



Introduction to Pattern Recognition

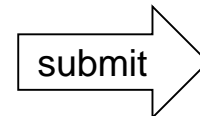
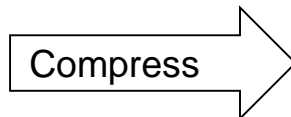
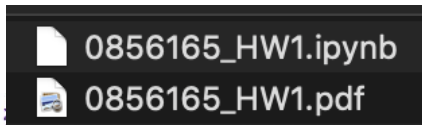
Homework 4 announcement

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Homework 4

- **Deadline: June. 12, Fri at 23:59.**
 1. Code assignment (80%): Implement cross-validation and hyperparameter searching for SVM model training
 2. Short answer questions (20%)
- Submit your **1) code (.py/.ipynb)** and **2) reports (.pdf)** on [E3](#)
 - [Sample Code](#)
 - [HW4 questions](#)
- Please follow the **file naming rules <STUDENT ID>_HW4.pdf**, otherwise, you will get penalty of your scores



[E3](#)





Coding

- Write beautiful Python codes with [PEP8 guidelines](#) for readability. Basic requirement: use whitespace correctly!
- [PEP8 online checker](#)

Python

Recommended

```
def function(default_parameter=5):  
    # ...
```

Not recommended

```
def function(default_parameter = 5):  
    # ...
```

PEP8 online

Check your code for PEP8 requirements

Just paste your code here

1

Check code



Reports

- Submit in PDF format
- Include the answers of coding part in the reports!
- Please see the sample submission file on E3

NCTU Pattern Recognition, Homework 1| Example

Part. 1, Coding (60%):

Q1: Your answer...

Q2: Your answer....

Q3: Your answer....

Q4: Your answer....

Q5: Your answer....

Part. 2, Questions (40%):

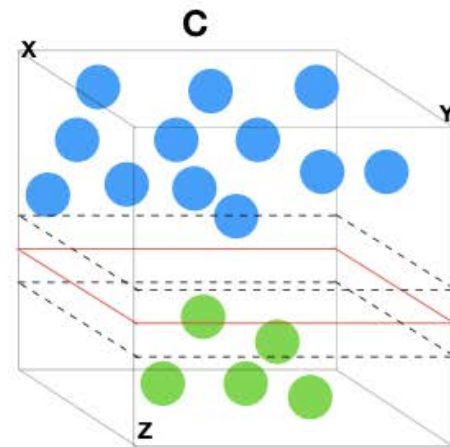
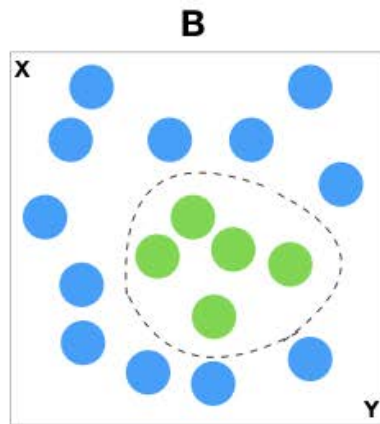
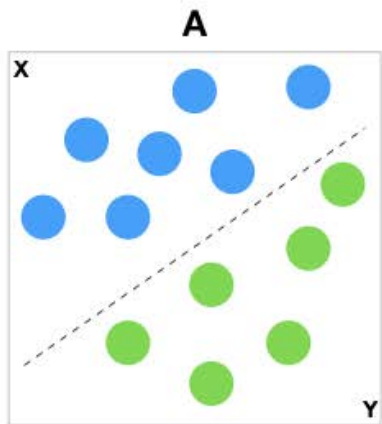
Q1: Your answer...

Q2: Your answer...



Support vector machines

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



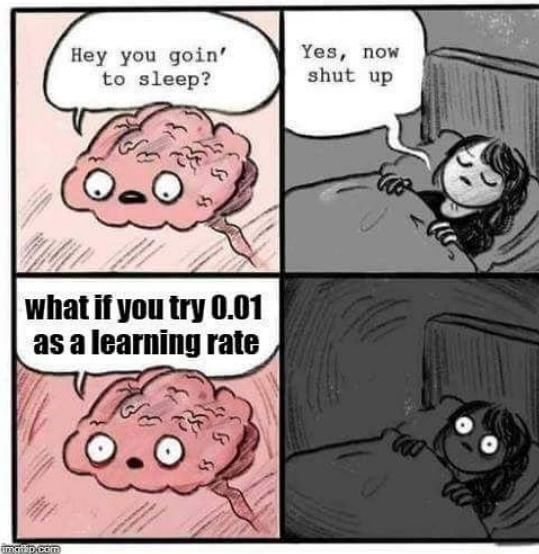
No need to implement SVM!

