

# IST 597: Foundations of Deep Learning

## Assignment 01

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TA : Neisarg Dave  
Due Date : Tuesday, August 29, 2023

Credits: Thanks and credits to materials from UCL and GeorgiaTech

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### Course Policy

- Carefully read all the instructions before you start working on the assignment
- Give maximum explanation for each sub-problem. Please avoid single-line answers; submissions without any explanations will receive 0 points.
- Assignments are due before class at 02:29 pm. Please check the due date on Canvas.
- Late exercises will receive 50% credits for the first 24 hours and no credits thereafter.
- All exercise solutions must be turned in, even if late. Failure to do so can result in a deferred grade.
- All source materials must be cited. The University Academic Code of Conduct will be strictly enforced.
- All queries related to Assignment should have a subject line *IST597 : Assignment\_01 Queries*

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### Assignment Instructions:

- This assignment consists of 4 problems for a total of 6 marks.
- Problems 1 and 2 are theory questions and do not require programming.
- Problems 3 and 4 are programming questions.
- The submission for this assignment must be a zipped folder:  $\{name\}_{assignment\_01}.zip$
- The folder must contain two files:
  1.  $\{name\}_{assignment\_01}.pdf$ : Answers for all theory questions and explanations for all problems.
  2.  $\{name\}_{assignment\_01}.py$ : Codes for programming problems

A template Python file is provided for programming problems.

## Problem 1

1 mark

Let  $T : R^3 \rightarrow R^4$  be defined by

$$Tx = \begin{bmatrix} x_1 - 5x_2 + 5x_3 \\ 5x_1 + 2x_2 - 10x_3 \\ -5x_1 - 8x_2 + 6x_3 \\ 3x_2 - 2x_3 \end{bmatrix}$$

for every  $x = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} \in R^3$ ,

1. Write  $T$  in matrix form.
2. Evaluate  $Tx$  for  $x = \begin{bmatrix} -1 \\ 3 \\ 2 \end{bmatrix}$
3. Is  $T$  linear ? Why?

## Problem 2

2 marks

Consider the following function of  $x = (x_1, x_2, x_3, x_4, x_5, x_6)$ :

$$f(x) = \sigma \left( \log \left( 3 \left( \max\{x_1, x_2\} \cdot \frac{x_3}{x_4} - (x_5 + x_6 - x_1) \right) \right) + \frac{1}{2} \right)$$

where  $\sigma$  is the sigmoid function, defined as:

$$\sigma(x) = \frac{1}{1 + e^{-x}}$$

Compute the gradient  $\nabla_x f$  and evaluate it at  $x = (-1, 3, 4, 5, -5, 7)$

## Problem 3

1 mark

Let  $a$  be an array of positive integers:

$$a = [9, 8, 15, 17, 14, 2, 15, 7, 12, 1, 5, 1, 8, 16, 3, 15, 8, 15, 3, 5]$$

Write code using numpy library to get all items in the range (5, 10] from  $a$

*Note:* Use only indexing methods, do not use iteration or if conditions

## Problem 4

2 marks

Let

$$x = [3, 4, 5]$$

$$W = \begin{bmatrix} 1 & 5 & 3 \\ 2 & 5 & 5 \\ 5 & 5 & 1 \end{bmatrix}$$

Write program to compute:

1.  $x^T$
2.  $z = Wx^T$
3. Softmax function is defined as

$$\sigma(x_i) = \frac{e^{x_i}}{\sum_j e^{x_j}}$$

Compute  $\sigma(z)$