



Introduction to Machine Learning

Homework 3 Announcement

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Homework 3

- Deadline: 23:59, Nov. 28th (Tue), 2023
- Coding (50%): Implement ensemble methods by only using **numpy**.
 - Part 1: Decision Tree
 - Part 2: Adaboost
 - Submit your python file (.py).
 - Answer the questions (by screenshots) in the report (.pdf).
- Handwritten Questions (50%): Answer questions about linear classification methods.
 - Answer the questions (handwritten, typed, digital, etc.) in the report.

Links

- Questions: [Link](#)
- Sample code: [Link](#)
- Dataset: [Link](#)
- Report template: [Link](#) (same as HW1)

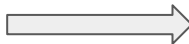
Environment

- Python version: 3.8 or newer
- Tips
 - We recommend that you use **virtual environments** when implementing your homework assignments.
 - Here are some popular virtual environment management tools:
 - [Conda](#)
 - [Miniconda](#)
 - [virtualenv](#)

Numpy

- Build-in array operations.
- Numpy Tutorial: [Link](#)

```
a = np.array([1, 2, 3])  
b = np.array([4, 5, 6])  
for i in range(a.shape[0]):  
    a[i] *= b[i]  
print(a)  
# a = [ 4 10 18]
```



```
a = np.array([1, 2, 3])  
b = np.array([4, 5, 6])  
a *= b  
print(a)  
# a = [ 4 10 18]
```

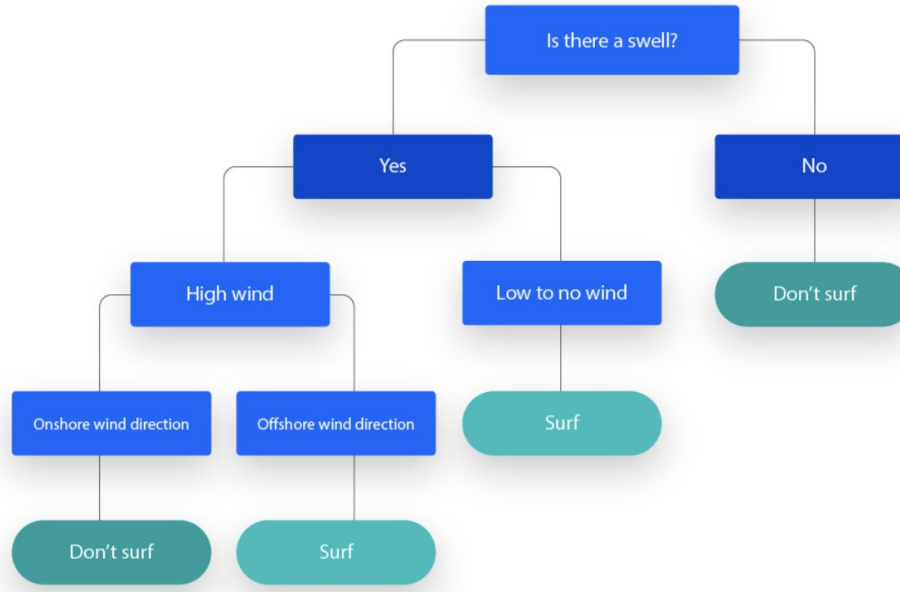
```
import math  
a = np.array([1, 4, 9])  
for i in range(a.shape[0]):  
    a[i] = math.sqrt(a[i])  
print(a)  
# a = [1 2 3]
```



```
a = np.array([1, 4, 9])  
a = np.sqrt(a)  
print(a)  
# a = [1 2 3]
```

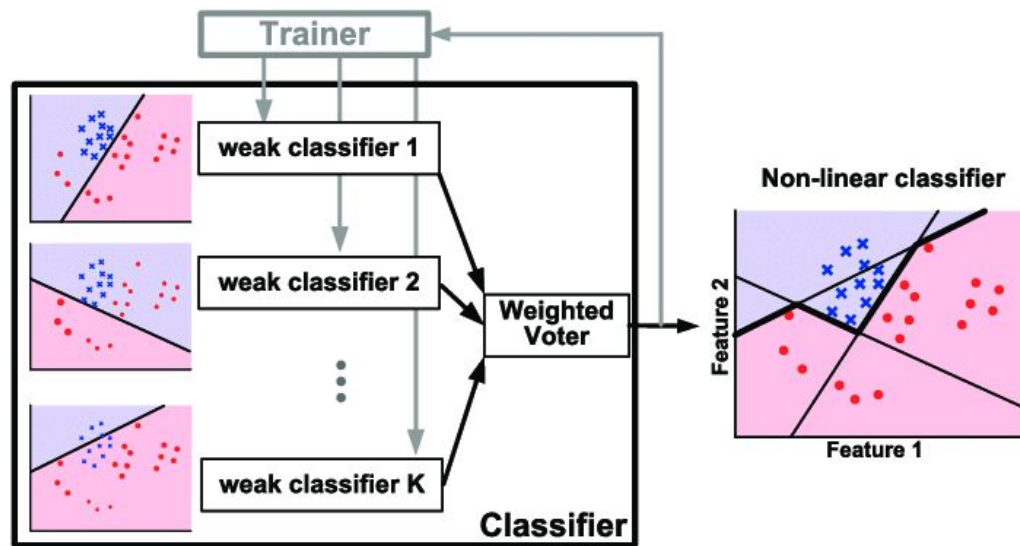
Decision Tree

- Decision tree is a non-parametric supervised learning algorithm which has a hierarchical, tree structure, which consists of a root node, branches, internal nodes and leaf nodes.



