Rajiv Gandhi Proudyogiki Vishwavidyalaya Bhopal

M.Tech (Artificial Intelligence & Machine Learning)

Third Semester Syllabus

MTAL 301(A) Computer Vision & Robotics

UNIT 1

Introduction to robotics, Robot Usage, Robot subsystems, Robot Classification, Technology of Robots, Basic Principles in robotics.Drive systems: hydraulic, pneumatic and electric systems. Sensors in robot –Sensor Classification, Internal Sensors, External sensors.Spatial Descriptions, Transformation and Sensors Robot Architecture, Descriptions: Positions, Orientations and Frames.

UNIT 2

Kinematics and Dynamics of Robots: 2D, 3D Transformation, Scaling, Rotation, Translation, Homogeneous coordinates, multiple transformations, Simple problems. Matrix representation, Forward and Reverse Kinematics of Degree of Freedom, Homogeneous Transformations, Inverse kinematics of Robot, Robot Arm dynamics, D-H representation of robots, Basics of Trajectory Planning. Statics: Forces and Moment Balance, Recursive Calculation, Equivalent Joint Torques, Force Ellipsoid, Dynamics: Inertia Properties, Dynamics Algorithms.

UNIT 3

Control Techniques, Second order linear systems, Feedback Control, Joint controller, Nonlinear Trajectory Control, Stability, Cartesian and force controls.Motion Planning and Computer for Robots Joint space Planning, Cartesian space planning, Position and orientation Trajectories, Point to Point Planning, Continuous path Generation, Computational speed, Hardware requirements, Control considerations, Robot Programming, Hardware architecture, A case study for Autonomous Mobile Robot.

UNIT 4

Digital Image fundamentals and low-level processing, Transformation, Image Enhancement, Restoration, Histogram Processing. Perspective, DLT, RANSAC, 3-D reconstruction framework; Auto-calibration.Image Segmentation, Region Growing, Edge Based approaches to segmentation, Graph-Cut, Mean-Shift, MRFs, Texture Segmentation; Object detection, Object localization, Region Analysis, Projective geometry, Inverse perspective Projection, Photogrammetry -from 2D to 3D, Image matching.

UNIT 5

Shape from X, Light at Surfaces; Phong Model; Reflectance Map; Albedo estimation; Photometric Stereo; Use of Surface Smoothness Constraint; Shape from Texture, color, motion and edges.

TEXT BOOKS RECOMMENDED:

1. Saha, Introduction to Robotics, TMH Pub.
2. Craig, Introduction to Robotics, Mechanics and control, Pearson Pub
3. "Digital Image Processing" by Rafael Gonzalez, Richard Woods, Pearson Publication, 4th edition, May 2017.
4. Richard Szeliski, Computer Vision: Algorithms and Applications, Springer-Verlag London Limited 2011.
5. Computer Vision: A Modern Approach, D. A. Forsyth, J. Ponce, Pearson Education, 2003.
6. Milan Sonka,VaclavHlavac, Roger Boyle: Image Processing, Analysis, and Machine Vision , 1st edition, Thomson Learning

REFERENCE BOOKS:

1. KrishnenduKar, Mastering Computer Vision with TensorFlow 2.x, 2020, Packt Publishing
2. "Hands-On Image Processing with Python: Expert techniques for advanced image analysis and effective interpretation of image data", by SandipanDey, Pakt Publication, January 2018.
3. "Python 3 Image Processing" by Ashwin Pajankar, BPB Publications, January, 2019.
4. Ghosal, Robotics –Fundamental Concepts and Analysis, Oxford Pub.
5. Niku, Introduction to Robotics: Analysis, System & Applications, PHI

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MTAL 301(B)NATURAL LANGUAGE PROCESSING

THEORY:

UNIT-I

Introduction to NLP: Different Data Models such as Boolean Model, Vector model, Probabilistic Model, comparison of classical models. Introduction to alternative algebraic models such as Latent Semantic Indexing etc.