- Since SVM requires lots of difficult mathematical operations, we will not ask you to implement SVM in homework 4 :)



Grid search and cross-validation

- There are lots of hyperparameters in SVM. In this homework, you will need to implement **grid search** and **cross-validation** to find the best hyperparameters of the SVM on the provided dataset



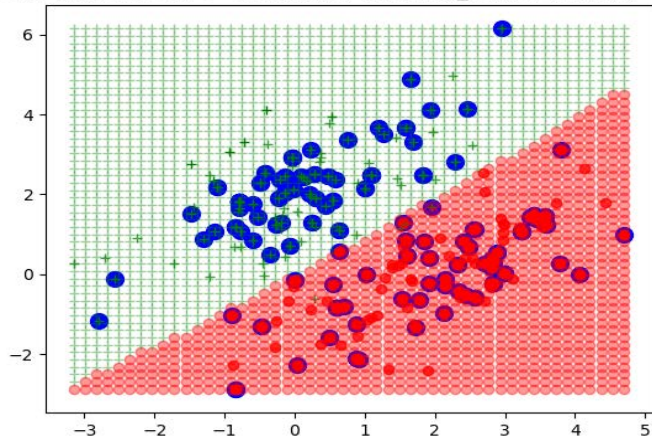


Hyperparameter searching

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

randipao toy (1000)

SVM with CVXOPT, C=0.01 kernel=gaussian_kernel: accuracy=0.97



Hyperparameter searching: Grid search

- Grid search exhaustively considers all hyperparameter combinations and picks the best one based on the model that gives the best performance
- For the searching space of C and gamma, we recommend using geometric sequence

C = [0.1, 1, 10] #3 values

gamma = [0.01, 0.1, 1, 10] #4 values

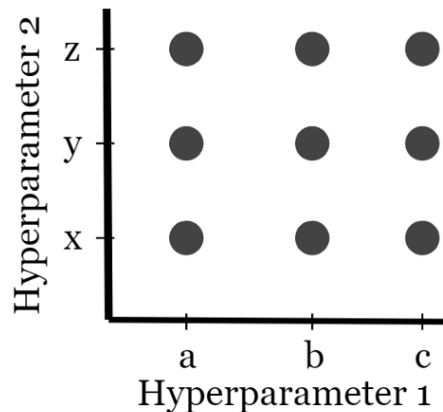
There are totally 12 combinations for tuning

C\gamma	0.01	0.1	1	10
0.1	[0.1, 0.01]	[0.1, 0.1]	[0.1, 1]	[0.1, 10]
1	[1, 0.01]	[1, 0.1]	[1, 1]	[1, 10]
10	[10, 0.01]	[10, 0.1]	[10, 1]	[10, 10]

Grid Search

Pseudocode

```
Hyperparameter_One = [a, b, c]  
Hyperparameter_Two = [x, y, z]
```



K-fold Cross-validation

- The main idea behind cross-validation is that each observation in our dataset has the opportunity of being tested
- Illustration of K-fold cross-validation when $n=12$ observations and $K=3$. After data is shuffled, a total of 3 models will be trained and tested.

