Artificial Neural Network and Deep Learning

Course Code: CSNN-342

Semester	Credit Hours	Prerequisite
[BSAI-5]	[2+1]	[CSPA-241]

Course Description

In this course the theory and practice of neural computation for machine learning are introduced. Artificial neural networks are used for many real-world problems: classification, time-series prediction, regression, pattern recognition. The class starts with an introduction to feed forward neural networks. More complicated multi-layered "deep" networks are then covered. Basic backpropagation, gradient descent and modern regularization techniques are implemented in assignments. The class will look at modern deep learning techniques: convolutional neural networks, deep belief networks and deep recurrent neural models such as LSTM nets.

Deep Learning is a hierarchical learning methodology based on artificial neural networks which are algorithms inspired by the structure and function of the brain. It has applications in wide-range of industries these days such as face-recognisers working at massive scales, robotics, speech translation, text analysis, improving customer experience, autonomous vehicles etc.

Course Learning Outcomes (CLOs)

The course learning outcome along with domain and BT level are listed below

S. #	CLO STATEMENT	DOMAIN	BT LEVEL	PLO
CLO-1	Explain basics of Artificial Neural Networks & Deep Learning.	C	C1 Knowledge	1
CLO-2	Apply supervised and unsupervised in Machine Learning using Neural Networks.	C	C3 Apply	3
CLO-3	Design and implementation of small problems using Neural Networks and Deep Learning	C	C3 Apply	2

*** BT= Bloom's Taxonomy, C=Cognitive Domain, P=Psychomotor Domain, A= Affective Domain**

Course Materials

This course introduces the following topics:

- Python programming
- Machine learning basics
- Neural networks
- Convolutional neural networks
- Recurrent neural networks
- Introduction to Deep Learning and comparison with Machine Learning
- Neural Networks

- Hyperparameters tuning, regularization and optimization
- Convolutional Neural Networks
- Deep Learning for Vision Problems
- Autoencoders
- Generative Models
- Sequence Models
- Attention Networks

Course Weekly Schedule

The course schedule for 16 weeks are detailed below

Week	Topic
1	Introduction and motivation to the course, Machine Learning introduction, advantages and applications, Machine Learning introduction, advantages and applications.
2	Machine learning basics (supervised, unsupervised, reinforcement), Training data, training objectives, overfitting and under fitting, Classification and regression
3	Introduction to neural networks, What are artificial neural networks
4	Multi-layer feed forward network-1, Multi-layer feed forward network-II
5	Gradient descent in neural networks I, Gradient descent in neural networks II
6	Implementing the neural networks in Python, Application of neural networks in telecommunication, Application of neural networks in bioinformatics.
7	Introduction to Deep Learning and comparison with Machine Learning. Neural Networks:, Single and Multi-Layer Neural Networks, Deep Neural Networks, Perceptron Rule, Gradient Descent
8	Back propagation, Loss Functions for Regression(e.g. Mean Squared Error, Mean Absolute Error) and Loss Functions for Classification (e.g. Binary Cross-Entropy and Categorical Cross-Entropy)
9	Hyperparameters tuning, Regularization and Optimization: Test Set, Validation Set, Overfitting, Underfitting, Regularization, Hyper parameter tuning, Data Augmentation, Vanishing/Exploding Gradients,Weight/Initialization Methods, Hyperparameters tuning, Regularization and Optimization, Activation Functions, Softmax, Optimization Algos, Gradient Descent with momentum, Learning rate adaptation (e.g. AdaGrad, RMSProp, Adam)
10	Convolutional Neural Networks (CNN): Classic CNNs: AlexNet, VGG, GoogleNet, ResNet, DenseNet. Transfer Learning

Week	Topic
11	Deep Learning for Vision Problems: Classification + Regression Object Localization & Detection, Bounding box predictions, Anchor boxes, Region Proposal Networks
12	Deep Learning for Vision Problems: Detection Algorithms: RCNN, Faster RCNN, Yolo, SSD
13	Autoencoders: Variational Auto-Encoders
14	Generative Models: Generative Adversarial Networks (GANs), Types of GANs (e.g. Cyclic GANS , DC)
15	Sequence Models: Intro to RNN & Back Prop through time Long Short-Term Memory (LSTM)
16	Sequence Models: Deep Captioning, Image Caption Generation, Machine Translation, Text Generation & Summarization, Attention Networks

Recommended Textbooks

1. Fundamentals of Deep Learning: Designing Next-Generation Machine Intelligence Algorithms 1st Edition by Nikhil Buduma
2. Neural Networks a Comprehensive-Foundation, 2 nd Ed. By Simon-Haykin, 2005
3. Neural Networks and Learning Machines - S.Hykin.3ed.2009