# APPLIED OPTIMIZATION FOR WIRELESS, MACHINE LEARNING, BIG DATA

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**PRE-REQUISITES :** Basic knowledge of - Calculus, Probability, Matrices

**INTENDED AUDIENCE :**

- -Students in Electrical Engineering, Electronics and Communication Engineering, Mathematics, Economics, Computer Science
- -Practicing engineers
- -Technical and Non-technical managers of Telecomm companies
- -Students preparing for Competitive Exams with focus on Wireless Communication, Signal Processing
- - Students pursuing projects or research in Optimization and Wireless Communication

**INDUSTRIES APPLICABLE TO :** Most companies in Electronics, Communication and Signal Processing. Examples are Qualcomm, Broadcom, Intel, MediaTek, Samsung etc. Companies in Machine Learning, AI, Big-Data and Finance will also find the content useful

**COURSE OUTLINE :**

This course is focused on developing the fundamental tools/ techniques in modern optimization as well as illustrating their applications in diverse fields such as Wireless Communication, Signal Processing, Machine Learning, Big-Data and Finance. Various topics will be covered in different areas such as; Wireless: MIMO/ OFDM systems, Beamforming, Cognitive Radio and Cooperative Communication; Signal Processing: Signal Estimation, Regularization, Image Reconstruction; Compressive Sensing: Sparse estimation, OMP, LASSO techniques; Machine Learning: Principal Component Analysis (PCA), Support Vector Machines (SVM); Big-Data: Recommender systems, User-rating prediction, Latent Factor Method; Finance: Financial models, Portfolio Optimization.

The course is suitable for all UG/PG students and practicing engineers/ scientists/ managers from the diverse fields mentioned above and interested in learning about the novel cutting edge applications of modern optimization technology.

**ABOUT INSTRUCTOR :**

Prof. Aditya K. Jagannatham received his Bachelors degree from the Indian Institute of Technology, Bombay and M.S. and Ph.D. degrees from the University of California, San Diego, U.S.A. From April '07 to May'09 he was employed as a senior wireless systems engineer at Qualcomm Inc., San Diego, California, where he was a part of the Qualcomm CDMA technologies (QCT) division. His research interests are in the area of next-generation wireless cellular and WiFi networks, with special emphasis on various 5G technologies such as massive MIMO, mmWave MIMO, FBMC, NOMA, Full Duplex and others. He has contributed to the 802.11n high throughput wireless LAN standard and has published extensively in leading international journals and conferences. He was awarded the CAL(IT)2 fellowship at the University of California San Diego and the Upendra Patel Achievement Award at Qualcomm.

He is currently a Professor in the Electrical Engineering department at IIT Kanpur, where he holds the Arun Kumar Chair Professorship, and is also associated with the BSNL-IITK Telecom Center of Excellence(BITCOE). He has been twice awarded the P.K. Kelkar Young Faculty Research Fellowship for excellence in research, the Qualcomm Innovation Fellowship (QInF) and the IIT Kanpur Excellence in Teaching Award. His popular video lectures for the NPTEL(National Programme on Technology Enhanced Learning) course on Advanced 3G and 4G Wireless Mobile Communications can found at the following YouTube link ( NPTEL 3G/4G ). He has also successfully conducted several Massive Open Online Courses (MOOCs) on various topics such as Applied Game Theory, MIMO OFDM Wireless Systems, Probability and Random Processes, Signals and Systems, Principles of Communication Systems, which have been widely adopted and appreciated. A book authored by him titled Principles of Modern Wireless Communications Systems has been published by McGraw Hill Education and comprehensively covers several key aspects of modern wireless technologies.

**COURSE PLAN :**

**Week 1 :** Introduction to properties of Vectors, Norms, Positive Semi-Definite matrices, Gaussian Random Vectors

**Week 2 :** Introduction to Convex Optimization – Convex sets, Hyperplanes/ Half-spaces etc. Application: Power constraints in Wireless Systems

**Week 3 :** Convex/ Concave Functions, Examples, Conditions for Convexity. Application: Beamforming in Wireless Systems, Multi-User Wireless, Cognitive Radio Systems

**Week 4 :** Convex Optimization problems, Linear Program, Application: Power allocation in Multi-cell cooperative OFDM

**Week 5 :** QCQP, SOCP Problems, Application: Channel shortening for Wireless Equalization, Robust Beamforming in Wireless Systems

**Week 6 :** Duality Principle and KKT Framework for Optimization. Application: Water-filling power allocation,Optimization for MIMO Systems, OFDM Systems and MIMO-OFDM systems

**Week 7 :** Optimization for signal estimation, LS, WLS, Regularization. Application: Wireless channel estimation, Image Reconstruction-Deblurring

**Week 8 :** Application: Convex optimization for Machine Learning, Principal Component Analysis (PCA), Support Vector Machines

**Week 9 :** Application: Cooperative Communication, Optimal Power Allocation for cooperative Communication, Geometric Program

**Week 10 :** Application: Compressive Sensing, Sparse Signal Processing, OMP (Orthogonal Matching Pursuit), LASSO (Least Absolute Shrinkage and Selection Operator) for signal estimation

**Week 11 :** Application: Radar for target detection, Array Processing, MUSIC, MIMO-Radar Schemes for Enhanced Target Detection

**Week 12 :** Application: Convex optimization for Big Data Analytics, Recommender systems, User Rating Prediction, Optimization for Finance