Birla Institute of Technology and Science Pilani

K.K. Birla Goa Campus

AY 2021–22, Semester II

Course Handout

Course Metadata

Course Name	**Deep Learning**
Course Code	CS F425
Instructors	Tirtharaj Dash (IC), Tanmay T. Verlekar
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", primarily due to, (a) availability of the large amount of data, (b) extensive use of powerful graphics processors, (c) availability of software libraries to facilitate deep network implementations, and (d) significant involvement of industrial research labs in deep learning research.

This course on "Deep Learning" would focus on the conceptual and mathematical foundation and computational investigations of recent deep models as part of a series of laboratory experiments and projects. For instance, we will focus on newer convolutional neural networks such as VGG Net, ResNet; various sequence models including attention-based models such as transformers; and also we will touch upon graph representation learning using graph neural networks.

At the end of this course, students should be able to (0) pose real-world problems in deep learning, (1) source and prepare datasets, (2) design suitable deep network architecture, (3) prepare input-output representation (and encodings), (4) decide and design a suitable loss function for training a deep network, (5) training and deploying deep models.

Book(s)

Primary textbooks:

1. A. Zhang, Z.C. Lipton, M. Li, A.J. Smola, Dive into Deep Learning.
2. Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press.
3. Aggarwal, C. C. (2018). Neural networks and deep learning, Springer.
4. W.L. Hamilton, Graph Representation Learning Book.

Other good reference books include:

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.

Textbook-3 is available in our library. Other books are available as e-books as href-ed. Additioanlly, we may also look at relevant papers from NeurIPS, ICLR, ICML, IJCAI, AAAI. These will be primarily used during major and minor projects design.

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

In the following, we assume that the maximum number of available weeks is **14**.

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, graph representation learning with graph neural networks. **[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]**

Course Websites

- Classroom website: Google Classroom link
- Lab website: CS-F425_Deep-Learning. (adapted from the previous semester)

We will update the lecture materials in both the places. Google classroom page will be used for official course-related communications including quizzes, scores and feedback.

Evaluation Scheme

Component	Mark	Type	Date and Time
Midsem Exam	30	Open Book (Online)	see timetable
Lab Assignment 1	10	-NA-	March, 2022
Lab Assignment 2	10	-NA-	April, 2022
Major Project	20	-NA-	April–May, 2022
Comprehensive Exam	30	Open Book (Online)	see timetable

- Midsem exam and comprehensive exam will be in the form of Google quizzes unless otherwise specified and announced by AUGSD.
- 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 announcements will be made on the Google Classroom page.

Attendence, Make-up and Malpractice Policies

- Attending lectures is optional and there is no weightage for attendance. Lectures have dependencies; If you miss out on one lecture you may not understand much in the lectures that follow.
- 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

We will notify this in the lecture. If you wish to talk to us or discuss anything, just drop an email at {tirtharaj,tanmayv}@goa.bits-pilani.ac.in and we should get back to you.