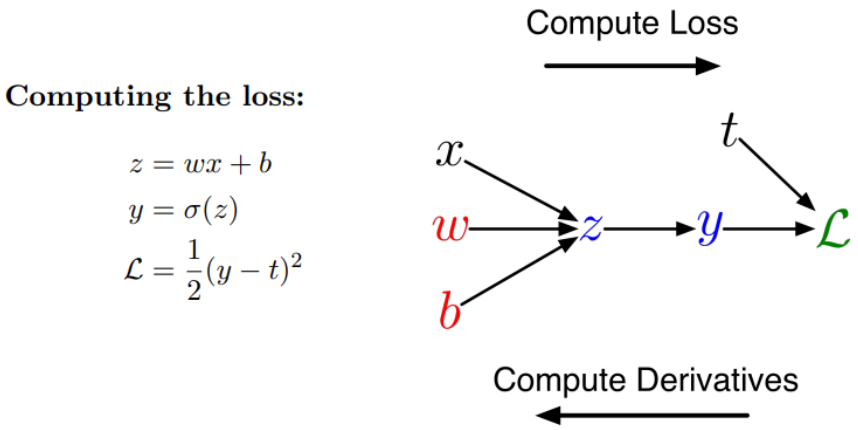
CSCI 416/516 Homework #3

DUE: April 03, 2024, at 11:59 pm

Submission: For all the problems excluding the multiple choice problem(s), you need to **show all your works, steps, and calculations** if applicable, or **your justification/expalantion to the answer(s) you provide**. You should submit a PDF to Blackboard with your answers that are recognizable/intelligible. Preferably, you should use LaTeX.

- **Problem 1 [2 pt(s)]: Backpropagation.** What does the back pass look like (in terms of the error signals of parameters/activations, such as but not limited to b, w), given the illustrated forward pass in Figure below? Show your work on how the conclusion is reached.



- **Problem 2 [2 pt(s)]: Activation Function.**
  Suppose we have a neural network with one hidden layer as represented in Equation 1 whereas $g(z)$ is defined as $\mathbb{I}(z \geq 0)$. Which of the following functions can be exactly represented as the activation function g? Indicate Yes or No to each choice.

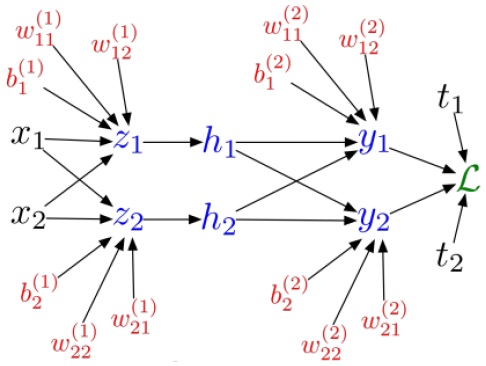
$$f(x) = w_0 + \sum_i w_i h_i(x); h_i(x) = g(b_i + v_i x) \tag{1}$$

  - Hard Threshold Activation Function

- Rectified Linear Unit
- Identity Activation Function
- Logistic Activation Function

- **Problem 3 [2 pt(s)]: 1D Convolution.**
  Given a kernel $k = \{2, 9, 3\}$ and a vector $v = \{1, 2, 3\}$, what is the result of $k * v$? After getting the result $k * v$, what is the new result after applying ReLU on $k * v$? Show the work that leads to your conclusion.

- **Problem 4 [2 pt(s)]: Backpropagation**
  What does the back pass look like (in terms of the error signals of parameters/activations, such as but not limited to b, w), given the illustrated forward pass in Figure below? Show your work on how the conclusion is reached.



- **Problem 5 [3 pt(s)]: MLP.**
  Which of the following statements about multi-layer perceptrons (MLPs) is incorrect?

  - A - An MLP with one hidden layer and a sufficient number of neurons can approximate any continuous function.
  - B - The activation function used in the hidden layers of an MLP must always be non-linear.
  - C - Dropout is a regularization technique used to prevent overfitting by randomly setting some neuron outputs to zero during training.
  - D - MLPs require all input features to be numerical, and categorical data must be transformed using techniques like one-hot encoding or embeddings.