CSCI 6751 V1 | Artificial Intelligence

Quiz#2

Dec 2, 2025

Total 50 points **Time: 50 minutes**

GOOD LUCK ***Group 1***

Student Name & ID ______________________________

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/40	/60	/100

Question 1. (40 points)

A binary classifier is used to detect *spam emails* (Positive class). You evaluate the model on **200 emails** and observe the following:

- The model predicted 70 emails as spam**.**
- Of those 70, 50 were actually spam**.**
- Out of the 130 emails predicted as not spam**,** 20 were actually spam**.**
- The remaining emails were legitimate.

Tasks:

a) Construct the confusion matrix (TP, FP, FN, TN).

b) Compute the following metrics: Precision, Recall, Accuracy, F1-Score

c) In the context of spam detection, which metric is most important—precision, recall, or accuracy? Explain *why* that metric should be prioritized in this problem.

Solution:

(a) Confusion Matrix

	Predicted Spam	Predicted Not Spam
Actual Spam	TP = 50	FN = 50
Actual Not Spam	FP = 20	TN = 20

(b) Evaluation Metrics

Precision

$$\text{Precision} = \frac{TP}{TP+FP} = \frac{50}{50+20} = \frac{50}{70} = 0.714$$

Recall

$$\text{Recall} = \frac{TP}{TP+FN} = \frac{50}{50+20} = \frac{50}{70} = 0.714$$

Accuracy

$$\text{Accuracy} = \frac{TP+TN}{200} = \frac{50+110}{200} = \frac{160}{200} = 0.80$$

F1-Score

$$F1 = 2 \cdot \frac{\text{Precision} \cdot \text{Recall}}{\text{Precision} + \text{Recall}} = 2 \cdot \frac{0.714 \times 0.714}{1.428} = 0.714$$

(c) In Spam filtering, Precision Avoid marking real emails as spam

Question 2. (60 points) Consider a small neural network for regression**:** Input layer: 3 neurons (x_1,x_2,x_3), Hidden layer: 2 neurons (h_1,h_2) with sigmoid activation, Output layer: 1 neuron (no activation function); You are given **one training sample**: $x=[x_1,x_2, x_3]=[0.5,-1.0,2.0], y_{true}=1.5$

Weights

First-layer weights (input → hidden):

$$\mathbf{W}_{hidden} = \begin{bmatrix} 0.2 & -0.1 \\ 0.4 & 0.5 \\ -0.3 & 0.2 \end{bmatrix}, \quad \mathbf{b}_{hidden} = [0.1, -0.2]$$

Last-layer weights (hidden → output):

$v=[v_1,v_2]=[0.3,-0.2], b_o=0.05$; v1 → weight from h1 to output and v2 → weight from h2 to output

a) Compute the **network output** $y^\wedge$.

b) Using **MSE loss**: $L=1/2(y^\wedge - y_{true})^2$

Calculate the gradients of the loss w.r.t only the last-layer weights v_1, v_2 and the output bias b_o.

Hint :

z	σ(z) ≈
-1.0	0.27
-0.8	0.31
-0.5	0.38
-0.35	0.41
0	0.50
0.35	0.59
0.5	0.62
0.8	0.69
1.0	0.73

Solution:

a) Forward Pass

Hidden layer pre-activations:

$z1=0.2(0.5)+0.4(-1)+(-0.3)(2)+0.1=-0.8$
$z2=-0.1(0.5)+0.5(-1)+0.2(2)-0.2=-0.35$

Hidden activations (sigmoid):

$h1=\sigma(-0.8)=0.310$

$h2=\sigma(-0.35)=0.413$

Output:

$y^\wedge=0.3(0.310)-0.2(0.413)+0.05=0.060$

Loss
$L=12(0.060-1.5)^2=1.04$

b) Gradients (Last Layer)

$(\hat{y} - y_{true}) = -1.44$

$$\frac{\partial L}{\partial v_1} = -1.44(0.310) = -0.446$$
$$\frac{\partial L}{\partial v_2} = -1.44(0.413) = -0.595$$
$$\frac{\partial L}{\partial b_o} = -1.44$$