RAMAKRISHNA MISSION VIDYAMANDIRA

Syllabus for M.Sc. Computer Science & Machine Intelligence

Course Code: CSMI CC11 **Credit: 4**

Course Type: Core Course Theory

Course Outcome:

The Introduction to Deep Learning course deals with background and working principles of different deep learning models e.g., multilayer-perceptrons, convolutional neural network, recurrent neural network etc. Furthermore, various optimization algorithms such as Gradient Descent, Adam, RELU etc. which are used for training such deep neural networks. At the end of this course students would have knowledge of different deep learning algorithms for solving various problems.

Key Learning Objectives:

The course is intended to provide the foundations of the practical implementation and usage of Deep Learning.

- Evaluate, in the context of a case study, the advantages and disadvantages of deep learning neural network architectures and other approaches.
- Implement deep learning models in Python using the PyTorch, Keras, Tensorflow libraries and train them with real-world datasets.
- Design convolution networks for handwriting and object classification from images or video.
- Design recurrent neural networks with attention mechanisms for natural language classification, generation, and translation.
- Evaluate the performance of different deep learning models (e.g., with respect to the bias-variance trade-off, overfitting and underfitting, estimation of test error).
- Perform regularization, training optimization, and hyperparameter selection on deep models.

CSMI CC11: Deep Learning

Credit: 4 **Marks: 50**

Introduction to Deep Learning **[5L]**

Overview of deep learning: From machine learning to deep learning. History of deep learning, deep learning success stories. Gradient descent, stochastic gradient descent, momentum, and adaptive subgradient method.

Neural network **[6L]**

Overview, XOR problem, two layer perceptrons. Architecture of multilayer feedforward network. Backpropagation algorithm for multilayer feedforward neural networks.

Convolutional Neural Networks (CNN) **[13L]**

Overview of convolution, design and analysis of CNN, stacking, striding and pooling. Different variants of CNN: LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet etc.

Recurrent Neural Network (RNN) **[13L]**

Concept and applications. Backpropagation through time (BPTT), Vanishing and Exploding Gradients, Truncated BPTT, GRU, LSTMs, bidirectional LSTMs and their applications.

Autoencoders **[13L]**

Undercomplete autoencoders, regularized autoencoders, sparse autoencoders, denoising autoencoders, representational power, layer, size, and depth of autoencoders. Sequence to Sequence Learning and Attention. Introduction to Transformers. Bidirectional Encoder Representations from Transformers (BERT).

Deep Generative Models **[10L]**

Boltzmann Machines, Restricted Boltzmann Machines, Deep Belief Networks, Deep Boltzmann Machines.

Text/References:

1. Deep Learning by I. Goodfellow, Y. Bengio and A. Courville. ISBN: 978-0262-03561-3.
2. Deep Learning and Neural Networks by Charu Aggarwal. ISBN: 978-3-319-94463-0.
3. Neural Networks and Learning Machines by S. Haykin. ISBN: 978-0-13-14713-99.
4. Probabilistic Graphical Models: Principles and Techniques by D. Koller and N.Friedman. ISBN: 978-0262-01319-2.
5. Machine Learning by Tom Mitchell, McGraw-Hill, 1997. ISBN 0070428077.

Journals/Periodicals:

1. IEEE Transactions on Neural Networks and Learning Systems
2. Machine Learning
3. Neurocomputing

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Syllabus for M.Sc. Computer Science & Machine Intelligence

Course Code: CSMI CC12 **Credit: 4**

Course Type: Core Course Theory

Course Outcome:

By the end of the course, the students will demonstrate proficiency with statistical analysis of data. They will develop the ability to build and assess data-based models. They will execute statistical analyses with professional statistical software and will demonstrate skill in data management. Students will also be able to develop an understanding of basic natural language processing. They will also gain an in-depth understanding of the computational and statistical properties of natural languages, the commonly used algorithms for processing linguistic information and compare them. Students will also be able to learn how to analyze large volume text data generated from a range of real-world applications.

