Introduction to Machine Learning
Homework 4 announcement

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Homework 3 reminder

- **[Optional]** save and upload your `y_pred` file

Question 6. Train and tune your model on a real-world dataset

Try you best to get higher accuracy score of your model. After parameter tuning, you can train your model on the full dataset (train + val).

- Feature engineering
- Hyperparameter tuning
- Implement any other ensemble methods, such as gradient boosting. Please note that you **can not** call any package. Also, only ensemble method can be used. Neural network method is not allowed to used.

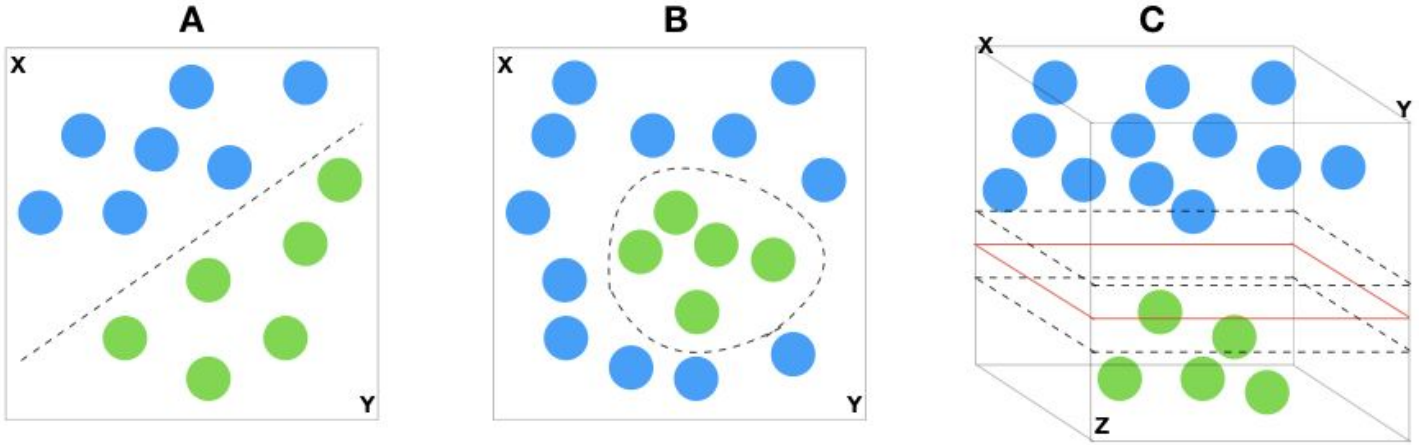
```
In [ ]: def train_your_model(data):
            ## Define your model and training
            return

In [4]: my_model = train_your_model(train_df)

In [ ]: y_pred = my_model.predict(x_test)

In [ ]: np.save('y_pred.npy', y_pred)

In [39]: assert y_pred.shape == (500, )
```

Homework 4

- **Deadline: Nov. 29, Tue. at 23:59.**
  1. Code assignment (50%): Implement cross-validation and hyperparameter searching for SVM model training
  2. Short answer questions (50%)
- 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

