

(Department of Electronics and Computer Engineering)

From

Academic Year 2024-25

(SVU-KJSCE 2.0)

(Approved by BOS dated _____, FOET dated _____,
and AC dated _____, Item No. _____)

Somaiya Vidyavihar University
K. J. Somaiya College of Engineering, Mumbai -77
(A Constituent College of Somaiya Vidyavihar University)

Honour Programme in AI, Computer Vision and Robotics

Offered by the Department of Electronics and Computer Engineering

Introduction

Artificial Intelligence (AI), Computer Vision, and Robotics honor program gives a broad perspective of modern technologies and applications in real life. AI, when combined with robotics, allows users to build smart robots that can work independently as per inputs from robotic sensors. Artificial Intelligence and Robotics allow theory, algorithms, and systems for making intelligent decisions in complex and uncertain environments. The course covers most aspects of artificial intelligence and robotics including perception and interpretation of sensor data, learning about environments, learning to make decisions, automated planning and reasoning, and interaction of AI robotic systems with each other and with humans. Computer vision, when added to smart robotics, gives true problem-solving solutions in industrial environments. Computer vision with artificial intelligence trains computers to interpret and understand the visual world. Machines can accurately identify and locate objects then react to what they "see" using digital images from cameras, videos, and deep learning models. After completing this Honors degree students will be equipped with knowledge from all three domains and will be industry-ready in the true sense.

Objectives:

The program aims to

1. Apply intelligent process automation with the help of Robotic Process Automation, Artificial Intelligence, and Machine learning technologies.
2. Assist the students to understand computer vision including the interfacing of camera and image processing to enhance detection and object recognition.
3. Understand the interfacing of the robotic systems to AI and complete the task using kinematics, path planning, and tool movements with minimum time and in an efficient way.

Learning Outcomes: At the successful completion of this Honors Degree Programme, students will able to
LO1: Apply core concepts of AI, computer vision, and robotics to real-world problems.
LO2: Explore advanced computer vision and machine learning approaches for industrial applications.

List of Courses:

1. Artificial Intelligence
2. Robotics
3. Intelligent Systems
4. Mini Project
5. Computer Vision

Eligibility Criteria:
Students who have passed the First Year of Engineering in Electronics Engineering successfully.

Assessment Methods: Laboratory performance evaluation, Mini Projects, Viva-voce, Online Quiz, Continuous Assessment through internal assessments and unit tests, End Semester Examination.

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Credit Scheme

Course Code	Course Name	Teaching Scheme (Hrs.) TH – P – TUT	Total (Hrs.)	Credits Assigned TH – P – TUT	Total Credits	Semester of Major Degree
216H07C401	**Artificial Intelligence**	3 – 0 – 0	03	3 – 0 – 0	03	IV
216H07L401	**Artificial Intelligence Laboratory**	0 – 2 – 0	02	0 – 1 – 0	01	IV
216H07C501	**Robotics**	3 – 0 – 0	03	3 – 0 – 0	03	V
216H07L501	**Robotics Laboratory**	0 – 2 – 0	02	0 – 1 – 0	01	V
216H07C601	**Intelligent Systems**	3 – 0 – 0	03	3 – 0 – 0	03	VI
216H07L601	**Intelligent Systems Laboratory**	0 – 2 – 0	02	0 – 1 – 0	01	VI
216H07P601	**Mini Project**	0 – 4 – 0	04	0 – 2 – 0	02	VI
216H07C701	**Computer Vision**	3 – 0 – 0	03	3 – 0 – 0	03	VII
216H07L701	**Computer Vision Laboratory**	0 – 2 – 0	02	0 – 1 – 0	01	VII
Total		**12– 12 – 0**	**24**	**12 – 06 – 0**	**18**	

Examination Scheme

Course Code	Course Name	Examination Scheme				
		Marks				
		CA		ESE	LAB/TUT CA	Total
		ISE	IA			
216H07C401	**Artificial Intelligence**	30	20	50	-	100
216H07L401	**Artificial Intelligence Laboratory**	-	-	-	50	50
216H07C501	**Robotics**	30	20	50	-	100
216H07L501	**Robotics Laboratory**	-	-	-	50	50
216H07C601	**Intelligent Systems**	30	20	50	-	100
216H07L601	**Intelligent Systems Laboratory**	-	-	-	50	50
216H07P601	**Mini Project**	-	-	-	50	50
216H07C701	**Computer Vision**	30	20	50	-	100
216H07L701	**Computer Vision Laboratory**	-	-	-	50	50
Total		**120**	**80**	**200**	**250**	**650**

