**BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI**

**WORK INTEGRATED LEARNING PROGRAMMES**

**Digital**

Part A: Content Design

|  |  |
| --- | --- |
| **Course Title** | Deep Learning |
| **Course No(s)** |  |
| **Credit Units** | 4 |
| **Credit Model** | 1 - 0.5 - 1.5.  1 unit for class room hours, 0.5 unit for Tutorial, 1.5 units for  Student preparation. 1 unit = 32 hours |
| **Content Authors** | Ms. Seetha Parameswaran |
| **Version** | 2.0 |
| **Date** | August 07th, 2019 |

**Course Objectives**

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| --- | --- |
| **No** | Course Objective |
| **CO1** | Introduce students to the basic concepts and techniques of Deep Learning. |
| **CO2** | Students will be able apply deep learning models to applications. |
| **CO3** | Students will be able to evaluate deep learning algorithms. |

**Text Book(s)**

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| --- | --- |
| T1 | Deep Learning by Ian Goodfellow , Yoshua Bengio, Aaron Courville. MIT Press 2016. |

**Reference Book(s) & other resources**

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| --- | --- |
| R1 | Introduction to Deep Learning by Eugene Charniak. The MIT Press 2019 |
| R2 | Deep Learning with Python by Francois Chollet. 1st Edition. Manning Publications Co 2018. |
| R3 | Dive into Deep Learning by Aston Zhang, Zack C. Lipton, Mu Li, Alex J. Smola. 2019 |

**Content Structure**

1. Introduction
   1. Objective of the course
   2. Review of Machine Learning and Neural Network
2. Deep Feedforward Network
   1. Multilayer Perceptron
   2. Gradient based learning
   3. Architecture design
   4. Back propagation
3. Regularization for Deep models
   1. L2 and L1 Regularization
   2. Constrained Optimization and Under-Constrained problems
   3. Early Stopping
   4. Parameter Tying and Parameter Sharing
   5. Sparse representations
   6. Dropout
4. Optimization of Deep models
   1. Challenges in Neural Network Optimization
   2. Basic algorithms in optimization
   3. Parameter Initialization Strategies
   4. Algorithms with Adaptive Learning Rates
   5. Approximate Second-Order Methods
   6. Optimization Strategies and Meta-Algorithms
5. Convolutional Networks
   1. The Convolution Operation
   2. Pooling
   3. Convolution and Pooling as an Infinitely Strong Prior
   4. Structured Outputs
6. Recurrent and Recursive Nets
   1. Computational Graphs
   2. Recurrent Neural Networks
   3. Bidirectional RNNs
   4. Encoder-Decoder Sequence-to-Sequence Architectures
   5. Deep Recurrent Networks
   6. Recursive Neural Networks
   7. The Long Short-Term Memory and Other Gated RNNs
7. Autoencoders
   1. Regularized Autoencoders
   2. Representational Power, Layer Size and Depth
   3. Stochastic Encoders and Decoders
   4. Denoising Autoencoders
   5. Applications of Autoencoders
8. Generative Adversarial Networks
   1. Overview
   2. Applications of GAN
9. Applications
   1. Computer Vision
   2. Speech Recognition
   3. Natural Language Processing
   4. Recommender Systems

**Learning Outcomes:**

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| No | Learning Outcomes |
| LO1 | Able to understand the basics of Deep Learning. |
| LO2 | Able to understand and apply techniques related to Deep Learning to applications. |
| LO3 | Able to identify appropriate tools to implement the solutions to problems related to Deep Learning and implement solutions. |

**Part B: Learning Plan**

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| **Academic Term** |  |
| **Course Title** | Deep Learning |
| **Course No** |  |
| **Lead Instructor** |  |

