Course Plans for CCE 2021-22 – Prof. Deepak Subramani, IISc deepakns@iisc.ac.in

Course 1: Foundations of Data Science and Machine Learning [Aug-Dec 2021]

Objectives:

The course provides an accessible, yet rigorous mathematical foundation in probability, statistics, linear algebra, and calculus required to understand data science including analytics, machine learning and deep learning. Classes involve hands-on problem solving along with concepts being introduced through examples from the viewpoint of data science. At the end of the course, students would have gained enough knowledge to solve problems in foundational mathematics topics and undertake further advanced courses in Data Science, Analytics and Machine Learning with confidence.

Syllabus:

Probability and Statistics Module: Probability axioms; Conditional Probability; Bayes' Theorem; Independence; Counting Problems; Discrete and Continuous Random Variables; Expectation; Iterated Expectation; Total Law of Probability; Covariance; Correlation; Entropy; Mutual Information; Frequentist Inference; Bayesian Inference.

Calculus Module: Functions; Derivatives; Multivariate Calculus; Jacobian; Hessian.

Linear Algebra Module: Vectors; Matrices; Basis; Norms; Orthonormality; Linear System, Rank, and Solution; Linear Transformation; Matrix Multiplication; Matrix Decomposition: QR Factorization; Cholesky Decomposition; Singular Value Decomposition; Eigen Decomposition.

Credits: 3:0

Target Audience:

Data Science Enthusiasts; Industry Professionals; Academic Teachers; Researchers

Pre-Requisites:

High-School Mathematics

Textbooks:

1. Bertsekas, Dimitri P., and John N. Tsitsiklis. Introduction to Probability. Vol. 1. Belmont, MA: Athena Scientific, 2002.
2. Gibert Strang. Linear Algebra for Everyone, Wellesley-Cambridge Press, 2020
3. Notes and problem sets from the instructor

Course 2: Hands-On Machine Learning [Jan-May 2022]

Objectives:

The course introduces and trains participants in different supervised and unsupervised Machine Learning and Deep Learning algorithms, with examples drawn from business, engineering, and sciences. Emphasis is laid on understanding the algorithms as well as using them in practice through hands-on mini-projects and case studies. At the end of the course, students would be able to recognize, model and solve problems that benefit from application of machine learning.

Syllabus:

Machine Learning Process and Workflow; Software Tools for Machine Learning: Python, Data Handling, Visualization, Scikit Learn, TensorFlow2, Keras; Supervised Learning: Regression, Classification, Support Vector Machines, Decision Trees, Ensemble Learning, Random Forests, Neural Networks; Unsupervised Learning: Clustering, Anomaly Detection, Dimensionality Reduction; Deep Learning: Multi-layer Perceptron, Convolutional Networks, Recurrent Networks.

Credits: 3:0

Target Audience:

Data Science Enthusiasts; Industry Professionals; Academic Teachers; Researchers

Pre-Requisites:

Basic Mathematics and Programming

Textbooks:

1. Géron, Aurélien. *Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow: Concepts, tools, and techniques to build intelligent systems*. Second Edition. O'Reilly Media, 2019.
2. Bishop, Christopher M. *Pattern Recognition and Machine Learning*. Springer, 2006.
3. Murphy, Kevin P. *Machine Learning: A Probabilistic Perspective*. MIT Press, 2012.

Course 3: Advanced Data Analytics and Optimization [Aug-Dec 2022] - Tentative

Objectives:

The course introduces and trains participants in advanced analytics (Time-Series Analysis and Forecasting, Spatio-Temporal Modeling, Bayesian Learning, Data Assimilation) and optimization methods (Linear and Nonlinear Programming) for business, engineering, and sciences. Emphasis is laid on understanding the algorithms as well as using them in practice through hands-on mini-projects and case studies. At the end of the course, students would be able to identify and apply advanced analytics and optimization in practical scenarios.

Syllabus:

Applied Time-Series Analysis: Review of Probability and Statistics; Auto-Regressive, Moving Average and ARMA Models; Models for Non-stationary Data.

Spatio-Temporal Modeling: Working with geospatial data in socio-technical, engineering and scientific domains; Machine Learning Models for geo-spatial data analytics.

