

Lab4

Neural Network

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Introduction

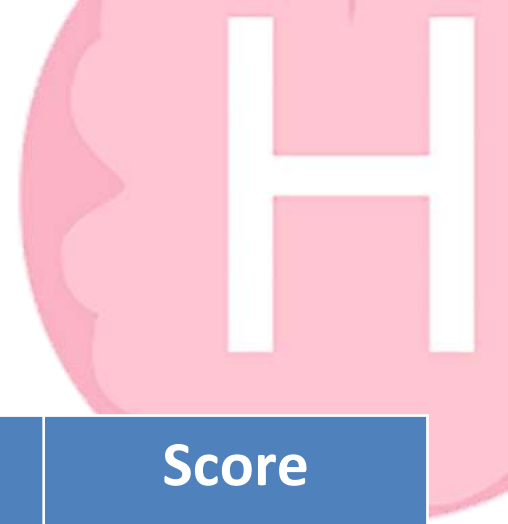
In this lab, you will apply neural networks to three tasks:

- **Regression:** Approximate a mathematical function.
- **Binary Classification:** Classify OCT retinal images as either normal or affected by Choroidal Neovascularization (CNV), a condition that can cause vision loss.
- **Multi-Class Classification:** Classify OCT retinal images into four categories:
 - CNV: Abnormal blood vessel growth in the eye
 - DME: Swelling of the macula due to diabetes
 - Drusen: Yellow deposits under the retina, potential sign of age-related macular degeneration
 - Normal: Healthy retina

Goal

- Build your own deep neural network step by step
- Implement all the functions required to build a deep neural network
- Understanding forward propagation, backward propagation and update
- Implement Binary Cross-Entropy loss and Categorical Cross-Entropy loss
- Implement **regression** (basic part), **binary classifier** (basic part) and **multi-class classifier** (advanced part)

Grading Policy



Item	Score
Basic Implementation	65%
Advanced Implementation	30%
Basic & Advanced Report	5%

Overview

Layer with parameters

Dense layer

initialize_parameters

forward

backward

update

Layer without parameters

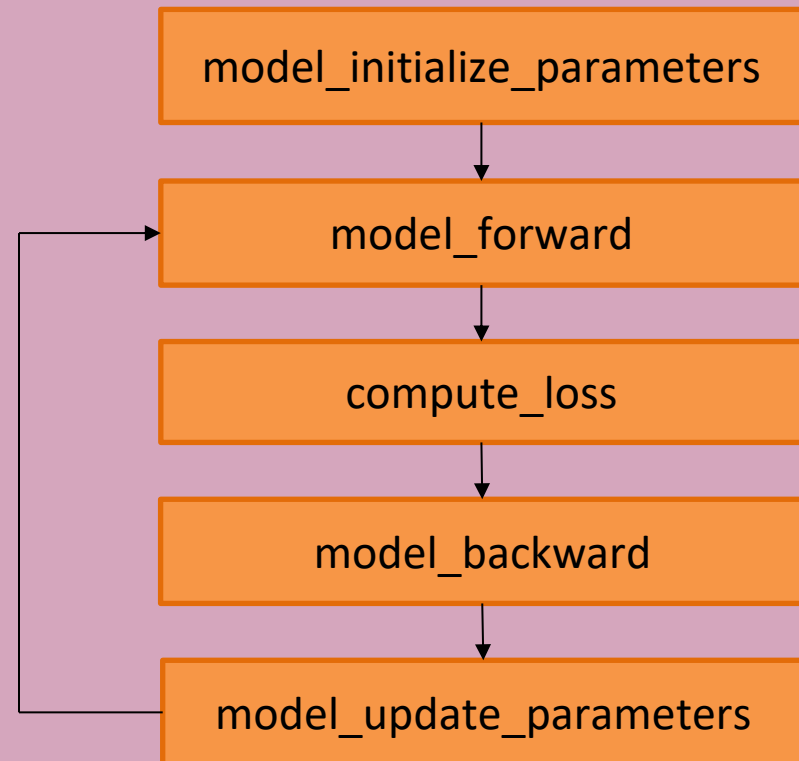
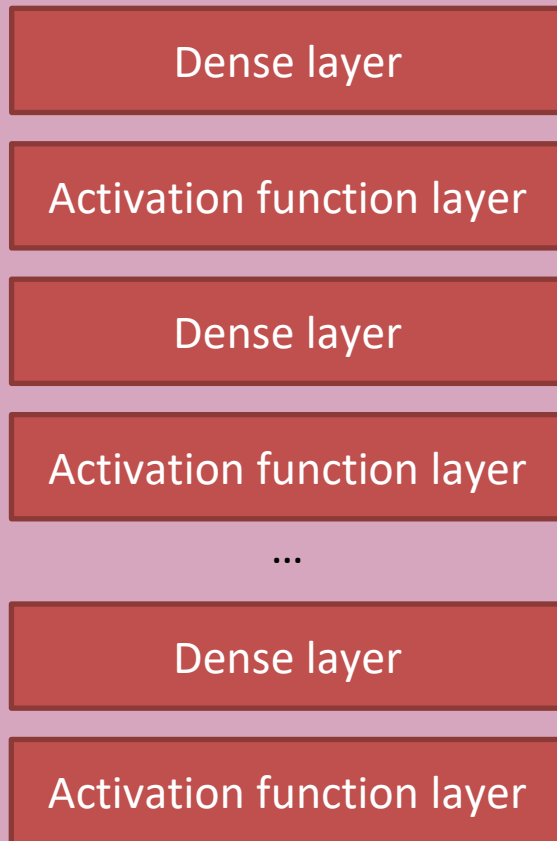
Activation function layer