$n = 12$

$k = 3$

Data



Test

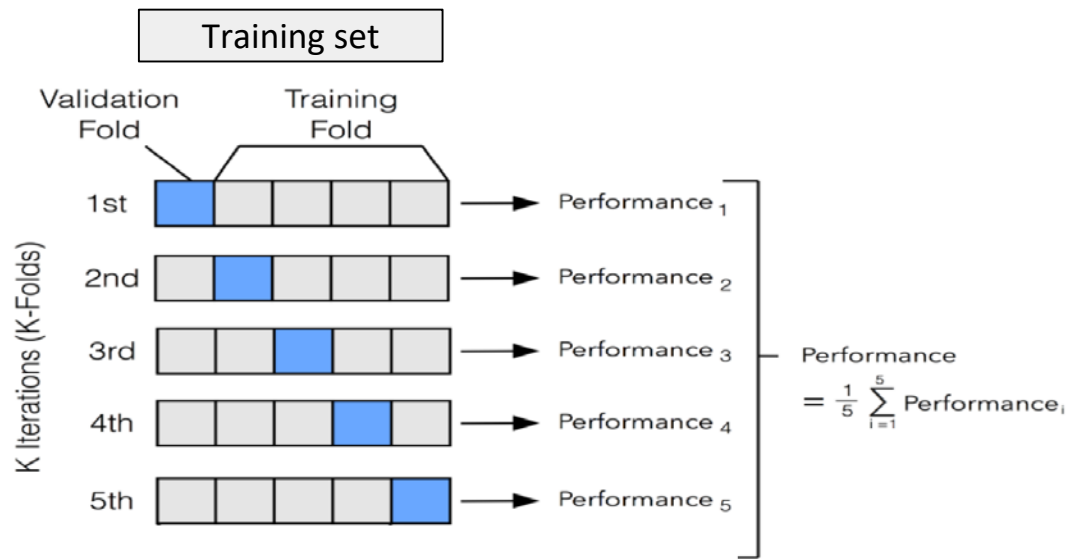


Train



K-fold Cross-validation

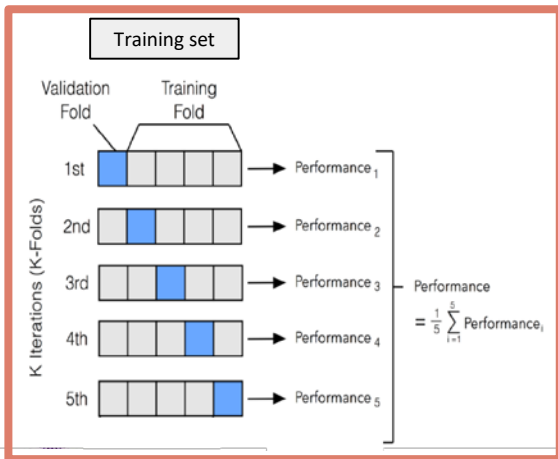
- We split the dataset into K parts: one part is used for validation, and the remaining $K-1$ parts are merged into a training subset. This process repeats K times, with each part used exactly once as the validation data



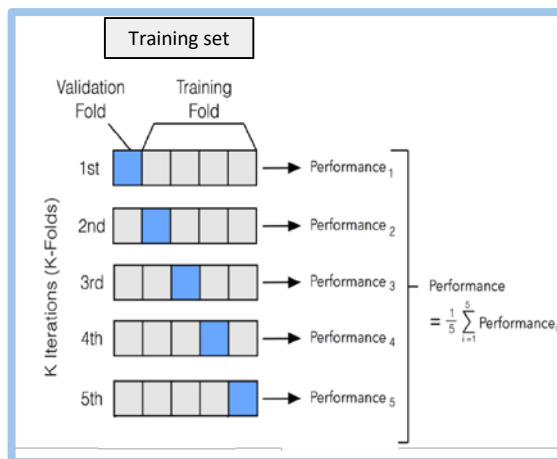
K-fold Cross-validation for hyperparameter searching

- We can experiment with 12 combinations of hyperparameters defined in page 9. For each combination, we apply the K-fold cross-validation and get the average performance
- Find the best combination which yield best performance

