STATS 235: Modern Data Analysis (Statistical Machine Learning)

Department of Statistics, UCI

Objective

The objective of this course is to introduces statistical methods in machine learning. We will discuss modern statistical methods commonly applied to complex, high dimensional problems, for which traditional methods might fail. Students are expected to have strong background in statistics and probability. Further, they need to be expert in at least one programming language. By the end of this course, students would learn a range of statistical methods and machine learning techniques, and they would learn how to use these methods to solve complex, high dimensional problems. Throughout this course, students would be exposed to both frequentist and Bayesian paradigms.

Instructor

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Syllabus

I will cover these topics:

- **An overview of some general concepts in statistics and machine learning**: Supervised vs. unsupervised learning; Parametric vs. non-parametric models; Discriminative vs. generative models; Exponential family; Overfitting; Curse of dimensionality; Bias-variance tradeoff; Model selection.
- **Learning**: Decision theory; Frequentist vs. Bayesian inference; Likelihood, prior, and posterior; Optimization vs. integration; Maximum likelihood estimates (MLE); Maximum a posteriori (MAP); Information theory; Entropy; Maximum entropy (Maxent).
- **Unsupervised learning**: K-means clustering; Hierarchical clustering; Mixture of Gaussians; Dirichlet process mixture models; Dimensionality reduction methods.
- **Regression models**: Regularization; Automatic Relevance Determination; Splines; Gaussian process regression models.

- **Classification models**: Linear Discriminant Analysis (LDA); Quadratic Discriminant Analysis (QDA); Naive Bayes classifier; Classification trees; Random forests; SVM; Neural networks.
- **Graphical models**: Bayesian networks; Markov Random Fields (MRF); Hidden Markov Models (HMM); Latent Dirichlet Allocation (LDA).
- **Deep learning**: Deep directed networks; Deep Boltzmann machines; Deep multi-layer perceptrons.

References

Main textbooks

- "Machine Learning, A Probabilistic Perspective," by Kevin Murphy.
- "Elements of Statistical Learning," by T. Hastie, R. Tibshirani, and J. Friedman.

Other relevant references

- "A First Course in Machine Learning," by S. Rogers and M. Girolami.
- "Information Theory, Inference, and Learning Algorithms," by D. MacKay.
- "Probabilistic Inference using Markov Chain Monte Carlo Methods," by R.M. Neal.
- "Bayesian Data Analysis," by A. Gelman, J.B. Carlin, H.S. Stern, and D.B. Rubin.