Foundations of Deep Learning

Coursetitle&C	Credits	Creditdistributionofthecourse			Eligibilitycriteria	Pre-requisiteofthe course (if any)
		Lecture	Tutorial	Practical/Pract		
Foundations of Deep Learning	4	3	0	1	Class XII Pass	NA

COURSE OBJECTIVE

- Apply deep learning techniques like logistic regression, gradient descent, and adaptive methods for supervised classification tasks.
- Design and optimize feedforward neural networks with regularization and hyperparameter tuning.
- Implement and apply Convolutional Neural Networks (CNNs) for image and text classification tasks.
- Explore and implement Recurrent Neural Networks (RNNs), including LSTMs and GRUs, for sequence modeling.
- Develop and evaluate various autoencoders, including regularized and variational autoencoders (VAEs), for feature learning and generative tasks.

COURSE OUTCOME

On completion of this course, the student will be able to:

- Implement deep learning models for supervised classification tasks using techniques like gradient descent and adaptive optimization methods.
- Design and optimize neural network architectures, applying regularization techniques and tuning hyperparameters for improved performance.
- Build and apply Convolutional Neural Networks (CNNs) to solve real-world problems in image and text classification.
- Develop and train Recurrent Neural Networks (RNNs), including advanced models like LSTMs and GRUs, for sequence prediction and processing.
- Create and evaluate various types of autoencoders, including denoising and variational autoencoders, for feature extraction and generative tasks.

SYLLABUS

Unit I **(7 Hours)**
Introduction to Deep Learning, Motivation and applications, Basic Supervised Classification, Logistic regression, Optimizing with Gradient Descent and Stochastic Gradient Descent (SGD), Momentum, Adaptive Methods (e.g., Adam).

Unit II **(8 Hours)**
Feedforward Neural Networks, Deep Networks, Regularization Techniques (Dropout, L2

regularization), Hyperparameter Tuning (Grid search, Random search).

Unit III **(8 Hours)**

Introduction to CNNs, Convolution layers, Pooling, Striding, Applications in Image and Text Classification, Hands-on with CNN architectures (e.g., LeNet, VGG).

Unit IV **(8 Hours)**

RNNs, Backpropagation Through Time (BPTT), Bidirectional RNNs, Sequence-to-Sequence Models, LSTMs and GRUs.

Unit V **(6 Hours)**

Autoencoders, Regularized Autoencoders, Sparse and Denoising Autoencoders, Variational Autoencoders (VAEs).

Unit VI **(8 Hours)**

Data Splits (Train/Dev/Test), Evaluation Metrics, Cleaning Data, Bias-Variance Tradeoff, Transfer Learning, Multi-task Learning.

PRACTICAL COMPONENT (IF ANY)

Use Python for practical labs.

LIST OF PRACTICALSPractical (30 Hours)

1. Implement and train a logistic regression model for a binary classification task using gradient descent and stochastic gradient descent (SGD).
2. Build and train a basic feedforward neural network for a classification task, implementing activation functions, forward and backward propagation.
3. Perform hyperparameter tuning using grid search and random search to optimize neural network performance on a classification problem.
4. Implement and train a CNN model for image classification using techniques like convolution, pooling, and striding on datasets like MNIST or CIFAR-10.
5. Apply CNNs to text classification tasks, such as sentiment analysis or spam detection, using datasets like IMDB reviews.
6. Implement a simple RNN model for sequence prediction tasks, such as time series forecasting, and understand backpropagation through time (BPTT).
7. Build a bidirectional RNN for sequence-to-sequence tasks, such as machine translation or named entity recognition.
8. Implement autoencoders, including regularized and denoising autoencoders, for dimensionality reduction or feature extraction tasks.
9. Fine-tune a pre-trained CNN model (e.g., VGG, ResNet) for a custom image classification task using transfer learning techniques.

REFERENCE BOOKS

1. Ian Goodfellow, **Deep Learning**, MIT Press, 2016.
2. Jeff Heaton, **Deep Learning and Neural Networks**, Heaton Research Inc., 2015.
3. Mindy L. Hall, **Deep Learning**, VDM Verlag, 2011.
4. Li Deng, Dong Yu, **Deep Learning: Methods and Applications**, Now Publishers Inc., 2009.