Advanced Topics in Machine Learning (COMP0083)

**Description**

**Aims:**
Kernel methods: To gain an understanding of the theory and applications of kernel methods, including:
- An overview of how kernel feature spaces can be constructed, including in infinite dimensions, and the smoothing properties of functions in these spaces;
- Simple and complex learning algorithms using kernels (ridge regression, kernel PCA, the support vector machine);
- Representations of probabilities in reproducing kernel Hilbert spaces. Statistical two-sample and independence tests, and learning algorithms using these embeddings (clustering, ICA);

Learning theory: To learn the fundamentals of statistical learning theory. In particular to:
- Understand what characterizes a learning problem and what it means for an algorithm/system/machine to “learn”;
- Understand the key role of regularization and the different approaches to use it efficiently in practice;
- Acquire familiarity with a variety of statistically consistent learning algorithms, both from modelling and practical perspectives;

**Learning outcomes:**
On successful completion of the module, a student will be able to:
- Gain in-depth familiarity with the selected research topics, understand how to design and implement learning algorithms;
- Individually read, understand and discuss research papers in the field;

**Content:**
Introduction to kernel methods:
- Definition of a kernel, how it relates to a feature space, The reproducing kernel Hilbert space;
- Simple applications: kernel PCA, kernel ridge regression;
- Distance between means in RKHS, integral probability metrics, the maximum mean discrepancy (MMD), two-sample tests;

**Key information**

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<tr>
<th>Year</th>
<th>2019/20</th>
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<tbody>
<tr>
<td>Credit value</td>
<td>15 (150 study hours)</td>
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<tr>
<td>Delivery</td>
<td>PGT L7, Campus-based</td>
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<td>Reading List</td>
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<tr>
<td>Tutor</td>
<td>Prof Arthur Gretton</td>
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<td>Term</td>
<td>Term 1</td>
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**Assessment**

**Find out more**

For more information about the department, programmes, relevant open days and to browse other modules, visit [ucl.ac.uk](http://ucl.ac.uk)
- Choice of kernels for distinguishing distributions, characteristic kernels;
- Covariance operator in RKHS: proof of existence, definition of norms (including HSIC, the Hilbert-Schmidt independence criterion);
- Application of HSIC to independence testing;
- Feature selection, taxonomy discovery;
- Introduction to independent component analysis, kernel ICA;
- Large margin classification, support vector machines for classification; Introduction to supervised learning in the context of statistical learning theory;
- A taxonomy of learning problems;
- No free lunch theorem;
- Regularization;
- Model selection;
- Stability and generalization;
- Measures of complexity for hypotheses spaces;
- Sample complexity, generalization bounds;

**Requisites:**
In order to be eligible to select this module, a student must be registered on a programme for which it is a formally-approved option or elective choice AND must have a strong understanding of Linear Algebra, Probability Theory, and Calculus.
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- **Tutor:** Prof Arthur Gretton
- **Term:** Term 1
- **Timetable:** View on UCL website

**Assessment**

- Written examination (main exam period): 50%
- Coursework: 25%
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**Find out more**

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**Disclaimer:** All information correct as of August 2019. Please note that aspects of the module may be subject to change. UCL will make best efforts to inform applicants of major changes.
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