

Homework 4

*Hand Out: May.18**Due: May.25*

- Feel free to talk to other students in the class when doing the homework. You should, however, write down your solution yourself. You also must indicate on each homework with whom you collaborated and cite any other sources you use including Internet sites.
- You will write your solution in LaTeX and submit the **pdf file through Gradescope**. You also need to submit the **zipped LaTeX files to CCLE**. We will grade your homework based on the final version of the pdf file submitted to Gradescope. We will not grade the zipped Latex files on CCLE. However, failure to submitting your LaTeX files to CCLE will incur 2 points penalty out of 100 points.
- The homework (both pdf and zipped Latex source files) is due at **1:59 PM before the class**.

The following questions are from *Understanding Machine Learning: From Theory to Algorithms* by Shai Shalev-Shwartz and Shai Ben-David. It can be found here <http://www.cs.huji.ac.il/shais/UnderstandingMachineLearning/> by courtesy of the authors.

1. (10 Points) Exercise **10.1**
2. (10 Points) Exercise **12.1**
3. (10 Points) Exercise **12.2**
4. (10 Points) Exercise **12.3**
5. (10 Points) Exercise **13.3**
6. (10 Points) Exercise **14.2**
7. (10 Points) Exercise **14.3**
8. (30 Points) In this problem, you are asked to implement Adaboost algorithm using decision stump as the weak learner for binary classification. Consider the base hypothesis class of decision stumps over \mathbb{R}^d is ¹

$$\mathcal{H}_{\text{DS}} = \{\mathbf{x} \mapsto \text{sign}(\theta - x_i) : \theta \in \mathbb{R}, i \in [d]\}$$

and the sign function is defined as:

$$\text{sign}(x) = \begin{cases} 1 & \text{if } x \geq 0 \\ -1 & \text{otherwise} \end{cases}$$

Please report your answer of the following questions to Gradescope, and submit your source code to CCLE. Your answer will NOT be graded if we do not see your source code submission on CCLE. Note that, you are allowed to use other programming languages for your implementation. If so, you may need to create an csv data loader yourself and read the data from `./data/*.csv`.

¹Note that the definition of decision stump is slightly different from the slides. Here we will follow the definition in the textbook.

- Run the skeleton code, report the training and testing error obtained by the Adaboost model using decision stump implemented in scikit-learn.
- Implement ERM algorithm for Decision Stumps. Replace skeleton code line 52-55 with your implementation. Report the training error and testing error of a single decision stump with uniform distribution.
- Implement Adaboost algorithm based on the above implemented Decision Stump classifier. Replace line 118-120 with your own implementation. Plot the training error and testing error with respect to the number of iterations of training the Adaboost.
- Report the final training error and testing error of adaboost.