DISCIPLINE SPECIFIC ELECTIVES (DSE-2)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Neural Networks and Deep Learning ELDSE7B	**4**	**3**	**-**	**1**	**Class XII passed with Physics + Mathematics/Applied Mathematics + Chemistry OR Physics + Mathematics/Applied Mathematics + Computer Science/Informatics Practices**	**-**

Learning Objectives

This course aims to develop a fundamental understanding of the basic principles behind deep learning and focuses on learning complex, hierarchical feature representation from raw data. The course applies and evaluates deep learning on standard data set and suggests examples of how deep learning can be used in different domains. This course must enable student to read and critically assess papers on deep learning and their applications, such as Image classification, Natural Language Processing.

Learning outcomes

On successful completion of this course, students will be able to

CO1 Describe the major differences between deep learning and other types of machine learning algorithms.

CO2 Differentiate between the major types of neural network architectures (multi-layered perceptrons, convolutional neural networks, recurrent neural networks, etc.) and what types of problems each is appropriate for.

CO3 Design neural network architectures for new data problems based on their requirements and problem characteristics and analyze their performance.

CO4 Describe some of the latest research being conducted in the field and open problems that are yet to be solved.

SYLLABUS OF ELDSE-7B **Total Hours- Theory: 45 Hours, Practicals: 30 Hours**

Unit I: (11 Hours)
Introduction to Deep Learning:
Definition of Deep Learning (as a subset to Machine Learning, Artificial Intelligence), Intuition and the need of Deep Neural Networks, structure of Artificial Neural Networks (ANNs) (input layer, hidden layer, output layer), need of Activation Functions, types of Activation Functions (Threshold function, Sigmoid function, ReLU function, Hyperbolic Tangent function). Softmax

Unit II : (12 Hours)
Neural Networks:
Idea of Perceptron, Multi-Layer Perceptron, Feed Forward Networks (FFNs), Backpropagation, Loss of functions, Gradient Descent.
Introduction to the types of Deep Neural Networks: Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), Radial Based Networks, Deep Neural Networks, Long Short-Term Memory Networks (LSTMs), Learning/Training and optimisation algorithms for each type, Restrictive Boltzmann Machines (RBMs), Stacking RBMs, Belief Nets.

Unit III: (11 Hours)
Principal Component Analysis and Regularization:
Eigen values and Eigen vectors, Principal Component Analysis (PCA) and its interpretation, Singular Value Decomposition, Autoencoders and relation to PCA, Regularization in Autoencoders, Bias Variance Trade-off, L1 and L2 regularization, Dropout regularization, Early Stopping to prevent overfitting, Ensemble method.

Unit IV: (11 Hours)
Introduction to CNNs and Deep Learning Application:
Convolution, Filter (Kernels), Pooling, Deep CNNs, state of the art Deep CNN architectures – LeNet, AlexNet, VGG, ResNet, ShuffleNet. Weights initialization, Batch normalization, Hyperparameter optimization, Understanding and visualizing CNNs. Use of optimization methods for neural networks (AdaGrad, RMSProp, Adam), Second order methods for training.
Applications: Virtual Assistants, Chatbots, Image captioning, Self-Driving Cars, Natural Language Processing, Visual Recognition, Large Language Models (LLMs).

Practical component (if any) – Neural Network and Deep Learning Lab
(Python- using the Deep Learning Libraries)

Learning outcomes

At the end of this course, Students will be able to

CO1 Implement fundamental building blocks.
CO2 Apply their learning to real world scenarios.
CO3 Design NN architectures for new Data problems.

LIST OF PRACTICALS (Total Practical Hours- 30 Hours)

1. Write a program to predict Handwritten Digits using a Neural Network.
2. Write a program to predict whether the income of a person exceeds a certain amount per year based on specific criteria, using TensorFlow and any data set from a Machine Learning Repository
3. Write a program to analyze various aspects of an individual and predict what class of income he/she belongs to (example: >50k or <=50k) by using census data.
4. Write a program to classify images of cats and dogs using a neural network.
5. Write a program to predict the prices of stocks using the "Google stock price" data using LSTM.
6. For the dataset (California Housing Price/Pima Indians Diabetes), apply regularization techniques.
7. Apply PCA to reduce MNIST dimensions (visualizing eigenvalues/vectors), then train a neural network with L2/dropout regularization to explore bias-variance tradeoffs and prevent overfitting.
8. Fine-tune a pre-trained VGG19 model on Kaggle's Chest X-Ray dataset (5,863 images) to classify pneumonia vs normal cases, experimenting with batch normalization and learning rate decay while analyzing performance metrics.

Note: Students shall sincerely work towards completing all the above listed practicals for this course. In any circumstance, the completed number of practicals shall not be less than seven.

Essential/recommended readings

1. Deep Learning, An MIT Press book, Ian Goodfellow and Yoshua Bengio and Aaron Courville http://www.deeplearningbook.org

2. S. Haykin, Neural Networks and Learning Machines, Prentice Hall of India, 2010
3. B. Yegnanarayana, Artificial Neural Networks, Prentice- Hall of India, 1999

Suggestive readings

1. Satish Kumar, Neural Networks - A Classroom Approach, Second Edition, Tata McGraw-Hill, 2013
2. C.M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.