Pattern Recognition

Course Logistics

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About Yen-Yu Lin

- Work Experience
  - Professor, *CS, NCTU,* August 2019 ~ present
  - Associate research fellow, *CITI, Academia Sinica*, 2015 ~ 2019
  - Assistant research fellow, *CITI, Academia Sinica*, 2011 ~ 2015

- Research interests
  - Computer Vision (**CV**):

    Let computers see, recognize, and interpret the world like humans
  - Machine Learning (**ML**):

    Provide a statistical way to learn how human visual system works
  - Goal: *Design **ML** methods to facilitate **CV** applications*

Today's agenda

- Course logistics
- Introduction to pattern recognition

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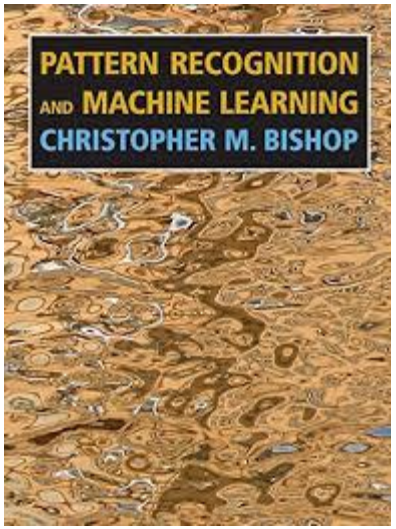
- Introduction to pattern recognition

Instructor and teaching assistants

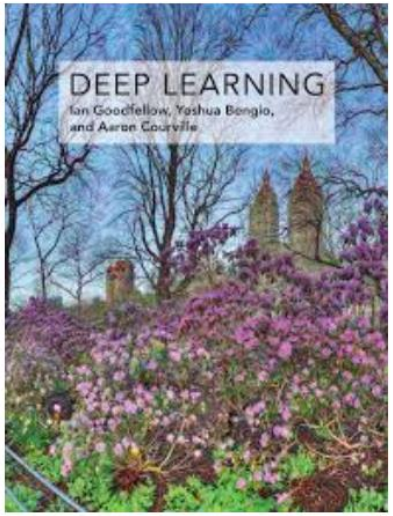
- Instructor: Yen-Yu Lin 林彥宇
  - Email: lin@cs.nctu.edu.tw
  - Office: EC706 (please email me first)
- Teaching assistants:
  - Jimmy Yang 楊証琨 Email: d08922002@ntu.edu.tw
  - Chen-Hsuan Tai 戴晨軒 Email: derekt.cs06@nctu.edu.tw
  - Cheng-Ju Ho 何政儒 Email: ace52751208@gmail.com
- Office hour
  - 2:00pm ~ 3:00pm on Wednesdays at EC218
  - Will move from EC218 to EC701 later

Textbook

- Pattern Recognition and Machine Learning
  - Christopher Bishop
  - Springer-Verlag, Berlin, 2006
  - Free online at
    https://www.microsoft.com/en-us/research/uploads/prod/2006/01/Bishop-Pattern-Recognition-and-Machine-Learning-2006.pdf



- Deep learning (optional)
  - I. Goodfellow, Y. Bengio, and A. Courville
  - MIT Press, 2016
  - Free online at
    https://www.deeplearningbook.org/



Grading policy (default)

- Four homework assignments: 60% (= 15% x 4)
- For each assignment
  - You are required to implement pattern recognition algorithms and complete some short answer questions
  - Late policy: 20% off per late day
- Final exam on June 1: 40%

Grading policy in case where final exam is not allowed

- Five homework assignments: 100% (= 20% x 5)
- For each assignment
  - You are required to implement pattern recognition algorithms and complete some short answer questions
  - Late policy: 20% off per late day
- No final exam

Pre-requisite

- Linear algebra, probability, calculus, and programming

- Python
  - We strongly encourage students who are not familiar with Python to complete the following tutorial first
  - http://cs231n.github.io/python-numpy-tutorial/