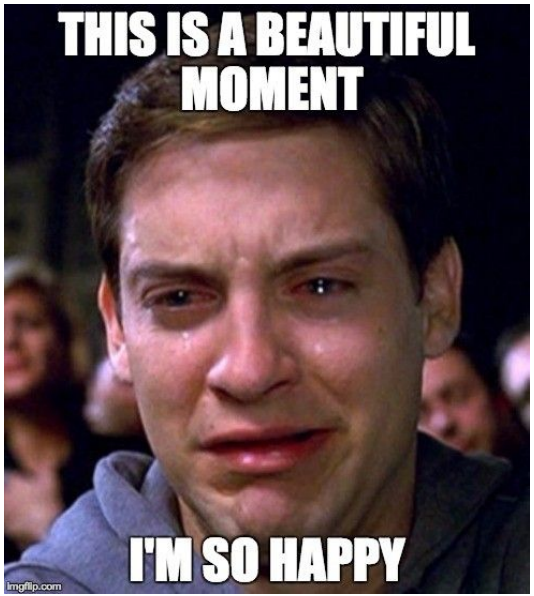
Support vector machines

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



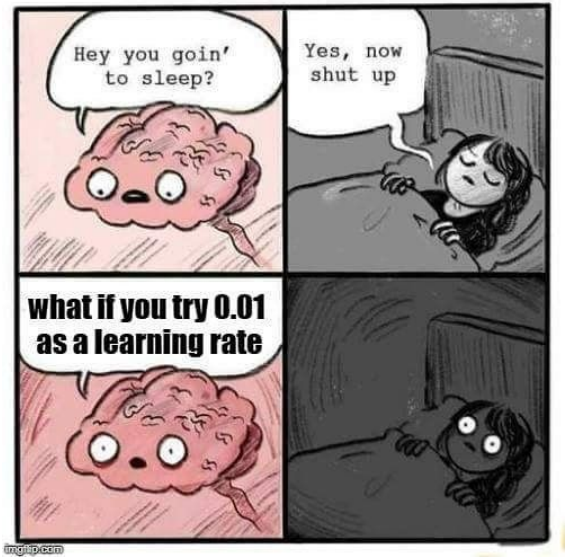
No need to implment SVM!

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



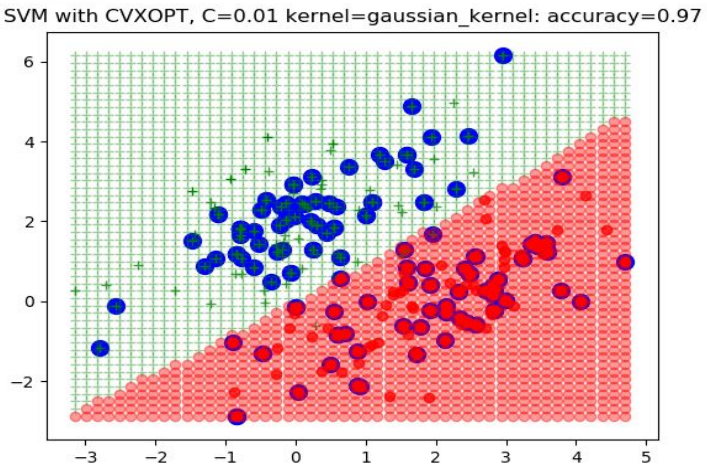
Grid search and cross-validation

- 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**
  - Interactive demo
  - Explanation of C and gamma
- There are many combinations to be considered!



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

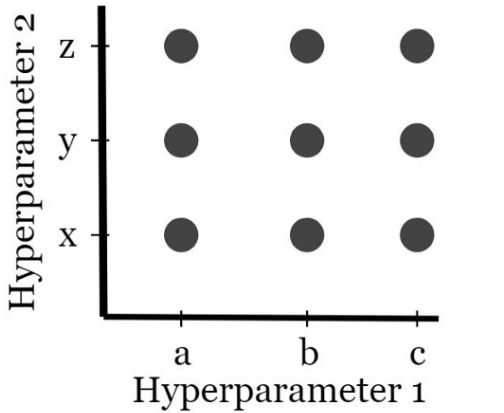
```
C = [0.1, 1, 10] #3 values
gamma = [0.01, 0.1, 1, 10] #4 values
# There are totally 12 combinations for tuning
```

