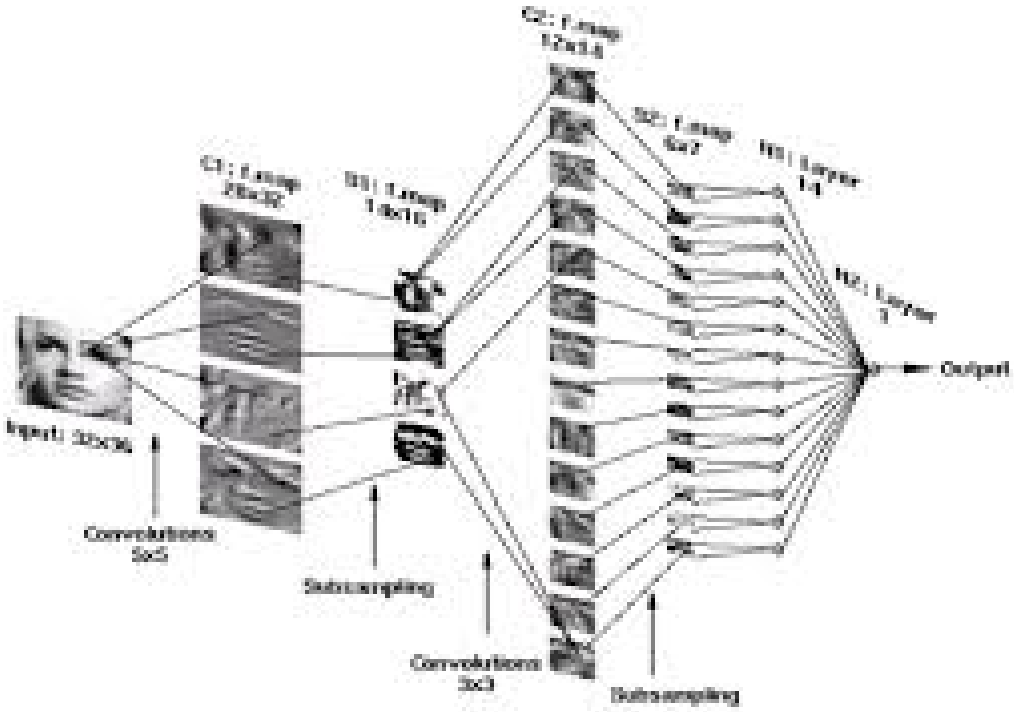
Advanced Machine Learning

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