forward

backward

Overview

Model



Basic Implementation (65%)

Section 1: Neural network implementation (30%)

Part 1: Linear layer (10%)

- Step 1: Linear Initialize parameters (0%)
- Step 2: Linear forward (4%)
- Step 3: Linear backward (4%)
- Step 4: Linear update parameters (2%)

Part 2: Activation function layer (10%)

- Step 1: Activation forward (5%)
- Step 2: Activation backward (5%)

Part 3: Build model (10%)

- Step 1: Model Initialize parameters (0%)
- Step 2: Model forward (4%)
- Step 3: Model backward (4%)
- Step 4: Model update parameters (2%)

Basic Implementation (65%)

Section 2: Loss function (10%)

Part 1: Binary cross-entropy loss (5%)

Part 2: Categorical cross-entropy loss (5%)

Part 3: Mean square error (0%)

Section 3: Training and prediction (25%)

Part 1: Training function & batch function (5%)

Part 2: Regression (10%)

- Baseline : MAE ≤ 0.05 (5%)
- Submit “**Lab4_basic_regression.gif**” (5%)

Part 3: Binary classification (10%)

- Baseline : Public f1 score ≥ 0.8 (5%)
- Baseline : Private f1 score ≥ 0.8 (5%)



Advanced Implementation (30%)

Multi-class classification

- Baseline : Public f1 score ≥ 0.6 (5%)
- Baseline : Private f1 score ≥ 0.6 (10%)
- Private Ranking (15%)

Loss function and Activation function

Warning: only the following 3 combinations are allowed!

1. Regression : linear + mse
2. Binary classification: sigmoid + cross_entropy
3. Multi-class classification: softmax + cross_entropy

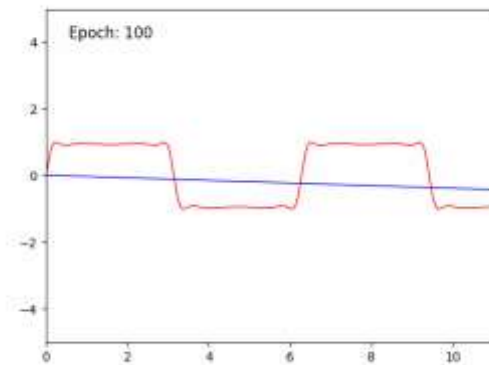
Data (Simulation data)

Regression: Math function approximation

The target function to approximate is:

$$y = \sin(2 * \sin(2 * \sin(2 * \sin(x))))$$

where x is in the range $[0.01, 11]$



Data (OCT scans)

Binary classification: OCT scan images of retina

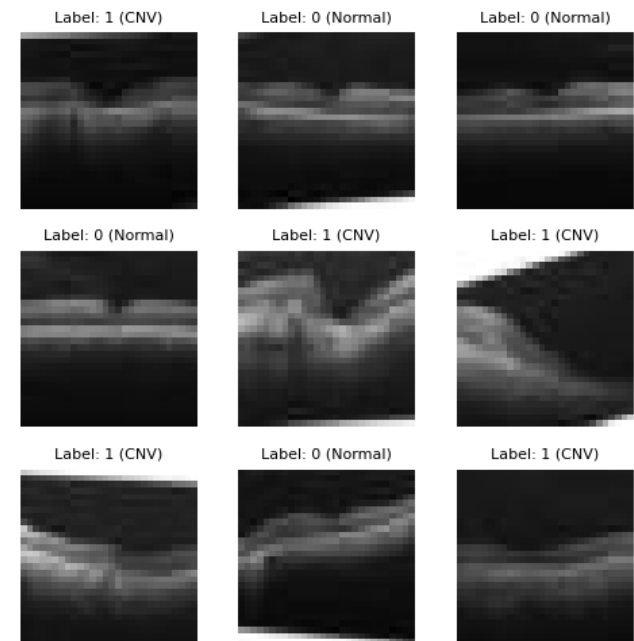
The dataset consists of 28x28 pixels grayscale OCT scan images of the retina, focusing on two classes: CNV (Choroidal Neovascularization) and Normal.

