Pattern Recognition
# Homework 4 announcement

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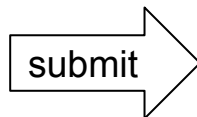**d08922002@csie.ntu.edu.tw**

Homework 4

- **Deadline: June. 9, Wed 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
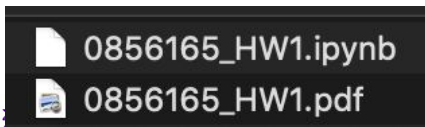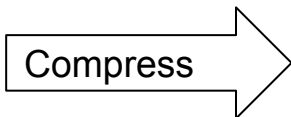
Coding

- 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

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….
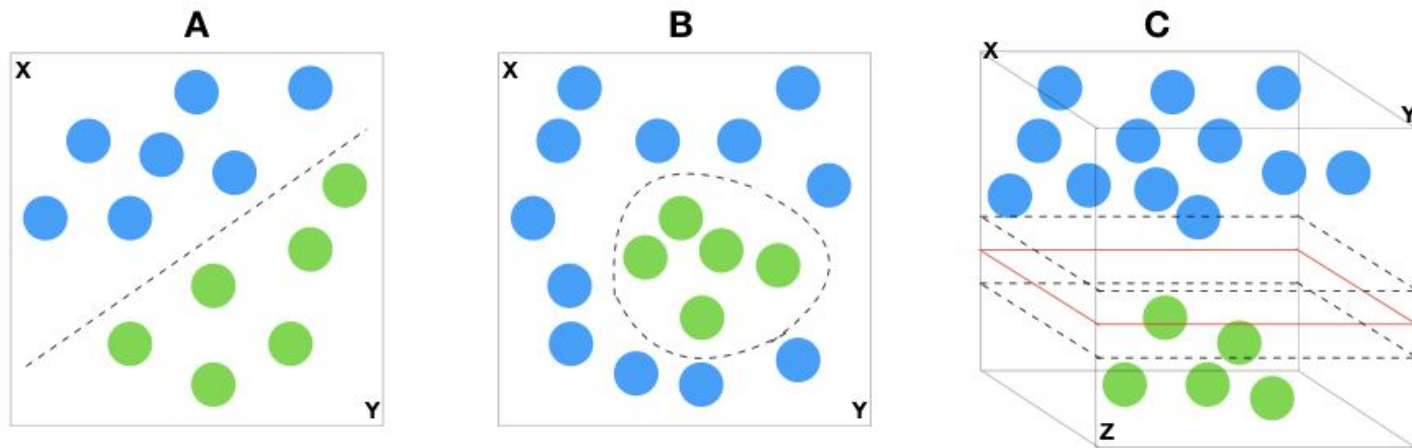Q4: Your answer….
Q5: Your answer….

Part. 2, Questions (40%):

Q1: Your answer…
Q2: Your answer…

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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
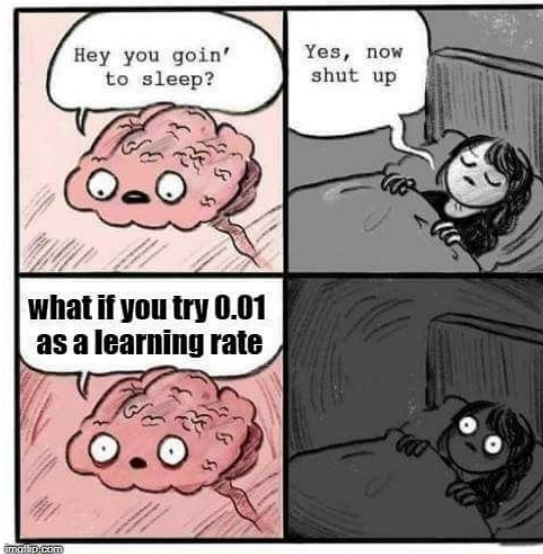
No need to implment SVM!