UNIT-II

Probabilistic language modeling and its applications. The role of language models. Simple N-gram models. Estimating parameters and smoothing. Evaluating language models. Markov models. Estimating the probability of a word, and smoothing. Generative models of language

UNIT-III

Part of Speech Tagging and Sequence Labeling: Lexical syntax. Hidden Markov Models Forward and Viterbi algorithms and EM training.

UNIT-IV

Syntactic parsing: Grammar formalisms and treebanks. Efficient parsing for context-free grammars (CFGs). Statistical parsing and probabilistic CFGs (PCFGs).

UNIT-V

Semantic Analysis: Lexical semantics and word-sense disambiguation. Compositional semantics. Semantic Role Labeling and Semantic Parsing.

TEXT BOOKS RECOMMENDED:

1. Daniel Jurafsky& James H. Martin, Speech and Language Processing, Perason publication, 2018.
2. Manning and Schutze "Foundations of Statistical Natural Language Processing", MIT Press,2009

REFERENCE BOOKS:

1. Dipanjan Sarkar, Text Analytics with Python (Apress/Springer, 2016)
2. Handbook of Natural Language Processing, Second Edition—Nitin Indurkhya, Fred J. Damerau, Fred J. Damerau (ISBN 13: 978-1420085921)
3. Natural Language Processing with Python by Steven Bird, Ewan Klein, Edward Lopper(ISBN 13:978-0596516499)

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MTAL 301(C) Information Security

THEORY:

UNIT-I

Introduction: Needs for Security; Basic security terminologies e.g. threats, vulnerability, exploit etc.; Security principles(CIA), authentication, nonrepudiation; security attacks and their classifications; **Mathematical foundation -** Prime Number; Modular Arithmetic; Fermat's and Euler's Theorem; The Euclidean Algorithms; The Chinese Remainder Theorem; Discrete logarithms.

UNIT-II

Symmetric Key Cryptography: Classical cryptography – substitution, transposition and their cryptanalysis; Symmetric Cryptography Algorithm – DES, 3DES, AES etc.; Modes of operation: ECB, CBC etc.; Cryptanalysis of Symmetric Key Ciphers: Linear Cryptanalysis, Differential Cryptanalysis.

UNIT-III

Asymmetric Key Cryptography: Key Distribution and Management, Diffie-Hellman Key Exchange algorithm; Asymmetric Key Cryptography Algorithm– RSA, ECC etc.; Various types of attacks on Cryptosystems.

UNIT-IV

Authentication & Integrity – MAC, Hash function, SHA, MD5, HMAC, Digital signature and authentication protocols; Authorization; Access control mechanism; X.509 Digital Certificate.

UNIT-V

E-mail, IP and Web Security: E-mail security – PGP, MIME, S/MIME; IP security protocols; Web security – TLS, SSL etc.; Secure Electronic Transaction(SET); Firewall and its types; Introduction to IDPS; Risk Management; Security Planning.

TEXT BOOKS RECOMMENDED:

1. Michael E. Whitman, Herbert J. Mattord, "Principles of Information Security", 6th Edition, Cengage Learning.

2. Stallings William, “Cryptography and Network Security - Principles and Practice”, 7th Edition, Pearson.

REFERENCE BOOKS:

1. Roberta Bragge, Mark Rhodes, Keith Straggberg, “Network Security the Complete Reference”, Tata McGraw Hill Publication,

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MTAL 301(D)INTERNET OF THINGS (IOT)

1. **Introduction to IoT:** Fundamentals and terminology of of IOT, Various Platforms for IoT, Real time Examples of IoT, Challenges in IOT, Architectural Overview, Design principles and needed capabilities Technology. Fundamentals- Devices andgateways, Data management, Business processes in IoT, Everything as a Service(XaaS), Role ofCloud in IoT, Security aspects in IoT.

2. **Elements of IoT:** Hardware Components- Computing (Arduino, Raspberry Pi), Communication, Sensing,Actuation, I/O interfaces.CommunicationProtocols-MQTT, ZigBee, Bluetooth, CoAP, UDP, TCP. Basics of Networking, M2M and IoT.