Details of the dataset:

- shape of x_train: (20000, 28, 28)
- shape of y_train: (20000, 1)
- shape of x_test: (5000, 28, 28)

Classes:

- CNV: label = 1
- Normal: label = 0



Data (OCT scans)

Multi-class classification: OCT scan images of retina

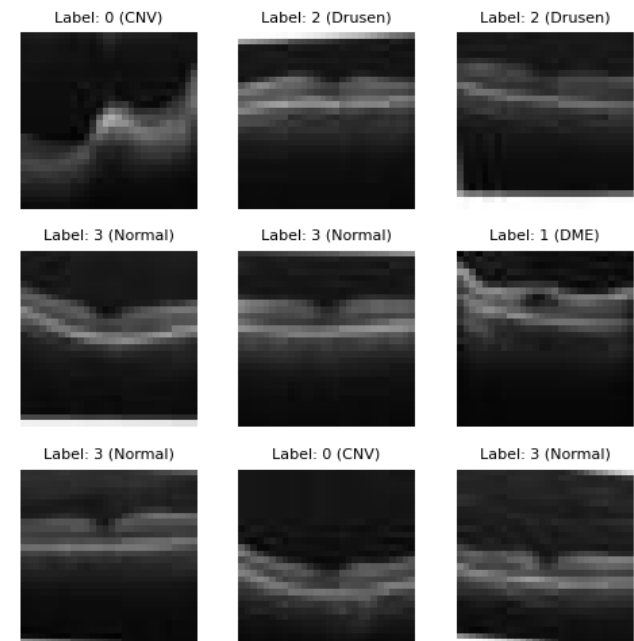
The dataset consists of 28x28 pixels grayscale OCT scan images of the retina, categorized into four classes: CNV (Choroidal Neovascularization), DME (Diabetic Macular Edema), Drusen, and Normal.

Details of the dataset:

- shape of x_train: (37754, 28, 28)
- shape of y_train: (37754,)
- shape of x_test: (3000, 28, 28)

Classes:

- CNV: label = 0
- DME: label = 1
- Drusen: label = 2
- Normal: label = 3



Output .csv file format

Basic Part : regression

There should be (1000+1) rows in your csv file


First row is the header ['ID', 'y']

ID starts from 0, and **y** is the predicted y value

Please make sure that your output format is correct

Submit the answer (Lab4_basic_regression.csv) to Kaggle

ML2024-Lab4-BasicPart-Reg



	A	B
1	ID	y
2	0	0.389933
3	1	0.420138
4	2	0.450343
5	3	0.480549
6	4	0.510754
7	5	0.540959
8	6	0.571164
9	7	0.601369
10	8	0.631574
11	9	0.66178
12	10	0.691985

Output .csv file format

Basic Part : binary classifier

There should be (5000+1) rows in your csv file

First row is the header ['ID', 'Label']

Your prediction answer should be either 0 or 1

ID starts from 0, and **Label** is the predicted answer

Please make sure that your output format is correct

Submit the answer (Lab4_basic.csv) to Kaggle

ML2024-Lab4-BasicPart-B.C.



	A	B
1	ID	Label
2	0	1
3	1	1
4	2	1
5	3	1
6	4	0
7	5	0
8	6	0



Output .csv file format

Advanced Part : multi-class classifier

There should be (3000+1) rows in your csv file

First row is the header ['ID', 'Label']

Your prediction answer should be (0~3)