- 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
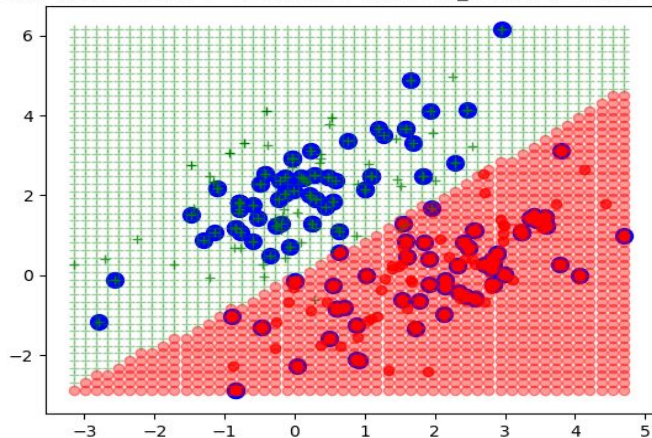
Hyperparameter searching

- Suppose we want to find the best values of two hyperparameters for an RBF kernel SVM namely C and gamma. In RBF kernel, $\gamma = \dfrac{1}{2\sigma^2}$

  - ☐ Interactive demo
  - ☐ Explanation of C and gamma

- Given many hyperparameter combinations to be considered!

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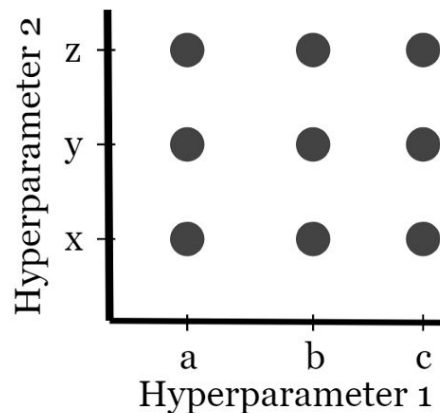
C\gamma	0.01	0.1	1	10
0.1	[0.1, 0.01]	[0.1, 0.1]	[0.1, 1]	[0.1, 10]
1	[1, 0.01]	[1, 0.1]	[1, 1]	[1, 10]
10	[10, 0.01]	[10, 0.1]	[10, 1]	[10, 10]