Adaboost

- AdaBoost is a boosting technique used as an ensemble method in machine learning. It is called Adaptive Boosting as the weights are re-assigned to each instance, with higher weights assigned to incorrectly classified instances.



Dataset

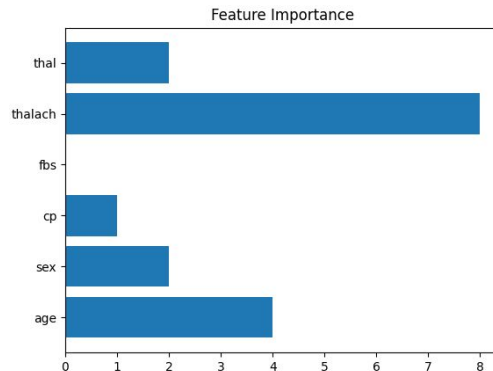
- Heart Attack Dataset
- Features
 - age
 - sex
 - cp: chest pain type (4 values)
 - fbs: fasting blood sugar > 120 mg/dl
 - thalach: maximum heart rate achieved
 - thal: 0 = normal; 1 = fixed defect; 2 = reversable defect
- Target
 - target (0 = no heart attack, 1 = heart attack)

Decision Tree

- Requirements:
 - Implement gini index and entropy for measuring the best split of the data.
 - Implement the decision tree classifier with the following two arguments:
 - **criterion**: The function to measure the quality of a split of the data. Your model should support "gini" and "entropy".
 - **max_depth**: The maximum depth of the tree.
- Tips
 - Your model should produce the same results when rebuilt with the same arguments.
 - You can use the recursive method to build the tree.

Decision Tree

- Criteria:
 - (5%) Compute the gini index and the entropy of the array [0, 1, 0, 0, 0, 0, 1, 1, 0, 0, 1].
 - (10%) Show the accuracy score of the testing data using criterion="gini" and max_depth=7.
 - (10%) Show the accuracy score of the testing data using criterion="entropy" and max_depth=7.
 - (5%) Train your model using criterion="gini", max_depth=15. Plot the feature importance of your decision tree model by simply counting the number of times each feature is used to split the data.



Adaboost

- Requirements:
 - Implement the Adaboost algorithm by using the decision tree classifier (`max_depth=1`) you just implemented as the weak classifier.
 - The Adaboost model should include the following two arguments:
 - **criterion**: The function to measure the quality of a split of the data. Your model should support "gini" and "entropy".
 - **n_estimators**: The total number of weak classifiers.
- Tips
 - You can set any random seed to make your result reproducible.

Adaboost

- Criteria:
 - (20%) Tune the arguments of AdaBoost to achieve higher accuracy than your Decision Trees.

Points	Testing Accuracy
20 points	$0.8 \leq \text{acc}$
15 points	$0.78 \leq \text{acc} < 0.8$
10 points	$0.76 \leq \text{acc} < 0.78$
5 points	$0.74 \leq \text{acc} < 0.76$
0 points	$\text{acc} < 0.74$

Code Output

- Do not modify the main function architecture.
- Your code output will look like this:

```
Part 1: Decision Tree
```

```
gini of [0, 1, 0, 0, 0, 0, 1, 1, 0, 0, 1]:
```

```
entropy of [0, 1, 0, 0, 0, 0, 1, 1, 0, 0, 1]:
```

```
Accuracy (gini with max_depth=7): 0.7049180327868853
```

```
Accuracy (entropy with max_depth=7): 0.7213114754098361
```

```
Part 2: AdaBoost
```

```
Accuracy: 0.8032786885245902
```

Report

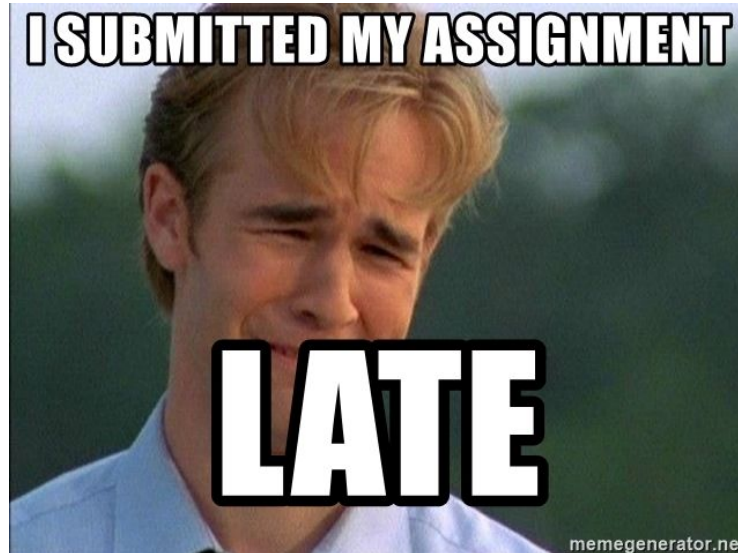
- Please follow the same report template format just like HW1.
- [Link](#)

Submission

- Compress your code and report into a **.zip file** and submit it on E3.
- <STUDENT ID>_HW3.zip
 - <STUDENT ID>_HW3.py
 - <STUDENT ID>_HW3.pdf (do not submit .doc, .docx or others format)

Late policy

- We will deduct a late penalty of 20 points per additional late day.
- For example, If you get 90 points but delay for two days, your will get only 50 points!



Have Fun!