Key Learning Objectives:

The course is intended to provide the foundations of the practical implementation and usage of Data Science and Natural Language Processing.

- Students will develop relevant programming abilities.
- Students will demonstrate proficiency with statistical analysis of data.
- Students will develop the ability to build and assess data-based models.
- Students will execute statistical analyses with professional statistical software.
- Students will demonstrate skill in data management.
- Students will apply data science concepts and methods to solve problems in real-world contexts and will communicate these solutions effectively.
- One objective is to ensure that the student will be able to understand the knowledge-based and statistical approaches to language processing for syntax, semantics and pragmatics/discourse.
- The second objective is to ensure the student will be competent enough to implement practically the basics of Natural Language Processing.

CSMI CC12: Data Science and Natural Language Processing (NLP)

Credit: 4 **Marks: 50**

Introduction to Data Science: **[3L]**

Elements, Variables, Data categorization, Measurement, Data management and indexing, introduction to statistical learning.

Data analysis techniques: **[8L]**

Descriptive Statistics:Measures of central tendency, Measures of location of dispersion's;, Basic analysis techniques: Statistical hypothesis generation and testing, Chi-Square test, t-Test, ANOVA(Analysis of variance), Non-Parametric Test: Wilcoxon signed rank test, Mann-Whitney U-test, Kruskal-Wallis H-test, Inferential Statistics through hypothesis tests.

Prescriptive analytics: **[3L]**

Creating data for analytics through designed experiments, Active learning, Reinforcement learning.

Big Data: **[6L]**

Distributed file system, Big Data and its importance, applications, Algorithms using MapReduce, Matrix- Vector multiplication by MapReduce, Apache Hadoop and Hadoop Ecosystem, Moving Data in and out of Hadoop, Understanding inputs and outputs of MapReduce – Data Serialization.

Case studies: **[4L]**

Understanding business scenarios, Feature engineering and visualization, Scalable and parallel computing with Hadoop and MapReduce, Sensitivity analysis, introduction to Spark and it's applications.

Introduction to Natural Language Processing **[2L]**

Introduction to Natural Language Processing (NLP), Aim of NLP, Why is NLP hard.

Basics of Linguistics **[5L]**

Morphology, Parts of Speech (POS), Named Entity Recognition (NER), Parsing

Computational NLP

Basic Text Processing **[3L]**

Tokenization, Zipf's law, tf-idf, Feature engineering, Stemming/Lemmatization, JSON

Word Representations **[3L]**

Distributional Semantics for meaning representation, Word Vectors

Language Models **[4L]**

N-gram Language Model, Recurrent Neural Network based Language Model

Text Classification and Sequence Labeling **[4L]**

Text Classification using Naive Bayes, POS and NER using Recurrent Neural Network

Sequence to Sequence (Machine Translation) **[3L]**

RNN for Sequence to Sequence, Decoding Algorithms: Beam Search,

Transformer Encoder-Decoder **[7L]**

Pretraining, Pretraining for contextual representation: ELMo, BERT

Applications **[5L]**

Sentiment Analysis, Text Summarization, Image Captioning

Text/References:

1. The Elements of Statistical Learning – Trevor Hastie, Robert Tibshirani and Jerome Friedman ; Springer
2. Applied statistics and probability for engineers – Douglas C. Montgomery and George C. Runger ; John Wiley and Sons.
3. Big Data and Analytics - Subhashini Chellappan, Seema Acharya ; WILEY.
4. Data Science and Big Data Analytics : Discovering, Analyzing, Visualizing and Presenting Data – EMC Eduation Services ; Wiley
5. Learning Spark: Lightning-Fast Data Analytics – Jules S. Damji, Brooke Wenig, Tathagata Das , Denny Lee ; O'Reilly
6. Speech and Language Processing - Jurafsky and Martin, Pearson Education, 3rd Edition.
7. Foundation of Statistical Natural Language Processing - Manning and Schutze, MIT Press.
8. Natural Language Processing with Python - Steven Bird, Ewan Klein and Edward Loper, O'Reilly Media.