Grid Search

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

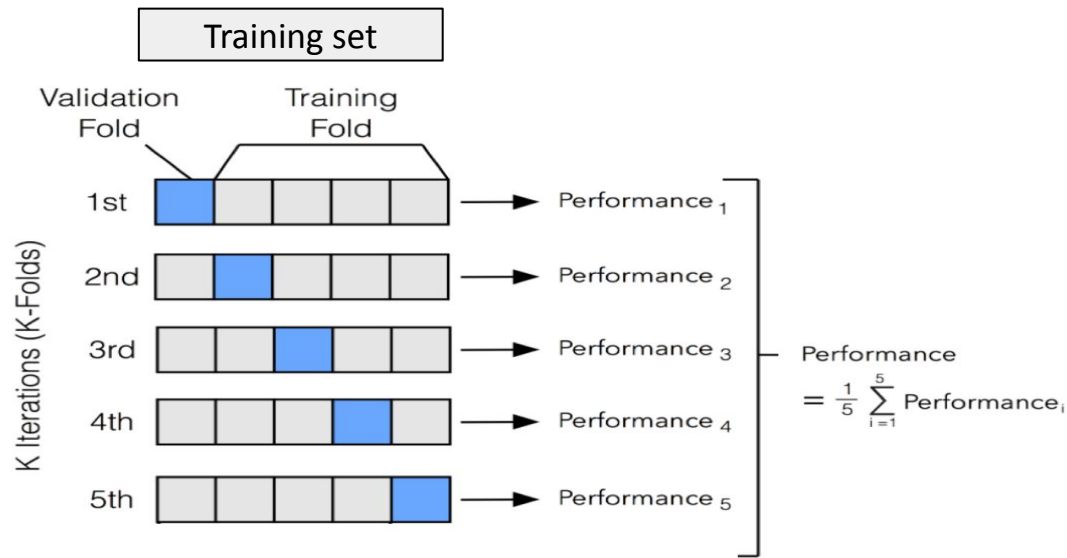Hyperparameter 2

z

y

x

a   b   c
Hyperparameter 1

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.
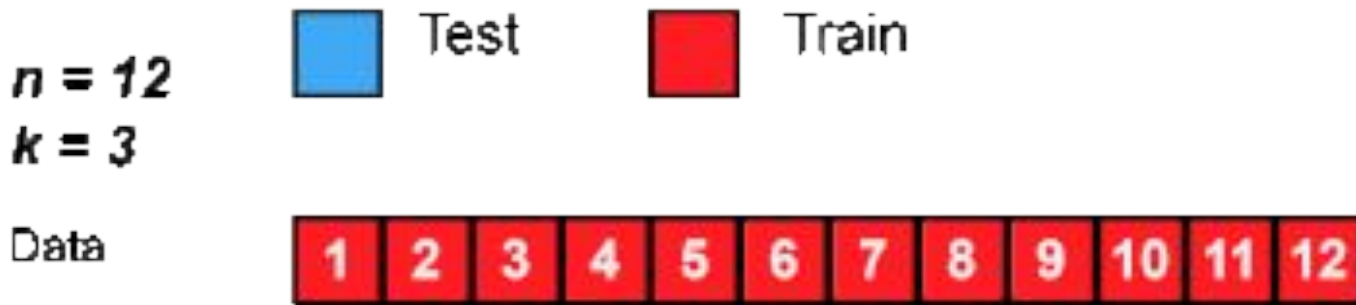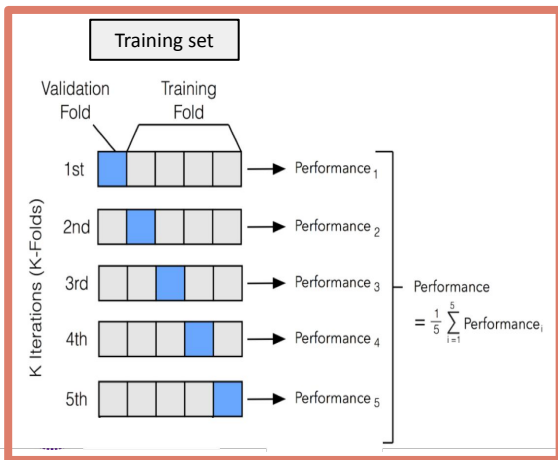
K-fold Cross-validation

- 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
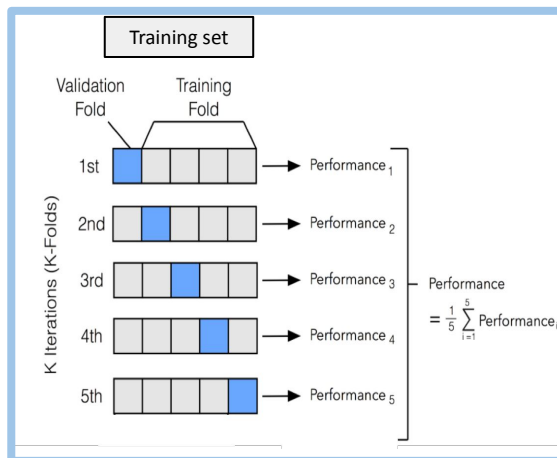
K-fold Cross-validation for hyperparameter searching

- 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

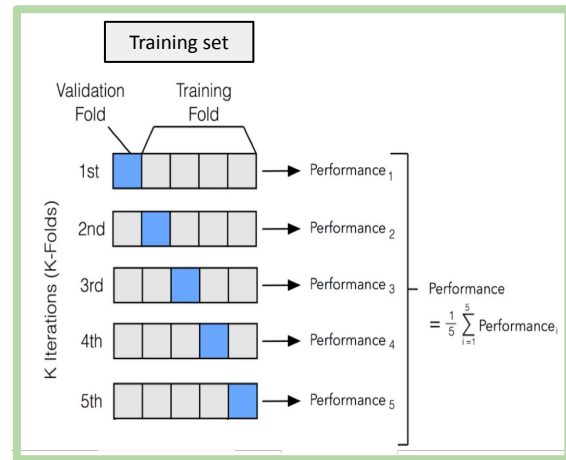Combination **1**: [0.1, 0.01]
avgerage score=0.8