Bayesian Learning and Data Assimilation: Fundamentals of Bayesian Thinking for Data Analytics; Data Assimilation of Dynamical Systems – Filtering, Ensemble Methods; Hidden Markov Models.

Optimization: Linear Programming, Quadratic Programming – Problem Formulation and Solution Algorithms

Credits: 3:0

Target Audience:

Data Science Enthusiasts; Industry Professionals; Academic Teachers; Researchers

Pre-Requisites:

Basic Mathematics and Programming; Some Knowledge of Machine Learning Helps

Textbooks:

1. Nielsen, Aileen. *Practical time series analysis: prediction with statistics and machine learning*. O'Reilly Media, Inc., 2019.
2. Särkkä, Simo. *Bayesian Filtering and Smoothing*. Cambridge University Press, 2013.
3. Bertsimas, Dimitris, and John N. Tsitsiklis. *Introduction to linear optimization*. Vol. 6. Belmont, MA: Athena Scientific, 1997.

Instructor's Website: http://cds.iisc.ac.in/faculty/deepakns/

About Instructor: Deepak Subramani received his Ph.D. in Mechanical Engineering and Computation, and MS in Computation for Design and Optimization from Massachusetts Institute of Technology (MIT), Cambridge USA. He has a B.Tech and M.Tech from IIT Madras. Currently he is an assistant professor in the Dept. of CDS, IISc where his research focuses on ML/AI for Environmental and Geoscience Applications, Data-Driven Modeling, Autonomous Vehicle Routing, Bayesian Learning, Uncertainty Quantification and Data Assimilation.

Student Feedback to the Instructor's courses at IISc regular classes and CCE programs:

IISc Courses Average Instructor Feedback Score: 4.73/5

The following are raw responses:

"Great lecture as always. Thank you for making it interactive."

"Prof. Deepak is not only thorough with the subject matter, but also great at communicating and articulating his knowledge. Wonderful!"

"His articulation skills and making someone understand the concepts is beyond excellence! Among, the best teachers basis my learning opportunities at different stages of life!"

"Brilliant session!! Crystal clear objectives; relatable examples and optimum pace."

"Thanks for using several techniques that helps to remember, reinforce and stay focused on the session. to quote few
- Summarizing the learning objectives post finishing that topic - reinforces the learning.
- small 5 mins breaks are more effective than a long break - it helps to regain our focus and adjust to the learning pace
- liked the quick survey/ test"

"Many thanks to the Prof to present such complex topics in lucid and easily correlated context."

"Simply love the knowledge of the professor, teaching methodology of the professor and relevant examples given"

"great clarity on the concepts, simple explanation, apt examples"

"The delivery and explanations were great."

Things I liked about the course: "1. The maths behind each algorithm. 2. Practical python commands. 3. Instructor's thumb rules/experience of when to use what. This helps a lot. 4. Knowledge beyond what's taught on ML courses in Coursera etc."

“The practical/coding aspects along with theory knowledge. Explanation of working/math behind each algorithm”

“To quote one example, I have heard explanations about posteriori and Priori in earlier courses, but your explanation was really good.”

“It's a gratitude mail for giving us one of the most enjoyable course in IISc. I had real fun studying Numerical Optimization, where each task didn't seem like a burden to complete. Proper mix of theory and practical implementations as most of us seek in courses at IISc.

In today's exam, I particularly enjoyed Part-C Q2 solving it by hand (Dynamic Program question). The exam pattern throughout has been consistent and well-planned. Also, the online semester didn't become a hurdle, which we saw in other courses.

Today is my birthday and this has been a good gift.”

“I just wanted to send a quick note to thank you for the best way you taught the concepts of optimization.

I recently had my comprehensive exam in which I have given 'Numerical Optimization' as one of my subjects. It was your teaching which aided in better understanding of optimization techniques and helped me in my comprehensive exam.”

“Thank you Sir. I found the course very useful, in the way it was taught. Helped improve the learning process and develop a way of thinking solutions to problems in general. It was also one of the best online course experience for me, extremely interactive like a classroom lecture.”

“Kudos to the effort to deliver these lectures in such a precise way”

“The best lecture from the best professor”

“Thank you so much for the best informative session!”