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Course Code	Course Title			
216H07C401	Artificial Intelligence			
	TH	P	TUT	Total
Teaching Scheme(Hrs.)	03	--	--	03
Credits Assigned	03	--	--	03

Examination Scheme	Marks				
	CA		ESE	LAB/TUT CA	Total
	ISE	IA			
	30	20	50	--	100

Course prerequisites: Linear algebra, Vector Calculus, Basic probability theory, Basic Programming Skills

Course Objectives: The course aims to learn the fundamentals of Artificial Intelligence (AI), and apply them. Design intelligent agents to solve real-world problems, Focuses on methods for deciding actions to be taken, and representation of knowledge about the intelligent agents' environment with reasoning and decision-making in the presence of uncertainty in the environment. It also discusses expert systems solving problems efficiently and effectively based on the knowledge of human experts.

Course Outcomes

At the end of the successful completion of the course, the student will be able to

CO1: Understand the idea of intelligent agents.

CO2: Apply the search methods in AI.

CO3: Construct plans and methods for generating knowledge.

CO4: Understand the reasoning and decision-making in an uncertain world.

CO5: Understand the concepts of expert systems.

Module No.	Unit No.	Details	Hrs.	CO
1		**Intelligent Agents**	**09**	**CO1**
	1.1	Introduction to AI, Risks and Benefits of AI, Agents and Environments, Performance measures, Rationality, Omniscience, learning, and autonomy		

	1.2	Task Environments: Performance measure, Environment, Actuator, Sensor (PEAS), Structure of Agents & its type		
2	**Search Techniques**		**12**	**CO2**
	2.1	Problem-Solving Agent, Search problems and solutions, Formulating problems, Example Problems, Redundant paths, Measuring problem-solving performance		
	2.3	Informed (Heuristic) Search Strategies, Heuristic Function, Greedy best-first search, A* search, Conditions for Optimality: Admissibility and Consistency, Recursive best-first search, Dominance of h(n)		
3	**Knowledge, Reasoning, and Planning**		**10**	**CO3**
	3.1	Knowledge Based Agents, Forward and Backward Chaining Logical Agents, First-Order Logic, Syntax and Semantics, Quantifier, Inference in First-Order Logic, The unification algorithm, Resolution		
	3.2	Planning: Classical Planning: Definition of Classical Planning, Algorithms for Planning with StateSpace Search, Planning Graphs, other Classical Planning Approaches, Analysis of Planning approaches. Planning and Acting in the Real World: Time, Schedules, and Resources, Hierarchical Planning, Planning and Acting in Nondeterministic Domains, Multi-agent Planning		
4	**Uncertain Knowledge and Prolog**		**09**	**CO4**
	4.1	Uncertainty: Acting under Uncertainty, Basic Probability Notation, Inference Using Full Joint Distributions, Independence, Bayes' Rule and Its Use, Probabilistic Reasoning: Representing Knowledge in an Uncertain Domain, The Semantics of Bayesian Networks, Efficient Representation of Conditional Distributions, Approximate Inference in Bayesian Networks, Relational and First-Order Probability, Other Approaches to Uncertain Reasoning; Dempster-Shafer theory.		
	4.2	Prolog: Introduction, Converting English to Prolog Facts and Rules, Goals, Prolog Terminology, Variables, Control Structures, Arithmetic operators, Matching, Backtracking, Lists, Input/Output and Streams		
5	**Expert Systems**		**05**	**CO5**
	5.1	Expert System definition, Features of an expert system, Components of an Expert System, Expert Systems in Organizations: Benefits and Limitations, Characteristics, Roles in Expert System Development		
	5.2	Knowledge Representation in expert systems		
	5.3	Expert system tools: MYCIN, E MYCIN		
		Total	**45**	

Recommended Books:

Sr. No.	Name/s of Author/s	Title of Book	Name of Publisher with country	Edition and Year of Publication
1	Stuart Russel and Peter Norvig	*Artificial Intelligence: A Modern Approach*	Pearson Education, PHI	Fourth Edition, 2020
2	Donald A.Waterman	*A Guide to Expert Systems*	Addison-Wesley, India	First edition, 2008
3	George F.Luger	*Artificial Intelligence – Structures and Strategies for Complex Problem Solving*	Pearson Education, India	Fourth Edition, 2002
4	W. Patterson	*Introduction to Artificial Intelligence and Expert Systems*	Prentice Hall of India, India	Second Edition, 2003

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<tr><td>216H07L401</td><td colspan="6">Artificial Intelligence Laboratory</td></tr>
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<tr><td rowspan="3">Examination Scheme</td><td colspan="6">Marks</td></tr>
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<tr><td>ISE</td><td>IA</td></tr>
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Term-Work:

Term work will consist of experiments/ tutorials covering the entire syllabus of the course ‘216H07C401’**. Students will be graded based on continuous assessment of their term work.**

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Course Code	Course Title			
216H07C501	Robotics			
	TH	P	TUT	Total
Teaching Scheme(Hrs.)	03	--	--	03
Credits Assigned	03	--	--	03

Examination Scheme	Marks				
	CA		ESE	LAB/TUT CA	Total
	ISE	IA			
	30	20	50	--	100

Module No.	Unit No.	Details	Hrs.	CO
1	**Fundamentals of Robotics**		5	CO1
	1.1	Automation and Robots, Classification, Actuator, Sensors and Controllers, Application, Specifications		
2	**Robot Kinematics and Inverse Kinematics: Arm Equation**		12	CO2
	2.1	Direct Kinematics: Rotation Matrix, Homogeneous Coordinates, Link Coordinates, Denavit-Hartenberg Representation, Arm Equation for Two axis planar robot and Four axis & Five axis Robots		
	2.2	Inverse Kinematics: General Properties of Solutions, Solutions for Two axis planar robot and Four-Axis & Five-axis Robots, Robot Work Cell		
3	**Workspace Analysis and Trajectory Planning**		12	CO3
	3.1	Workspace Analysis, Dexterous workspace, Workspace Fixtures, Pick-and-Place Operation, Continuous-Path Motion, Interpolated Motion, Straight-Line Motion		
	3.2	Basics of Trajectory planning , Joint-space trajectory planning, Cartesian-space trajectories, Differential motions and velocities: Differential relationships, Jacobian, Manipulator Jacobian Singularities		
4	**Robot Dynamics and Robot Control**		10	CO4
	4.1	Dynamic Analysis, Torques and Forces: Lagrange's equation, Kinetic and Potential energy, Lagrange-Euler Dynamic model of a two-axis planar robot		
	4.2	Control Problem, State Equations of a two-axis planar robot		
5	**Robot Vision and Task Planning**		6	CO5
	5.1	Image Representation & Analysis, Template Matching, Robot Vision system, Servoing, Lighting system,		

		Segmentation, Applications of vision controlled robotic systems		
	5.2	Task-Level Planning, Phases, Challenges, Uncertainty, Configuration Space, Obstacle Avoidance, Motion level planning: Visibility Graph, Cell Decomposition, Gross-Motion, Fine-Motion, and Grasp Planning		
			Total	**45**

Recommended Books:

Sr. No.	**Name/s of Author/s**	**Title of Book**	**Name of Publisher with country**	**Edition and Year of Publication**
1	Robert Shilling	*Fundamentals of Robotics - Analysis and control*	Prentice Hall of India, India	First edition, 2009
2	Saeed Benjamin Niku	*Introduction to Robotics – Analysis, Control, Applications*	Wiley India Pvt. Ltd., India	Third Edition, 2019
3	John J. Craig	*Introduction to Robotics –Mechanics & Control*	Pearson Education, India	Fourth Edition, 2017
4	Mikell P. Groover et.al.	*Industrial Robots-Technology, Programming & applications*	McGraw Hill, New York	First edition, 2008
5	Mark W. Spong, Seth Hutchinson, M. Vidyasagar	*Robot Modeling & Control*	Wiley India Pvt. Ltd., India	First edition, 2006

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<tr><td>216H07L501</td><td colspan="6">Robotics Laboratory</td></tr>
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Term-Work:

Term work will consist of experiments/ tutorials covering the entire syllabus of the course ‘216H07C501’ **. Students will be graded based on continuous assessment of their term work.**

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Course Code	Course Title			
216H07C601	Intelligent Systems			
	TH	P	TUT	Total
Teaching Scheme(Hrs.)	03	--	--	03
Credits Assigned	03	--	--	03

Examination Scheme	Marks				
	CA		ESE	LAB/TUT CA	Total
	ISE	IA			
	30	20	50	--	100

Course prerequisites: Computer vision, Artificial Intelligence, Robotics

Course Objectives: The course aims at developing students to make intelligent systems. Having gained knowledge in the areas of Artificial Intelligence, Robotics, and Computer vision this course gives combined exposure of all three on the application level.

Course Outcomes:

At the end of successful completion of the course, the student will be able to

CO1: Understand basic concepts of parallel computing
CO2: Introduction to Compute Unified Device Architecture
CO3: Integrate AI with Robotics
CO4: Make an intelligent robot with computer vision integrated with it
CO5: Apply concepts of deep learning to real-time images and videos

Module No.	Unit No.	Details	Hrs.	CO
1		**Parallel Computing**	9	CO1
	1.1	**B**asics of parallel computing for accelerated computer vision, Flynn's classical Taxonomy, Parallel Computer Memory Architecture, Parallel Programming Models, Designing Parallel programmes, Distributed Systems.		
2		**Accelerated Computer Vision**	9	CO2
	2.1	Introduction to Compute Unified Device Architecture (CUDA), CUDA architecture and applications, Working with videos in OpenCV.		
	2.2	CUDA program structure, Threads, Synchronization, and Memory. Application of Cuda and OpenCV.		

3	**AI for Robotics**		**9**	**CO3**
	3.1	Basic principle and designing process of AI robot, Observe, Orient, Decide, Act loop (OODA loop), Introduction to different AI-Robotic paradigm, Hierarchical Paradigm, Non Hierarchical Control (NHC), Reactive Paradigms		
	3.2	Designing a Reactive Behavioural System with case study, Introduction to AI hardware processors, Advanced robotics applications with AI (Autopilot planes, Autonomous vehicles) Setting Up of AI Robot		
4	**Sensing Techniques and Intelligent Robotics with Applications of CV**		**9**	**CO4**
	4.1	Model of sensing, Behavioral Sensors, Fusion Sensors, Suite Proprioceptive Sensors, computer vision sensing		
	4.2	Introduction to Hybrid Paradigm of Robotic AI Distributed mobile robot systems		
5	**Computer Vision Applications with Deep Learning**		**9**	**CO5**
	5.1	Recognition in Computer Vision, Feature Extraction Feature Selection & Reduction, Convolutional Neural Networks, Derivation of Convolution , Designing a CNN Recognition with artificial neural networks (ANN)		
	5.2	Tensor flow recognition, Graph Visualization Using Tensorboard (TB), Linear Model, Building FFNN, Recognition of Images with deep learning		
		Total	**45**	

Recommended Books:

Sr. No.	**Name/s of Author/s**	**Title of Book**	**Name of Publisher with country**	**Edition and Year of Publication**
1	Bhaumik Vaidya	*Hands-On GPU-Accelerated Computer Vision with OpenCV and CUDA*	Packt Publishing Ltd, USA	First Edition, 2018
2	Francis X. Govers	*Artificial Intelligence for Robotics*	Packt Publishing Ltd, USA	First t Edition, 2018
3	Robin Murphy	*Introduction to AI Robotics*	MIT Press, USA	First Edition, 2000
4	Dominik Sankowski, Jacek Nowakowski	*Computer Vision In Robotics And Industrial Applications*	World Scientific, USA	First Edition, 2014

5	Ahmed Fawzy Gad	*Practical Computer Vision Applications Using Deep Learning with CNNs*	Apress publication, USA	First Edition, 2018

Course Code	**Course Title**			
216H07L601	**Intelligent Systems Laboratory**			
	TH	**P**	**TUT**	**Total**
Teaching Scheme(Hrs.)	**-**	**2**	**0**	**2**
Credits Assigned	**-**	**1**	**0**	**1**