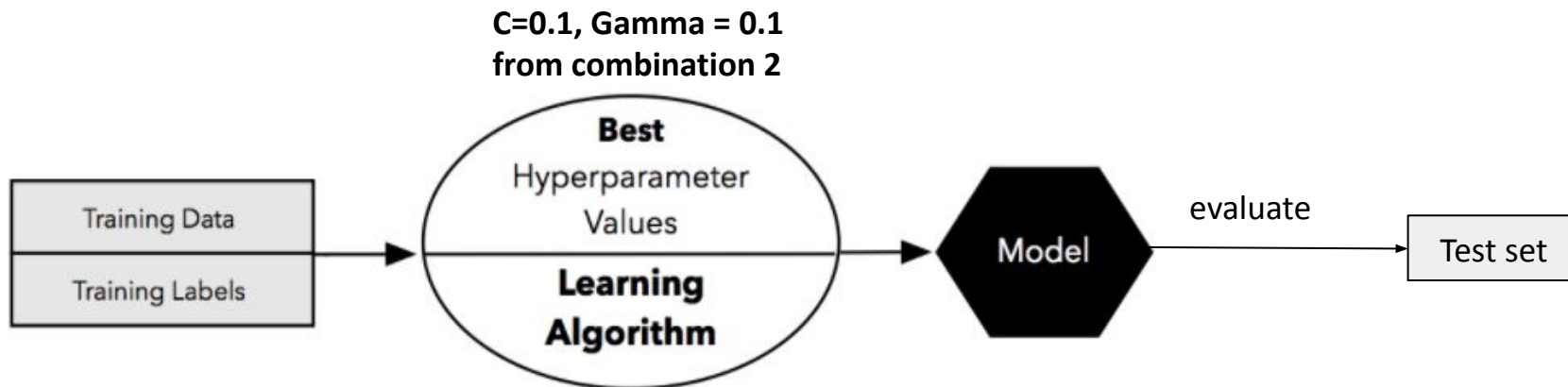<u>**Combination 2: [0.1, 0.1]**</u>
<u>**avgerage score=0.91**</u>

Combination **12**:[10, 10]
avgerage 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
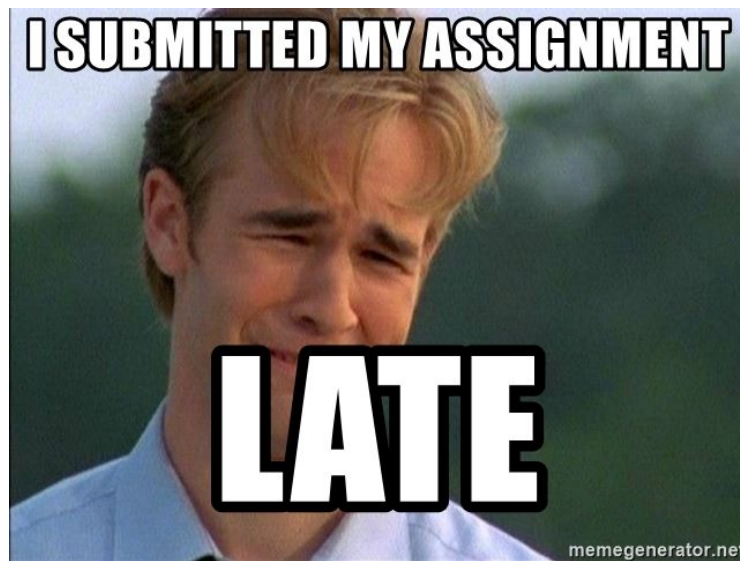
C=0.1, Gamma = 0.1
from combination 2

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 x 2) = 50 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 TAs and cc Prof. Lin
  - Prof. Lin, **lin@cs.nctu.edu.tw**
  - TA Jimmy, **d08922002@csie.ntu.edu.tw**
  - TA 柏聲, **bensonliu0904@gmail.com**
  - TA 玉霖, **oscar861201@gmail.com**

Have fun!