Indian Institute of Technology Guwahati

Proposal for a New Course

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| Course Number & Title: ME 6\_ \_ Principles of Machine Learning | |
| L-T-P-C: 3-0-0-6 | |
| Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): Regular Letter Grades | |
| Kind of Proposal (New Course / Revision of Existing Course): New Course | |
| Offered as (Compulsory / Elective): Elective | |
| Offered to: B.Tech (Fourth Year); M.Tech and Ph.D. | |
| Offered in (Odd/ Even / Any): Any | |
| Offered by (Name of Department/ Center): Mechanical Engineering | |
| Pre-Requisite: None | |
| Preamble / Objectives:  Principles of Machine Learningintroduces the mathematical models and algorithms required to implement core tasks in machine learning. It focuses on fundamental algorithmic and statistical concepts in machine learning. The course is designed to develop not only an in-depth understanding of Machine Learning but also learn to apply techniques from Machine Learning to solve engineering problems. The proposed course is markedly different in terms of its orientation. Emphasis is on understanding AI and ML techniques for Intelligent Mechatronic Systems and Data-driven Mechanics, increasingly gaining importance in view of the emphasis on Industry 4.0, Smart Manufacturing and Digital Twins within Mechanical Engineering. | |
| Course Content/ Syllabus  Introduction: Learning from Observations; Overview of different forms of Learning. History, Trends and Future Directions. Basics of Probability, Linear Algebra, and Optimization.  Supervised Learning: Regression and Linear Classification. Logistic Regression. Nonparametric Methods. Decision Trees. Support Vector Machine. Nonlinear models, Kernel Methods. Neural Networks and Connectionist Learning. Deep Learning.  Unsupervised Learning: Clustering problem, K-means, Mixtures of Gaussian, Expectation maximization. Dimension reduction, PCA. Representation Learning, Matrix Factorization. Autoencoders, Generative Adversarial Networks. Reinforcement Learning: Markov Decision Processes. Policy Evaluation and Iteration, Value Iteration, Extensions to  Dynamic Programming and Contraction Mapping. Model-Free Prediction. Model-Free Control. Value Function Approximation. Different Policy Gradients, including Finite Difference, Monte-Carlo and Actor Critic. Integrating Learning and Planning. Case Study: RL in Classical Control Problems. | |
| Books (In case UG compulsory courses, please give it as “Text books” and “Reference books”. Otherwise give it as “References”. | |
| References: (Format: Authors, *Book Title in Italics font,* Volume/Series, Edition Number, Publisher, Year.) | |
| 1. | Tom M. Mitchell. *Machine Learning*. McGraw-Hill, 1997. |
| 2. | Trevor Hastie, Robert Tibshirani and Jerome Freidman. *The Elements of Statistical Learning: Data Mining, Inference, and Prediction.* 2nd Edition, Springer, 2009. |
| 3. | Stuart Russell and Peter Norvig. *Artificial Intelligence: A Modern Approach*. 3rd Edition, PHI, 2009. |
| 4. | Richard S. Sutton and Andrew G. Barto. *Reinforcement Learning: An Introduction*. 2nd Edition, MIT Press, 2018. |
| 5. | Stephen Marsland. *Machine Learning: An Algorithmic Perspective*. 2nd Edition, CRC Press, 2015. |

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|  | Detailed Course Content (Optional)  It will not be included in the Courses of Study Booklet |  |
| Sl.  No. | Broad Title / Topics | Number of Lectures |
| 1 | Introduction. Basics of Probability, Linear Algebra, and Optimization. | 02 |
| 2 | Regression and Linear Classification. | 02 |
| 3 | Logistic Regression. | 01 |
| 4 | Nonparametric Methods. Decision Trees | 02 |
| 5 | Support Vector Machine. Nonlinear models, Kernel Methods. | 03 |
| 6 | Neural Networks and Connectionist Learning. | 02 |
| 7 | Deep Learning. | 04 |
| 8 | Clustering, K-Means, Mixtures of Gaussians and Expectation Maximization | 03 |
| 9 | Dimension reduction, PCA. | 01 |
| 10 | Representation Learning, Matrix Factorization. | 02 |
| 11 | Autoencoders. Generative Adversarial Networks. | 04 |
| 12 | Markov Decision Processes. | 01 |
| 13 | Policy Evaluation and Iteration, Value Iteration, Extensions to Dynamic Programming and Contraction Mapping. | 03 |
| 14 | Model-Free Prediction. Model-Free Control. | 02 |
| 15 | Value Function Approximation. | 02 |
| 16 | Different Policy Gradients, including Finite Difference, Monte-Carlo and Actor Critic. | 04 |
| 17 | Integrating Learning and Planning. | 02 |
| 18 | Case Study: RL in Classical Control Problems. | 02 |
|  | Total Number of Lectures = | 42 |