ME 592X: Data Analytics and Machine Learning for Cyber-Physical Systems Applications

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Lecture Class Time (Location): Spring 2017 - T R 3:40 pm – 5:00 pm (TBD)

Course content:

- Problem/data identification - Temporal, spatial, spatiotemporal, continuous, discrete, event-driven, text, categorical
- Categorization/association of CPS problems – design and verification, anomaly detection, cyber-attack/physical fault detection and diagnostics, event classification, condition monitoring and prediction, failure mitigation strategies, remaining useful life calculation
- Data preparation – variable selection, data quality check, basic transformation/filtering, basic image processing – segmentation, enhancement and registration
- Domain knowledge utilization and handling physical (time, energy, cost and safety criticality) constraints from a CPS perspective
- Feature extraction and Modeling – (1) Supervised vs. unsupervised vs. reinforcement; shallow vs. hierarchical; spatial, temporal and spatiotemporal; semantic vs. dimension reduction; time-series vs. image. (2) Brief introduction to learning and inference techniques for variety of ML approaches such as regression, mixture models, kernel methods, matrix factorization based methods, ensemble approaches with a special focus on Probabilistic Graphical Modeling and Deep Learning
- Inference and decision-making – solving CPS problems (as mentioned above) and result interpretation from a CPS perspective, cause-effect relationships and visualization
- Selected applications in complex cyber-physical systems such as energy systems, smart grid, transportation networks, commercial buildings, manufacturing and agricultural systems.
- Introduction to open source ML libraries and platforms

Measurable learning outcomes: Upon successful completion of the course, students will be able to –

• Formulate various CPS problems in different domains as a data analytics problem

• Curate and pre-process data (time-series and image) obtained from a CPS

• Utilize domain knowledge of a CPS within data-driven models

• Perform feature extraction and data driven modeling of CPS

• Perform inference with data-driven models and interpret results from a CPS perspective

Class Credits: Three credits (3)

Prerequisites: Basic knowledge in Linear algebra, Probability theory and computer programming

Text Book: No particular text book, various technical papers selected by the instructor, reference books will include “Pattern recognition and Machine Learning” by Bishop, “Probabilistic Graphical Models” by Koller and Friedman, “Deep Learning” by Goodfellow, Bengio and Courville

Grade Makeup: Assignments (60%): Will involve problem solving and computer programming related to machine learning application to various problems of interest; Term project (35%): Group project at the end of the semester, written report and oral presentation will be needed; Class participation (5%)