ID starts from 0, and **Label** is the predicted answer

Please make sure that your output format is correct

Submit the answer (Lab4_advanced.csv) to Kaggle

ML2024-Lab4-AdvancedPart



	A	B
1	ID	Label
2		0
3		1
4		2
5		3
6		4
7		5
8		6



Output .npy File Format

- Named as “**Lab4_output.npy**”
- This file is a dictionary that stores your output for each function.
- We will test your “**Lab4_output.npy**” to verify the correctness of your neural networks.

```
dense_forward: <class 'tuple'>
dense_backward: <class 'tuple'>
dense_update_parameters: <class 'dict'>
sigmoid: <class 'tuple'>
relu: <class 'tuple'>
softmax: <class 'tuple'>
linear: <class 'tuple'>
sigmoid_backward: <class 'numpy.ndarray'>
relu_backward: <class 'numpy.ndarray'>
softmax_backward: <class 'numpy.ndarray'>
linear_backward: <class 'numpy.ndarray'>
model_forward_sigmoid: <class 'tuple'>
model_forward_relu: <class 'tuple'>
model_forward_softmax: <class 'tuple'>
model_backward_sigmoid: <class 'tuple'>
model_backward_relu: <class 'tuple'>
model_update_parameters: <class 'dict'>
compute_BCE_loss: <class 'numpy.float64'>
compute_CCE_loss: <class 'numpy.float64'>
```

Evaluation Metric

Regression

- MAE (mean absolute error)

summation of all values
(with i ranging from 1
to n)

this operator gives the
absolute value of a
number

$$\text{MAE} = \frac{\sum_{i=1}^n |y - \hat{y}_i|}{n}$$

No. of data
points

y = actual value, \hat{y} = predicted value

Evaluation Metric

Classification

- F1-score

$$F1\text{-score} = 2 \times \frac{(\text{Precision} \times \text{Recall})}{(\text{Precision} + \text{Recall})}$$

		Actual/True value	
		positive	negative
Predicted value	positive	TP	FP
	negative	FN	TN

Given Items

- Template: Lab4_template.ipynb
- Basic data (binary classifier): basic_data.npz
- Advanced data: advanced_data.npz

Template

Important notice

- Please **do not** change the code outside this code bracket in the basic part.

```
### START CODE HERE ###  
...  
### END CODE HERE ###
```

- Please **do not** import any other packages in both basic and advanced part
- Please **do not** change the random seed `np.random.seed(1)`.

Remember to save the code file to **Lab4.ipynb**

Kaggle

We've created competitions for 3 tasks respectively.

- Basic regression link:
<https://www.kaggle.com/competitions/ml-2024-lab-4-basic-part-fa>
- Basic binary classification link:
<https://www.kaggle.com/competitions/ml-2024-lab-4-basic-part-bc>
- Advanced link:
<https://www.kaggle.com/competitions/ml-2024-lab-4-advanced-part>
- For regression, only **public** data are provided.
- For both binary and multi-class classification tasks, we split the testing data randomly into **public** (50%) and **private** (50%) parts, maintaining the same class distribution ratio.
- Only the public score will be visible on Kaggle.

Kaggle

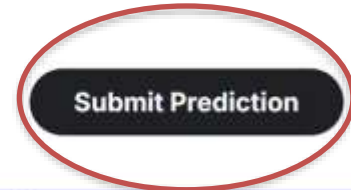
- Please register your account.
- Click the 'Join competition' button to join.



ADELINED0415 · COMMUNITY PREDICTION COMPETITION · 22 DAYS TO GO

ML2024-Lab4-BasicPart-Reg

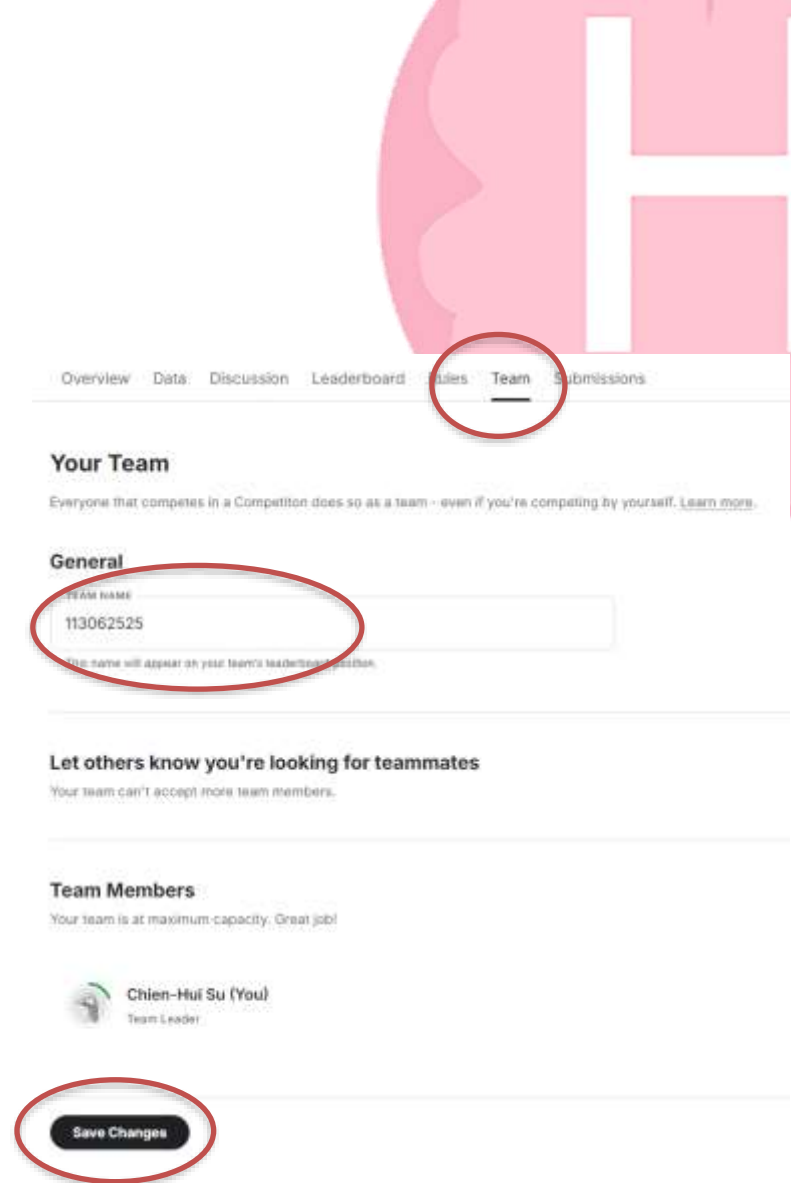
Use deep neural network to approximate a function.



