Homework Assignment 1
Perceptron and Logistic Regression

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Submission Instruction   You must typeset the answers to the theory questions using LaTeX or Microsoft Word and compile them into a single PDF file. For the programming assignment, complete the two Jupyter notebooks. Create a ZIP file containing both the PDF file and the two completed Jupyter notebooks, and name it "⟨Your-NetID⟩_hw1.zip". Email this file to intro2ml@gmail.com within two weeks since the announcement of the homework.

1.   When defining a perceptron, we have augmented an input vector $\mathbf{x}$ with an extra 1:

$$M(\mathbf{x}) = \text{sign}(\mathbf{w}^\top \tilde{\mathbf{x}}),$$

where $\tilde{\mathbf{x}} = [\mathbf{x}; 1]$. Why is this necessary? Provide an example in which this extra 1 is necessary.

2.   We used the following distance function for perceptron in the lecture:

$$D(M^*(\mathbf{x}), M, \mathbf{x}) = -(M^*(\mathbf{x}) - M(\mathbf{x}))\left(\mathbf{w}^\top \tilde{\mathbf{x}}\right).$$

This distance function has a problem of a trivial solution. What is the trivial solution? Propose a solution to this.

3.   The distance function of logistic regression was defined as

$$D(y^*, \mathbf{w}, \mathbf{x}) = -(y^* \log M(\mathbf{x}) + (1 - y^*) \log(1 - M(\mathbf{x}))).$$

Derive its gradient with respect to the weight vector $\mathbf{w}$ step-by-step.

4. (Programming Assignment) Complete the implementation of perceptron and logistic regression using Python and scikit-learn. The completed notebooks must be submitted together with the answers to the questions above.

Perceptron `https://github.com/nyu-dl/Intro_to_ML_Lecture_Note/`
`blob/master/notebook/Perceptron1.ipynb`

Logistic Regression `https://github.com/nyu-dl/Intro_to_ML_Lecture_`
`Note/blob/master/notebook/Logistic%20Regression%201.ipynb`