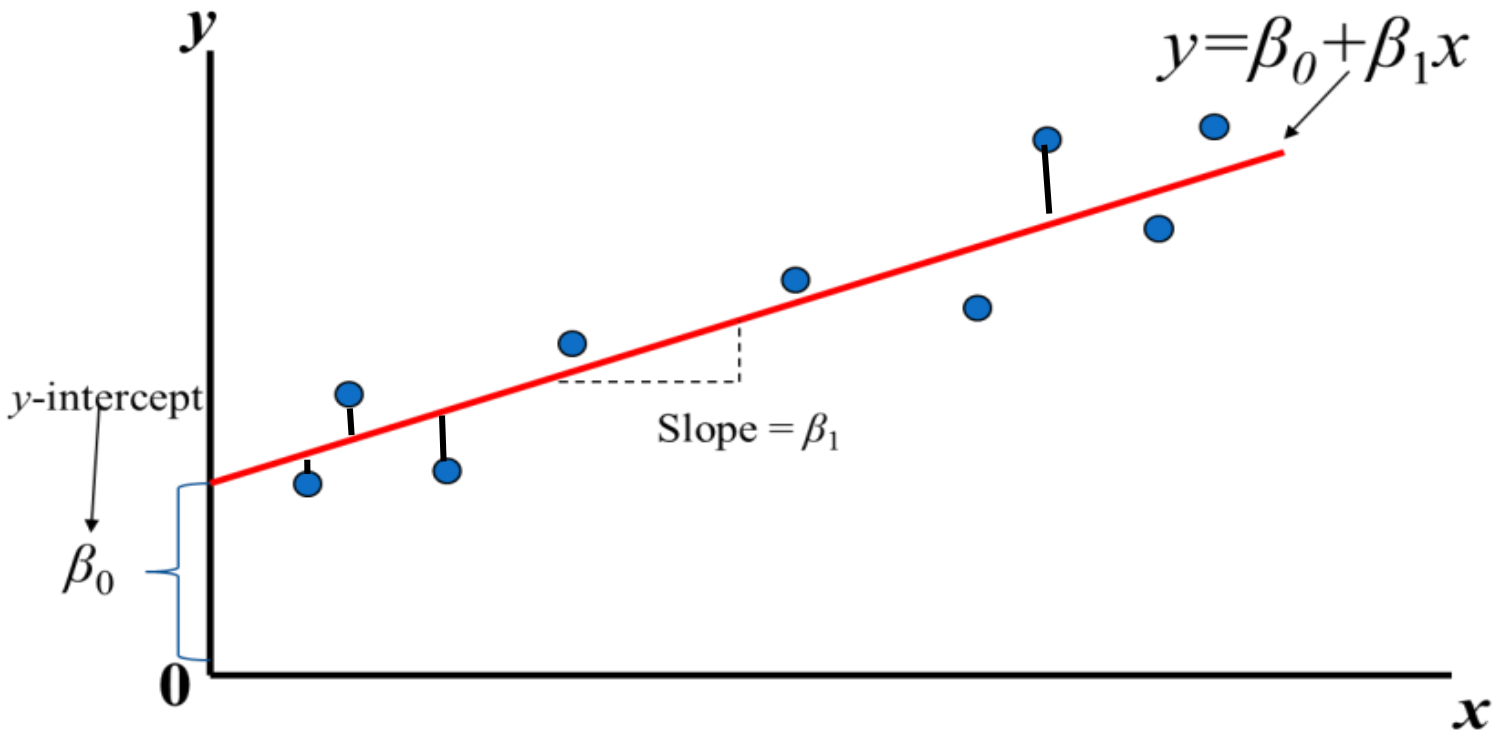
- One deep learning framework, Pytorch or Keras
  - Pytorch: https://pytorch.org/tutorials/
  - Keras: https://elitedatascience.com/keras-tutorial-deep-learning-in-python

Syllabus

1	2/16		University Anniversary Celebrations: No lecture
2	2/23		Introduction to Pattern Recognition
3	3/2		Linear Model for Regression
4	3/9	HW1	Linear Model for Classification I
5	3/16		Linear Model for Classification II
6	3/23	HW2	Neural Networks
7	3/30		Dimensionality Reduction
8	4/6		Holiday/Cross-university Activities: No lecture
9	4/13		Ensemble Model I
10	4/20	HW3	Ensemble Model II
11	4/27		Kernel Method I
12	5/4	HW4	Kernel Method II
13	5/11		Clustering
14	5/18		Deep Neural Networks (DNN) and Convolutional Neural Networks (CNN)
15	5/25	HW5?	Attention and Transformers
16	6/1		Final Exam

