**Fundamentals of Machine Learning (Fall 2022)**

**Homework #2 (120 Pts, Due date: Oct 5)**

**Student ID**

**Name**

**Instruction:** Once solving the problems, submit two files as follows.

* **'ML\_HW2\_YourName\_STUDENTID.zip'**: Compress the 'models' folder including 'models/SoftmaxClassifier.py' and 'models/LogisticRegression.py.'
* **'ML\_HW2\_YourName\_STUDENTID.pdf'**: Convert your document into a pdf file.

1. Solve the following problems.
2. **[10 pts]** Suppose we have the following samples from the Bernoulli distribution. Calculate the parameter using the maximum likelihood estimation method.

{0, 1, 1, 1, 1, 0, 1, 1, 1, 0}

**Answer:**

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**(b) [10 pts]** Suppose we have the following samples from the Gaussian distribution. Calculate the parameter μ and using the maximum likelihood estimation method.

{0.3, 0.5, 0.7, 0.8, 1.2}

**Answer:**

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**Instruction:** For problems 2 and 3, we provide two classification datasets, the Banknote authentication dataset and the Litmus dataset. The banknote authentication dataset is used for binary classification. It consists of 4 features (e.g., the variance of image, skewness, kurtosis, and entropy) to predict authentication for banknotes. The Litmus dataset is used for multi-class classification, representing a pH scale from 0 to 14. It consists of 3 features (e.g., blue, red, and green). The detailed information for each dataset is as follows.

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| --- | --- | --- | --- | --- |
| Dataset | # of training data | # of test data | # of classes | Details |
| Banknote | 1,029 | 343 | 2 | [link](https://archive.ics.uci.edu/ml/datasets/banknote+authentication) |
| Litmus | 488 | 165 | 15 | - |

**NOTE 1**: You should write your codes **only in 'EDIT HERE.'** Once you complete your implementation, run the checker code ('**0\_LogitisticRegression\_Checker.py**' or '**1\_SoftmaxClassifier\_Checker.py**') to validate if your code is executed correctly.

**NOTE 2:** You may need to install NumPy and Matplotlib libraries.

**NOTE 3**: Please carefully read the comments in the code.

1. **[Logistic regression]** Write your code to implement logistic regression. (Default hyperparameter settings for (b), (c): Epoch = 50, Batch\_size = 512, learning\_rate = 0.1)
2. **[30 pts]** Implement functions in 'models/LogisticRegression.py'. ('**forward**', '**compute\_grad**', '**\_sigmoid**', and '**eval**' respectively). Given a mini-batch data the error function for a mini-batch is defined as follows:

**Fill in your code here. You also have to submit your code to i-campus.**

**Answer:**

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1. **[5 pts]** For the Banknote dataset, draw the plots by adjusting the **learning rate**. (Let the other hyperparameters fix as default hyperparameter settings.) The x-axis is the value of hyperparameters searched, and the y-axis is the accuracy score. Try at least five different values and explain your results.

**Answer:**

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1. **[5 pts]** For the Banknote dataset, draw the plots by adjusting the number of **epochs**. (Let the other hyperparameters fix as default hyperparameter settings.) The x-axis is the value of hyperparameters searched, and the y-axis is the accuracy score. Try at least five different values and explain your results.

**Answer:**

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1. **[Softmax classifier]** Write your code to implement the softmax classifier. (Default hyperparameter settings for (b), (c): Epoch = 150, Batch\_size = 512, learning\_rate = 0.0005)
2. **[30 pts]** Implement functions in 'models/SoftmaxClassifier.py'. ('**forward**', '**compute\_grad**', '**\_softmax**', and '**eval**' respectively). Given a mini-batch data the error function for a mini-batch is defined as follows:

**Fill in your code here. You also have to submit your code to i-campus.**

**Answer:**

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1. **[5 pts]** For the Litmus dataset, draw the plots by adjusting **the learning rate**. (The other hyperparameters are fixed as default hyperparameter settings.) The x-axis is the value of hyperparameters searched, and the y-axis is the accuracy score. Try at least five different values and explain your results.

**Answer:**

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1. **[5 pts]** For the Litmus dataset, draw the plots by adjusting the number of **epochs**. (The other hyperparameters are fixed as default hyperparameter settings.) The x-axis is the value of hyperparameters searched, and the y-axis is the accuracy score. Try at least five different values and explain your results.

**Answer:**

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**4. [BONUS CREDIT 20 pts]** Write your review about the SKKU AI Colloquium held on Sep 22nd – 23rd in more than five lines. Please summarize the talk and write your comment about one or more lectures.

**Answer:**

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