Engineering Tripos Part IIB, 4F10: Deep Learning & Structured Data, 2018-19

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

Prerequisites
Part IIA Modules 3F1, 3F3 and 3F8 advisable

Aims
The aims of the course are to:

- This module aims to teach the basic concepts of deep learning and forms of structure that can be used for generative and discriminative models. In addition the use of models for classifying structured data, such as speech and language, will be discussed

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

- Understand the basic principles of pattern classification and deep learning;
- Understand generative and discriminative models for structured data;
- Understand the application of deep-learning to structured data;
- Be able to apply pattern processing techniques to practical applications.

Content

Introduction (1L)
Links with 3F8 and 4F13. General machine learning, examples of structured data, DNA, vision, speech and language processing.

Decision Boundaries and Probability of Error (1L)
Definition of a decision boundary and forms that result from Gaussian class-conditional probability density functions. Calculation of probability of Error.
Graphical Models and Conditional Independence (1L)
Graphical models and Bayesian networks. Simple inference examples.

Latent Variable and Sequence Models (2L)
Gaussian mixture models and factor analysis; hidden Markov models and expectation maximisation;

Deep Learning (2L)

Deep Learning for Sequences (2L)
Recurrent neural networks, and long-short-term memory models. Variants of RNN including bidirectional RNNs. Use in generative and discriminative models.

Deep Generative Models (1L)
Auto-encoders and variational extension.

Ensemble Methods (1L)
Ensemble methods: random forests, bagging, boosting and model combination.

Support Vector Machines (2L)
Maximum margin classifiers, handling non-separable data, training SVMs, non-linear SVMs, kernel functions. Links with other kernel methods Gaussian Processes, Relevance Vector Machines. Multi-class SVMs and structured SVMs.

Kernels over Structured Data (1L)
Tree kernels, graph kernels, Fisher kernels. Relationship to RNNs.

Booklists
Please see the Booklist for Group F Courses [2] for references for this module.
Examination Guidelines

Please refer to [Form & conduct of the examinations](http://teaching.eng.cam.ac.uk/content/form-conduct-examinations) [3].

**UK-SPEC**

The [UK Standard for Professional Engineering Competence (UK-SPEC)](http://www.engc.org.uk/ukspec.aspx) [4] 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](http://www.engc.org.uk/standards-guidance/standards/accreditation-of-higher-education-programmes-ahep/) [5] which sets out the standard for degree accreditation.

The [Output Standards Matrices](http://teaching.eng.cam.ac.uk/content/output-standards-matrices) [6] 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**

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