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

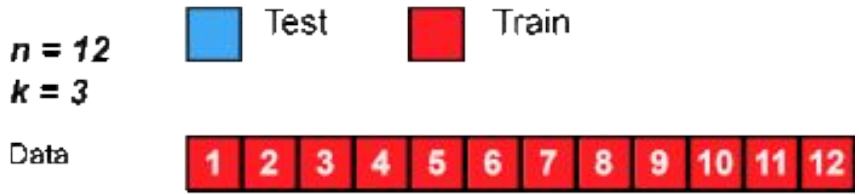
Pseudocode

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



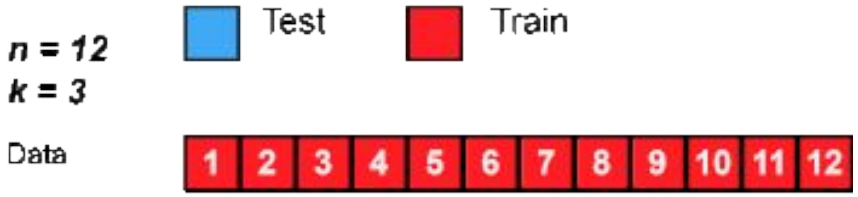
K-fold Cross-validation

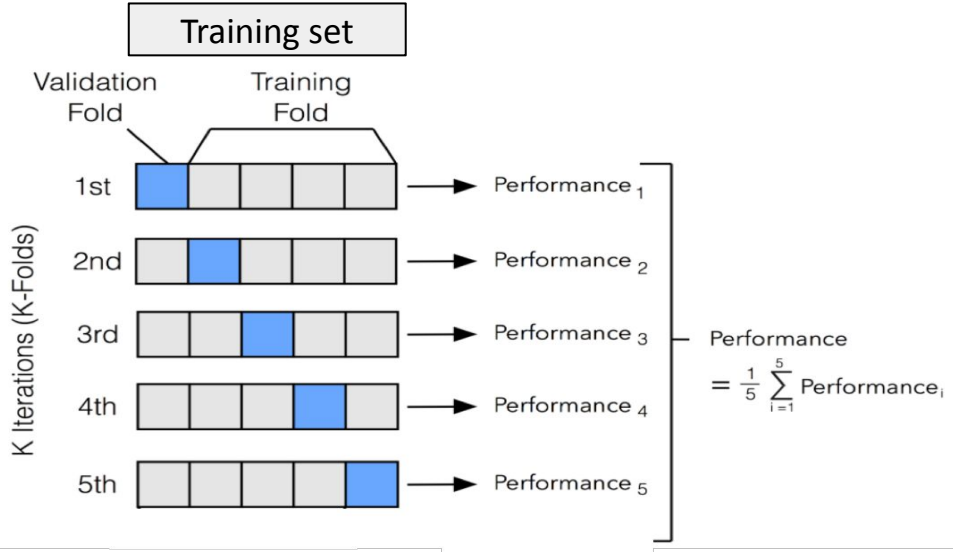
- The main idea behind cross-validation is that **each data point** in the dataset has the opportunity of being tested
- Illustration of K-fold cross-validation when n=12 observations and K=3. After data is shuffled, a total of 3 models will be trained and tested.



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

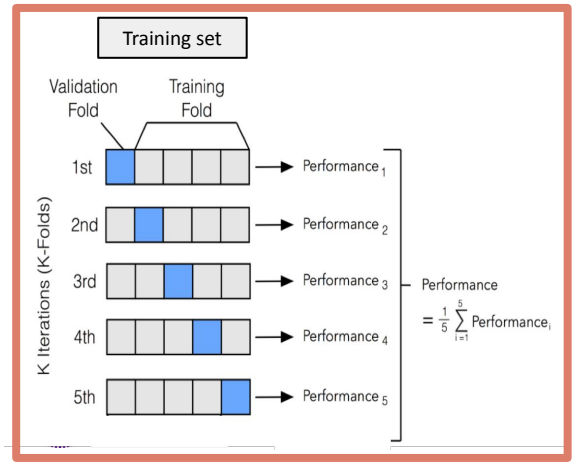




K-fold Cross-validation for hyperparameter searching

- We can experiment with 12 combinations of hyperparameters defined in page 7. For each combination, we apply the K-fold cross-validation and get the average performance
- Find the best combination which yield best performance

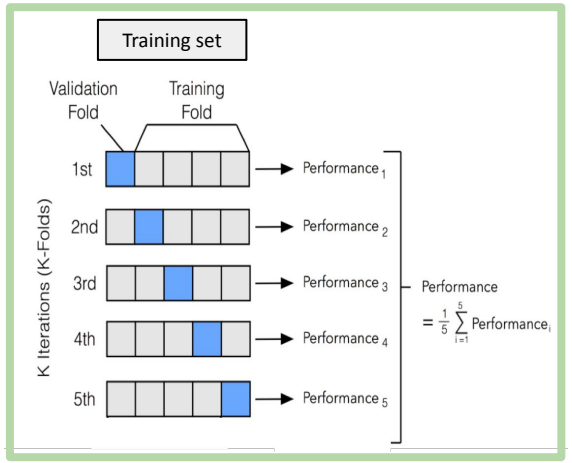
Combination 1: [0.1, 0.01]
avgerage score=0.8



