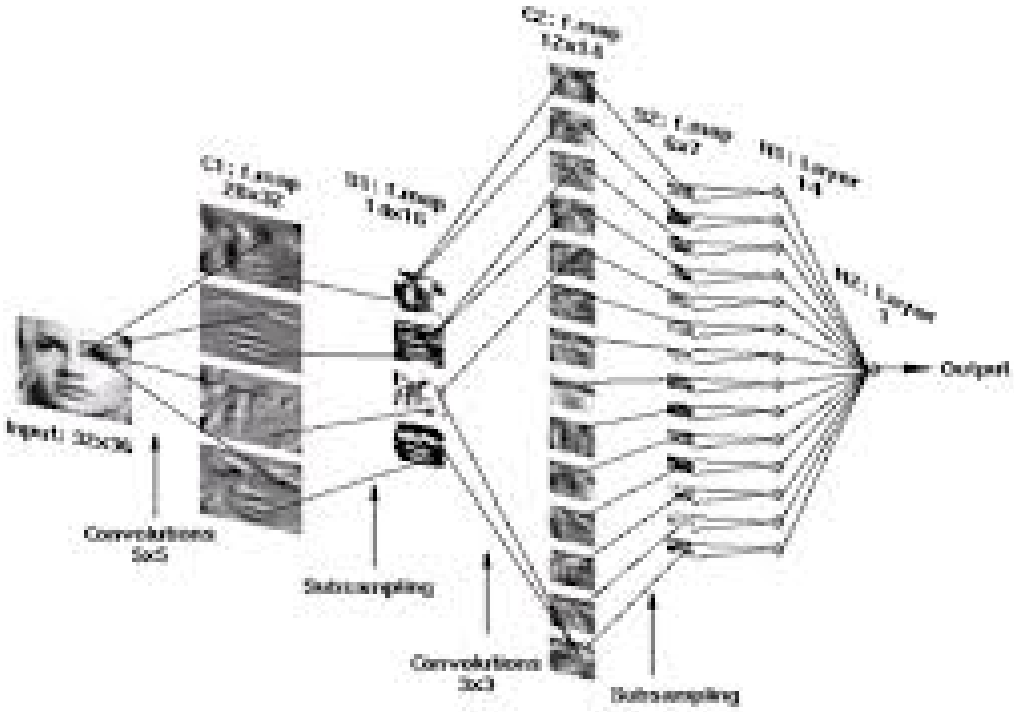
# Advanced Machine Learning

## *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