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Course Code: INT405

MACHINE LEARNING TECHNIQUES

Course Objectives

This course aims at introducing the basics of Machine Learning, its scope and applications. It further helps the learners to understand and analyse simplest algorithms such as linear regression to recent deep learning algorithms

UNIT - I **15 Periods**

Machine Learning Basics: Why probability? Random Variables, Probability Distributions, Marginal Probability, Conditional Probability, The Chain Rule of Conditional Probabilities, Independence and Conditional Independence, Expectation, Variance and Covariance, Common Probability Distributions, Useful Properties of Common Functions.
Learning Algorithms - Capacity - Overfitting and Underfitting - Hyperparameters and Validation Sets - Estimators, Bias and Variance - Maximum Likelihood Estimation - Bayesian Statistics - Supervised Learning Algorithms - Unsupervised Learning Algorithms - Gradient-Based Optimization - Constrained Optimization - Example: Linear Least Squares, Stochastic Gradient Descent

UNIT - II **15 Periods**

Linear Models for Classification: Discriminant Functions - Two classes - Multiple classes - Least squares for classification - Fisher's linear discriminant - Relation to least squares - Fisher's discriminant for multiple classes - The perceptron algorithm
Probabilistic Generative Models: Continuous inputs - Maximum likelihood solution - Discrete features - Exponential family
Probabilistic Discriminative Models: fixed basis functions - Logistic regression - Iterative reweighted least squares - Multiclass logistic regression - Probit regression - Canonical link functions - The Laplace Approximation - Model comparison and BIC - Bayesian Logistic Regression - Laplace approximation - Predictive distribution
Sparse Kernel Machines: Maximum Margin Classifiers - Overlapping class distributions - Relation to logistic regression - Multiclass SVMs - SVMs for regression - Computational learning theory - **Relevance Vector Machines**: RVM for regression - Analysis of sparsity - RVM for classification

UNIT - III **15 Periods**

Neural Networks: Feed -forward Network Functions - Weight -space symmetries - Network Training - parameter optimization - Local quadratic approximation - Use of gradient information - Gradient descent optimization - Error Backpropagation - A simple example.
Regularization for Deep Learning: Dataset Augmentation - Noise Robustness - Semi - Supervised Learning - Multi -Task Learning - Early Stopping - Parameter Tying and Parameter Sharing - Sparse Representations - Bagging and Other Ensemble Methods - Dropout.
Convolutional Networks: The Convolution Operation - Motivation - Pooling - Convolution and Pooling as an Infinitely Strong Prior - Variants of the Basic Convolution Function - Structured Outputs

UNIT - IV **15 Periods**

Sequence Modeling: Markov Models - Hidden Markov Models - Maximum likelihood for the HMM - The forward-backward algorithm - The sum-product algorithm for the HMM - Scaling factors - The Viterbi algorithm - Extensions of the hidden Markov model.
Recurrent and Recursive Nets: Unfolding Computational Graphs - Recurrent Neural Networks - Bidirectional RNNs - Encoder-Decoder Sequence-to-Sequence Architectures - Deep Recurrent Networks - Recursive Neural Networks - The Challenge of Long-Term Dependencies - Echo State Networks - Leaky Units and Other Strategies for Multiple Time Scales - The Long Short-Term Memory and Other Gated RNNs

REFERENCES

1. C. M. Bishop. *Pattern Recognition and Machine Learning*. Springer: 2006
2. Ian Good Fellow, YoshuaBengio, and Aaron Courville, *Deep Learning*. The MIT Press: 2016
3. Nikhil Buduma. *Fundamentals of Deep Learning*, O'REILLY Media, 1st Edition: 2017
4. M. Mohri, A. Rostamizadeh, and A. Talwalkar, *Foundations of Machine Learning*. MIT Press: 2012
5. Kevin P. Murphy. *Machine Learning: A Probabilistic Perspective*. MIT Press: 2012
6. D. Barber. *Bayesian Reasoning and Machine Learning*. Cambridge University Press: 2012

UNITWISE LEARNING OUTCOMES

Upon successful completion of each unit, the learner will be able to

Unit I	• Describe the nature of different categories of machine learning techniques
Unit II	• Apply and analyse any generative and discriminative learning algorithms
Unit III	• Implement simple neural network, deep learning techniques and evaluate results
Unit IV	• Demonstrate the use of a basic sequential data modelling technique

COURSE LEARNING OUTCOMES

Upon successful completion of each unit, the learner will be able to

- Explain the fundamental issues and challenges of machine learning: data, model selection, model complexity, etc.
- Explain the strengths and weaknesses of many popular machine learning approaches.
- Influence the importance of mathematical relationships within and across Machine Learning algorithms and the paradigms of machine learning and deep learning.
- Develop machine learning solutions to classification, regression, and clustering problems and apply various regularization and optimization techniques
- Design and implement various machine learning and deep learning algorithms in a range of real-world applications
- Evaluate and interpret the results of the machine learning and basic deep learning algorithms