Combination **1**: [0.1, 0.01]
average score=0.8

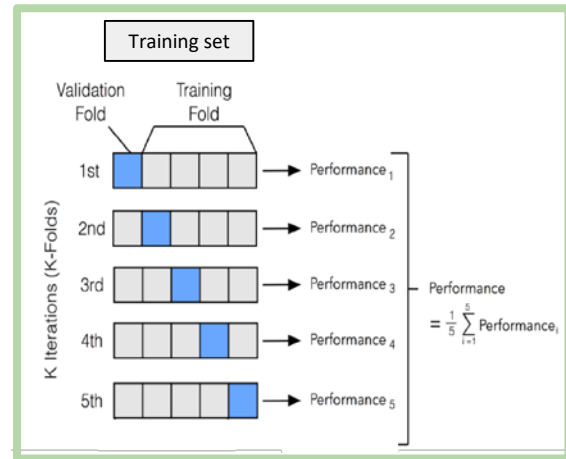


Combination **2**: [0.1, 0.1]
average score=0.91



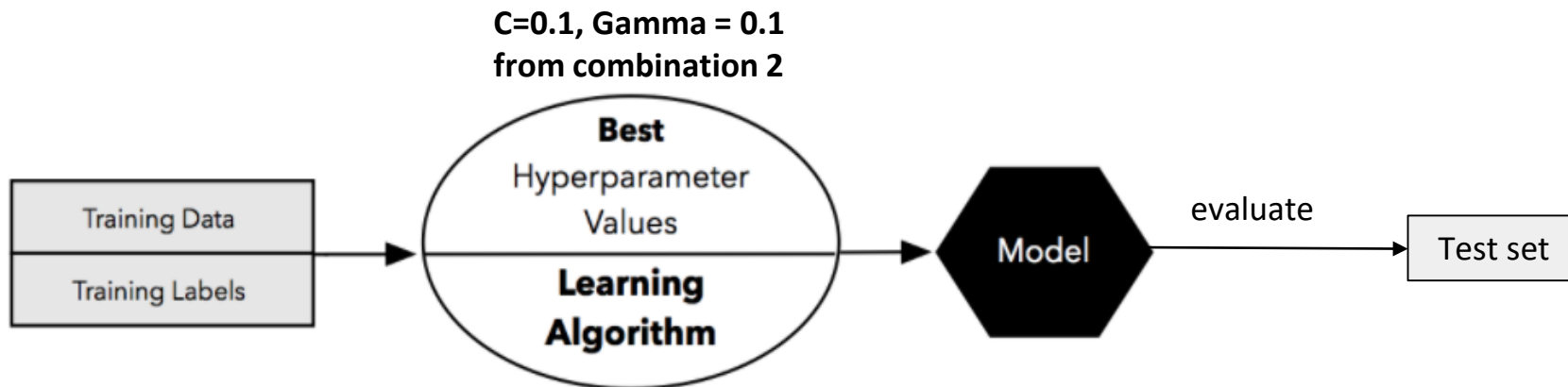
...

Combination **12**: [10, 10]
average score=0.75



K-fold Cross-validation for hyperparameter searching

- Then you train your model **on the whole training set** with the best hyperparameters and evaluate on the test set



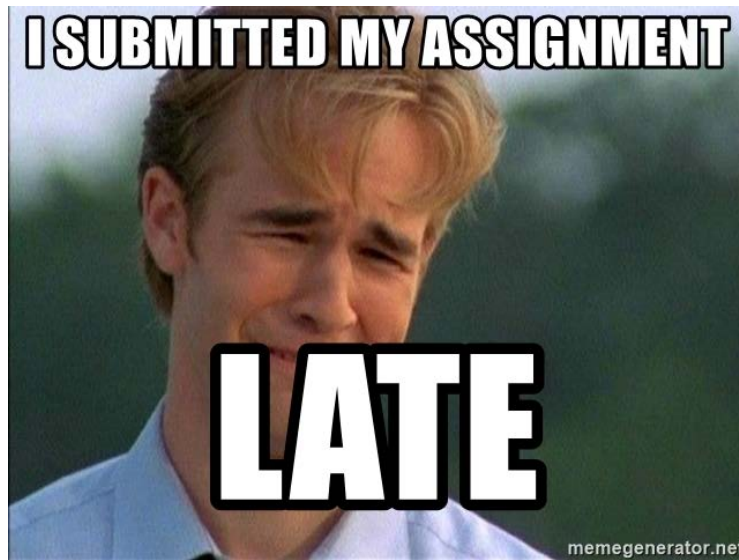
Reference

- [K-fold Cross-Validation & Grid Search](#)
- [SVM hyperparameter tuning](#)



Late Policy

- We will deduct a late penalty of 20 points per additional late day
- For example, If you get 90 points of this HW but delay for **two days**, your will get only $90 - (20 \times 2) = 50$ points!



Honor code

- We have found that some students develop their codes based on those by other classmates or on Internet in HW1
 - It is **NOT** allowed
- You should implement all algorithms by yourself
- If there is any plagiarism in your homework, you will get no points



Notice

- Submit your homework on [E3-system](#) !
- Check your email regularly, we will mail you if there are any updates or problems of the homework
- If you have any questions or comments for the homework, please mail Jimmy and Chung-Hsuan and cc Prof. Lin
 - Prof. Lin: lin@cs.nctu.edu.tw
 - TA, Jimmy: d08922002@ntu.edu.tw
 - TA, Chung-Hsuan: scott19880525@gmail.com



Have fun!



Neural
Network



HOG+SVM

