The Fu Foundation School of Engineering and Applied Science Department of Electrical Engineering

Signals, Information and Data

James Anderson

COLUMBIA UNIVERSITY

IN THE CITY OF NEW YORK

Signals, Information and Data











John W Paisley

Xiaodong Wang

John N. Wright

James Anderson

Shih-Fu Chang

Faculty

James Anderson – Control, optimization, learning

Shih-Fu Chang – Multimedia

John Paisley - Bayesian nonparametrics, deep learning

Xiaodong Wang – Communications, statistical and genomic signal processing

John Wright – High-dimensional data, optimization, images

Many faculty have connections, e.g., *Dimitris Anastassiou* – Computational Biology, *Nima Mesgarani* – neural signal processing, *Aurel Lazar* – neuroengineering...

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Possible Course Sequences

Please consult the web version!



Green = Senior/grad; Orange = Advanced graduate; Bold border = offered regularly; Updated June 2021

Recent topics for ELEN E688*, EECS E689*, EECS E669*, & other related topics courses: (Red=Offered Spring '21)

ELEN E4903 Topic: Machine Learning (*Spring* '16) EECS E6690 Topic: Stat. Learning in Bio. & Info. Sys. (*Fall* '21 - '18, *Spring* '18) EECS E6691 Topic: Advanced Deep Learning (*Spring* '21) EECS E6699 Topic: Mathematics of Deep Learning (*Spring* '21, '19) ELEN E6880 Topic: Mathematics of Deep Learning (*Spring* '21, '19) ELEN E6880 Topic: Mathematics of Deep Learning (*Spring* '14, '13, '12, '11) ELEN E6881 Topic: Multicarrier Resource Allocation (*Fall* '14) ELEN E6882 Topic: Valuticarrier Resource Allocation (*Fall* '14) ELEN E6882 Topic: Visual Search Engine (*Spring* '12, '11) ELEN E6883 Topic: Detection & Estimation (*Fall* '10, '09, '08, '06) ELEN E6883 Topic: An Intro to Blockchain Technology (*Spring* '21, '20, '19) ELEN E6884 Topic: Data Compression (*Spring* '14, '13, '12, '11) ELEN E6885 Topic: Reinforcement Learning (*Fall* '17- '21) ELEN E6885 Topic: Sprise Rep. / High Dim. Geom. (*Spri* '17, *Fall* '15, ..) ELEN E6887 Topic: Statistical Learning Theory (*Spring '10, '09*) ELEN E6888 Topic: Broadband Wireless (*Spring '17, '10 - '16*) ELEN E6888 Topic: Large-Scale Stream Proc. (*Spr '21,'17, Fall '15, Spr '14, '10*) EECS E6890 Topic: Visual Recognition and Search (*Spring '14, '13*) EECS E6890 Topic: Reproducing Computational Results (*Spring '14, '13*) EECS E6892 Topic: Bayesian Models in Machine Learning (*Fall '15, Spring '14*) EECS E6893 Topic: Bayesian Models in Machine Learning (*Fall '15, Spring '14*) EECS E6894 Topic: Deep Learning for Comp. Vision & NLP (*Fall'18,Spr '17, '15*) EECS E6895 Topic: Adv. Big Data Analytics (*Spring '21, '15-'20*) EECS E6895 Topic: Distributed Storage Sys. For Big Data (*Fall '21, '20', '19*) EECS E6895 Topic: From Data to Solutions (*Fall '12, '16, Spr '16, Fall '12, '21, '17*)

E4810 Digital Signal Processing

John Wright, Mondays, 1:10-3:40





Digital filtering in time and frequency domain

Discrete-time signals and systems, sampling theory, transform analysis, system structures, IIR and FIR filter design

Discrete Fourier Transform, Fast Fourier Transforms.

E4650 Convex Optimization

James Anderson, Thursdays, 4:10-6:40

Theory, applications, and algorithms for solving convex optimization problems



Fundamental analysis of the geometry of convex

sets, functions, and optimization problems

Develop theory behind first and second-order algorithms for optimally solving CO problems

Application to data fitting (learning), feedback control, and optimal power flow (energy systems)

E4750 Heterogeneous Computing for Signal and Data Processing

Prof. Zoran Kostic. Thursdays 1:10-3:40



Deploying signal processing and communications algorithms on contemporary mobile processors

Signal processing with heterogeneous computing infrastructures consisting of general purpose, graphics and digital signal processors

Programming languages such as OpenCL and CUDA for computational gains

Project/applications in audio, image and video processing and

E4720 Machine Learning for Signals, Information and Data

Prof. John Wright, Wednesday 1:10-3:40



Introduction to supervised and unsupervised machine learning

Classification and regression models, clustering, sequential models

Linear / logistic regression, support vector machines, boosting, K-means clustering,

mixture models, hidden Markov models

Applications to extraction of information from signals and datasets.

