Minor in Advanced Machine Learning **Semester: VII**

Program: Common for All Programs (except Computer Science and Engineering (Data Science)

Course: Advanced Machine Learning (DJ19MN4C3)

Course: Advanced Machine Learning Laboratory (DJ19MN4L2)

Pre-requisite:

1. Basic arithmetic
2. Linear Algebra
3. Calculus and Probability,
4. Python programming
5. Statistics and Machine Learning Basics.

Objectives:

To introduce students to the fundamental concepts of artificial neural networks, different deep learning network models working on time series data and computational linguistic concepts.

Outcomes: On completion of the course, the learner will be able to:

1. Develop solution using appropriate neural network models.
2. Apply appropriate model for a time series dataset.
3. Apply appropriate pre-processing and semantic analysis techniques on linguistic data.

Advanced Machine Learning (DJ19MN4C3)		
Unit	**Description**	**Duration**
1.	**Introduction to Artificial Neural Learning:** History of Deep Learning, Fundamental concepts of biological Neural Networks, Important terminologies of ANN: Activation functions: weights, bias, threshold, learning rate, momentum factor; McCulloch Pitts Neuron: Theory and Architecture; Linear separability; **Perceptron:** The Perceptron Training Rule, Gradient Descent and Delta Rule; Multilayer Networks; Backpropagation Algorithm: Convergence and local minima, Generalization, overfitting and stopping criteria. Regularization for Deep Learning: Parameter Norm Penalties, Dataset Augmentation, Noise Robustness, Early Stooping, Sparse Representation, Dropout. Optimization for Training, Parameter Initialization Strategies.	**12**
2.	**Convolutional Networks:** The Convolution Operation, sparse interactions, parameter sharing, Pooling, Convolution and Pooling as an Infinity Strong Prior, Variants of Basic Convolution Function, Efficient Convolution Algorithms.	**06**
3.	**Sequence Modelling:** Recurrent Neural Networks (RNN), Bidirectional RNNs, Deep recurrent Networks, Recursive Neural Networks, The challenges of Long-Term Dependencies, Echo State Networks, Leaky Units, The Long Short-Term Memory.	**06**

4.	**Time Series Analysis:** Types of forecasting methods, Types of Time Series, types of stationarity, trends in time series. Linear time series: MA models, The AR model, The ARMA model, The ARIMA model, Unit roots, Box – Jenkins Model Selection, Seasonality, The SARIMA model, Dickey-Fuller tests, Multiequation Time Series Models: Intervention Analysis, ADLs and Transfer Functions, Introduction to VAR Analysis, Multivariate Time Series: Convolution, Non-linear time series: ARCH and GARCH model.	**11**
5.	**Computational Linguistic:** Introduction and Stages of NLP, Word Tokenization and Segmentation, Stemming, Lemmatization, N-gram language model. Morphological Analysis-Inflectional morphology & Derivational morphology, Regular expression, Finite State Transducer.	**05**
6.	**Syntax and Semantics Analysis:** Introduction to POS Tagging, Probabilistic Tagging, Markov Models, Hidden Markov Models (HMM), Named Entity Tagging, Context-Free Grammars Derivation, Constituency Parsing, Dependency Parsing, Lexical Semantics, Vector Semantics, Words and Vectors, Cosine for measuring similarity, Pointwise Mutual Information (PMI), Term Frequency-Inverse Document Frequency (TFIDF), PPMI vector models, Word2vec, Continuous Bag of Words, Vector Visualizing Embedding's, Word Senses -Relations Between Senses, WordNet: A Database of Lexical Relations, Word Sense Disambiguation, Coherence Relation, Discourse Structure Parsing	**12**
	Total	**52**

Advanced Machine Learning Laboratory (DJ19MN4L2)	
Exp.	**Suggested experiments**
1	Implement Boolean gates using perceptron.
2	Implement backpropagation algorithm from scratch.
3	Evaluate and analyse Prediction performance using appropriate optimizers for deep learning models.
4	Building CNN models for image categorization.
5	Implement Sentiment analysis on text dataset to evaluate customer reviews.
6	Document classification using RNN models.
7	Outlier detection in time series dataset using RNN.
8	Analyze seasonality of a time series data using the following visualizations: • Multiple Box Plots • Autocorrelation Plot • Deseasoning of Time-Series Data • Seasonal Decomposition • Detecting Cyclic Variations
9	Implementation for detection of unit roots for Data Stationary: Augmented Dickey –Fuller Test.
10	Comparative Analysis of AR, MA and ARIMA model on finance application.
11	Perform Pre-processing steps in Natural Language Processing (Tokenization, Stop Word detection, Stemming and Lemmatization.
12	Implement Parts of Speech tagging using HMM
13	Implement word-embedding and TF-IDF vectors in Natural Language Processing

Books Recommended:

Text books:

1. S. N. Sivanandam and S. N. Deepa, “Introduction to Soft Computing”, Wiley India Publications, 3rd Edition, 2018.
2. Ian Goodfellow and Yoshua Bengio and Aaron Courville, “Deep Learning”, An MIT Press, 2016.
3. Walter Enders,” Applied Econometric Time Series,” Fourth Edition, Wiley, 2014.
4. B. V. Vishwas and Ashish Patel, “Hands-on Time Series Analysis with Python,” First Edition, Apress, 2020.
5. Jurafsky and Martin, “Speech and Language Processing”, Prentice Hall, 3rd Edition, 2020.

Reference Books:

1. François Chollet, “Deep Learning with Python”, Manning Publication, 2017.
2. Josh Patterson, Adam Gibson, “Deep Learning: A Practitioner's Approach”, O’Reilly Publication, 2017.
3. Chris Chatfield, “Time- Series Forecasting,” First Edition, Chapman & Hall/CRC, 2001.
4. Douglas C. Montgomery, Cheryl L. Jennings and Nurat Kulahci, “Introduction to Time Series Analysis and Forecasting,” Second Edition, Wiley, 2015.
5. Yuli Vasiliev “Natural Language Processing with Python and spaCy - A Practical Introduction”, No Starch Press, 2022.
6. Sowmya Vajjala, Bodhisattwa Majumder, Anuj Gupta, Harshit Surana, “Practical Natural Language Processing: A Comprehensive Guide to Building Real-World NLP Systems”, O'Reilly, 1st Edition, 2020.

Web Links:

1. Virtual Lab on Deep Learning: https://vlab.spit.ac.in/ai/#/experiments
2. A course on Time Series Analysis. https://web.stat.tamu.edu/~suhasini/teaching673/time_series.pdf
3. Virtual Lab on NLP: -https://nlp-iiith.vlabs.ac.in

Prepared by Checked by Head of the Department Principal