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ML IN ROBOTICS **Course Code : 315350**

Programme Name/s : Automation and Robotics
Programme Code : AO
Semester : Fifth
Course Title : ML IN ROBOTICS
Course Code : 315350

I. RATIONALE

Machine Learning (ML) is a subfield of artificial intelligence. Machine learning algorithms enable robots to learn from data and adapt to dynamic environments. These algorithms allow robots to identify patterns, make predictions, and improve their performance over time, making them more versatile and effective in a wide range of applications. This course will enable students to apply principles of ML in the field of robotics. This will make students to appreciate how machine learning is used for robotic applications.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help students to attain the following Industry/Employer expected outcome through various teaching learning experiences :
Integrate machine learning with robotics for real-world applications.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Validate a given predictive machine learning model .
- CO2 - Apply supervised machine learning algorithms for solving problems in robotics.
- CO3 - Use unsupervised machine learning for solving practical problems in robotics.
- CO4 - Choose artificial neural network (ANN) for robotic applications.
- CO5 - Apply machine learning in robotics.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme												
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical							
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
315350	ML IN ROBOTICS	MIR	DSC	5	-	2	2	9	3	3	30	70	100	40	25	10	25@	10	25	10	175

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Total IKS Hrs for Sem. : Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 10 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 State the need of machine learning in robotics. TLO 1.2 Classify machine learning methods. TLO 1.3 Explain the use of evaluation metrics in machine learning. TLO 1.4 List various cross validation methods in machine learning. TLO 1.5 Describe the concept of deep learning. TLO 1.6 List different types of deep learning.	**Unit - I Basics of Machine Learning** 1.1 Definition of Machine Learning (ML), need of ML 1.2 Classification of machine learning : supervised and unsupervised, semi - supervised and reinforcement 1.3 Evaluation metrics : confusion matrix, accuracy, precision, recall/sensitivity and specificity 1.4 Validation techniques : k-fold cross validation, hyperparameter tuning 1.5 Deep learning : definition, concept and classification of deep learning - artificial neural network, fuzzy logic, expert systems(only enlist, No explanation)	Lecture using Chalk-Board Presentations Hands-on

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Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
2	TLO 2.1 Describe supervised learning. TLO 2.2 Differentiate regression and classification. TLO 2.3 Explain the procedure of implementing simple linear regression algorithm. TLO 2.4 Differentiate binary, multiclass and multilabel. TLO 2.5 State key points of logistic regression for classification problems. TLO 2.6 State key points of the decision tree for classification problems. TLO 2.7 Illustrate key points of random forest for classification problems.	**Unit - II Supervised Machine Learning** 2.1 Supervised learning: Definition and categories (regression and classification) 2.2 Regression: implementation of simple linear regression algorithm 2.3 Classification: Binary, Multiclass and Multilabel 2.4 Classification algorithm: K-nearest neighbours, logistic regression, support vector machine, decision tree, random forest (No mathematical derivation, only key points of each algorithm)	Lecture using Chalk-Board Presentations Hands-on
3	TLO 3.1 Explain the features of unsupervised machine learning. TLO 3.2 Differentiate clustering and association unsupervised machine learning methods. TLO 3.3 Illustrate key points of K-means clustering algorithm. TLO 3.4 Explain association rule learning. TLO 3.5 State applications of unsupervised ML method. TLO 3.6 Compare supervised and unsupervised ML methods.	**Unit - III Unsupervised Machine Learning** 3.1 Definition of unsupervised machine learning, types - clustering and association, applications 3.2 Working of unsupervised learning algorithms 3.3 Unsupervised learning algorithms: Types- K-means clustering, hierarchical clustering (Only key points) 3.4 Association rule learning: types-support, confidence and lift, types of algorithms- Apriori algorithm, Eclat algorithm, F-P Growth algorithm (enlist only, no explanation)	Lecture using Chalk-Board Presentations Hands-on Simulation
4	TLO 4.1 Describe the construction of biological neuron with the help of sketch. TLO 4.2 Explain the functioning of biological neural network communication with the help of sketch. TLO 4.3 Describe artificial neural networks(ANN) function with diagram. TLO 4.4 Explain the architecture of single layer feed-forward and multi layer feed-forward neural networks. TLO 4.5 Describe the concept of back-propagation neural networks.	**Unit - IV Overview of Artificial Neural Network** 4.1 Biological neuron: structure and function 4.2 Neural networks: basics of neural networks, artificial neural networks(ANN). unit in neural networks 4.3 ANN structure: artificial neuron structure and functions 4.4 Types of ANN: single layer feed-forward and multi-layer feedforward neural networks 4.5 Back-propagation in neural network: working of forward pass and backward pass(No mathematical derivation)	Lecture using Chalk-Board Presentations Hands-on

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Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
5	TLO 5.1 Describe the concept of robotic perception. TLO 5.2 Differentiate Model-based and data-driven robotic systems TLO 5.3 List the applications of ML in robotics. TLO 5.4 Describe working of computer vision using ML. TLO 5.5 Explain the functioning of ML based assistive and medical robots.	**Unit - V Applications of Machine Learning in Robotics** 5.1 Machine learning in robotics: role, concept of robotic perception 5.2 Model-based and data-driven robotic systems 5.3 Case study and Applications of ML in robotics: Computer vision using ML and ANN , ML based pick and place robots , Assistive and medical robots using unsupervised ML	Lecture using Chalk-Board Presentations Video Demonstrations