3. **Software Components**- Programming API's (using Python/Node.js/Arduino), Arduino Simulation Environment: Arduino Libraries, Basics of Embedded C programming for Arduino, Interfacing Arduino with LCD, Interfacing of Actuators with Arduino.

4. **IoT Application Development: Solution framework for IoT applications**- Implementation of Device integration, Data acquisitionand integration, Device data storage- Unstructured data storage on cloud/local server,Authentication, authorization of devices.

5. **IoT Case Studies:** IoT case studies and mini projects based on Industrial automation, Transportation, Agriculture,Healthcare, Home Automation.

TEXT BOOKS RECOMMENDED:

1. Vijay Madisetti, ArshdeepBahga, Ïnternet of Things, "A Hands on Approach", University
2. Press
3. Dr. SRN Reddy, RachitThukral and Manasi Mishra, "Introduction to Internet of Things: A practical Approach", ETI Labs
4. Pethuru Raj and Anupama C. Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", CRC Press
5. Jeeva Jose, "Internet of Things", Khanna Publishing House, Delhi
6. Adrian McEwen, "Designing the Internet of Things", Wiley
7. Raj Kamal, "Internet of Things: Architecture and Design", McGraw Hill
8. CunoPfister, "Getting Started with the Internet of Things", O Reilly Media

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MTAL 302(A) Machine Learning in Computer Vision & Robotics

Unit 1

Common probability distributions, Fitting probability models, Normal distribution Learning and inference in vision. Modeling complex data densities. Dimensionality reduction, Model evaluation and selection

Unit 2

Regression, Classification and Graphical models, Models for chains, trees and grids, Image preprocessing and feature extraction, pinhole camera Models for transformations.

Unit 3

Multiple cameras, Models for shape, models for style and identity, Temporal models

Unit 4

Stochastic gradient descent and averaging,Bandits, Markov decision processes,Value function approximation, Policy gradient methods, Classical control approaches, Controlling Dynamixels

Unit 5

Challenges in real-time learning, Architectures for real-time learning tasks, Simulation-to-reality transfer, Learning from demonstration

Reference Books:

1. Computer Vision: Models, Learning, and Inference Simon J.D. Prince, Cambridge University Press
2. Reinforcement Learning: An Introduction Richard S. Sutton and Andrew G. Barto, MIT Press
3. Computer Vision: A Modern Approach , 2nd Edition by David Forsyth, Jean Ponce, Pearson Education India

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Third Semester Syllabus

MTAL 302(B) Machine learning in natural language processing

UNIT I INTRODUCTION

Learning – Types of Machine Learning , Supervised Learning ,The Brain and the Neuron , Design a Learning System , Perspectives and Issues in Machine Learning ,Concept Learning Task , Concept Learning as Search ,Finding a Maximally Specific Hypothesis , Version Spaces and the Candidate Elimination Algorithm , Linear Discriminants, Perceptron , Linear Separability , Linear Regression.

UNIT II LINEAR MODELS

Multi-layer Perceptron , Going Forwards , Going Backwards: Back Propagation Error, Multi-layer Perceptron in Practice , Examples of using the MLP , Overview , Deriving Back-Propagation , Radial Basis Functions and Splines , Concepts , RBF Network, Curse of Dimensionality , Interpolations and Basis Functions , Support Vector Machines

UNIT III TREE AND PROBABILISTIC MODELS

Learning with Trees , Decision Trees , Constructing Decision Trees , Classification and Regression Trees , Ensemble Learning , Boosting , Bagging , Different ways to Combine Classifiers , Probability and Learning , Data into Probabilities , Basic Statistics , Gaussian Mixture Models , Nearest Neighbor Methods , Unsupervised Learning , K means Algorithms, Vector Quantization , Self Organizing Feature Map

UNIT IV NATURAL LANGUAGE PROCESSING

Origins and challenges of NLP – Language Modeling: Grammar-based LM, Statistical LM – Regular Expressions, Finite-State Automata – English Morphology, Transducers for lexicon and rules, Tokenization, Detecting and Correcting Spelling Errors, Noisy Channel Model , Minimum Edit Distance

UNIT V WORD LEVEL ANALYSIS

Unsmoothed N-grams, Evaluating N-grams, Modelling with N-gram, Simple N-gram models , Smoothing, Interpolation and Backoff – Word Classes, Part-of-Speech Tagging, Rule-based, Stochastic and Transformation-based tagging, Issues in PoS tagging – Hidden Markov and Maximum Entropy models, Case study: application of neural language model in NLP system development.

