# CSE 4392 Special Topic: Natural Language Processing

Homework 6 - Spring 2025

Due Date: Mar 3, 2025, 11:59 p.m. Central Time

# Problem 1 (40%)

Consider a neural network with the following hypothesis function:

Input: x,  

$$\mathbf{h}_1 = \tanh(\mathbf{W}_1\mathbf{x} + \mathbf{b}_1),$$
  
 $\mathbf{h}_2 = \tanh(\mathbf{W}_2\mathbf{h}_1 + \mathbf{b}_2),$   
 $\mathbf{y} = \sigma(\mathbf{w}^{\top}\mathbf{h}_2 + b),$ 

and the loss function is given by

$$\mathcal{L}(\mathbf{y}, y^*) = -y^* \log y - (1 - y^*) \log(1 - y).$$

**Task:** Compute the gradient of  $\mathcal{L}$  with respect to each parameter in the network, namely:

 $\mathbf{W}_1$ ,  $\mathbf{b}_1$ ,  $\mathbf{W}_2$ ,  $\mathbf{b}_2$ ,  $\mathbf{w}$ , and b.

Your solution must include four sections:

- 1. Chain Rule Expression: Write the full chain rule expression for each gradient.
- 2. **Differentiation Identities:** List the differentiation identities expected to be used to compute the chain terms.
- 3. **Step-by-Step Computation:** Compute each chain term step by step, referencing the identity used.
- 4. Final Gradient Equations: Present the final gradient and thereby show the gradient descent update equation.

Ensure an organized solution to prevent losing marks. It's good to start with a draft and then rewrite in an organized way or just ust Latex!

# Problem 2 - 60%

In this problem, you will leverage your understanding of neural network fundamentals to build a simple fully connected neural network for classifying MBTI (Myers-Briggs Type Indicator) personality types based on preprocessed posts.

dataset: MBTI 500.csv columns:

- **posts**: Equal-sized posts with 500 words per sample.
- type: MBTI personality types indicating differing psychological preferences.

#### instructions:

#### 1. Dataset Exploration:

• Load the provided CSV file (**MBTI500.csv**). Split it into training and testing splits after randomizing it. It's sufficient for the test set to include 5K examples.

#### 2. Data Preprocessing:

• Decide whether to perform a 4-way classification (based on dichotomies) or a 16-way classification (considering each personality type independently). Your decision will guide how you preprocess the type column.

## 3. Feature Extraction:

• Utilize existing libraries to extract features from the posts to map each of them into a vector.

### 4. Neural Network Construction:

• Use PyTorch to build a neural network for this task

### 5. Training:

• Tune different hyperparameters of the neural network to optimize it for this task.

### 6. Evaluation:

• For each hyperparameter setting, evaluate the model using Macro F1, Macro Precision, Macro Recall and Accuracy. Show results in the report for at least 7 different hyperparameter configurations.

### 7. Documentation:

• Create a PDF report detailing your approach, including decisions made during data preprocessing, feature extraction, and network architecture. Provide insights into your model's performance and discuss any challenges faced.

### 8. Attach your codes and report.

Evaluation will partly be part of the best evaluation result of your model. Do not zip your files before submission.