Syllabus

Honours Programme in AI, Computer Vision and Robotics

Department of Electronics Engineering

From
Academic Year 2021-22
Revision 1

(Approved in Academic Council meeting dated)

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 Department of Electronics Engineering

Introduction

Artificial Intelligence (AI), Computer vision and Robotics honour 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 allows 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. The 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 Honours degree students will be equipped with knowledge from all the three domains and will be industry ready in true sense.

Objective: 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 Honours 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. Modern Artificial Intelligence
2. Advanced Computer Vision
3. Applied Robotics
4. Intelligent systems
5. Project on AI, Robotics, and computer vision/ Internship *

(* Internship of 4 weeks or more approved by the department)

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.

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
116h59C401	Modern Artificial Intelligence	3 –0– 0	03	3 – 0 – 0	03	IV
116h59L401	Modern Artificial Intelligence Laboratory	0 – 2 – 0	02	0 – 1 – 0	01	IV
116h59C501	Advanced Computer Vision	3 – 0 – 0	03	3 – 0 – 0	03	V
116h59L501	Advanced Computer Vision Laboratory	0 – 2 – 0	02	0 – 1 – 0	01	V
116h59C601	Applied Robotics	3 – 0 – 0	03	3 – 0 – 0	03	VI
116h59L601	Applied Robotics Laboratory	0 – 2 – 0	02	0 – 1 – 0	01	VI
116h59C701	Intelligent systems	3 – 0 – 0	03	3 – 0 – 0	03	VII
116h59L701	Intelligent systems Laboratory	0 – 2 – 0	02	0 – 1 – 0	01	VII
116h59P801	Project on AI, Robotics, and computer vision / Internship*	0 – 8 – 0	08	0 – 4 – 0	04	VII/VIII
Total		**12—16 -- 0**	**28**	**12 – 8 – 0**	**20**	

(* Internship of 4 weeks or more approved by the department)

Examination Scheme

Course Code	Course Name	Examination Scheme							
		Marks							
		CA		ESE	TW	O*	P	P&O	Total
		ISE	IA						
116h59C401	Modern Artificial Intelligence	30	20	50		-	-	-	100
116h59L401	Modern Artificial Intelligence Laboratory	-	--	-	50	-	-	-	50
116h59C501	Advanced Computer Vision	30	20	50		-	-	-	100
116h59L501	Advanced Computer Vision Laboratory	-	-		50	-	-	–	50
116h59C601	Applied Robotics	30	20	50					100
116h59L601	Applied Robotics Laboratory				50				50
116h59C701	Intelligent systems	30	20	50					100
116h59L701	Intelligent systems Laboratory				50				50
116h59P801	Project on AI, Robotics, and computer vision/ Internship *				50	25	-	-	50
Total		**120**	**80**	**200**	**250**	**25**			**675**

(* Internship of 4 weeks or more approved by the department)

Course Code	Course Title
116h59C401	Modern Artificial Intelligence

	TH	P	TUT	Total
Teaching Scheme(Hrs.)	3	0	0	3
Credits Assigned	3	0	0	3

Examination Scheme	Marks							
	CA		ESE	TW	O	P	P&O	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, 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 system solving problems efficiently and effectively based on knowledge of human experts.

Course Outcomes

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

CO1: Understand the idea of intelligent agents
CO2: Apply the search methods.
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**		10	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, Structure of Agents		
2	**Search Techniques**		9	CO2
	2.1	Search problems and solutions, Formulating problems, Example Problems, Search Algorithms: Best-first search,		