Reference Books:

1. Machine Learning, Tom M. Mitchell , McGraw-Hill Education (India) Private Limited, 2013.
2. Speech and Language Processing: An Introduction to Natural Language Processing, Daniel Jurafsky, James H. Martin, Pearson Publication, 2014.
3. Natural Language Processing with Python, Steven Bird, Ewan Klein and Edward Loper First Edition, O'Reilly Media, 2009.
4. Introduction to Machine Learning (Adaptive Computation and Machine Learning), Ethem Alpaydin The MIT Press 2004.
5. Machine Learning: An Algorithmic Perspective, Stephen Marsland, Chapman and Hall/CRC
6. Natural Language Processing with Java, Richard M Reese, Packt Publishing
7. Handbook of Natural Language Processing, Nitin Indurkhya and Fred J. Damerau Second Edition, Chapman and Hall/CRC Press, 2010.
8. Natural Language Processing and Information Retrieval, Tanveer Siddiqui, U.S. Tiwary Oxford University Press, 2008.

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MTAL 302(C) Machine learning in information Security

THEORY:

UNIT-I

Classification and Clustering-Machine Learning: Problems and Approaches, Model Families, Loss Functions, Optimization; Supervised Classification Algorithms- Logistic Regression. Decision Trees, Decision Forests, Support Vector Machines, Naive Bayes, k-Nearest neighbors, Neural Networks; Practical Considerations in Classification: Selecting a Model Family, Training data Construction, Feature Selection, Overfitting and Underfitting, Choosing Thresholds and Comparing ModelsClustering: Clustering Algorithms, Evaluating Clustering Results.

UNIT-II

Anomaly Detection- Anomaly Detection Versus Supervised Learning, Intrusion Detection with Heuristics, Data-Driven Methods, Feature Engineering for Anomaly Detection: Host Intrusion Detection, Network Intrusion Detection, Web Application Intrusion Detection, Anomaly Detection with Data and Algorithms: Forecasting Supervised machine Learning, Statistical Metrics, Goodness-of-Fit, Unsupervised Machine Learning Algorithms, Density-Based Methods, Challenges of Using Machine Learning in Anomaly Detection, Response and Mitigation, Practical System Design Concerns, Optimizing for Explainability, Maintainability of Anomaly Detection Systems, Integrating Human Feedback,Mitigating Adversarial Effects

UNIT-III

Malware Analysis- Understanding Malware: Defining Malware Classification, Feature generation: Data Collection, Generating Features, Feature Selection, From Features to Classification: How to Get Malware Samples and Labels

UNIT-IV

Network Traffic Analysis: Access Control and Authentication, Intrusion Detection, Detecting In-Network Attackers, Data-Centric Security, HoneypotsBuilding a Predictive Model to Classify Network Attacks: Exploring the Data, Data Preparation, Classification, ,Supervised Learning, Semi-Supervised , Learning, Unsupervised Learning, Advanced Ensembling

UNIT-V

Production Systems- Machine Learning System Maturity and Scalability, Data Quality: Bias in Datasets, Missing Data, Data quality; Model Quality: Hyperparameter Optimization, Feature: Feedback Loops, A/B Testing of Models, Repeatable and Explainable Results; Performance: Goal: Low Latency, High Scalability, Performance Optimization; Maintainability: Problem: Check pointing, Versioning, and Deploying Models, Graceful Degradation, Tuning and Configurable, Monitoring and Alerting; Security and Reliability: Robustness in Adversarial Contexts, Data Privacy Safeguards and Guarantees, Feedback and Usability

TEXT BOOKS RECOMMENDED:

1. Clarence Chio and David Freeman, Machine Learning & Security: Protecting Systems With Data And Algorithms Protecting Systems, Latest Edition, O'Reilly.
2. Mark Stamp, Introduction To Machine Learning With Applications In Information Security, CRC Press, Taylor & Francis Group.

