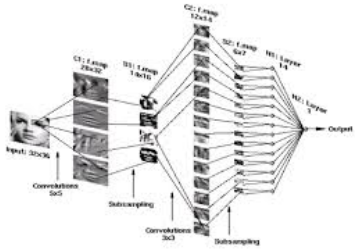
Advanced Machine Learning

Course Outline



Course Details and Topics

Course Structure

- Notes on Moodle and

  https://ecs-vlc.github.io/aice1005/
  https://tinyurl.com/bddhrhcw

- Lectures
  - 11:00-11:45 Tuesday, Building 35 room 1005
  - 16:00-16:45 Tuesday, Building 44 room 1041 (L/T A)
  - 15:00-15:45 Thursday, Building 44 room 1041 (L/T A)

- 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
- Advanced Methods
  - Divergences: KL and Wasserstein
  - VAEs and GANs
  - Entropy and information theory
  - Variational Approximation