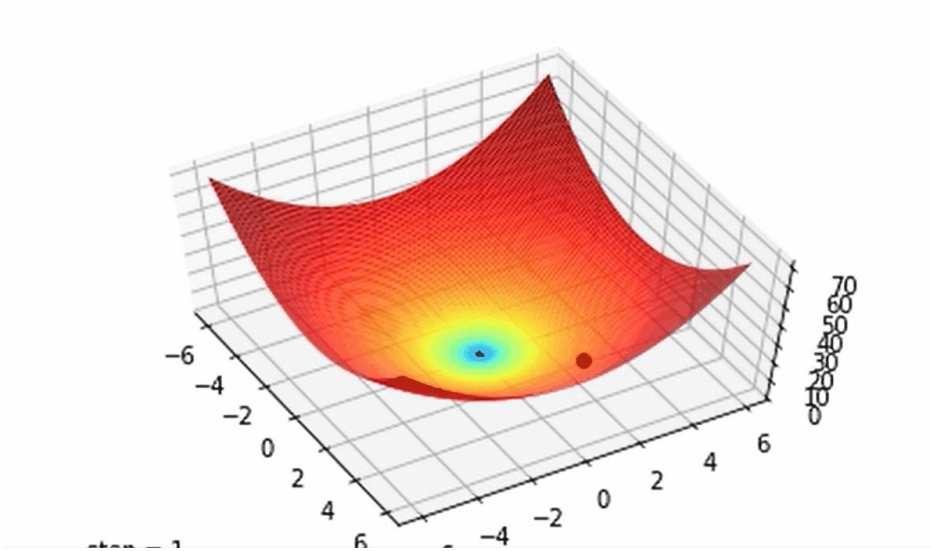
Homework 1: Linear regression (last year)

- Find the value of β0 and β1



Gradient descent

- x-axis and y-axis represent the value of weights
- z-axis represents the loss of the corresponding weights
- Targets: Find the weights that minimize the loss



