

## Engineering Tripos Part IIA, 3F8: Inference, 2024-25

### Leader

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### Timing and Structure

Lent Term.

### Prerequisites

3F3 Statistical Signal Processing

### Aims

The aims of the course are to:

- Provide a thorough introduction into the topic of statistical inference including maximum-likelihood and Bayesian approaches
- Introduce inference algorithms for regression, classification, clustering and sequence modelling
- Introduce basic concepts in optimisation and dynamic programming

### Objectives

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

- Understand the use of maximum-likelihood and Bayesian inference and the strengths and weaknesses of both approaches.
- Implement methods to solve simple regression, classification, dimensionality reduction, clustering and sequence modelling problems.
- Implement simple optimisation methods (gradient and coordinate descent, stochastic gradient descent) and dynamic programming (Kalman filter or forward algorithm).

### Content

#### Introduction to inference (2L)

- ~~Introduction to inference~~ decision theory, estimation

## Regression (3L)

- [REDACTED]

## Classification (2L)

- [REDACTED]

## Dimensionality Reduction (2L)

- [REDACTED]

## Clustering (3L)

- [REDACTED]

## Sequence models (3L)

- [REDACTED]

## Very Basic Monte Carlo (introduced through the lectures above)

- [REDACTED]

## Further notes

Lecture allocations above are approximate.

## Coursework

Title: **Logistic Regression for Binary Classification**

To implement an algorithm for performing classification, called logistic regression, using gradient descent optimisation.

### Learning objectives:

- understand the logistic regression model through visualising predictions
- how to apply maximum likelihood and MAP fitting using optimisation
- how to implement gradient ascent
- understand how feature expansions can turn linear methods into non-linear methods

### Practical information:

- Sessions will take place in the DPO, during week(s) [TBD].
- This activity involves a small amount of preliminary work [estimated duration 1hr].

### Full Technical Report:

Students will have the option to submit a Full Technical Report.

### Booklists

There is no required textbook. However, the material covered is treated excellent recent text books:

Kevin P. Murphy Machine Learning: a Probabilistic Perspective [3], the MIT Press (2012).

David Barber Bayesian Reasoning and Machine Learning [4], Cambridge University Press (2012), available freely on the web.

Christopher M. Bishop Pattern Recognition and Machine Learning [5]. Springer (2006)

David J.C. MacKay Information Theory, Inference, and Learning Algorithms [6], Cambridge University Press (2003), available freely on the web.

### Examination Guidelines

Please refer to [Form & conduct of the examinations](#) [7].

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### Links

[1] <mailto:ret26@cam.ac.uk>

[2] <mailto:jmh233@cam.ac.uk>

[3] <http://www.cs.ubc.ca/~murphyk/MLbook>

[4] <http://www.cs.ucl.ac.uk/staff/d.barber/brml>

[5] <http://research.microsoft.com/~cmbishop/PRML/index.htm>

[6] <http://www.inference.phy.cam.ac.uk/mackay/itila/>

[7] <https://teaching24-25.eng.cam.ac.uk/content/form-conduct-examinations>