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Write a program to evaluate supervised machine learning model using confusion matrix. LLO 1.2 Analyze the supervised machine learning model using confusion matrix.	1	Implementation of confusion matrix for a given supervised machine learning model	2	CO1
LLO 2.1 Develop a program to evaluate accuracy,precision,sensitivity and specificity for a given predictive ML model .	2	* Implementation of evaluation metrics for a given predictive ML model .	2	CO1
LLO 3.1 Write a program to implement regression type supervised ML.	3	Implementation regression benchmark for a given predictive model.	2	CO2
LLO 4.1 Develop a program using simple Linear regression algorithm for predicting a response using a single feature.	4	* Implementation of simple linear regression algorithm	2	CO2
LLO 5.1 Write a program to implement multiclass classification for iris data set.	5	Implementation of multiclass classification	2	CO2
LLO 6.1 Execute a program to implement support vector machine algorithm for a given data set	6	*Implementation of support vector machine algorithm	2	CO2
LLO 7.1 Write a program to implement decision tree algorithm for a given supervised ML model OR Write a program to implement random forest algorithm for a given supervised ML model	7	Implementation of decision tree algorithm OR Implementation of random forest algorithm	2	CO2
LLO 8.1 Write a program to implement K-means clustering for a given unsupervised ML model.	8	*Implementation of K-means clustering	2	CO3
LLO 9.1 Execute a python program to implement artificial neural network OR Execute a python program to implement back propagation neural network	9	*Implementation of basic artificial neural network using python OR *Implementation of backpropagation neural network	2	CO4

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Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 10.1 Simulate ML program to pick and place operation in robotics.	10	*Implementation of ML program to pick and place operation in robotics	2	CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Assignment

- Prepare a powerpoint presentation on ML techniques used in robotics
- Prepare the list of various ML techniques used in various types of robots. Also write their specifications.
- Prepare a power point presentation to correlate machine learning work flow with student life
- Prepare a powerpoint presentation based on daily life activities as supervised and unsupervised machine learning.

Micro project

- Case study: House price prediction using unsupervised ML- resources required, Literature review,python program, output
- Develop a program using Machine learning algorithm allows robots to grasp and manipulate objects with precision and dexterity. By analyzing the shape, size, and texture of objects,
- Case study: Any specific disease prediction using supervised ML-Data set collection resources required, Literature review,python program, output

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Computer System (minimum requirement : Processor - 1.5 GHz, RAM - 4GB, Operating System - Windows 7 or above)	All
2	Python Interpreter / IDE	All
3	Python 3.9 or latest version	All

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Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
4	Robotics simulation software : RT Toolbox3 / Roboanalyzer or any other simulation software	All

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Basics of Machine Learning	CO1	10	2	4	4	10
2	II	Supervised Machine Learning	CO2	12	2	8	8	18
3	III	Unsupervised Machine Learning	CO3	10	2	8	8	18
4	IV	Overview of Artificial Neural Network	CO4	12	2	8	6	16
5	V	Applications of Machine Learning in Robotics	CO5	6	2	2	4	8
Grand Total				**50**	**10**	**30**	**30**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- For formative assessment of laboratory learning 25 marks.
- Two offline unit tests of 30 marks and average of two unit test marks will be considered for out of 30 marks.
- Each practical will be assessed considering 60% weightage to process, 40% weightage to product

Summative Assessment (Assessment of Learning)

- End semester assessment is of 70 marks.
- End semester summative assessment is of 25 marks for laboratory learning.

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	2	2	1	1	-	-	1			
CO2	2	3	2	2	1	1	2			
CO3	2	3	2	2	1	1	2			
CO4	2	3	2	2	1	1	2			
CO5	2	-	3	3	1	1	3			

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Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Saroj Kaushik	Artificial Intelligence	CENGAGE Learning. ISBN-13: 978-81-315-1099-5 ISBN-10: 81-315-315-1099-9
2	Munesh Chandra Trivedi	A Classical Approach to Artificial Intelligence	Khanna Book Publishing Co. (P) Ltd. New Delhi 978-81-90698-89-4
3	Monica Bianchini, Milan Simic, Ankush Ghosh, Rabindra Nath Shaw	Machine Learning for Robotics Applications	Springer 978-981-16-0597-0
4	Indranath Chatterjee, Sheetal Zalte	Machine Learning Applications: From Computer Vision to Robotics	Wiley 978-1-394-17334-1
5	Govers, Francis X.	Artificial Intelligence for Robotics: Build intelligent robots that perform human tasks using AI techniques	Packt Publishing Limited ISBN : 978- 1788835442

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://doi.org/10.1007/978-981-16-0598-7	e-book on Machine Learning for Robotics Applications
2	https://www.youtube.com/watch?v=PmxPXYtn1ew	Machine learning applications
3	https://www.youtube.com/watch?v=k64wPf_WSDQ	YouTube Video : The Basics of Robotics Theory: Machine learning applied to robotics
4	https://www.youtube.com/watch?v=4Rl8S7stN5A	Machine learning applications
5	https://onlinecourses.nptel.ac.in/noc23_cs18/preview	Introduction to Machine Learning By Prof. Balaraman Ravindran IIT Madras
6	https://onlinecourses.nptel.ac.in/noc23_ee87/preview	Machine Learning And Deep Learning - Fundamentals And Applications By Prof. M. K. Bhuyan IIT Guwahati
7	https://medium.com/eni-digitalks/machine-learning-for-beginners-with-orange-data-mining-0690372533b9#:~:text=How%20to%20install%20and%20configure,ways%20to%20install%20this%20tool	ML simulator software

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students