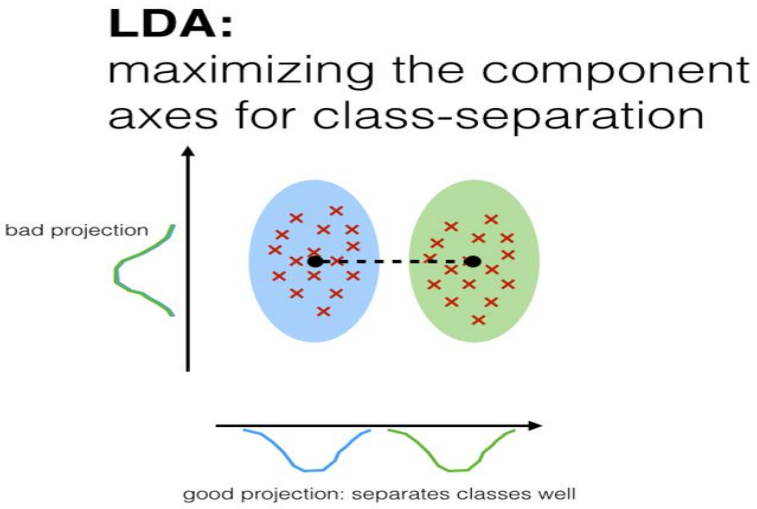
Gradient descent pseudo code

Algorithm

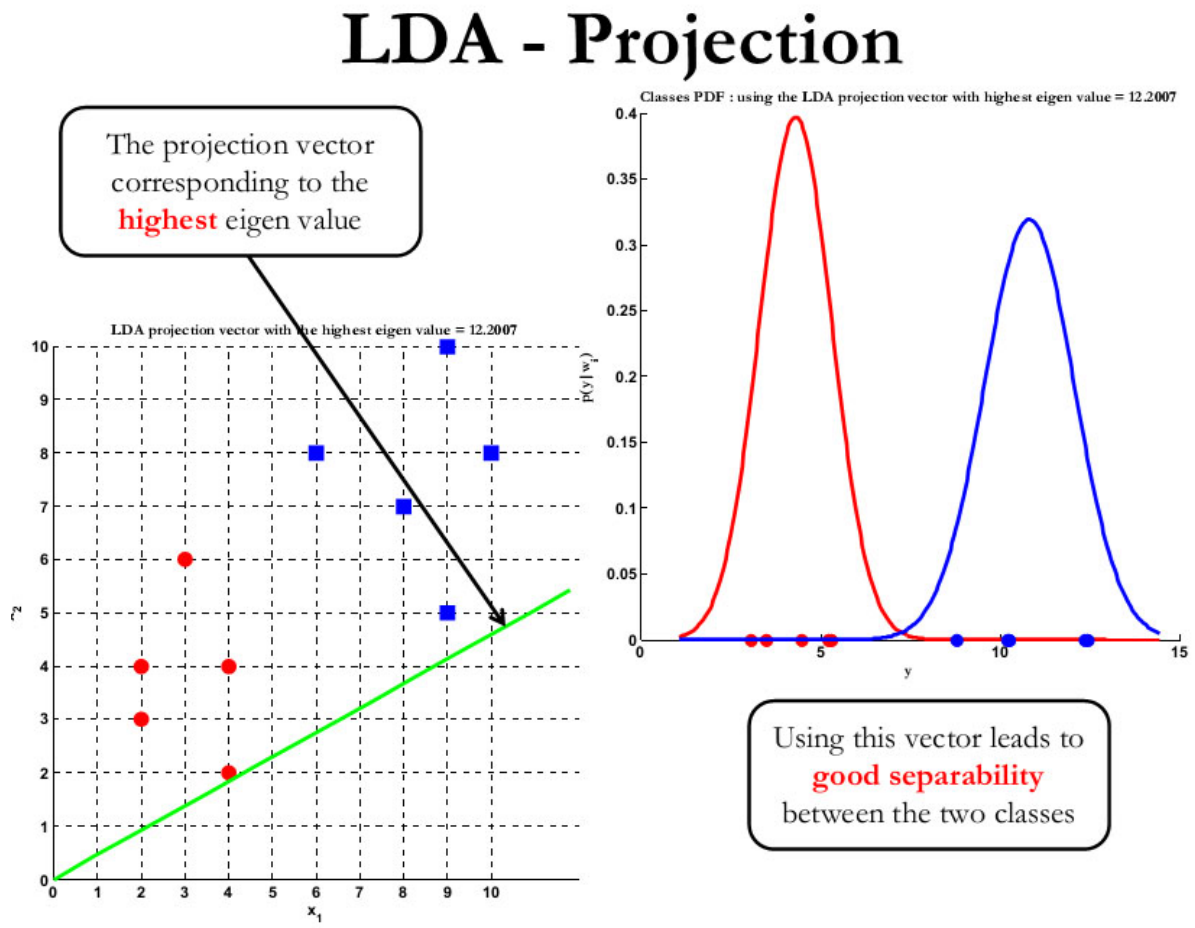
1. Initialize weights randomly $\sim N(0, \sigma^2)$
2. Loop until convergence:
   i. Pick batch of B data points
   ii. Compute gradient. $\frac{\partial J(\Theta)}{\partial \Theta} = \frac{1}{B}\sum_{k=1}^{B} \frac{\partial J_k(\Theta)}{\partial \Theta}$
   iii. Update weights $\theta <- \theta - \eta \frac{\partial J(\Theta)}{\partial \Theta}$
3. Return weights

Homework 2: Fisher's linear discriminant (last year)

- FLD (or LDA) is a "supervised" method and computes the directions representing the axes that maximize the separation between multiple classes.
- FLD seeks the projection **w** that gives a large distance between the projected data means while giving a small variance within each class

