IE585

Machine Learning and Optimization

Fall, 2021

Description

Machine learning techniques are successfully used in important application areas, which include manufacturing, operations management, finance and healthcare as well as the more well-known areas such as social networks, recommendation systems, speech recognition and image processing. On the other hand, optimization methods are vital components of machine learning algorithms. This course provides an introduction to machine learning, and introduces the basics of continuous optimization. It covers several examples of supervised learning, various optimization formulations that arise in training those learning models, and some of the basic optimization concepts and algorithms relevant to the structural properties of the resulting optimization problems.

Tentative Schedule

W.1. What is machine learning? Case studies.

W.2. From machine learning to optimization. Linear regression and the least squares problem.

W.3. Smooth unconstrained optimization: Basics.

W.4. Maximum likelihood estimation. Generalized linear models.

W.5. Stochastic optimization methods. Variance reduction.

W.6. In class experimentation with selected algorithms. Some popular machine learning libraries.

W.7. Overfitting and regularization. Optimality without smoothness.

W.8. Midterm

W.9. Basics of convex constrained optimization.

W.10. Classification with support vector machines.

W.11. Paper discussion.

W.12. Matrix completion. Nonconvexity and decompositions in optimization.

W.13. The perceptron algorithm. Introduction to deep learning.

W.14. Overview. What is more?

Prerequisites

Knowledge of probability, statistics, and linear algebra (at the undergraduate level). Working knowledge of a programming language.

Grading

- Assignments (5%)
- Project (30%)
- Midterm (30%)
- Final (35%)

References

- Introductory Lectures on Convex Optimization: A Basic Course, Y. Nesterov, Springer Science & Business Media, 2003.
- Convex Optimization, S.Boyd and L.Vandenberghe, Cambridge University Press, 2004.
- Numerical Optimization, J.Nocedal and S.Wright, Springer, 2006.
- Optimization Methods for Large-scale Machine Learning, L. Bottou, F. E. Curtis, J. Nocedal, SIAM Review, 60(2), 223-311, 2018.
- Machine Learning: A Probabilistic Perspective, K.P. Murphy, MIT Press, 2012.
- Introduction to Machine Learning, E. Alpaydin, MIT Press, 2010.
- Mathematics for Machine Learning, M. P. Deisenroth, A. A. Faisal, and C. S. Ong, Cambridge University Press, 2020.
- Optimization for Machine Learning, Ed. S.Wright and S.Sra, MIT Press, 2011.