REFERENCE BOOKS:

1. Marcus A. Maloof, Machine Learning and Data Mining for Computer Security Methods and Applications (Advanced Information and Knowledge Processing).

2. Tony Thomas, Athira P. Vijayaraghavan, Sabu Emmanuel, Machine Learning Approaches in Cyber Security Analytics, Springer.

3. Gupta, Brij Sheng, Quan Z, Machine learning for computer and cyber security principles, algorithms, and practices-CRC Press (2019).

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Third Semester Syllabus

MTAL 302(D) Machine Learning in Internet of Things

Unit I

Introduction to Machine Learning:
Introduction to ML, Introduction to Statistical Learning Methods, Classic and adaptive machines,Machine-LearningProblem,Machine-LearningTechniquesandParadigms,MachineIntelligence,Elements of Machine Learning, Introduction to Advanced ML - Deep Learning, Reinforcement Learning

Unit II

IOT Data Pre-processing:
Data Preparation for Predictive Maintenance Modeling, Cleaning and Standardizing I o T Data, Applying Advanced Data Exploration Techniques
Feature Engineering:
Exploring Feature Engineering, Applying Feature Selection Techniques, Feature set selection using ML, Machine learning for Internet of Things data analysis

Unit III
Machine learning (ML) methods for I o T Applications:
Decision Trees (DTs), Support Vector Machines (SVMs), Bayesian theorem-based algorithms, k-Nearest neighbor (KNN), Random forest (RF), Association Rule (AR) algorithms, Ensemble learning (EL), k-Means clustering, Principal component analysis (PCA)
Deep learning (DL) methods for I o T Applications:
Convolutional neural networks (CNNs),Recurrent neural networks (RNNs),Deep auto encoders(AEs), Restricted Boltzmann machines (RBMs), Deep belief networks (DBNs), Generative adversarial networks(GANs), Ensemble of DL networks(EDLNs)

Unit IV Compact fast Machine Learning Accelerators for IOT devices:
Edge Computing on IOT Devices, IOT Based Smart Buildings, Distributed Machine Learning, Machine Learning Accelerator, Machine Learning Model Optimization, Least-Squares-Solver for Shallow Neural Network: Introduction, Algorithm Optimization, Hardware Implementation

Unit V
Deep Learning for IOT:
Deep Learning Models for Sensor Data, Embedded Deep Learning, Real Time IOT Imaging with Deep Neural Network
Applications of ML and IOT:
Case Studies: IOT for Agriculture, Remote Patient Monitoring, Smart City, Smart Transportation, IOT Security using ML

Reference Books:

1. Introduction to Machine Learning, Ethem Alpaydin, The MIT Press, October 2004,
2. Compact and Fast Machine Learning Accelerator for I o T Devices, Hantao Huang and Hao Yu, Edition:1 Springer Singapore Year:2019 ISBN:978-981-13-3323
3. The Elements of Statistical Learning: Data Mining, Inference, and Prediction, Trevor Hastie Robert Tibshirani, Jerome Friedman, Second Edition, Springer
4. Machine Learning, Tom M. Mitchell , McGraw-Hill (March 1,1997)ISBN:0070428077
5. Machine Learning in Cognitive IoT, Neeraj Kumar and Aaisha Makkar Published June1,2020 by CRC Press
6. I o T Machine Learning Applications in Telecom, Energy, and Agriculture: With Raspberry Pi and Arduino Using Python, Puneet Mathur, ISBN978-1-4842-5549-0, Apress
7.Real-Time I oT Imaging with Deep Neural Networks-Using Java on the Raspberry Pi 4", Nicolas Modrzyk, Apress Publication