CIS606: Machine Learning (Spring 2014)

Credits	3
Number	CIS606
Title	**Machine Learning**
Pre-requisites	CIS501 Data Mining: Finding the Data and Models that Create Value
Co-requisites	None
Mathematics topics	Almost all topics to some extent, but, in particular the following: Support Vector Machines, EM Algorithm, Hidden Markov Models,
Fraction of the course requiring proficiency in mathematics	100%
Catalogue Text	This course significantly extends the topics covered in the pre-requisite course, CIS501. The aim is to provide an in-depth treatment of a variety of important concepts, techniques, and algorithms in machine learning. Topics covered include linear regression, boosting, support vector machines, hidden Markov models, and Bayesian networks. The underlying theme in the course is statistical inference as it provides the foundation for most of the methods covered.

Learning Outcomes

Academic knowledge: Students will be able to demonstrate knowledge of:

1. The key concepts and algorithms in machine learning
2. The relationship between mathematical modeling , statistical inference and machine learning techniques

Intellectual skills: Students will be able to:

3. Determine *when, how* and *why* particular algorithms work in given situations.

Subject practical skills: Upon completion, students will be able to do the following:

4. Use machine learning tools to perform key operations such as regression, classification, clustering and visualization
5. Implement and test machine learning techniques using an appropriate scientific computing environment such as Octave (Matlab).

Transferable skills: Upon completion, students will be able to:

6. Communicate scientific and technical issues effectively, both in written and verbal format.

Relationship of course objectives to program outcomes	
Program Outcome 1	Use and apply current technical concepts and practices in core computing and information technologies.
Program Outcome 2	Analyze a problem, and identify and define the computing requirements appropriate to its solution.
Program Outcome 4	Communicate effectively with a range of audiences.

Syllabus

Breakdown by week:

1. Introduction, linear classification; perceptron update rule, convergence, and generalization
2. Maximum margin classification, Classification errors, regularization, logistic regression
3. Linear regression, estimator bias and variance, active learning, non-linear predictions.
4. Kernels, kernel regression.
5. Support vector machines, kernel optimization.
6. Model selection, model selection criteria
7. Description length, feature selection, combining classifiers, boosting
8. **Review + Midterm examination**
9. Boosting (cont'd), margin and complexity
10. Margin and generalization, mixture models
11. Mixtures, EM algorithm, regularization, clustering
12. Clustering (Cont'd), spectral clustering, markov models.
13. Hidden markov models (HMMs), Bayesian networks
14. Learning Bayesian networks, probabilistic inference
15. Review and final examination
16. **Project presentations and wrap-up**

Assessment

- Examinations 40% (divided into midterm and finals with ratio 3:5)
- Projects 55% (three projects, 12.5%, 12.5%, 30%)
- Class participation 5%

Course Texts

- Haykin, Simon. **Neural Networks and Learning Machines**. 3rd Edition. Prentice Hall, 2008. ISBN: 978-0131471399
- Bishop, Christopher. **Pattern recognition and machine learning**. Springer, 2007. ISBN: 978-0387310732

Additional Reading

- Hastie, T., R. Tibshirani, and J. H. Friedman. **The Elements of Statistical Learning: Data Mining, Inference and Prediction**. 2nd Edition. New York, NY: Springer, 2009. ISBN: 978-0387848570.
- Bishop, Christopher. **Neural Networks for Pattern Recognition**. New York, NY: Oxford University Press, 1995. ISBN: 9780198538646.
- Duda, Richard, Peter Hart, and David Stork. **Pattern Classification**. 2nd ed. New York, NY: Wiley-Interscience, 2000. ISBN: 9780471056690.
- MacKay, David. **Information Theory, Inference, and Learning Algorithms**. Cambridge, UK: Cambridge University Press, 2003. ISBN: 9780521642989.