CS5691: Pattern Recognition and Machine Learning: 15 credits

1. **Basics of Probability, Random Processes and Linear Algebra (recap)**
   - Probability: independence of events, conditional and joint probability, Bayes' theorem
   - Random Processes: Stationary and nonstationary processes, Expectation, Autocorrelation, Cross-Correlation, spectra.
   - Linear Algebra: Inner product, outer product, inverses, eigen values, eigen vectors, singular values, singular vectors.
2. **Linear Regression**
   - Polynomial regression
   - Ridge regression
   - Lasso regression
   - Bias-variance decomposition
   - Bayesian Linear Regression

   Short Exam 1
   Programming Assignment 1
3. **Bayes Decision Theory**
   - Minimum-error-rate classification
   - Classifiers, Discriminant functions, Decision surfaces
   - Normal density and discriminant functions
   - Discrete features
4. **Parameter Estimation Methods**
   - Maximum-Likelihood estimation: Gaussian case
   - Maximum a Posteriori estimation
   - Bayesian estimation: Gaussian case
   - Score normalisation – ROC, DET, DCF

   Short Exam 2
   Programming Assignment 2
5. **Unsupervised learning and clustering**
   - Criterion functions for clustering
   - Algorithms for clustering: K-Means, Hierarchical and other methods
   - Cluster validation
6. **Gaussian Mixture Models**
   - Gaussian mixture models
   - Expectation-Maximization method for parameter estimation
   - Maximum entropy estimation
   - UBM-GMM
7. **Sequential Pattern Recognition**
   - Hidden Markov Models (HMMs)
     - Discrete HMMs
     - Continuous HMMs

   Short Exam 3
   Programming Assignment 3
8. **Nonparametric techniques for density estimation**
   - Parzen-window method
   - K-Nearest Neighbour method
9. **Linear discriminant functions**

- Logistic regression
- Perceptron, multilayer perceptron
- Gradient descent procedures, backpropagation
- Support vector machines – a brief introduction

10. **Dimensionality reduction**
    - Principal component analysis – it relationship to eigen analysis
    - Fisher discriminant analysis – Generalised eigen analysis
    - Multiple discriminant analysis
    - PPCA, JFA, NMF – if time permits
11. **Non-metric methods for pattern classification**
    - Non-numeric data or nominal data
    - Decision trees: Classification and Regression Trees (CART).
    - Random forests
12. **Ensemble Methods for classification**
    - Bagging, Boosting, Gradient boosting

Short Exam 4
Programming Assignment 4/Project

Text Books:

bish C.M.Bishop, Pattern Recognition and Machine Learning, Springer, 2006

duda R.O.Duda, P.E.Hart and D.G.Stork, Pattern Classification, John Wiley, 2001

References:

papers Some relevant papers/notes will be put up on the website from time-to-time.

haykin Simon Haykin, Neural Networks: A Comprehensive foundation to Neural Networks or Neural Networks and Learning Machines, any edition will do.

kout S.Theodoridis and K.Koutroumbas, Pattern Recognition, 4th Ed., Academic Press,

Course Schedule:

Week 1	Probability and & Random Processes (A recap) *bishop,class notes*
Week 2	Linear Algebra (A recap) *bishop,class notes*
Week 3	Regression *bishop,class notes*
Week 3-4	Bayesian Decision Theory *duda*
Week 5	Parametric estimation methods *duda,kout,bish*
Week 6	Unsupervised clustering methods *bish*
Week 7	Gaussian Mixture Models *bish*
Week 8	Sequential Pattern recognition *classnotes,duda,bish,Some papers*
Week 9	Non Parametric Methods *duda*
Week 10-11	Linear discriminant functions *duda,bish,haykin*
Week 12	Dimensionality reduction *duda,Some papers*
Week 13	Non-metric methods for classification *class notes*
Week 14	Ensemble methods for classification *class notes*
Week 15	Revision

Teaching Assistants (Tentative):

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Instructor: Hema A Murthy (e-mail: hema@cse.iitm.ac.in, Phone number: 2257-4364)
Evaluation: MidSem (20), Endsem exam (25), Short exams (15), Programming assignments (may include a project) (40)
Assignments: These must be submitted as reports on moodle. Please create an account in moodle for yourself. Ideally done in pairs of two (depends on class size)
Note: Please check the moodle website for cs5691 regularly.