Examination Scheme	**Marks**				
	CA		**ESE**	**LAB/TUT CA**	**Total**
	ISE	**IA**			
	-	**-**		**50**	**50**

Term-Work:

Term work will consist of experiments/ tutorials covering the entire syllabus of the course ‘216H07C601’ **. Students will be graded based on continuous assessment of their term work.**

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<tr><td>216H07P601</td><td colspan="6">Mini-Project</td></tr>
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<tr><td colspan="2">CA</td><td rowspan="2">ESE</td><td rowspan="2">LAB/TUT CA</td><td rowspan="2">Total</td></tr>
<tr><td>ISE</td><td>IA</td></tr>
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Applications of Artificial Intelligence, Computer Vision and Robotics in the real world can be designed using various platforms and concepts studied in different courses. The student can design and develop the project individually or in a pair based on scope of the work approved by the faculty mentor.

*An industrial application can also be developed during an internship of minimum 4 weeks approved by a faculty mentor.

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Course Code	Course Title			
216H07C701	Computer Vision			
	TH	P	TUT	Total
Teaching Scheme(Hrs.)	03	--	--	03
Credits Assigned	03	--	--	03

Examination Scheme	Marks				
	CA		ESE	LAB/TUT CA	Total
	ISE	IA			
	30	20	50	--	100

Module No.	Unit No.	Details	Hrs.	CO
1		**Introduction to Computer Vision**	6	CO1
	1.1	Overview of Computer Vision, Document Image post processing, Biometric images, Object Recognition, Object Tracking, Medical Image Analysis, Content-Based Image Retrieval, Video Data Processing		
2		**Image Formation Models**	9	CO2
	2.1	Orthographic & Perspective Projection, Camera model and Camera calibration, Binocular imaging systems, Multiple views geometry		
	2.2	Structure determination, shape from shading, Shapelets, Photometric Stereo, Depth from Defocus , Construction of 3D model from images		
	2.3	Feature Extraction, Image preprocessing, Image representations, Edge detection		
3		**Motion Estimation**	12	CO3
	3.1	Regularization theory, Optical computation, Stereo Vision-based Motion estimation, Structure from motion, Kalman Filter, Speeded Up Robust Features (SURF), Scale-Invariant Feature Transform (SIFT)		

	3.2	Contour-based representation, Region-based representation, Deformable curves and surfaces, Snakes and active contours, Level set representations, Fourier and wavelet descriptors, Multiresolution analysis		
4	**Object recognition and Image Understanding**		**10**	**CO4**
	4.1	Hough transforms and other simple object recognition methods, Shape correspondence and shape matching, Principal component analysis, Shape priors for recognition, Pattern recognition methods, Hidden Markov Model (HMM), Gaussian Mixture Model (GMM) and Expectation-Maximization (EM)		
5	**Applications**		**8**	**CO5**
	5.1	Surveillance, foreground-background separation, particle filters, Chamfer matching, tracking, and occlusion detection, combining views from multiple cameras		
	5.2	Photo album, Face detection, Face recognition, Eigen faces, Active appearance and 3D shape models of faces Application.		
	5.3	Human gait analysis, In-vehicle vision system: locating roadway, road markings, identifying road signs, locating pedestrians		
		Total	**45**	

Recommended Books:

Sr. No.	**Name/s of Author/s**	**Title of Book**	**Name of Publisher with country**	**Edition and Year of Publication**
1.	E. Trucco and A. Verri	*Introductory Techniques for 3D Computer Vision*	Prentice Hall, USA	First Edition, 1993
2.	Richard Szeliski	*Computer Vision: Algorithms and Applications (CVAA)*	Springer, Washington	Second Edition, 2010
3.	Sonka, Hlavac, and Boyle. Thomson	*Image Processing , Analysis, and Machine Vision*	Thomson, Prague	Fourth Edition, 2008
4.	E. R. Davies	*Computer Vision: Models, Learning, and Inference*	Cambridge University Press, London	First Edition, 2009
5.	Mark Nixon and Alberto S. Aquado	*Feature Extraction & Image Processing for Computer Vision*	Academic Press, UK	Third Edition, 2012

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<tr><td>ISE</td><td>IA</td></tr>
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Term-Work:

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