

Course Structure

- Lectures
 - ★ Tuesday 14:00-14:45 (02/1039)
 - ★ Thursday 16:00-16:45 (54/5025)
 - ★ Friday 17:00-17:45 (35/1005) ■
- Assessment
 - ★ 80% Exam
 - ★ 20% Problem Sheet ■

Problem Sheets

- I am going to provide many problem sheets■
- One problem sheets will be marked and worth 20% (you will know which one this is)■
- The other problem sheets are optional, but some small proportion of the questions will be on the exam■
- I will go through the problem sheets, but if you have not attempted the questions you won't learn that much■

What's in the Course

- This course is going to cover the core principles and mathematics behind machine learning■
- It is not going to explicitly teach different machine learning algorithms■, although some will be covered■
- We are not looking at advanced algorithms but cover the principles■ fish■
- There are very good implementation available (e.g. scikit-learn)■
- Along the way though we will meet (often many times) particular algorithms■

Cracking the Code

- Mathematics is the language of machine learning■
- You can do machine learning without mathematics, but if you want to develop and understand advanced algorithms then you have no choice■
- This course invites you on a journey to crack the code of mathematics for machine learning■
- If this isn't a challenge you want, then this is probably not the course for you■

Topics

- Learning Theory
 - ★ Bias-Variance
 - ★ Overfitting, symmetry and regularisation
 - ★ Ensembling, bagging and boosting■
- Mathematics
 - ★ Function Spaces: Kernel Methods and Gaussian Processes
 - ★ Linear Algebra, embeddings, positive definiteness, subspace, determinants■

Topics Continued

- Optimisation
 - ★ Newton/Quasi-Newton Methods: convergence rates
 - ★ SGD, momentum, ADAM■
- Constrained Optimisation
 - ★ KKT conditions
 - ★ Duality Linear/Quadratic Programming
 - ★ SVMs■
- Convexity
 - ★ Convex sets: linear constraints, PD matrices
 - ★ Convex functions
 - ★ SVMs, Lasso
 - ★ Jensen's inequality■

Topics Continued

- Probability
 - ★ Naive Bayes
 - ★ Gaussian Processes
 - ★ Dependencies and Graphical Models
 - ★ Expectations and MCMC■
- Variational Methods
 - ★ Divergences: KL and Wasserstein
 - ★ VAEs and GANs
 - ★ Entropy and information theory
 - ★ Variational Approximation■