FALL 2018 Electrical Engineering Electives

ECE311 Hardware Design

Prereq: ECE211 Signals, ECE241 Electronics I, ECE251 Comp. Arch. *Prof. Shlayan* **3 credits**

Development for signal processing hardware systems: RTL, HDL, synthesis and verification. Special processors including FPGA, multicore, ARM and GPU. ADC and DAC, interchip and intrachip communication; mixed-signal systems, clock and power distribution; loading, sensors and actuators, embedded systems. PCB and surface mount devices. Systems engineering. Course work includes projects involving hardware realizations, simulation and emulation, and software tools for system design.

ECE320 Control Systems

Prereq: ECE211 Signals, Ma240 Diff. Eqns. *Prof. Shlayan* **3 credits**

Block and signal-flow diagrams, Mason's theorem. Laplace transform, frequency response, Bode plots, root locus, Routh-Hurwitz array. Analysis of feedback control systems: open-loop and closed-loop gain, Nichols chart, Nyquist diagram, gain and phase margin. Continuous-time state-space analysis, state-variable feedback, canonical forms, observability and controllability. Second-order models, transient and steady-state performance. Emphasis on analog systems, although digital control systems will be discussed as time allows. Control system simulation or design projects.

ECE357 Computer Operating Systems

Prereq: ECE160/161 Programming for EEs, ECE251 Comp. Arch. *Prof. Hakjner* **3 credits**

Theory and implementation of modern computer operating systems. Message-based and multiprocessor kernels. Networking and interprocess communication. Security, auditing and authentication. Device drivers, interrupt handling, task switching, virtual memory, memory management, scheduling, synchronization and locking. File systems, resource allocation and management. Real-time, fault-tolerant and high security operating systems. User environment and interface issues. Projects in operating system design and programming, case studies.

ECE401 Sel. Top. Comm.: Communication Coding

Prereq: ECE300 Comm. Theory *Prof. Hoerning* **3 credits**

Error-control coding as used in 4G wireless systems, as well as new coding schemes for 5G. Block codes: Hamming codes, Galois fields, BCH and Reed-Solomon codes, cyclic codes, CRC. Convolutional and turbo codes: review of encoders, systematic schemes, RSC, Viterbi algorithm; variations such as tail-biting and duo-binary; the Turbo Principle; log likelihood, MAP decoder and alternatives (log MAP, max log MAP, SOVA). LDPC codes: basics, topics of interest for 5G codes such as spatially coupled and non-binary LDPC. Polar codes, trellis coded modulation. Hybrid ARQ, higher layer interactions.

ECE453 Advanced Computer Architecture

Prereq: ECE251 Comp Arch. *Prof. Kapelyan* **3 credits**

Modern, advanced techniques to design state of the art computer architectures. Technology, performance, and price. The quantitative principle and Amdahl's law. Instruction sets; addressing modes, operands, and opcodes; encoding instruction sets. RISC versus CISC architectures; MIPS. Pipelining; the classic five stage pipeline, hazards, exceptions, floating point operations. Advanced pipelining techniques: dynamic scheduling, branch prediction. Multiple issue, speculation. Limits of parallelism. Compiler support for parallelism, VLIW. Caches. Students design and implement an ISA and working computer.

ECE455 Cybersecurity ***NEW COURSE***

Prereq: ECE303 Comm. Nets, ECE357 Op. Sys. *Prof. Gitzel* **3 credits**

This course covers both attacker and defender perspectives of applied information security. Topics will include networked and embedded applications, access control systems and their failure modes, privilege escalation, intrusion detection, privacy and data breaches and applied cryptography. Each topic will be approached through analysis and discussion of historical cybersecurity incidents and possible mitigations. Safe coding practices and OS flaw mitigation will be explored through case studies and reinforced through security sensitive programming projects. Coursework will include penetration testing, code auditing, and independent projects.

FALL 2018 Electrical Engineering Electives

ECE464 Databases

Prereq: ECE264 Data Struc I *Prof. Sokolov* **3 credits**

Engineering and design of databases. Topics to be covered may include: data models, database and scheme design; schema normalization and integrity constraints; query processing and optimization; distributed and parallel databases; SQL and XML.

ECE469 Artificial Intelligence

Prereq: ECE264 Data Struc. I . *Prof. Sable* **3 credits**

This course covers many subtopics of AI, focusing on a few important subtopics in detail. The "intelligent agent" approach is explained and forms a foundation for the rest of the course. Intelligent search: uninformed search, depth-first search, breadth-first search, iterative deepening; informed search, best-first search, A*, heuristics, hill climbing; constraint satisfaction problems; intelligent game playing, minimax search, alpha-beta pruning. Machine learning: probability, Bayesian learning; decision trees; statistical machine learning, neural networks, Naive Bayes, k-nearest neighbors, support vector machines. Natural language processing: syntax, semantics and pragmatics; real-world knowledge; parsing; statistical NLP. Philosophy of AI: AI and consciousness, the Turing test, the Chinese room experiment. Coursework includes two large individual programming projects.

ECE471 Sel. Top. ML: Computational Graphs for Machine Learning

Prereq: ECE211 Signals,, MA223 Vec. Calc., MA224 Prob. *Prof. Curro* **3 credits**

A survey of computational graphs for machine learning, with a particular focus on differentiable directed acyclic graphs covering applications in unsupervised learning, as well as generative and discriminative modeling. Gradient based methods for optimization (stochastic gradient descent, Nesterov momentum, ADAM). Fast gradient computation for arbitrary computational graphs (automatic differentiation). Exploding and vanishing gradient problems. Convolutional networks. Arbitrary graphs for regression, classification, and ranking. Autoencoders, adversarial networks and variations for unsupervised representation learning, generative modeling and other applications. Focus on applications in computer vision and speech processing; considers research problems in communication theory.

ECE475 Frequentist Machine Learning ***NEW COURSE***

Prereq: ECE211 Sig. Proc., Ma223 Vec. Calc., Ma224 Prob. *Prof. Keene* **3 credits**

Statistical inference, exploratory data analysis and data visualization. Linear regression methods such as ridge, LASSO, elastic net. Classification methods such as logistic regression, SVM. Regularization and feature selection methods. Additive models. Classification and regression trees including random forests and extreme gradient boosting. Model selection and cross validation. Clustering methods such as K-nearest neighbors, spectral clustering. Unsupervised learning methods such as market basket analysis and the a-priori method. Non-negative matrix factorization and recommendation systems.

ECE478 Financial Signal Processing ***NEW COURSE***

Prereq: ECE211 Sig. Proc., Ma224 Prob. *Prof. Fontaine* **3 credits**

This course approaches financial engineering from a signal processing perspective. Stochastic processes: random walks, Brownian motion, Ito calculus, continuous models including Black-Scholes, discrete models including negative binomial, martingales, stopping times. Representation and analysis of financial concepts such as price, risk, volatility, futures, options, arbitrage, derivatives, portfolios and trading strategies. Analysis of single and multiple nonstationary time series, GARCH models. Optimization methods, big data and machine learning in finance.