Ph.D. and Industrial Short Course on Machine Learning in Power Systems

Chalmers University of Technology – in cooperation with IEEE Sweden PE/PEL Joint Chapter

General information

Instructor: Lang Tong, Fulbright Distinguished Chair in Alternative Energy
Cornell University
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Lectures: June 10 & 11 10AM-12PM, 1-4PM (with breaks).
June 14, 10 AM – preliminary 3PM (project presentation)

Locations: Chalmers University of Technology

Credits: 1

Registration: Send an email to Annie Grundevik <annie.grundevik@chalmers.se> with your name, affiliation and research interest. If you are a PhD student, indicate if there is a paper that you would like to choose as part of the project.

Course description

This course introduces three types of machine learning problems and some of their applications in power systems: (i) classification; (ii) regression; (ii) sequential learning and decisions.

Machine learning in classification deals with problems of learning functions with discrete values. Examples in power systems are fault detection, classification, and all types of detection problems. A standard machine learning technique is the support vector machine (SVM). Regression learning deals with learning functions with continuous values. Examples in power systems include state estimation, load or price forecasting, and system parameter estimations. A typical method is the empirical risk minimization with neural networks. Sequential learning and decision-making deal with problems of continuous learning as more data are collected and decisions are made sequentially based on the information available at the time of decision. A popular learning model is reinforcement learning.

Course organization

There are eight one-hour lecture sessions in two days. The course covers some of the basic concepts and formulations in machine learning as well as selected power system applications. On the last day of the course, there will be a 10-minute presentation on a research paper relating to machine learning techniques in power system. The project presentation is required for all PhD students that would like to receive the course credit. The Pass/Fail grade of the course is given based on attendance and the completion of the presentation.

Course material. Lecture notes and research papers.

References

[1] T. Hastie, R. Tibshirani, and J. Friedman, *The elements of statistical learning: data mining, inference, and prediction*, 2nd edition, Springer 2009

[2] R. Sutton and A. G. Barto, *Reinforcement Learning*, 2nd edition, MIT Press, 2018.

Tentative topics

1. Neural networks and learning
    a. Structure of neural network and universal approximation.
    b. Supervised (and unsupervised) learning. Empirical risk minimization
    c. Bag of tricks: stochastic gradient descent, drop-out, early stopping.
    d. Performance: PAC learning, VC dimension, bias-variance tradeoff
    e. Special neural networks: CNN, RNN, GANS, Auto encoder, and LTSM
2. Classification
    a. Hypothesis testing and classification problems.
    b. Structure of classifiers and learning algorithms: SVM, Naïve Bayes, K-mean.
    c. Power system applications: voltage instability detection and assessment.
3. Regression
    a. The regression problem and supervised learning
    b. Power system application: state estimation and bad-data detection
4. Sequential (online) learning
    a. The Markov decision problem (MDP), decision tree, and reinforcement learning
    b. The multi-armed bandit problem (MAB)
    c. Power system application: virtual bidding in the electricity market