Kaggle

- After joining the competition, you should change your team name (each student is a team) to your **student ID**.
- Please remember to **SAVE CHANGES**
- You can submit 50 times per day.

Notes: Please verify your team name on the leaderboard - changing profile name does not change team name.



Kaggle

You can manually select up to 1 submission that will count towards your final leaderboard score. If no submission is selected, Kaggle will automatically select your submission with the best public score.

Submissions

Select up to 1 submissions that will count towards your final leaderboard score. If less than 1 are selected, Kaggle will automatically select from your best scoring submissions. [Learn More](#)

1/1

Auto-selection candidates ⓘ

Submission and Description		Public Score ⓘ	Select
✓	Lab4_basic.csv Complete · 4m ago	0.92063	<input checked="" type="checkbox"/>
✓	Lab4_basic.csv Complete · 5m ago	0.92063	<input type="checkbox"/>

Manual-selection

Submissions

Select up to 1 submissions that will count towards your final leaderboard score. If less than 1 are selected, Kaggle will automatically select from your best scoring submissions. [Learn More](#)

0/1

Auto-selection candidates ⓘ

Submission and Description		Public Score ⓘ	Select
✓	Lab4_basic.csv Complete · 6m ago	0.92063	<input type="checkbox"/>
✓	Lab4_basic.csv Complete · 7m ago	0.92063	<input type="checkbox"/>

Auto-selection

Basic & Advanced Report (5%)

1. What are the key differences between sigmoid and softmax activation functions, and why did we choose them for binary and multi-class classification respectively? (1%)
2. Why does the loss oscillate during model training? (list at least 2 reasons) (2%)
3. How does changing the learning rate and batch size affect model training time? (1%)
4. Put your regression results (*lab4_basic_regression.jpg*) on report. (1%)

Notes:

1. Do not exceed 1 page!
2. Name your report file as “**Lab4_report.pdf**”.

Requirement

- Do it individually! Not as a team! (team is for final project)
- Announce date: 2024/10/31
- Deadline: **2024/11/12 23:59** (Late submission is not allowed!)
- Submit the answers (csv) to corresponding Kaggle competition.
 - **ML2024-Lab4-BasicPart-Reg**
 - **ML2024-Lab4-BasicPart-B.C.**
 - **ML2024-Lab4-AdvancedPart**
- Hand in following files to **eeclclass** in the following format (Do not compressed!)
 - **Lab4.ipynb**
 - **Lab4_report.pdf**
 - **Lab4_basic_regression.gif**
 - **Lab4_output.npy**



Penalty

0 points if any of the following conditions happened

- Plagiarism
- Late submission
- Not using a template or importing any other packages
- No submission record on Kaggle (we cannot identify who you are)
- Wrong team name on Kaggle (we cannot identify who you are)
- No code(**“Lab4.ipynb”**) submission on eeclass
- Your submission was not generated by your code

5 Points would be deducted if your submission format is incorrect

0 Points will be given in the Basic section 1&2 if you don't submit

“Lab4_output.npy”



Questions?

- TA: Chia-Suan Yu 余佳軒 (adeline041503@gmail.com)
- No debugging service