Journals/Periodicals:

1. Natural Language Processing for Human Computer Interaction (VSI-hci2)
2. Association for Computational Linguistics
3. ACL Anthology

RAMAKRISHNA MISSION VIDYAMANDIRA

Syllabus for M.Sc. Computer Science & Machine Intelligence

Course Code: CSMI CC13 **Credit: 4**

Course Type: Elective I Theory

Course Outcome:

By the end of the course, the students will be able to demonstrate knowledge and understanding of human and computer vision systems, current approaches to image formation and image modelling, current approaches to basic image processing and computer vision, identify basic concepts, terminology, theories, models and methods in the field of computer vision, · describe known principles of human visual system, · describe basic methods of computer vision related to multi-scale representation, edge detection and detection of other primitives, stereo, motion and object recognition, suggest a design of a computer vision system for a specific problem

Key Learning Objectives:

The course is intended to provide the foundations of the practical implementation and usage of Computer Vision.

- Students will demonstrate awareness of the current key research issues in computer vision
- Students will develop and evaluate solutions to problems in computer vision
- Students can analyse and design a range of algorithms for image processing and computer vision
- Students will be able to implement basic image processing algorithms
- To introduce students the fundamentals of image formation
- To introduce students the major ideas, methods, and techniques of computer vision and pattern recognition
- To develop an appreciation for various issues in the design of computer vision and object recognition systems
- To provide the student with programming experience from implementing computer vision and object recognition applications

Elective I
CSMI CC13: Computer Vision

Credit: 4 **Marks: 50**

Introduction to Computer Vision **[8L]**

Machine vision system and its task, image brightness optics and lenses, sensing of monochrome and colour images, Binary and gray level image, Human vision structure and neurovisual model.

Imaging Geometry **[12L]**

Pin-hole camera model, World Point-image point projection, 3-D transforms, co-ordinate transformations, Homogeneous and inhomogeneous co-ordinate systems, Camera Calibration.

Early processing **[14L]**

Smoothing and noise cleaning, Concept of primal sketch, Edge detection and finding - differential operators and their discrete approximation. Properties of different types of edge operators, effect of noise on local edge operators, detection and localisation of edges, scale space, Some algorithms like those of Canny and Hough.

Reflectance map and photometric stereo **[6L]**

Image brightness and radiometry, image formation and surface reflectance under different source conditions. Reflectance map and bidirectional reflectance distribution function, photometric stereo - recovering albedo and surface orientation.

Range measurement and recovering scene geometry **[8L]**

Stereo (binocular) technique – Depth from disparity, Epipolar line and plane, matching based on edge and feature, Invariance, Key points, Corner Detection including Harris algorithm.

Motion field and optical flow **[8L]**

Motion field, optical flow - smoothness, boundary conditions, solution of optical flow under constraint conditions, Brightness constancy, discontinuities of optical flow, Lucas-Kanade and Horn-Schunck algorithm.

Application based vision systems **[4L]**

Model based recognition system, 3-D model based vision system, architecture for computer vision.

Text/References:

1. B. K. P. Horn: Robot vision, M.I.T. Press. 2. Brown & Ballard: Computer vision, Prentice Hall
2. D. Ballard: Computer vision, Brown Prentice Hall.
3. B. K. P. Horn and M. J. Brooks : Shape from Shading, M.I.T. Press.
4. Y. Shriai: 3-D Vision, Springer and Verlag.
5. M. A. Fisher and O. Fischan : Readings in Computer Vision, Morgan and Kaufman Publisher.
6. H. Weschler: Computational Vision, Academic Press.

Journals/Periodicals:

1. Proceedings of the IEEE International Conference on Computer Vision
2. Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition
3. IEEE Transactions on Pattern Analysis and Machine Intelligence
4. International Journal of Computer Vision

RAMAKRISHNA MISSION VIDYAMANDIRA

Syllabus for M.Sc. Computer Science & Machine Intelligence

Course Code: CSMI CC14 **Credit: 4**

Course Type: Practical

Deep Learning Lab and Data Science and NLP Lab

Credit: 4 **Marks: 50**

Deep Learning Lab

Credit: 2 **Marks: 25**

Learn to work with different deep learning frameworks like Keras, Tensorflow, Pytorch etc, Implementation of SVM/Softmax classifier using KNN and 3 layer neural network, 2. Study the effect of batch normalization and dropout in neural network classifier, Implementation of various CNN, RNN, Autoencoders models, working with Generative Adversarial Networks, Familiarization of cloud based computing like Google Colab.

