2024 Autumn Intro-to-Machine Learning Homework 2 Announcement

Release Date: 2024/10/15 15:00

Homework 2

- Deadline: 23:59, Oct. 29th (Tue), 2024
- **Coding** (60%): Implement linear classification methods by **only** using ***numpy*.**
  - Submit your code in executable python files (.py).
  - Report the outcome and parameters by screenshots to the questions.
- **Handwritten Questions** (40%): Answer questions about linear classification.
  - Answer the questions in the report.
  - You **must use the template** and in **digital-typed** (**no handwritten scan**)
  - In English

Links

- Questions and Report template
- Sample code / Dataset

Coding Environment

- Recommnedation: Python 3.9 or higher
- Tips
  - We recommend you to use **virtual environments** when implementing your homework assignments.
  - Here are some popular virtual environment management tools
    - Poetry
    - Conda
    - Virtualenv

Numpy

- High efficient vector and matrix operations
- Numpy Tutorial: Link

element-wise multiply

```
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]
```

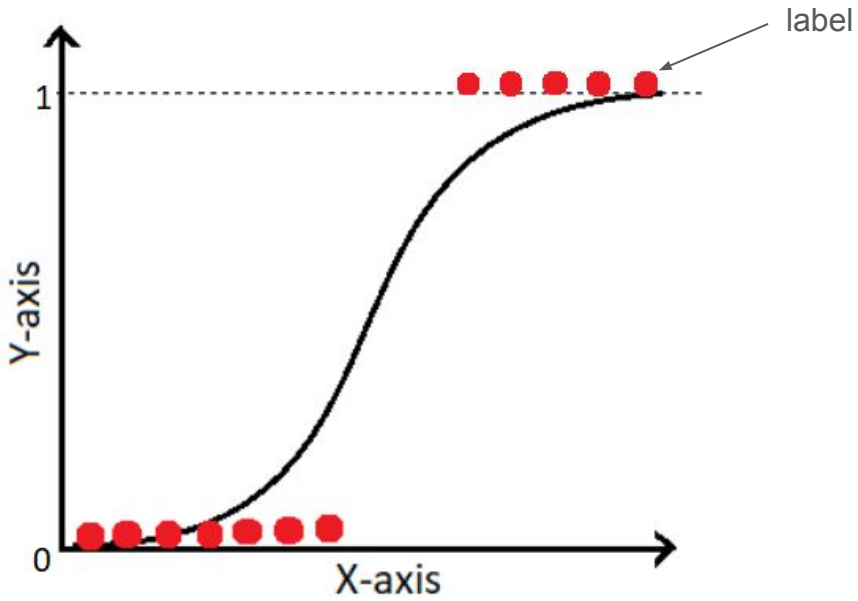
squre root

```
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]
```

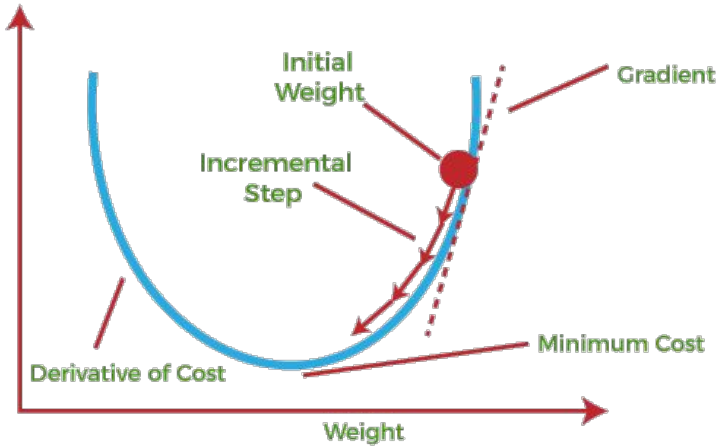
Logistic Regression for Binary classification

