Birla Institute of Technology and Science Pilani

K.K. Birla Goa Campus

AY 2021–22, Semester I

Course Handout

Course Metadata

Course Name	**Deep Learning**
Course Code	CS F425
IC Name	Tirtharaj Dash
IC Chamber No.	D-168
Lecture modes	Board, PPT, Python-Notebooks

Scope and Objective of the course

Neural Networks has had a long and rich history and the reincarnated viewpoint has shifted towards "Deep Neural Networks" or "Deep Learning" since the extensive use of powerful graphics processors. This course on Neural Networks would focus on the conceptual and mathematical foundation of Deep Learning along with computational investigations of various models as a part of series of laboratory experiments and projects.

At the end of this course, students should be able to deal with various real-world problems and can model such deep learning machines which, of course, depends on whether the problem is a machine learnable (or neuro-computable) problem.

Book(s)

Primary text books:

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville, *Deep Learning*, MIT Press.
2. Aggarwal, C. C. (2018). Neural networks and deep learning, Springer.

Other good books that I will refer:

1. Graves, A. (2012). Supervised sequence labelling with recurrent neural networks.
2. Francois Chollet, Deep Learning with Python, Manning Publishers.
3. E. Stevens, L. Antiga, T. Viehmann, Deep Learning with PyTorch, Manning Publishers.

We will also look at relevant papers from: NeurIPS, ICLR, ICML, IJCAI, AAAI.

Course plan (Weeks: 'W', Labs: 'L')

In the following, we assume that the maximum number of available weeks is **14**. At present, I have not yet created a crisp chapter-wise reference materials for my lectures; I will be updating this information soon.

Preliminaries Shallow neural nets, cost function, search space, derivative based optimisation, gradient descent and its variants (stochastic, mini-batch, batch), effects of search hyperparameters, various learning algorithms: `SGD`, `RMSProp`, `Adam`. **[W: 1–2, L: 1]**

Multilayered Neural Nets Multilayer perceptron (intuition and maths), width and depth of neural network, activation functions, parameter initialisation strategy, cost function, backpropagation using gradient descent (importance of chain rule of derivative), hyparparamter tuning, regularisation, dropout, dropconnect. **[W: 3–5, L: 2]**

Neural Nets for Computer Vision Learning from visual data, convolution operation (intuition and maths), pooling, variants of convolution function, dense convolutional neural networks (DenseNets), backpropagation in convolutional neural networks, state-of-the-art CNN architectures, application to image classification and object detection. **[W: 6–8, L: 3]**

Neural Nets for Sequence Learning Learning from sequential data, recurrence in input and recurrence in hidden layers, backpropagation through time, truncated backpropagation, problem of vanishing or exploding gradients in backpropagation, Long short-term memory cells, gated recurrent units, attention mechanism, Transformers, BERT **[W: 9–11, L: 4–5]**

Neural Nets for Representation Learning Idea behind neural networks as representation learning machines, autoencoder (intuition and maths), under- and over-complete autoencoders, loss functions, learning in autoencoders, de-noising autoencoders, deep networks pretraining and autoencoder as a pretrained model. **[W: 12–13, L: 6]**

Neural Nets for Generative Modeling Intuition behind learning probability distribution in neural networks, variational autoencoders (VAE), β-VAE, restricted Boltzmann machine, energy function as joint probability distribution, generative adversarial networks (inutition and maths). **[W: 13–14, L: 7]**

Evaluation Scheme

Component	Mark	Type
Midsem Exam	30	Open Book (Online)
Lab Assignment 1	10	-NA-
Lab Assignment 2	10	-NA-
Major Project	20	-NA-
Comprehensive Exam	30	Open Book (Online)

- This course will be taken by Undergrads and Grad students (Masters and PhDs).
- This evaluation scheme will apply to students from all degrees and streams including Masters and PhDs.

Course Notices

All the announcement will be made in Google Classroom page.

Attendence, Make-up and Malpractice Policies

- Either come to all the lectures or don't come at all!
- Make-up shall be granted only in genuine cases based on individual's need and circumstances.
- No marks for an evaluative component will be awarded without a make-up.
- Malpractice policies are as per institute regulations.

Chamber Consultation Hour

Will be notified in the class.