		Search data structures, Redundant paths, Measuring problem-solving performance		
	2.2	Uninformed Search Strategies, Breadth-first search, Dijkstra's algorithm or uniform-cost search, Depth-first search and the problem of memory		
	2.3	Informed (Heuristic) Search Strategies: Greedy best-first search, A* search, Search contours		
3	**Knowledge, Reasoning, and Planning**		**9**	**CO3**
	3.1	Logical Agents, First-Order Logic, Propositional vs. First-Order Inference, Unification and First-Order Inference		
	3.2	Categories and Objects of Knowledge Representation, Events, Reasoning Systems for Categories, Reasoning with Default Information		
	3.3	Automated Planning, Algorithms for Classical Planning, Heuristics for Planning, Hierarchical Planning		
4	**Uncertain Knowledge and Reasoning**		**9**	**CO4**
	4.1	Uncertainty, Representing Knowledge in an Uncertain Domain, The Semantics of Bayesian Networks, Probabilistic Reasoning over Time, Time and Uncertainty.		
	4.2	Combining Beliefs and Desires under Uncertainty, The Basis of Utility Theory and Functions, Decision Networks		
5	**Expert Systems**		**8**	**CO5**
	5.1	Expert System definition, Features of an expert system, Organization, Characteristics, Prospector		
	5.2	Knowledge Representation in expert systems		
	5.3	Expert system tools: MYCIN, EMYCIN		
		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	2008
3	George F.Luger,	Artificial Intelligence – Structures and Strategies for Complex Problem Solving	Pearson Education	Fourth Edition, 2002
4	W. Patterson	Introduction to Artificial Intelligence and Expert Systems	Prentice Hall of India	Second Edition, 2003

Course Code	Course Title						
116h59L401	Modern Artificial Intelligence Laboratory						
	TH		P	TUT	Total		
Teaching Scheme(Hrs.)	-		2	0	2		
Credits Assigned	-		1	0	1		
Examination Scheme	Marks						
	CA		ESE	TW	O	P	P&O	Total
	ISE	IA						
	-	-		50	--	--	--	50

Term-Work:

Term work will consist of experiments/ tutorials covering entire syllabus of the course '116h59C401'**. Students will be graded based on continuous assessment of their term work.**

Course Code	Course Title
116h59C501	Advanced Computer Vision

	TH	P	TUT	Total
Teaching Scheme(Hrs.)	3	0	0	3
Credits Assigned	3	0	0	3

Examination Scheme	Marks							
	CA		ESE	TW	O	P	P&O	Total
	ISE	IA						
	30	20	50		--	--	--	100

Course Prerequisites:
Programming Skills, Linear Algebra, Vector Calculus

Course Objectives: Computer Vision is a growing and fast evolving field. This course serves the purpose of informing students of the state-of-art approaches in computer vision, and providing them a platform to read and critique current trends in this field.

Course Outcomes:
At the end of successful completion of the course the student will be able to
CO1. To implement fundamental image processing techniques required for computer vision
CO2. Understand Image formation process
CO3. To perform shape analysis
CO4. Extract features from Images and do analysis of Images
CO5. Understand 3D models from images, and video processing, motion computation and 3D vision and geometry.

Module No.	Unit No.	Details	Hrs.	CO
1	**Introduction to Computer Vision**		6	CO1
	1.1	Overview of Computer Vision, Document Image, Biometrics, Object Recognition, 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 , Photometric Stereo, Depth from Defocus , Construction of 3D model from images		

	2.3	Feature Extraction, Image preprocessing, Image representations (continuous and discrete), Edge detection		
3	**Motion Estimation**		**12**	**CO3**
	3.1	Regularization theory, Optical computation, Stereo Vision, Motion estimation, Structure from motion, Kalman Filter, SURF, 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, HMM, GMM and EM		
5	**Applications**		**8**	**CO5**
	5.1	Surveillance – foreground-background separation – particle filters – Chamfer matching, tracking, and occlusion – 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 Application: 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.	D. Forsyth and J. Ponce	Computer Vision - A modern approach	Prentice Hall Robot Vision, by B. K. P. Horn, McGraw-Hill.	1992
2.	E. Trucco and A. Verri,	Introductory Techniques for 3D Computer Vision	Publisher: Prentice Hall.	1993
3.	R. C. Gonzalez, R. E. Woods.	Digital Image Processing	Addison Wesley Longman, Inc., 1992.	1992

4.	D. H. Ballard, C. M. Brown.	Computer Vision.	Prentice-Hall, Englewood Cliffs, 1982	1982
5.	Richard Szeliski,	Computer Vision: Algorithms and Applications (CVAA).	Springer, 2010	2010
6.	Sonka, Hlavac, and Boyle. Thomson.	Image Processing, Analysis, and Machine Vision.		2008
7.	E. R. Davies	Computer Vision: Models, Learning, and Inference	Cambridge University Press, 2012	2009
8.	Mark Nixon and Alberto S. Aquado,	Feature Extraction & Image Processing for Computer Vision,	Third Edition, Academic Press, 2012.	2012