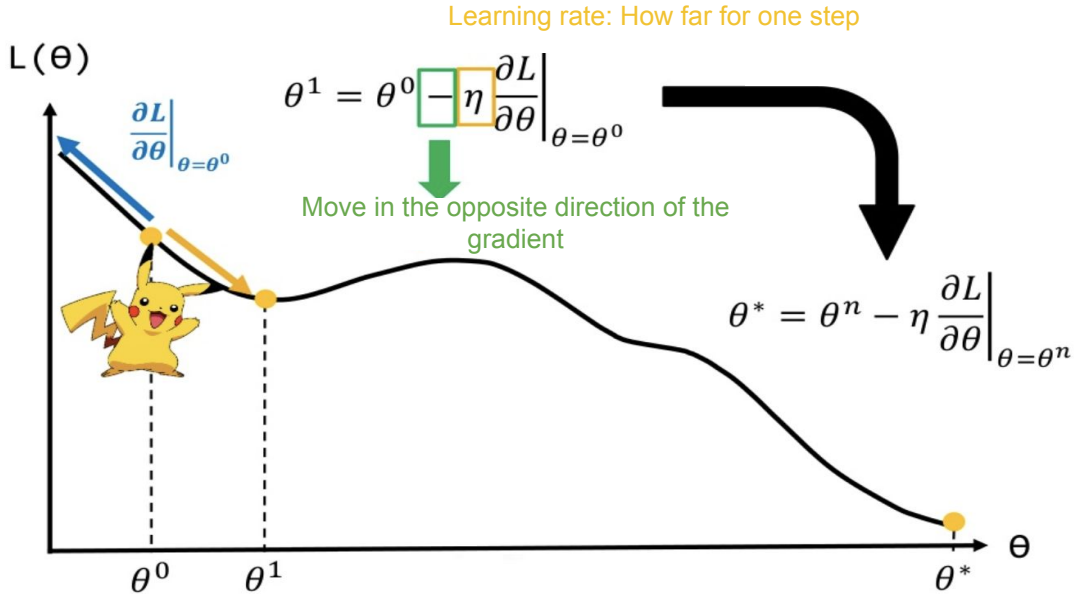
- Find the best value of the weights and the intercept of a logistic model



Logistic Regression

- Gradient Descent

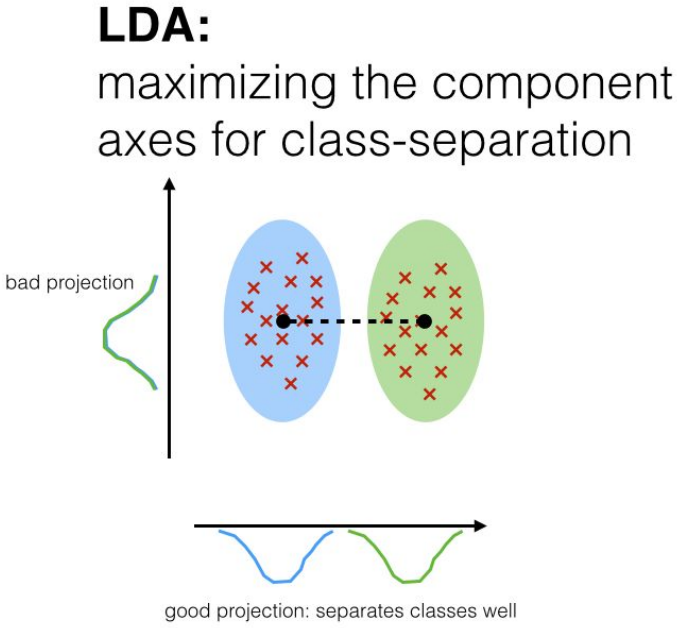




To better understand GD, see https://www.youtube.com/watch?v=yKKNr-QKz2Q

Fisher's Linear Discriminant, FLD

- FLD seeks the projection *w* that gives a large distance between the projected data center (means) while giving a small variance within each class.