Combination 2: [0.1, 0.1]
avgerage score=0.91

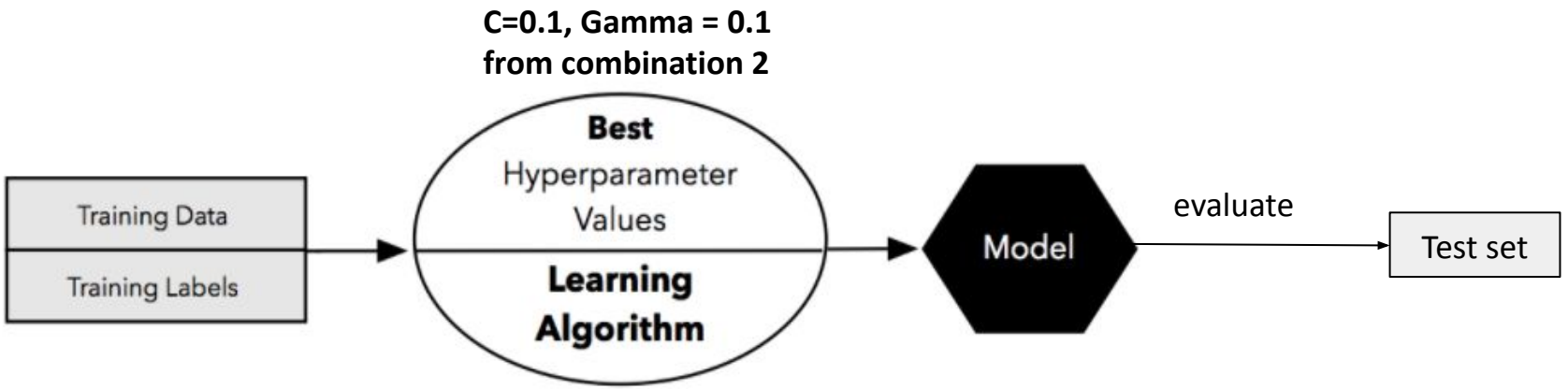
...

Combination 12:[10, 10]
avgerage score=0.75



K-fold Cross-validation for hyperparameter searching

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

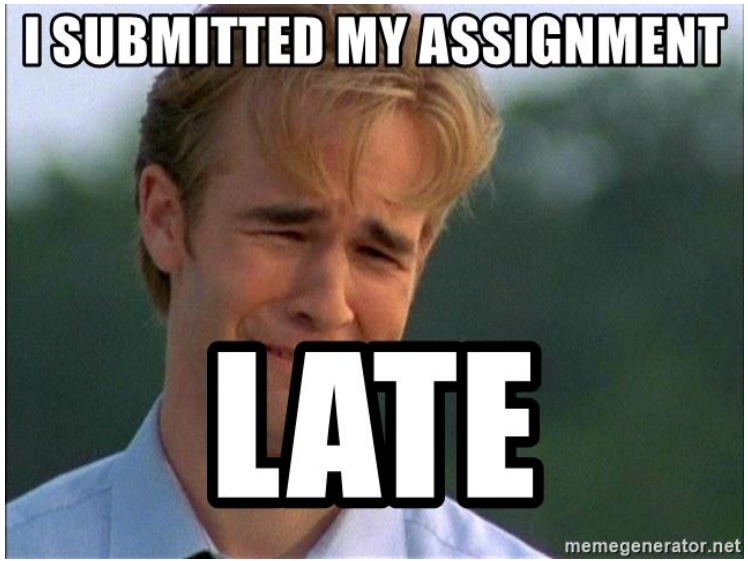


Reference

- 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 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
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Have fun!

Final project preview

- Join a competition for real-world machine learning problem
- No grouping