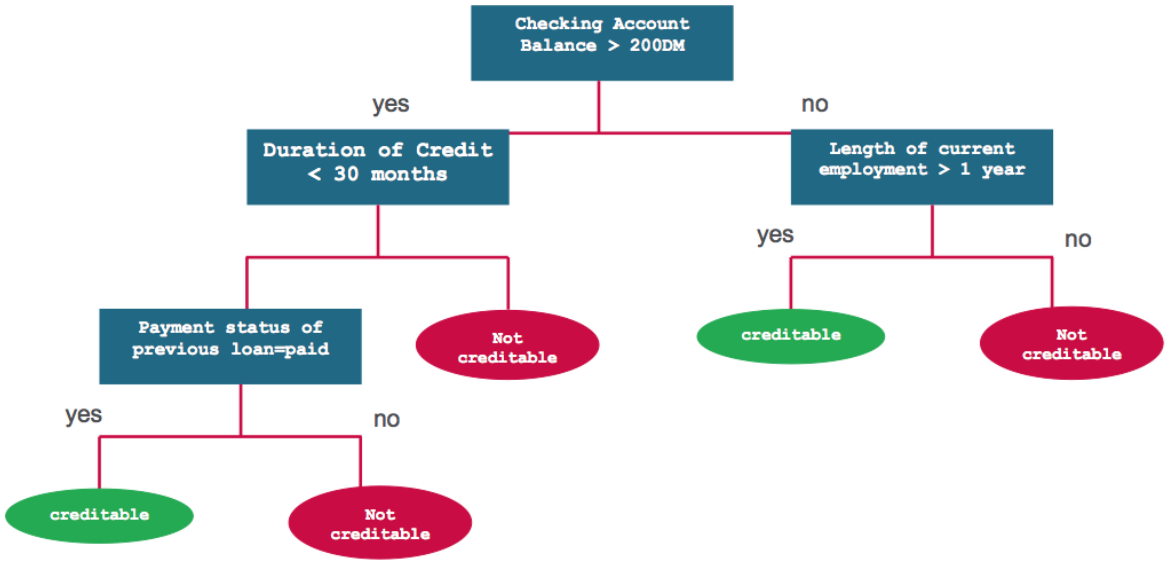


Eigenvalue problem



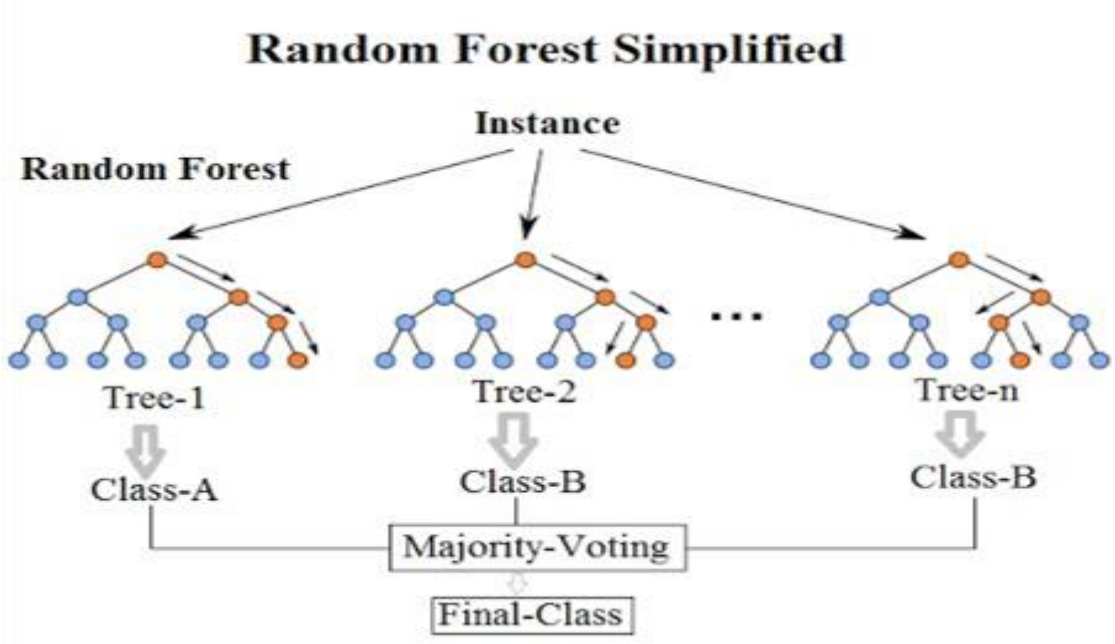
Homework 3: Decision tree algorithm (last year)