|  |  |  |
| --- | --- | --- |
| Session No. | Topic Title | Study / HW Resource Reference |
| 1 | Objective of the course  Review of Machine Learning and Learning algorithms– Task, Performance Measure, Experience  Review of Neural Network – Activation function, Loss function, Optimizer, Stochastic Gradient Descent, Back propagation Algorithm | T1 – Ch5  R2 – Ch2 |
| 2 | Deep Feedforward Networks  Review of Multilayer Perceptron, Gradient based learning, Cost function, output units, hidden units  Demo of one application using Keras and tensorflow  Architecture design, Universal Approximation Properties and Depth, Computational Graph | T1 – Ch6  R2 – Ch3 |
| 3 | Regularization for Deep models  L2 and L1 Regularization, Constrained Optimization and Under- Constrained | T1 – Ch7 |
| 4 | Regularization for Deep models (contd)  Early Stopping, Parameter Tying and Parameter Sharing, Sparse representations, Dropout | T1 – Ch7 |
| 5 | Optimization of Deep models  Challenges in Neural Network Optimization, Basic algorithms in optimization, Stochastic Gradient Descent, Momentum, Parameter Initialization Strategies | T1 – Ch8 |
| 6 | Optimization of Deep models (contd)  Algorithms with Adaptive Learning Rates, AdaGrad, RMSProp, Adam, Approximate Second-Order Methods, Conjugate gradient, BFGS, Optimization Strategies and Meta-Algorithms , Batch normalization | T1 – Ch8 |
| 7 | Convolutional Networks  The Convolution Operation, Pooling, Convolution and Pooling as an Infinitely Strong Prior, Structured Outputs, Demo of CNN on computer vision application | T1 – Ch9  R2 – Ch5 |
| 8 | Review of Session 1 to 7 | Books, Slides, Web references |
| 9 | Convolutional Networks (contd)  Variants of CNN – ImageNet, VGG16, Inception, ResNet, AlexNet  Recurrent and Recursive Nets  Unfolding Computational Graphs, Recurrent Neural Networks | Web references T1 – Ch10  R2 – Ch6 |
| 10 | Recurrent and Recursive Nets (contd)  Bidirectional RNNs, Deep Recurrent Networks, Encoder-Decoder Sequence-to-Sequence, Recursive Neural Networks | T1 – Ch10  R2 – Ch6 |
| 11 | Recurrent and Recursive Nets (contd)  The Long Short-Term Memory, Optimization for Long-Term Dependencies, Demo of RNN for text and sequences | T1 – Ch10  R2 – Ch6 |
| 12 | Autoencoders  PCA, ICA, Regularized Autoencoders, Sparse encoders, Representational Power, Layer Size and Depth | T1 – Ch14  R2 – Ch8 |
| 13 | Autoencoders (contd)  Stochastic Encoders and Decoders, Denoising Autoencoders, Applications of Autoencoders, Demo of Autoencoder | T1 – Ch14  R2 – Ch8 |
| 14 | Generative Adversarial Networks  An overview, applications of GAN | T1 – Ch20 |
| 15 | Applications of Deep Learning  Case studies related to Speech Recognition, Natural Language Processing, Recommender Systems | T1 – Ch12 |
| 16 | Review of session 9 to 15 | Books, Slides, Web references |

**Detailed Plan for Lab work**

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| **Lab No.** | **Lab Objective** | **Lab Sheet Access URL** | **Session Reference** |
| 1 | Introduction to Tensorflow and Keras |  | 2 |
| 2 | Deep Neural Network with Back-propagation and optimization |  | 4 |
| 3 | CNN |  | 7 |
| 4 | RNN |  | 10 |
| 5 | LSTM |  | 11 |
| 6 | Autoencoders |  | 13 |

**Evaluation Scheme**:

Legend: EC = Evaluation Component; AN = After Noon Session; FN = Fore Noon Session

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| --- | --- | --- | --- | --- | --- |
| No | Name | Type | Duration | Weight | Day, Date, Session, Time |
| EC-1 | Quizzes | Online |  | 10% |  |
| EC-2 | Assignments | Take Home |  | 15% |  |
| EC-3 | Mid-Semester Test | Closed Book | 1.5 Hrs | 30% |  |
| EC-4 | Comprehensive Exam | Open Book | 2.5 Hrs | 45% |  |

**Note:**

Syllabus for Mid-Semester Test (Closed Book): Topics in Session Nos. 1 to 8

Syllabus for Comprehensive Exam (Open Book): All topics (Session Nos. 1 to 16)

**Important links and information:**

Elearn portal: [https://elearn.bits-pilani.ac.in](https://elearn.bits-pilani.ac.in/) or Canvas

Students are expected to visit the Elearn portal on a regular basis and stay up to date with the latest announcements and deadlines.

Contact sessions: Students should attend the online lectures as per the schedule provided on the Elearn portal.

Evaluation Guidelines:

1. EC-1 consists of two Quizzes. Students will attempt them through the course pages on the Elearn portal. Announcements will be made on the portal, in a timely manner.
2. EC-2 consists of either one or two Assignments. Students will attempt them through the course pages on the Elearn portal. Announcements will be made on the portal, in a timely manner.
3. For Closed Book tests: No books or reference material of any kind will be permitted.
4. For Open Book exams: Use of books and any printed / written reference material (filed or bound) is permitted. However, loose sheets of paper will not be allowed. Use of calculators is permitted in all exams. Laptops/Mobiles of any kind are not allowed. Exchange of any material is not allowed.
5. If a student is unable to appear for the Regular Test/Exam due to genuine exigencies, the student should follow the procedure to apply for the Make-Up Test/Exam which will be made available on the Elearn portal. The Make-Up Test/Exam will be conducted only at selected exam centres on the dates to be announced later.

It shall be the responsibility of the individual student to be regular in maintaining the self-study schedule as given in the course hand-out, attend the online lectures, and take all the prescribed evaluation components such as Assignment/Quiz, Mid-Semester Test and Comprehensive Exam according to the evaluation scheme provided in the hand-out.