$$J(\boldsymbol{W}) = \frac{(m_2 - m_1)^2}{s_1^2 + s_2^2}$$

Between-class variance

Within-class variance

https://sebastianraschka.com/Articles/2014_python_lda.html, https://sthalles.github.io/fisher-linear-discriminant/

Dataset and Environment

- Sonar dataset - A binary classification problem
- Datapoints
  - 208 (166 for train / 42 for test)
- Features
  - 60 features (already normalized)
- Target
  - Rock or Mine (0 / 1)

- Required packages: `numpy`, `pandas`, `matplotlib`, `loguru`, `flake8`, `pytest`, `scikit-learn`

Logistic Regression (25%)

- Requirements
  - Use Gradient Descent to update your model.
  - Use CE (Cross-Entropy) as your loss function.
- Grading Criteria
  - (5%) Show the hyperparameters (learning rate and iteration, etc) that you used and the weights and intercept of your model.
  - (5%) Show the AUC score of the classification results on the testing set.
    - sklearn is allowed to compute AUC score (only for this)
  - (15%) Show the **accuracy score** of your model **on the testing set**.

Accuracy	Score (pt)
>=0.8	15 pt
>=0.75, <0.8	10 pt
>=0.7, <0.75	5 pt
<0.7	0 pt

Fisher’s Linear Discriminant, FLD (25%)

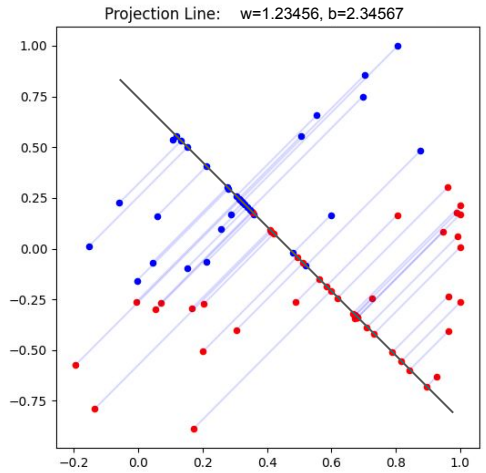
- Requirements:
  - Implement FLD to project the data from 2-dimensional to 1-dimensional space.
- Criteria:
  - (5%) Show the **mean vectors $\mathbf{m_i}$ (i=0, 1) of each class**, the **within-class scatter matrix $\mathbf{S_w}$**, and the **between-class scatter matrix $\mathbf{S_b}$** of the training set.
  - (5%) Show the Fisher’s linear discriminant ***w*** of the training set.