- How to find the feature for making decisions? What's the value of feature?
- Find the features to separate data that the class at the resulting nodes are as **pure** as possible



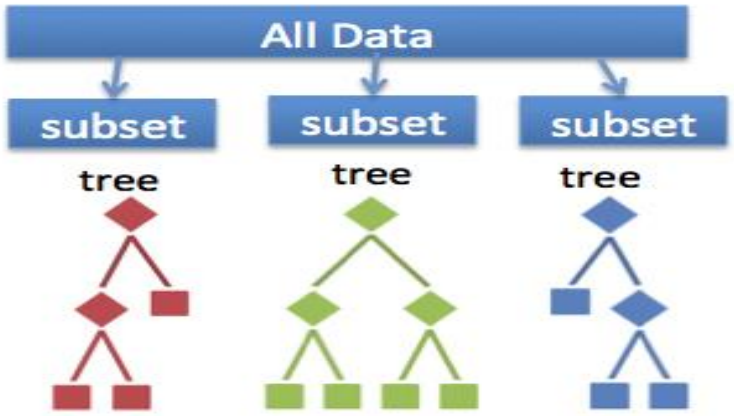
Ensemble method of decision trees: Bagging

- **Bagging (Bootstrap aggregating)**: Fit many large trees to bootstrap-resampled versions of the training data, and classify by majority vote



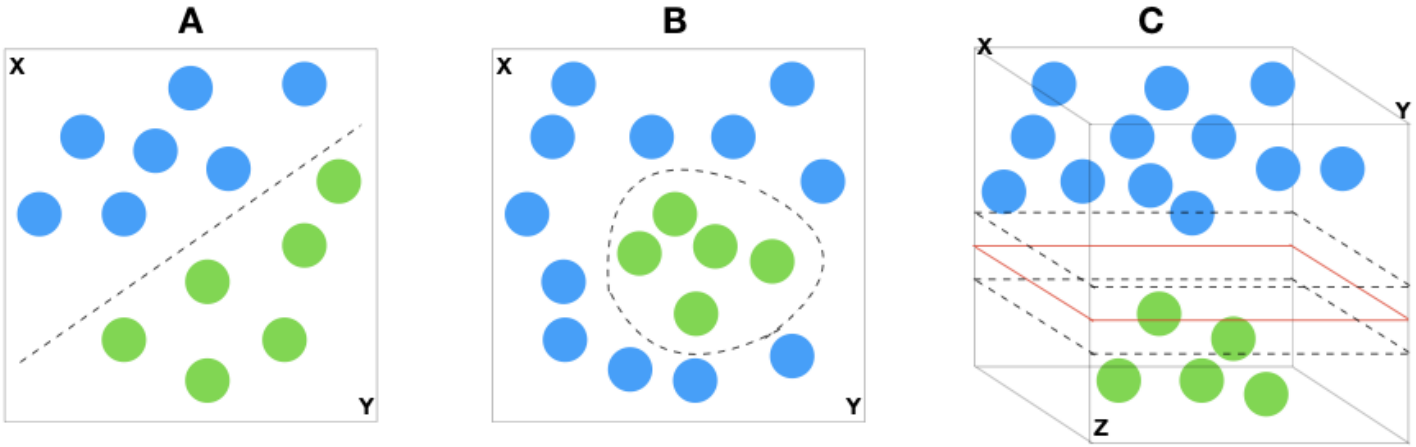
Another ensemble method: Random Forest

- Bootstraped dataset
- Each tree in the forest may grow with different data and features
- Which features or data to be used is **randomly** sampled to grow the tree



