Approved in 38th BoA Meeting (22-01-2021)

Course Name: Advanced Topics in Deep Learning
Course Number: CS672
Credits: 3-0-2-4
Prerequisites: CS671: Deep Learning and its Applications.
Distribution: Discipline Elective for final year BTech CSE, DSE and EE, Elective for other final year B.Tech disciplines, MS, M.Tech, and Ph.D. students.

Preamble: In the recent world deep learning has taken the center stage to solve most of the real-world problems that can be framed as an AI/ML problem. It has been observed that deep learning has started from scaling and tweaking existing algorithms. But now deep learning-based optimization frameworks are now exploring new horizons of machine learning to solve real-world problems with human-level precision. In this course, our focus will be to unravel some of these new learning paradigms and explore their feasibility and scope.

Course Outline: This course will start by exploring some recent generative and adversary network (GAN) architectures utilized for generating new media by learning the data distribution directly. Later a whole new series of Transformer networks will be covered followed by the latest deep learning paradigm of Deep Reinforcement Learning. The graph-based neural networks will be studied in order to understand learning over irregular data. Finally, several recently proposed deep learning paradigms such as capsule nets of teacher-student networks will be covered.

Course Content :

1. **GAN series** (8 Hrs)**:** Deep Convolutional GAN (DCGAN), Conditional GAN (cGAN), Wasserstein GAN (WGAN), Stacked GAN (StackGAN), Attention GAN, Picture to Picture GAN (Pix2Pix), Cyclic GAN (Cycle GAN), Discover Cross-Domain Relations (DiscoGAN), Super Resolution GAN (SRGAN), Texture GAN, Self Attention GAN (SAGAN)

2. **Transformer Networks** (6 Hrs): Drawbacks of Recurrent Neural Networks, Self Attention, Transformers, Bidirectional Encoder Representation from Transformer (BERT), Generative pre-trained Transformer (GPT).

3. **Deep Reinforcement Learning** (10 Hrs): Basic of reinforcement learning, Markov decision process, Value and Q-value functions, Deep Q-learning, Deep Policy Gradient iteration (Reinforce Algo)

4. **Graph-based Deep Learning** (5 Hrs): Basics of Graph Convolutional Neural Network (GCN), Graph Embeddings, Spectral and Spatial GCNs, Graph Autoencoders.

5. **Some latest miscellaneous deep learning paradigms and concepts** (10 Hrs)**:**
   a. Capsule Network
   b. Teacher-student network
   c. Attention and Self-attention mechanism

d. Multi-task learning
e. Novel loss functions
f. Model compression/Network Pruning: redundant filter removal, filter ranking, and filter attention.
g. Explainable AI

6. **Advance deep learning application** (3 hrs) **(optional/cover in above topics/related to projects):**
   a. CV related: Object detection, Tracking with Re-id, Flow networks,
   b. NLP related: Summarization, text generation,
   c. Misc: Domain Adaptation etc.

Reference Material:

- **[Lecture Material]** Most of the material will be covered from the recently published research papers at prestigious venues like NIPS, CVPR, ECCV, ICCV, ICLR, etc.

- **[Textbook]** Dive into Deep Learning by Aston Zhang et.al.
  (Book website: https://d2l.ai/) (Book PDF: https://d2l.ai/d2l-en.pdf)

- **[Reference Books]** Deep Learning by Ian Goodfellow and Yoshua Bengio and Aaron Courville (Book website: https://www.deeplearningbook.org/)

- **[Few Reference Courses]**
  - [CS231n, DL Stanford course] https://www.youtube.com/watch?v=vT1JzLTH4G4&list=PLC1qU-LWwrF64f4QKQT-Vg5Wr4qEE1Zxk
  - [CS224n, NLP Stanford course] https://www.youtube.com/watch?v=8rXD5-xhemo&list=PLoROMvodv4rOhcuXMZkNm7j3fVwBBY42z
  - [DeepMind RL course by David Silver] https://www.youtube.com/watch?v=2pWv7GOvuf0&list=PLqYmG7hTraZDM-OYHWgPebj2MfCFzFObQ

1. Similarity Content: Less than 5%. Only some overlap in the first topic of Modules 1 and Module 2 with "CS671: Deep learning and its Applications".