ECBM 4040 Neural Networks and Deep Learning Prof. Zoran Kostic, Fridays 10:10-12:40



Introduction to neural networks and recent advances in deep learning

Focuses on models and intuition – feedforward networks, convolutional networks, recurrent networks, feature learning for classification

Analytical study and software / programming projects

Applications in speech and object recognition

E6601 Introduction to Control Theory

Prof. Richard Longman, Wednesdays 7-9:30 PM





Gruman X-29 Wikipedia

Introduction to classical and modern feedback control (graduate level)

Scalar and matrix differential equation models. Transfer functions, block diagram manipulations, closed-loop response.

Proportional, rate, and integral controllers, and compensators. Design by root locus and frequency response.

Controllability, observability. Luenberger observers, pole placement, and linear-quadratic cost controllers.

E6690 Statistical Learning in Biological and Information Systems

Prof. Predrag Jelenkovic, Tuesdays 4:10-6:40 PM



Fundamental statistical (machine) learning techniques

Basics of statistics and optimization

Supervised & unsupervised learning, inference and prediction, models, regularization

High dimensionality graphs communities ranking association rules

E6893 Topics in Info Processing: Big Data Analytics Prof. C. Y. Lin, Friday 7-9:30 PM



Tree of Life by Dr. Yifan Hu



Facebook friendship graph by Paul Butler

Analyzing Big Data: from acquisition and storage to processing

Platforms, including Hadoop, Spark

Uploading, distribute, and processing data, including HDFS, HBase, KV stores, document database, and graph database

Large-scale machine learning for big data

E6885 Topics in Info Processing: Reinforcement Learning Profs. Li and Zhang, Friday 8:10-10 PM

Reinforcement learning: theory, methods and applications

Learning optimal policies in an online setting, applicable to games, robotics / autonomy, internet user interaction



E6896 Topics in Info. Processing:

Quantum Computing and Communications earning_diagram.svg/500px-Reinforce ment learning diagram.svg.png

Prof. Alexi Ashikhmin, Wednesdays 1:10-3:40 PM



Image: https://upload.wikimedia.org/wikipedia/ commons/thumb/1/1b/Reinforcement_I gearning_diagram.svg/500px-Reinforce ment_learning_diagram.svg.png

Special topics (688X):

ELEN E6880 Topic: Space-Time Coding / SP Wireless Comm. (Sp. '07) ELEN E6880 Topic: MIMO Wireless Communication (Spring '13, '12, '11) ELEN E6881 Topic: Video Coding and Communications (Spring '09, '08) ELEN E6882 Topic: Stat. Methods for Video Index & Analysis (Fall '07) ELEN E6882 Topic: Visual Search Engine (Spring '12, '11) ELEN E6883 Topic: Detection & Estimation (Fall '10, '09, '08, '06) ELEN E6884 Topic: Speech Recognition (Fall '05) ELEN E6884 Topic: Data Compression (Spring '13, '12, '11) ELEN E6885 Topic: Network Science (*Fall '13, '12, '11, '10*) ELEN E6886 Topic: Multimedia Security Systems (Spring '06) ELEN E6886 Topic: Sparse Rep. / High Dim. Geometry (Fall '12, '11) ELEN E6887 Topic: Statistical Learning Theory (Spring '10, '09) ELEN E6888 Topic: Intro. to LTE & WiMax Systems (Spring '13, '12, '11, '10) ELEN E6889 Topic: Distributed Stream Processing and Analysis (Spring '10) EECS E6890 Topic: Visual Recognition and Search (Spring '13) EECS E6891 Topic: Replicating Computational Results (Spring '13) EECS E6898 Topic: From Data to Solutions (Fall '13, '12) EECS E6899 Topic: Auntonomous Multi-Agent Systems (Spring '20)

Related course offerings (coding, communications, etc.)

ELEN 4702 Digital Communications
ELEN 4764 Internet of Things – Intelligent and Connected Systems
ELEN 6761 Computer Communications Networks
ELEN 6776 Topics: Content Distribution Networks
ELEN 6718 Error Correcting Codes: Classical and Modern
ELEN 6322 VLSI hardware architectures for signal processing and machine learning
ELEN 6950 Wireless and Mobile Networking
EEME 6602 Modern Control