Spring 2013

CS 7900-03: Information Security

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CS 7900 Foundations of Machine Learning 03

Instructor: Shaojun Wang
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Lecture Hours and Location: 4:40 pm – 6:00 pm MW, RC 154A
Office Hours: 3:30 pm – 4:30 pm, MW or by appointment

Course Description: Machine learning studies automatic methods for learning to make accurate predictions or useful decisions based on past observations. This course introduces theoretical machine learning, including mathematical models of machine learning, and the design and rigorous analysis of learning algorithms for classification, regression and ranking etc. Topics include: bounds on the number of random examples needed to learn; learning from non-random examples in the on-line learning model (for instance, for investment portfolio selection); how to boost the accuracy of a weak learning algorithm; kernel methods such as support-vector machines; consistency of machine learning methods.

Schedule

1. General introduction; consistency model, basic probability
2. PAC model; PAC Bayesian model; Occam's razor; Chernoff bounds
3. Geometric concepts; VC-dimension; Rademacher complexity; upper and lower bounds on sample complexity
4. Boosting and margins theory; consistency of Adaboost
5. Support-vector machines and kernels; consistency of SVMs
6. Mistake-bounded algorithms; halving algorithm; weighted majority algorithm
7. Linear-threshold algorithms; perceptron; winnow
8. On-line regression; EG and WH; Kivinen and Warmuth's framework
9. Portfolio selection; Cover's algorithm
10. Reinforcement learning; Markov decision processes (MDPs)
11. Game theory; Algorithmic Mechanism Design

Textbook:

1. *Foundations of Machine Learning.* M. Mohri, A. Rostamizadeh, and A. Talwalkar, MIT Press, 2012 **(required)**
2. *Neural Network Learning: Theoretical Foundations.* M. Anthony and P. Bartlett. Cambridge University Press, 1999.
3. *Prediction, Learning, and Games.* N. Cesa-Bianchi and G. Lugosi. Cambridge University Press, 2006.
4. *A Probabilistic Theory of Pattern Recognition.* L. Devroye, L. Gyorfi and G. Lugosi. Springer, 1996.
5. *An Introduction to Computational Learning Theory.* M. Kearns and U. Vazirani. MIT Press, 1994.
6. *Estimation of Dependences Based on Empirical Data.* V. Vapnik, Springer, 2006.
7. *Statistical Learning Theory.* V. Vapnik, John-Wiley, 1998.
8. *Concentration Inequalities.* S. Boucheron, G. Lugosi and P. Massart, Oxford University Press, 2013.
9. *Uniform Central Limit Theorems.* R. Dudley, Cambridge University Press, 1999.
10. *Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations.* Y. Shoham and K. Leyton-Brown, Cambridge University Press, 2008.

Prerequisite: Familiarity with basics in linear algebra, probability, and analysis of algorithms.

Projects and Assignments: There will be 3 to 4 homeworks and two presentations.