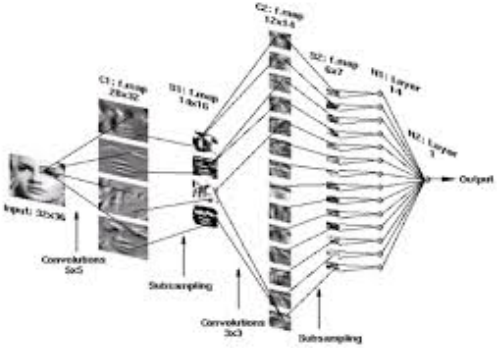
# Advanced Machine Learning

## *Course Outline*



*Course Details and Topics*



# 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