MAIE 5421 Computer Vision: Assignment-1

September 26, 2025

1 Simple Linear Regression (15 Points)

Given the input variable X and the observed variable Y, derive the parameter estimates α and β for Simple Linear Regression.

$$Y = \alpha X + \beta + \epsilon$$

$$SSR = \sum_{i=1}^{n} (y_i - (\beta + \alpha x_i))^2$$

2 Confusion Matrix (10 Points)

Suppose you are working on a binary classification problem and obtained the following confusion matrix:

Table 1: Confusion Matrix

	Actual Positive	**Actual Negative**
Predicted Positive	40	5
Predicted Negative	10	45

Please calculate the True Positive Rate (TPR), True Negative Rate (TNR), False Positive Rate (FPR), False Negative Rate (FNR), Recall, Precision, Accuracy, and F1-Score.

3 K-Nearest Neighbors (10 Points)

Your are given a dataset of 10 points with three features (x, y, z), and their respective class label A and B, shown in Table 2. Using the dataset , your task is to classifiy the point $(3.5, 4.0, 6.0)$ using K-Nearest Neighbors clustering ($K = 3$) with the two distance metrics (L_1 distance and cosine distance).

Table 2: Dataset for KNN.

Data ID	Feature x	Feature y	Feature z	Label
1	1.0	2.0	3.0	A
2	0.5	1.8	2.7	B
3	1.2	2.2	3.5	B
4	4.6	5.6	3.7	A
5	2.4	4.6	3.6	A
6	3.5	2.0	4.1	B
7	3.6	4.6	7.1	A
8	6.2	4.1	1.3	B
9	8.4	3.5	1.8	A
10	5.8	3.4	2.7	B

4 Naive Bayes Classifier (10 Points)

Consider the observations in Table 3, a new sample is given with the following attributes [Sunny, Hot, Normal, False]. Use the Naive Bayes Classifier to determine the most likely decision for the given data point.

Table 3: Data Samples for Naive Bayes Classifier

Data ID	Outlook	Temperature	Humidity	Windy	Play Golf
1	Rainy	Hot	High	True	No
2	Overcast	Hot	High	False	Yes
3	Sunny	Mild	High	False	Yes
4	Sunny	Cool	Normal	False	Yes
5	Sunny	Cool	Normal	True	No
6	Overcast	Cool	Normal	True	Yes
7	Rainy	Mild	High	False	No
8	Rainy	Cool	Normal	False	No

5 Decision Tree (15 Points)

Given the following dataset (Table 4), you are asked to complete the following tasks.

- Using ID3 algorithm to calculate the entropy of the entire dataset and the information gain for weather, temperature, and wind.
- Using ID3 algorithm to construct the entire decision tree. Reasoning details are required.

Table 4: Data Samples for Decision Tree

Data ID	Weather	Temperature	Wind	Class
1	Sunny	High	High	No
2	Overcast	High	High	Yes
3	Rain	Medium	High	Yes
4	Rain	Low	Medium	Yes
5	Overcast	Low	Medium	Yes
6	Sunny	Medium	High	No
7	Sunny	Medium	Medium	Yes
8	Rain	Medium	Medium	Yes
9	Overcast	Medium	High	Yes

6 K-Means (10 Points)

Given the following 3-dimensional dataset containing 8 data points (Table 5), use the K-Means algorithm to divide these data points into 2 clusters ($k = 2$) and calculate the centroid of each cluster.

Table 5: Data Points in Three Dimensions

Data Point	Dimension 1 (X)	Dimension 2 (Y)	Dimension 3 (Z)
1	2.0	3.0	1.0
2	1.5	2.5	1.2
3	8.0	7.0	9.0
4	7.5	6.5	8.5
5	2.5	3.5	1.5
6	7.0	6.0	8.0
7	1.8	2.8	1.1
8	8.5	7.5	9.5

- Step-1. Select 2 initial centroids (Data Point 1 and Data Point 3).
- Step-2. Use Euclidean distance to calculate the distance between data points and centroids.
- Step-3. Iteratively update the centroids for 2 rounds.
- Step-4, Output the centroid of each cluster and the data points it contains.

7 CNN Q1 (15 Points)

A neural network is defined below for a classification problem. The input to the neural network is an image with size 1 by 64 by 64.

1: 2D Convolutional Layer 1 with input channel as 1, output channel as 8, kernel size as 3 by 3, stride as 2, and padding as 1.

2: 2D Convolutional Layer 2 with input channel as 8, output channel as 16 kernel size as 3 by 3, stride as 2, and padding as 1.

3: 2D Convolutional Layer 3 with input channel as 16, output channel as 32, kernel size as 3 by 3, stride as 1, and padding as 1.

4: Max Pooling Layer with kernel size as 2 by 2.

5: Flatten layer: flatten the feature with size 32 by 8 by 8 into a size with 2048.

6: Linear Layer: input neuron is 2048 and the output neuron is 10.

You are asked to calculate the total number of parameters in the above neural network. The parameters include weights and biases.

8 CNN Q2 (15 Points)

Given the following neural network structure:

1. Input: A 5×5 matrix A.

2. Convolutional Layer: Apply a 3×3 convolutional kernel K to the standardized A (no padding, meaning we do not expand boundaries of A, stride=1, no bias).

3. ReLU Activation: Apply the ReLU activation function to the convolution results.

4. Flatten: Flatten the results into a 1D vector.

5. Linear Layer: Pass the flattened vector through a 9×1 weight matrix W for linear transformation (no bias), yielding a scalar.

$$A = \begin{bmatrix} 2 & 0 & 14 & 5 & 4 \\ 11 & 12 & 16 & 4 & 8 \\ 12 & 6 & 12 & 3 & 12 \\ 10 & 10 & 2 & 20 & 11 \\ 4 & 11 & 8 & 12 & 4 \end{bmatrix}$$

$$K = \begin{bmatrix} 1 & 0 & -1 \\ 1 & 0 & -1 \\ 1 & 0 & -1 \end{bmatrix}$$

$$W = \begin{bmatrix} 1 & -2 & 1 & -1 & -3 & 0 & 1 & -1 & 1 \end{bmatrix}^T$$

Please calculate the output.