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
   - 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 – its 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:**

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