

Indian Institute of Technology, Kanpur

Proposal for a New Course

1. Course No: **EE 798L**
2. Course Title: **Machine Learning for Wireless Communications**
3. Per Week Lectures: 3
4. Credits: 9 Duration of Course: Full Semester
5. Proposing Department/IDP: Electrical
Other Departments/IDPs which may be interested in the proposed course: None
6. Other faculty members interested in teaching the proposed course:
Rajesh Hegde, Washim Uddin Mondal
7. Proposing Instructor(s): Rohit Budhiraja
8. Course Description:
Machine learning is now being applied to design sixth generation (6G) wireless communication systems. Objective of this course is to bridge the gap between theory of machine learning and its applications to wireless systems. To achieve the objective, this course will teach underlying machine learning concepts in the class. Students will then design various applications of machine learning for signal processing and wireless systems and implement using MATLAB/PYTHON/CUDA programming languages. Course will therefore involve MATLAB/PYTHON/CUDA coding component, which will also be considered for evaluation.
At the end of the course, students will be able to understand and appreciate the machine learning model requirements specific for wireless communication systems, and design the models accordingly.

A) Contents (*preferably in the form of 5 to 10 broad titles*):

S. No	Broad Title	Topics	No. of Lectures
1.	Linear Modeling: A Least Squares Approach	Linear modeling, Generalization and over fitting, Regularized least squares. Wireless application - zero-forcing receiver design	3
2.	Linear Modelling: A Maximum Likelihood Approach	Errors as noise – thinking generatively, Maximum likelihood, Bias-variance trade-off, Effect of noise on parameter estimates, Wireless application – minimum mean squared receiver design	3
3.	Bayesian inference	Exact posterior, Marginal likelihood, Hyperparameters, conjugate and non-conjugate models, exponential family distribution, K-means clustering, Gaussian mixture models, sparse Bayesian learning Wireless application - Massive multiple input multiple output (MIMO) channel estimation	6
4.	Approximate Bayesian inference	General Problem, latent variable model, variational learning, and variational EM, local variational inference, variational learning as optimization, point estimate, Laplace approximation, MH sampling Wireless application - Variational Bayes for IoT device detection	9
5.	Deep neural network	Introduction and principles, Idea of bias, different activation functions, basic of multilayer perceptron and convolutional	3

		neural network. Application: 6G transceiver chain design.	
6.	Transformers	Attention: Transformer processing, self attention, multi-head attention, Natural language: word embedding, tokenization, Transformer language models: decoder transformer, encoder transformer. Wireless application – 6G channel state information compression	6
7.	Generative Adversarial Networks (GAN)	Adversarial training: loss function, GAN training in practice, Wireless application – 6G channel generation	2
8.	Diffusion models	Forward encoder: Diffusion kernel, conditional distribution, Reverse decoder: Training the decoder, predicting the noise, generating new samples. Wireless application – 6G channel prediction, direction of arrival estimation in 6G integrated sensing and communication (ISAC) wireless systems	7

B) Pre-requisites, if any: Undergraduate/Graduate linear Algebra, probability, and basic programming skills

C) Short summary for including in the Courses of Study Booklet: Course teaches probabilistic and deep machine learning architectures to design state-of-the-art wireless Communication systems. Objective of this course is to bridge the gap between theory of machine learning and its applications to 6G wireless systems.

▪ Recommended books:

9. Textbooks:

- Pattern Recognition and Machine Learning by Christopher Bishop [PRML]
Christopher Bishop, Springer, 2010.

Reference Books/documents:

- Probabilistic Machine Learning: by Christopher Bishop [PML]
Kevin P. Murphy, MIT Press 2021.

10. Any other remarks: Taught it thrice already in 2021, 2022, 2023 as EE798L with 200, 100 and 80 students, respectively

Dated: _____ Proposer: Rohit Budhiraja

Dated: _____ DUGC/DPGC Convener: _____

The course is approved / not approved

Chairman, SUGC/SPGC

Dated: _____