The ECE 619 - Intelligent Sensing for Smart Grid and Smart City is taught by Prof. Philip Pong. This course introduces the fundamentals and applications of intelligent sensing technology to smart grid and smart city. Sensors, AI, computational intelligence and big data can be integrated and do something smart and impactful. It is appropriate for UG(Junior, Senior)/MS/PhD students of all disciplines.

Department: Electrical and Computer Engineering

College: Newark College of Engineering

Course Instructor: Dr. Philip Pong

Credits: 3

Course description:

This course introduces the fundamentals and applications of intelligent sensing technology to smart grid and smart city. The course covers the fundamental sensing principles, types and selection of sensors. Engineering design of sensing techniques, estimation and evaluation of sensor calibration and their responses by using finite element method, sensor noise and shielding design will be addressed. Signal analysis techniques such as wavelet analysis and sensor fusion will be discussed. Anomaly detection, fault classification and prediction and decision making on sensor data by machine learning, and the applications of electromagnetic sensing in power systems will be covered. Advanced sensor applications topics in smart grid and smart city will also be included.

Prerequisites

Basic knowledge on electromagnetics and circuit theory.

Why is the course needed?

The purpose of this course is to fulfill the growing need of learning and applying sensors in engineering. The 21st century is an age of sensors. We will soon be living in a world with trillions of sensors with connectivity. People are calling it an Internet of Things (IoT) or Internet of Sensors (IoS). Together with big data and machine learning, this new sensing paradigm is going to bring about revolutionary changes to smart grid and smart city. Sensors are going to play a major role in practical engineering projects as well as blue sky research.

Skillsets to be learned:

Data analytics such as supervised and unsupervised learning, support vector machine
Handling big data
Behaviorally-inspired and evolution-based algorithms such as particle swarm optimization and genetic algorithm
Machine learning
Finite element method (FEM) simulation
MATLAB, Simulink, Simscape

For whom is the course intended?

UG(Junior, Senior)/MS/PhD students

Course assessment:

Homework (16%), mini-capstone project (17%), quizzes (8%), midterms (25%), final exam (25%), classroom participation (9%)

Day, time and location:

Wednesday, 6 – 8:50pm, FMH 407

Syllabus:

Topic 1:	Sensors: fundamentals • Sensors for realizing smart homes, autonomous vehicles, root of IoT • Sensors and transducers, common transduction principles, common sensor categories in IoT • Current status of power grids, autonomous energy grids, Monitoring challenges for the existing power grids • Electromagnetic sensors in smart phones, Comparison of magnetic sensors, Sensor applications in smart grid and smart city • Terminology, sensor classification, magnetic sensors
Topic 2:	Engineering design of sensing techniques • Sensor calibration and response • Design tool: finite element method (FEM) simulation • Physical phenomena can be solved by FEM

	• MATLAB partial differential equation (PDE) toolbox • FEM simulation of electrostatically actuated MEMS device
Topic 3:	Design consideration: noise and shielding • Nature of noise, why is noise a concern • Intrinsic noise • Extrinsic noise • Shieldings
Topic 4:	Sensor signal analysis • Time-frequency analysis, Morlet wavelet convolution, convolution in the time domain • Filter-Hilbert method • Basic frequency-domain manipulation • Multivariate time series analysis • Principal component analysis
Topic 5:	Sensor fusion • Sensor fusion, fusion architectures, approaches of sensor fusion • Least-square error method, maximum likelihood estimation, Bayesian inference, Kalman filter • Neural network, activation function, training, backpropagation, feed-forward neural network, recurrent neural network, recurrent neural network long short term memory, radial basis function neural network, convolutional neural network • Machine fault diagnosis • Voting methods, majority (plurality) vote, voting for fusion of ranked data, Condorcet criterion, Borda count, monotonicity criterion, instant runoff voting, Copeland's method, threat assessment problem, voting logic fusion
Topic 6:	Data analytic • Big data • K-nearest neighbor algorithm • Regression models • Density-based spatial clustering of applications with noise • Support vector machine classifier
Topic 7:	Finding answers from measurement: inverse problem & search algorithm • Inverse problem, unconstrained minimization, basic optimization, minimization with equality constraint, economic dispatch Lagrangian, • Newton-Raphson algorithm for root finding • Steepest descent method • Genetic algorithm • Particle swarm optimization

Reference books:

"Sensors and Actuators: Engineering System Instrumentation," by Clarence W. de Silva, ISBN 9781466506817, 2nd ed., Publisher: CRC Press.
"Fundamentals of Time-Frequency Analyses in Matlab/Octave," by Mike X Cohen, 1st ed., Publisher: sinc(x) Press. (available for free on Amazon Kindle)
"Computational and Statistical Methods for Analysing Big Data with Applications," by S. Liu, J. Mcgree, Z. Ge, Y. Xie, ISBN 9780128037324, 1st Edition, Publisher: Academic Press (available online through NJIT Library)

NJIT statement on academic integrity:

"Academic Integrity is the cornerstone of higher education and is central to the ideals of this course and the university. Cheating is strictly prohibited and devalues the degree that you are working on. As a member of the NJIT community, it is your responsibility to protect your educational investment by knowing and following the academic code of integrity policy that is found at: http://www5.njit.edu/policies/sites/policies/files/academic-integrity-code.pdf.

Please note that it is my professional obligation and responsibility to report any academic misconduct to the Dean of Students Office. Any student found in violation of the code by cheating, plagiarizing or using any online software inappropriately will result in disciplinary action. This may include a failing grade of F, and/or suspension or dismissal from the university. If you have any questions about the code of Academic Integrity, please contact the Dean of Students Office at dos@njit.edu"

Policy on Generative AI:

This course expects students to work without artificial intelligence (AI) assistance in order to better develop their skills in this content area, except for the mini-capstone project.