Course Type	Course Code	Name of Course	L	T	P	Credit
OE	CSO507	Deep Learning	3	0	0	9

Course Objective

The main goal of this course is to equip the students with the knowledge of different deep learning algorithms and architectures and give them exposure to different applications of deep learning.

Learning Outcomes

At the end of the course, the students will

- have an overall knowledge of the different deep learning algorithms and architectures.
- be able to analyze a problem and determine the deep learning model that can be applied to solve the problem effectively.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	**Introduction:** Course overview, brief overview of basic concepts in linear algebra, probability and vector calculus, Optimization: Types of errors, bias-variance trade-off, overfitting-underfitting, brief review of concepts from optimization, variants of gradient descent, momentum based methods.	6	Motivate the students in the subject and provide a brief introduction to the mathematical tools required for the course. Make the students familiar with the optimization techniques and some general aspects of machine learning.
2	**Linear and Logistic Regression:** MSE in linear regression, squared loss error from white noise, Logistic regression, properties of sigmoid function, cross-entropy error	2	Introduce regression and classification using linear and logistic regression as examples. Give an understanding of the basic framework of working of ML training and testing.
3	**Artificial neural network**: Basic concepts of artificial neurons, single and multi layer perceptrons, perceptron learning algorithm, its convergence proof, different activation functions, softmax cross entropy loss function	3	Familiarize the students with concepts of perceptron, multi-layer perceptron, perceptron learning algorithm, backpropagation algorithm, loss and activation functions.
4	**Convolutional neural network:** Basic concepts of CNN, Famous CNN architectures in computer vision, Regularization, Dropout, Batch normalization, CNN in language processing, Applications of CNN: Detection, segmentation problem definition, challenges, Evaluation, Datasets and Localization by regression. Discussion on detection as classification, region proposals, RCNN and YOLO architectures, fully convolutional segmentations, Mask-RCNNs.	8	Familiarize students with CNN and its applications in computer vision and natural language processing.
5	**NLP basics, Recurrent Architectures, Transformers, NLP Applications, Vision Transformers:** Word and sentence embeddings, Language Models, Discussion on Recurrent Neural Networks (RNNs), Long-Short Term Memory (LSTM) architectures, Attention, Transformers, NLP applications and vision transformers.	8	Familiarize students with RNN and its variants, attention models and transformers and their applications in natural language processing and computer vision.
6	**Representation Learning:** Unsupervised representation learning, Transfer learning, Domain adaptation.	3	Familiarize students with concepts of unsupervised representation learning, layer

			pre-training, auto-encoders, transfer learning and domain adaptation
7	**Structured Probabilistic Models for Deep Learning:** Using graphs to describe models, directed and undirected models, energy-based models, restricted Botlzman machine.	2	Familiarize the students with deep learning approaches to deep probabilistic models
8	**Generative Adversarial models:** Stochastic AutoEncoders, Variational Autoencoders, Generative Adversarial Networks.	4	Introduce the concepts of generative models, distribution modeling and adversarial training.
9	**Graph Neural Networks:** Graph Embeddings, Shallow and deep graph embeddings, Graph neural networks, Applications of GNN	3	Familiarize the students with the concepts of graph representation, spectral analysis of graphs, learning representation for graphs, graph based neural architectures

Text Books:

1. Deep learning - Bengio, Yoshua, Ian J. Goodfellow and Aaron Courville - MIT Press, 2016.
2. Probabilistic Machine Learning: An introduction - Kevin P. Murphy - 1st Edition, MIT Press, 2022

Reference Books:

1. Neural Networks for Pattern Recognition - Christopher Bishop - Clarendon Press 1st Edition 1996
2. Neural Networks and Learning Machines - Simon Haykin, Pearson Education; 3rd Edition 2016
3. Pattern Recognition and Machine Learning - Christopher Bishop - Springer, 1st Edition, 2006