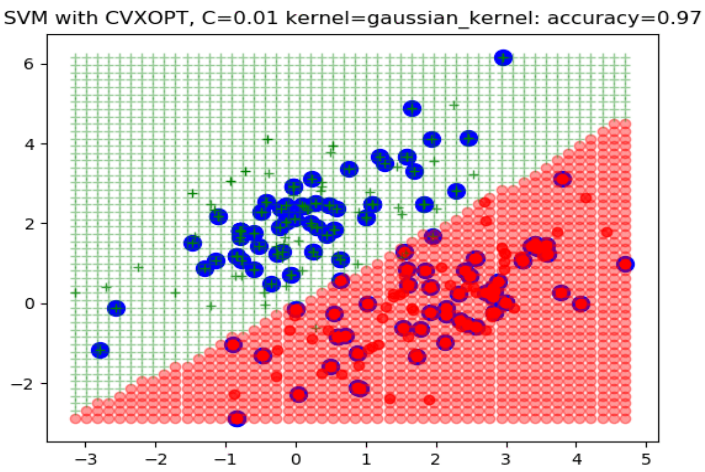
Homework 4: Support vector machines (last year)

- Support Vector Classifier tries to find the best hyperplane to separate the different classes by maximizing the distance between sample points and the hyperplane



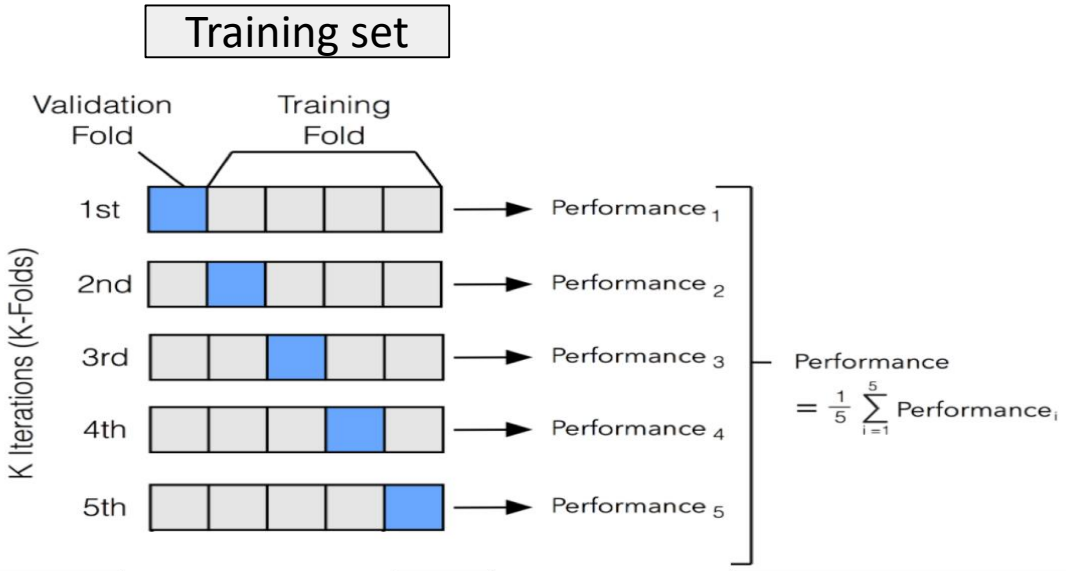
Hyperparameter searching

- Suppose we want to find the best values of two hyperparameters for an RBF kernel SVM namely C and gamma. In RBF kernel, $\gamma = \frac{1}{2\sigma^2}$
- Given many hyperparameter combinations to be considered!



K-fold Cross-validation

- We split the dataset into K parts: one part is used for validation, and the remaining K-1 parts are merged into a training subset. This process repeats K times, with each part used exactly once as the validation data



Classroom and Webex link

- This course is given in EC114

- Once we cannot have physical lectures in the classroom, we use Webex for online lectures. The link is given below:

  https://nycu.webex.com/meet/yylincs

How to choose and take this course?

- Please use the course management system
  - Max number: 100 students
- I do not plan to add additional students
  - The size of EC114
  - If you have some reason why you must take this course, send me an email with the reason
- Be a guest student?
  - Yes. Send me an email with your student ID. I will add you to the student list on E3

Thank You for Your Attention!

Yen-Yu Lin (林彥宇)

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