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<tr><th>Course Code</th><th colspan="8">Course Title</th></tr>
<tr><td>116h59L501</td><td colspan="8">Advanced Computer Vision Laboratory</td></tr>
<tr><td></td><td colspan="3">TH</td><td colspan="2">P</td><td colspan="2">TUT</td><td>Total</td></tr>
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<tr><td>Credits Assigned</td><td colspan="3">0</td><td colspan="2">1</td><td colspan="2">0</td><td>1</td></tr>
<tr><td rowspan="3">Examination Scheme</td><td colspan="8">Marks</td></tr>
<tr><td colspan="2">CA</td><td rowspan="2">ESE</td><td rowspan="2">TW</td><td rowspan="2">O</td><td rowspan="2">P</td><td rowspan="2">P&O</td><td rowspan="2">Total</td></tr>
<tr><td>ISE</td><td>IA</td></tr>
<tr><td>-</td><td>-</td><td></td><td>50</td><td>--</td><td>--</td><td>--</td><td>50</td></tr>
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Term-Work:

Term work will consist of experiments/ tutorials covering entire syllabus of the course ‘116h59C501’ **. Students will be graded based on continuous assessment of their term work.**

Course Code	Course Title
116h59C601	Applied Robotics

	TH	P	TUT	Total
Teaching Scheme(Hrs.)	3	0	0	3
Credits Assigned	3	0	0	3

Examination Scheme	Marks							
	CA		ESE	TW	O	P	P&O	Total
	ISE	IA						
	30	20	50	-	--	--	--	100

Course prerequisites: Matrix Algebra, Applied Mechanics, Control Systems

Course Objectives: The course aims in discussing the requirements, kinematics and dynamics involved in designing an industrial robot. Various control perspectives are also discussed. It helps in making an appropriate choice of the robotic system for a particular application.

Course Outcomes:
At the end of successful completion of the course, the student will be able to
CO1: Understand basic principles of robot specifications, technology, configurations and control.
CO2: Apply the theory of robotic arm kinematics in the robotic design applications.
CO3: Analyse the workspace and perform the trajectory planning.
CO4: Describe the dynamics of robots.
CO5: Apply techniques to solve problems in robot control.

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**		10	CO2
	2.1	Direct Kinematics: Rotation Matrix, Homogenous Coordinates, Link Coordinates, Denavit-Hartenberg Representation, Arm Equation for Four axis SCARA Robot.		
	2.2	Inverse Kinematics: General Properties of Solutions, Tool Configuration, Solutions for Four-Axis SCARA Robot.		
3	**Workspace Analysis and Trajectory Planning**		8	CO3
	3.1	Workspace Analysis of four axis SCARA robot, Workspace Fixtures		
	3.2	Basics of Trajectory planning , Joint-space trajectory planning, Cartesian-space trajectories, Pick-and-Place		

		Operation, Continuous-Path Motion, Interpolated Motion, Straight-Line Motion		
4	**Robot Dynamics**		**12**	**CO4**
	4.1	Differential motions and velocities: Differential relationships, Jacobian, Differential motion of a frame and robot, Tool configuration Jacobian Matrix, Tool Jacobian Matrix of a 4 axis SCARA Robot, The Manipulator Jacobian, Manipulator Jacobian of a 4 axis SCARA Robot, Singularities		
	4.2	Dynamic Analysis and Forces: Lagrangian mechanics, Newton Euler formulation, Dynamic model of a SCARA Robot		
5	**Robot Control**		**10**	**CO5**
	5.1	The control problem, State equations, State space model of a SCARA robot, Linear feedback systems, Single axis PID control, PD gravity control, Variable structure control, Impedance control		
		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	First edition, 2009
2	Saeed Benjamin Niku	Introduction to Robotics – Analysis, Control, Applications	Wiley India Pvt. Ltd.	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.	First edition, 2006

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<tr><td>116h59L601</td><td colspan="8">Applied Robotics Laboratory</td></tr>
<tr><td></td><td colspan="3">TH</td><td>P</td><td colspan="2">TUT</td><td colspan="2">Total</td></tr>
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<tr><td>Credits Assigned</td><td colspan="3">0</td><td>1</td><td colspan="2">0</td><td colspan="2">1</td></tr>
<tr><td rowspan="3">Examination Scheme</td><td colspan="8">Marks</td></tr>
<tr><td colspan="2">CA</td><td rowspan="2">ESE</td><td rowspan="2">TW</td><td rowspan="2">O</td><td rowspan="2">P</td><td rowspan="2">P&O</td><td rowspan="2">Total</td></tr>
<tr><td>ISE</td><td>IA</td></tr>
<tr><td>-</td><td>-</td><td>-</td><td>50</td><td>--</td><td>--</td><td>--</td><td>50</td></tr>
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Term-Work:

Term work will consist of experiments/ tutorials covering entire syllabus of the course ‘116h59C601’ **. Students will be graded based on continuous assessment of their term work.**

Course Code	Course Title						
116h59C701	Intelligent System						
	TH		P	TUT	Total		
Teaching Scheme(Hrs.)	03		0	--	03		
Credits Assigned	03		0	--	03		
Examination Scheme	Marks						
	CA		ESE	TW	O	P	P&O	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 the latest techniques in parallel computing for Computer Vision.
CO2: Implement object detection and recognition using hardware
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	**Accelerated Computer Vision**		9	CO1
	1.1	Basics of parallel computing for accelerated computer vision, Introduction to Compute Unified Device Architecture (CUDA), Working with videos in OpenCV.		
2	**Object Detection and Recognition**		9	CO2
	2.1	Introduction to object detection and object tracking, Color, and shape-based object detection using GPU hardware.		
	2.2	Key point detection and extraction. Robust feature extraction, Hardware used in object detection and recognition		
3	**AI for Robotics**		9	CO3
	3.1	Practical AI robot designing process, Introduction to AI hardware processors, Advanced robotics applications with		

		AI (Autopilot planes, Autonomous vehicles)		
	3.2	Foundation of AI robotics, Software for AI robotics (ROS, Linux), Reactive robotics		
4	**Intelligent Robotics with Applications of CV**		**9**	**CO4**
	4.1	Distributed mobile robot systems, Advanced vision in detection analysis		
	4.2	Fractional order edge detection, High-speed detection, and object sorting		
5	**Computer Vision Applications with Deep Learning**		**9**	**CO5**
	5.1	Recognition with artificial neural networks (ANN) using featured engineering		
	5.2	Tensor flow recognition, Cross-platform data science, Deploying pre-trained models, Filters, Wrapper, 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	1st Edition, Year 2018
2	Francis X. Govers	Artificial Intelligence for Robotics	Packt Publishing Ltd, USA	1st Edition, Year 2018
3	Robin Murphy	Introduction to AI Robotics	MIT Press, USA	1st Edition, Year 2000
4	Dominik Sankowski, Jacek Nowakowski	Computer Vision In Robotics And Industrial Applications	World Scientific, USA	1st Edition, Year 2014
5	Ahmed Fawzy Gad	Practical Computer Vision Applications Using Deep Learning with CNNs	Apress publication USA	1st Edition, Year 2018

Course Code	Course Title							
116h59L701	Intelligent System Laboratory							
	TH		P	TUT	Total			
Teaching Scheme(Hrs.)	0		02	--	02			
Credits Assigned	0		01	--	01			
Examination Scheme	Marks							
	CA		ESE	TW	O	P	P&O	Total
	ISE	IA						
	-	-	-	50	--	--	--	50

Term-Work:

Term work will consist of experiments/ tutorials covering entire syllabus of the course ‘116h59C701’ **. Students will be graded based on continuous assessment of their term work**

<table>
<tr><th>Course Code</th><th colspan="8">Course Title</th></tr>
<tr><td>116h59P801</td><td colspan="8">Project on AI, Robotics, and computer vision/ Internship*</td></tr>
<tr><td></td><td colspan="2">TH</td><td>P</td><td colspan="2">TUT</td><td colspan="2">Total</td></tr>
<tr><td>Teaching Scheme(Hrs.)</td><td colspan="2">0</td><td>08</td><td colspan="2">--</td><td colspan="2">08</td></tr>
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<tr><td>ISE</td><td>IA</td></tr>
<tr><td>-</td><td>-</td><td>-</td><td>50</td><td>25</td><td>--</td><td>--</td><td>75</td></tr>
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Course Objectives:

Applications of Artificial Intelligence, Computer Vision and Robotics in 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 faculty mentor.

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

Course Outcomes:

At the successful completion of this honor program an engineering graduates will be able to
CO1: Develop small Artificial Intelligence, Computer Vision and Robotics based application.
CO2: Communicate the project work in the form of report, presentation/ demonstration.