Engineering Tripos Part IIB, 4F13: Probabilistic Machine Learning, 2020-21

Module Leader
Prof Z Ghahramani [1]

Lecturers
Prof Z Ghahramani & Dr M Hernandez-Lobato [2]

Timing and Structure
Michaelmas term. 14 lectures + 2 examples classes. Assessment: 100% coursework

Prerequisites
3F3 useful

Aims
The aims of the course are to:

- introduce students to basic concepts in machine learning, focusing on statistical methods for supervised and unsupervised learning.

Objectives
As specific objectives, by the end of the course students should be able to:

- demonstrate a good understanding of basic concepts in statistical machine learning.
- apply basic ML methods to practical problems.

Content
Machine learning (ML) is an interdisciplinary field focusing on both the mathematical foundations and practical applications of systems that learn, reason and act. The goal of machine learning is to automatically extract knowledge from observed data for the purposes of making predictions, decisions and understanding the world.

The aim of this module is to introduce students to basic concepts in machine learning, focusing on statistical methods for supervised and unsupervised learning. The module will be structured around three recent illustrative successful applications: Gaussian processes for regression and classification, Latent Dirichlet Allocation models for unsupervised text modelling and the TrueSkill probabilistic ranking model.

- Linear models, maximum likelihood and Bayesian inference
- Gaussian distribution and Gaussian process
- Model selection
- The Expectation Propagation (EP) algorithm
- Latent variable models
The Expectation Maximization (EM) algorithm  
Dirichlet Distribution and Dirichlet Process  
Variational inference  
Generative models, graphical models: Factor graphs

Lectures will be supported by Octave/MATLAB demonstrations.

A detailed syllabus and information about the coursework is available on the moodle website: 

Coursework

<table>
<thead>
<tr>
<th>Coursework activity #1 Gaussian Processes</th>
<th>Format</th>
<th>Due date &amp; marks</th>
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</thead>
<tbody>
<tr>
<td>Coursework 1 brief description</td>
<td>Individual/group Report / Presentation</td>
<td>day during term Fri week 5</td>
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<tr>
<td>Learning objective:</td>
<td>anonymously marked for MPHIL/MLSALT &amp; Undergraduates</td>
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<tr>
<th>Coursework activity #2 Probabilistic Ranking</th>
<th>Format</th>
<th>Due date &amp; marks</th>
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<tbody>
<tr>
<td>Coursework 2 brief description</td>
<td>Individual Report</td>
<td>Fri week 7</td>
</tr>
<tr>
<td>Learning objective:</td>
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<tr>
<th>Coursework activity #3 Latent Dirichlet Allocation models for documents</th>
<th>Format</th>
<th>Due date &amp; marks</th>
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<tbody>
<tr>
<td>Coursework 3 brief description</td>
<td>Individual Report</td>
<td>Fri week 9</td>
</tr>
<tr>
<td>Learning objective:</td>
<td>Anonymously marked for MPHIL/MLSALT &amp; Undergraduates</td>
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Coursework

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<th>Format</th>
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<tr>
<td>• To perform unsupervised learning using Latent Dirichlet Allocation model on a collection of documents.</td>
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**Booklists**

Please refer to the Booklist for Part IIB Courses for references to this module, this can be found on the associated Moodle course.

**Examination Guidelines**

Please refer to Form & conduct of the examinations [4].

**UK-SPEC**

The [UK Standard for Professional Engineering Competence (UK-SPEC) [5]](http://www.engc.org.uk/ukspec.aspx) describes the requirements that have to be met in order to become a Chartered Engineer, and gives examples of ways of doing this.

UK-SPEC is published by the Engineering Council on behalf of the UK engineering profession. The standard has been developed, and is regularly updated, by panels representing professional engineering institutions, employers and engineering educators. Of particular relevance here is the 'Accreditation of Higher Education Programmes' (AHEP) document [6] which sets out the standard for degree accreditation.

The [Output Standards Matrices] [7] indicate where each of the Output Criteria as specified in the AHEP 3rd edition document is addressed within the Engineering and Manufacturing Engineering Triposes.

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**Links**

[1] mailto:zg201@cam.ac.uk
[2] mailto:zg201@cam.ac.uk, jmh233@cam.ac.uk
[4] [http://teaching.eng.cam.ac.uk/content/form-conduct-examinations](http://teaching.eng.cam.ac.uk/content/form-conduct-examinations)
[7] [http://teaching.eng.cam.ac.uk/content/output-standards-matrices](http://teaching.eng.cam.ac.uk/content/output-standards-matrices)