M. Sc. (Artificial Intelligence and Machine Learning)

Course Name: Advanced Python

Course Code: MSCAI 122

Objectives:

This course will introduce students to advanced python implementations and the latest Machine Learning and Deep learning libraries, Scikit-Learn and TensorFlow. The course will be hands on with major focus on practical implementation of concepts. The course will have two mini projects to help the students master the concepts.

Prerequisites:

1. Introductory course in Python

Contents:

1. Review of Important Python Concepts [5%]
   Classes, String, Tuples, Lists, Dictionaries, sorting, handling exceptions, using iPython

2. Machine Learning Algorithms with Scikit-learn [10%]
   Pandas Library, Using Scikit-Learn for Logistic Regression, Support Vector Machines, Building Neural Networks,

3. Introduction to Tensor Flow [30%]
   Concept of Computational Graph and Nodes, Virtual Environment and Anaconda, Installing TensorFlow with GPU support on a Linux System, TF Datatypes, Placeholders, TF Variables, TF Session, Softmax, One Hot Encoding, Dropout, building hidden layers, Batching, Stochastic Gradient Descent, Building an Optimizer, Training and displaying results

4. Building a Neural Network with Tensor Flow [5%]
   Using inbuilt TensorFlow functionality to build a Neural Network and train on MNIST Dataset for classification

5. Practical Implementation [50%]
   Mini Project on Machine Learning Application using Scikit-Learn, Mini Project on TensorFlow implementation for a classification problem

Reference Books:

1. Python Machine Learning, Sebastian Raschka
2. Getting Started with TensorFlow, Giancarlo Zaccone

M. Sc. (Artificial Intelligence and Machine Learning)

Course Name: Introduction to Computer Vision

Course Code: MSCAI 124

Objectives:
A.I. has major applications in Computer Vision, especially in object detection, recognition & classification. This course introduces the student to the fundamentals of Image processing and Computer Vision to provide sufficient background so that the student can then tackle the hard problems in later courses.

Prerequisites:
1. Introductory course in Linear Algebra
2. Introductory course in Calculus
3. Introductory course in Probability

Contents:
1. Introduction [20%]
   Overview, Smoothing, Image Morphology, Flood Fill, Resize, Image Pyramids, Thresholding operation

2. Image Transforms [30%]
   Convolution, Gradients and Sobel Derivatives, Laplace, Canny & Hough Transforms, Remap, Stretch, Shrink, Warp, and Rotate, Discrete Fourier Transform (DFT), Discrete Cosine Transform (DCT), Integral Images, Distance Transform, Histogram Equalization

3. Image Parts and Segmentation [20%]
   Parts and Segments, Background Subtraction, Watershed Algorithm, Image Repair by Inpainting, Mean-Shift Segmentation, Delaunay Triangulation, Voronoi Tessellation.

4. Tracking and Motion [20%]
   The Basics of Tracking, Corner Finding, Subpixel Corners, Invariant Features, Optical Flow, Mean-Shift & Camshift Tracking, Motion Templates, Estimators

5. Camera Models and Calibration [10%]
   Developing Camera Model, Calibration, Un-distortion, Putting Calibration Together, Rodrigues Transform

Reference Books:
1. Image Processing: Analysis and Machine Vision, Sonka & Hlavac
2. Digital Image Processing, Gonzalez

M. Sc. (Artificial Intelligence and Machine Learning)

Course Name: Introduction to Machine Learning

Course Code: **MSCAI 123**

Objectives:

Introduce the concept of learning patterns from data and develop a strong theoretical foundation for understanding state of the art Machine Learning algorithms. This course is broad in scope and gives the student a holistic understanding of the subject.

Prerequisites:

4. Undergraduate level course in Linear Algebra
5. Undergraduate level course in Calculus

Contents:

1. Introduction [5%]
   Idea of Machines learning from data, Classification of problem – Regression and Classification, Supervised and Unsupervised learning

2. Linear Regression [15%]
   Model representation for single variable, Single variable Cost Function, Gradient Decent for Linear Regression, Multivariable model representation, Multivariable cost function, Gradient Decent in practice, Normal Equation and non-invertibility

3. Logistic Regression [15%]
   Classification, Hypothesis Representation, Decision Boundary, Cost function, Advanced Optimization, Multi-classification (One vs All), Problem of Overfitting, Regularization

4. Neural Networks [20%]
   Non-linear Hypothesis, Biological Neurons, Model representation, Intuition for Neural Networks, Multiclass classification, Cost Function, Back Propagation Algorithm, Back Propagation Intuition, Weights initialization, Neural Network Training

5. Support Vector Machines [15%]
   Optimization Objective, Large Margin Classifiers, Kernels, SVM practical considerations

6. Unsupervised learning [20%]
   Unsupervised learning introduction, k-Means Algorithm, Optimization objective, Random Initialization, Choosing number of clusters

7. Recommender Systems [10%]
   Problem Formulation, Content based recommendations, Collaborative Filtering, Vectorization, Implementation details.

Reference Books:

1. Machine Learning, Tom M. Mitchell
2. Building Machine Learning Systems with Python, Richert & Coelho

M. Sc. (Artificial Intelligence and Machine Learning)

Course Name: Numerical Optimization

Course Code: MSCAI 121

Objectives:

To teach the student fundamental concepts of optimization both from the point of view of theory as well as practical implementation of algorithms relevant to Machine Learning applications.

Prerequisites:

6. Undergraduate level course in Linear Algebra
7. Undergraduate level course in Multivariable Calculus

Contents:

8. Review of Multivariable Calculus [10%]
   Multivariable functions, Partial Derivatives, Total Derivative, Vector Functions, Gradient, Physical interpretation of Gradient, Existence of Minimum and a Maximum, Continuity of Functions, Taylor's Theorem, Convex Functions

9. Optimization Problem Formulation [10%]
   Statement of an Optimization problem, Historical development, Classification of Optimization problems and techniques, Single variable optimization problem, Iterative algorithmic approach

10. One Dimensional Unconstrained Optimization [10%]
    Unimodality and bracketing, Fibonacci Method, Golden Section Method, Line search

11. Unconstrained Optimization [30%]
    Necessary and Sufficient conditions for optimality, Convexity, Steepest Descent Method, Hessian Matrix, Conjugate Gradient Method, Newton's Method, Quasi-Newton Method, Approximate Line Search

12. Constrained Optimization [20%]
    Necessary conditions for optimality, sufficient conditions for optimality, sensitivity of solution, Sequential Quadratic Programming, Duality, Exterior penalty functions, interior penalty functions

13. Direct Search methods [20%]
    Hooke-Jeeves Pattern Search, Powell's Methods of Conjugate directions, Nelder-Mead's Simplex methods, Simulated Annealing, Genetic Algorithms

Reference Books:

a) Optimization Concepts and Applications in Engineering, Belegundu
b) Engineering Optimization, 2^{nd} Edition, Ravindran & Reklaits
c) Practical Methods of Optimization, R. Fletcher