Fisher’s Linear Discriminant

Accuracy	Score (pt)
>=0.75	10 pt
>=0.6, <0.75	5 pt
<0.6	0 pt

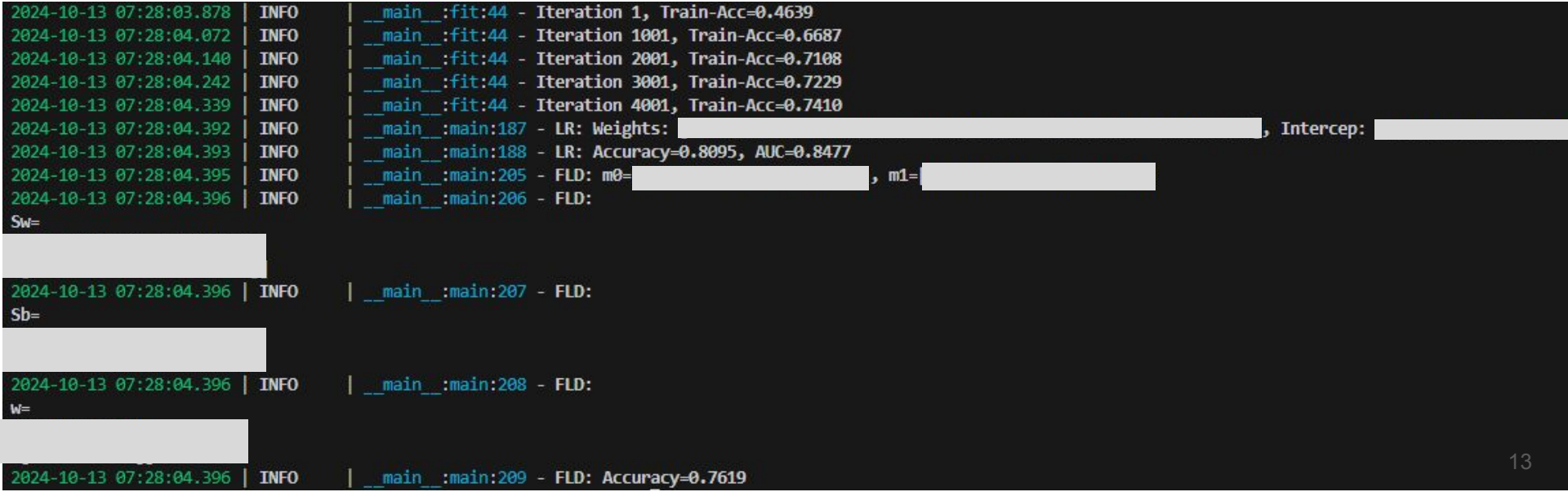
- Criteria
  - (15%, Acc=10%, Plot=5%) Obtain predictions for the testing set by measuring the distance between the projected value of the testing data and the projected means of the training data for the two classes. (Also, plot for training data)
    - **Plot the projection line** trained on the training set and show the slope and intercept on the title.
    - **Obtain the prediction of the testing set**, plot and **colorize** them based on the prediction.
    - Project all testing data points onto 1d space.
  - Also, **Show the accuracy score** on the testing set.

Just an example



Code Output

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



Python Coding Style Guide Reference

1. PEP8
2. Google Python Style

Additional Requirements

Code Check and Verification: **Lint** the code and show the **PyTest** results (10%)

- Code linting: `$ flake8 main.py`
  - -2pt per warning / error
- Run PyTest: `$ pytest ./test_main.py -s`
  - -5pt per failed case

```
./main.py:103:1: W391 blank line at end of file
1     W391 blank line at end of file
```

```
============================= test session starts ==============
platform linux -- Python 3.9.16, pytest-8.1.1, pluggy-1.4.0
rootdir: /home/seanyu/lectures/nycu/ml-and-pattern-recognition/hw2
configfile: pyproject.toml
collected 2 items

test_main.py (395, 2) (395,)
2024-10-13 07:36:37.581 | INFO     | test_main:test_logistic_regression:35 - accuracy=0.9517
.(395, 2) (395,)
2024-10-13 07:36:37.587 | INFO     | test_main:test_fld:45 - accuracy=0.8759
.

============================== 2 passed in 3.73s ===============
```

Handwritten Questions (40%)

2-1 (10%) Is logistic ‘regression’ used for regression problems? If not, what task is it primarily used? (without any additional techniques and modification) If yes, how can it be implemented? Why are we using the logistic function in such a task? (list two reasons) If there are multi-class, what should we use to substitute it?

2-2 (15%) When a trained classification model shows exceptionally high precision but unusually low recall and F1-score, what potential issues might arise? How can these issues be resolved? List at least three solutions.

2-3 (15%) In this homework, we use Cross-Entropy as the loss function for Logistic Regression. Can we use Mean Square Error (MSE) instead? Why or why not? Please explain in detail.

Report

- Please follow the report template format. (-5pts if not use the template)
- Link

Submission

- Compress your **code** and **report** into a **.zip file** and submit it to E3.
- Report should be written in English. (-5 pts if not English)
- <STUDENT ID>_HW2.zip
  - main.py
  - setup.cfg
  - test_main.py
  - <STUDENT ID>_HW2.**pdf** (NO .doc, .docx or others format)
- Don’t put the data (e.g. train.csv / test.csv) into submission file (-5 pts if you put data into the zipped file)

Other rules

- **Late Policy**: A penalty of **20 points** per additional late day. (-20pt / delayed.day)
  - For example, If you get 90 points but delay for two days, your will get only 50 points!

