CS422/522 Intro to Machine Learning

Due: Sep. 18 (Monday), the end of the day

This assignment includes two parts: written problems in Part1 and python programming exercises in Part2. For Part1, please create a high-quality pdf file with your solutions to those written problems. For part2, please complete the coding in the HW1.ipynb file coming with this assignment. After you are done with both parts, update the pdf and the completed HW1.ipynb to Blackboard.

Part1

1. Hyperbolic tangent is a rescaled sigmoid function that we discussed in class, defined as:

$$\tanh(x) = \frac{e^{2x} - 1}{e^{2x} + 1}.$$

   This function is used as the activation function very frequently in recurrent neural networks. Please calculate the value of this function corresponding to inputs: -5, -4, -3, -2, -1, 0, 1, 2, 3, 4 and 5. Then, show the curve of this function by drawing a line plot by hand using these input-value pairs as data points. Please write down the steps that you follow through. Do not just give a plot.

2. Given three vectors:

$$\mathbf{s}_1 = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix}, \quad \mathbf{s}_2 = \begin{bmatrix} 0 \\ 1 \\ 1 \end{bmatrix}, \quad \mathbf{s}_3 = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}.$$

   (1), Find the linear combination $2\mathbf{s}_1 + 3\mathbf{s}_2 + 4\mathbf{s}_3 = \mathbf{v}$. Then write $\mathbf{v}$ as a matrix-vector multiplication $\mathbf{Sx}$ with $\mathbf{s}_1$, $\mathbf{s}_2$ and $\mathbf{s}_3$ going into the columns of $\mathbf{S}$. Compute the dot product of each row $\mathbf{s}_i^T$ in $\mathbf{S}$ with $\mathbf{x}$, i.e., $\mathbf{s}_i^T \odot \mathbf{x}$. Dot product of two vectors is the inner product between the two.

   (2), Assume we have a matrix $\mathbf{M}$, which is given by $\mathbf{M} = [2\mathbf{s}_1, 3\mathbf{s}_2, 4\mathbf{s}_3]$, write $\mathbf{M}$ as a matrix-matrix multiplication $\mathbf{SA}$. Then compute $\mathbf{SA}$ to find $\mathbf{M}$.

3. Suppose we have a small sample of a patient population suffering from a genetic disorder. The age of all patients in this sample is provided in below:

Patient	age
1	25
2	26
3	38
4	45
5	31
6	30
7	29
8	43

   Please calculate the sample mean and variance of the patient age.

4. You ask your neighbor to water a sickly plant while you are on vacation. Without water, it will die with probability .8; with water, it will die with probability .15. You are 90 percent certain that your neighbor will remember to water the plant.

   (a) What is the probability that the plant will be alive when you return?

   (b) If the plant is dead upon your return, what is the probability that your neighbor forgot to water it?

Part2

Please follow instructions in the HW1.ipynb file found in this assignment.