Text/References:

1. Deep Learning From Scratch: Building with Python from First Principles by Seth Weidman published by O`Reilley.
2. Deep Learning with Python by Francois Chollet.
3. Advanced Deep Learning with Keras by Rowel Atienza.
4. Hands-On Deep Learning Algorithms with Python by Sudharsan Ravichandran.
5. Machine Intelligence: Demystifying Machine Learning, Neural Networks and Deep Learning by Suresh Samudrala.

Data Science and NLP Lab

Credit: 2 **Marks: 25**

Data Science Lab

Credit: 1 **Marks: 12.5**

Develop distributed code using the Scala programming language; Transform structured data using SparkSQL, DataSets, and DataFrames; Frame big data analysis problems as Apache Spark scripts; Optimize Spark jobs through partitioning, caching, and other techniques; Build, deploy, and run Spark scripts on Hadoop clusters; Process continual streams of data with Spark Streaming; Traverse and analyze graph structures using GraphX; Analyze massive data set with Machine Learning on Spark.

Text/References:

1. Practical Statistics for Data Scientists, 2nd Edition by Peter Bruce, Andrew Bruce, Peter Gedeck ; O'Reilly Media, Inc. ISBN: 9781492072942
2. Python Data Science Handbook by Jake VanderPlas, O'Reilly Media Publication
3. Big Data for Chimps A Guide to Massive-Scale Data Processing in Practice byPhilip Kromer, Russell Jurney ; O'Reilly

NLP Lab

Credit: 1 **Marks: 12.5**

Work with Text Files with Python, practical on Zipf's and Heaps' law, utilize Regular Expressions for pattern searching in text, learn about Stemming and Lemmatization, use Part of Speech Tagging to automatically process raw text files, understand Named Entity Recognition, use SciKit-Learn for Text Classification, use logistic regression, naïve Bayes, and word vectors to implement sentiment analysis, complete analogies & translate words, use the Word2Vec algorithm, Use dynamic programming, hidden Markov models, and word embeddings to implement autocorrect, autocomplete & identify part-of-speech tags for words, working with PDF files in Python, use Spacy for ultra fast tokenization, understand Vocabulary Matching with Spacy, visualize POS and NER with Spacy, use Latent Dirichlet Allocation for Topic Modelling, use NLTK for Sentiment Analysis

Text/References:

1. Practical Statistics for Data Scientists, 2nd Edition by Peter Bruce, Andrew Bruce, Peter Gedeck ; O'Reilly Media, Inc. ISBN: 9781492072942
2. Python Data Science Handbook by Jake VanderPlas, O'Reilly Media Publication
3. Big Data for Chimps A Guide to Massive-Scale Data Processing in Practice by Philip Kromer, Russell Jurney ; O'Reilly
4. Speech and Language Processing - Jurafsky and Martin, Pearson Education, 3rd Edition.
5. Natural Language Processing with Python - Steven Bird, Ewan Klein and Edward Loper, O'Reilly Media.
6. Natural Language Processing with Python and spaCy: A Practical Introduction - Yuli Vasiliev. No Starch Press.

RAMAKRISHNA MISSION VIDYAMANDIRA

Syllabus for M.Sc. Computer Science & Machine Intelligence

Course Code: CSMI CC15 **Credit: 4**

Course Type: Practical

Elective-I Lab and Project Designing

Credit: 4 **Marks: 50**

Elective I
Computer Vision Lab

Credit: 2 **Marks: 25**

Implementation of various techniques of computer vision using python.

Project Designing

Credit: 2 **Marks: 25**

Designing the synapsis of project / internship and presentation.