- **No Plagiarism**: You should complete the assignment by yourself. Students engaged in plagiarism will be penalized heavily. Super serious penalty.
  - e.g. -100pt for the assignment or failed this course, etc
  - Report to academic integrity office

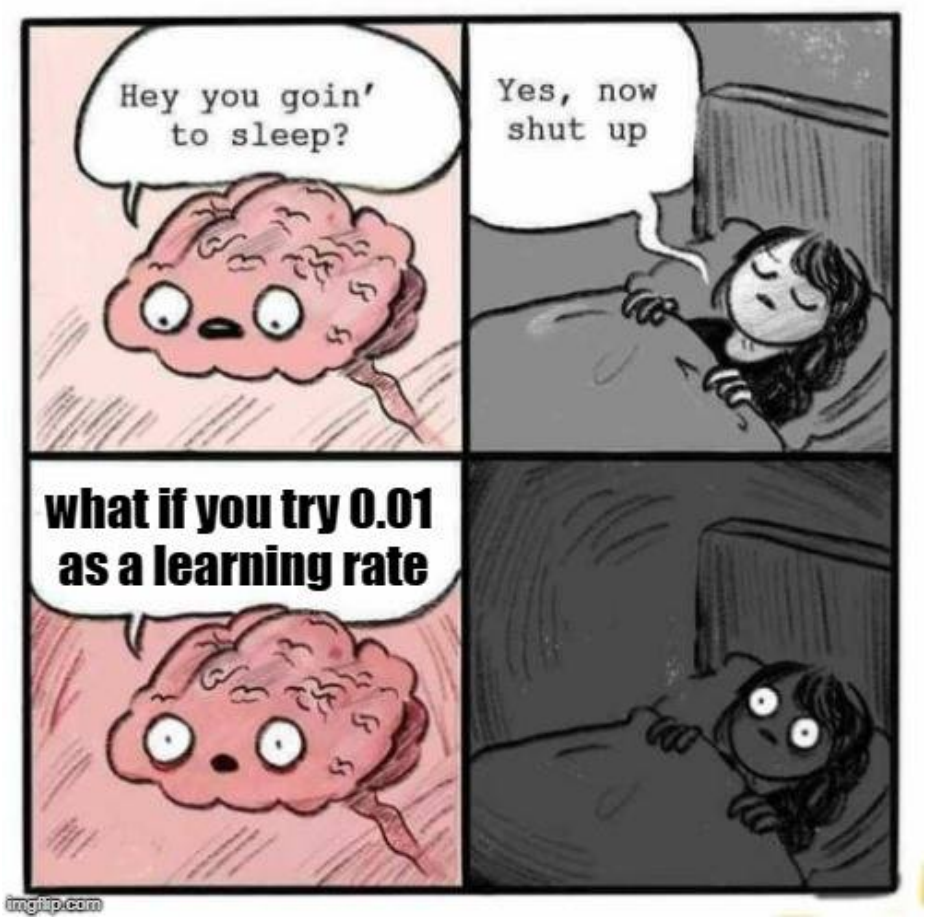
AI-Assistant

- Not recommended but no forbidden
- Copy-and-Paste answers from the AI-Assiant will be seen as Plagiarism
  - However, you can have your own answer first then rephrase it by AI-Assiant.
- Some questions might be parts of final exam, make sure you understand the concept

FAQs

- If you have other questions, ask on **E3 forum** first! We will reply as soon as possible.
  - Also, feel free to write email to TAs (And remember to cc all TAs).

Have Fun!


Hey you goin' to sleep?
Yes, now shut up
what if you try 0.01 as a learning rate
imgflip.com