Scientific Problem Set

1. Matrix Chain Multiplication

Given 5 matrices:

$$A_1(5 \times 7), \quad A_2(3 \times 7), \quad A_3(11 \times 7), \quad A_4(7 \times 5), \quad A_5(7 \times 3)$$

Find the optimal sequence of multiplication to minimize the number of scalar multiplications.

2. Random Matrix Analysis

Generate a random 100×100 matrix. For each column, calculate:

1. Mean
2. Variance
3. Kurtosis
4. Skewness

Plot four graphs corresponding to these metrics for all columns.

3. Fuzzy Set Union and Intersection

1. Take two fuzzy sets A and B with values in the range $[10, 200]$ as user input.
2. Assign membership values randomly in the range $[0, 1]$.
3. Implement fuzzy set union and intersection for A and B.

4. Membership Function Fitting

1. Consider a fuzzy set A with values in the range $[1, 10]$.
2. Fit the following membership functions:
   - Triangular
   - Trapezoidal
   - Gaussian
3. Plot the graphs of these membership functions.

5. Fuzzy Union and Membership Functions

1. Consider two fuzzy sets A and B with 10 elements each.
2. Fit a triangular membership function on each set.
3. Perform the fuzzy union operation ($A \cup B$) and plot:
   - $A \cup B$
   - $\mu_{A \cup B}$

6. Composite Relationships of Fuzzy Relations

Given two fuzzy relations R and S, where:

$$R \in \mathbb{R}^{5\times 6}, \quad S \in \mathbb{R}^{6\times 3}$$

with random values between $[0, 1]$, compute the composite relationship using:

1. Max-Min Composition
2. Min-Max Composition
3. Max-Product Composition
4. Max-Average Composition

Plot the graphs for the derived principles.

7. Centre of Gravity and Weighted Average

1. Consider two fuzzy sets A and B, each with 20 elements and corresponding membership values.
2. Calculate:
   - Centre of Gravity (COG)
   - Weighted Average (WAV)
3. Plot graphs for both COG and WAV.

8. Genetic Algorithm for Maximization

Solve the maximization problem:

$$f(x) = x^2, \quad \text{where } x \in [0, 31]$$

using a Genetic Algorithm with:

1. Binary encoding with 5-length chromosomes.

2. Selection operator: Roulette wheel.
3. One-point crossover.

Given the initial population:

$$x = \{13, 24, 8, 19\}$$

Find the best value of x for which $f(x)$ is maximized.

9. Genetic Algorithm Optimization

Given chromosomes of the form $x = abcdefgh$ with length 8 and genes in the range $[0, 9]$, solve the optimization problem:

$$f(x) = (a + b) - (c + d) + (e + f) - (g + h)$$

with the initial population:

$$X_1 = 65413532, \quad X_2 = 87126601, \quad X_3 = 23921285, \quad X_4 = 41852094$$

Perform the following operations:

1. Evaluate the fitness of each individual.
2. Perform one-point crossover at the middle for the two highest-ranked individuals.
3. Perform crossover at positions b and f for the 2nd and 3rd ranked individuals.
4. Perform uniform crossover for the 1st and 3rd ranked individuals.

Optimize the function and print the optimal/fittest value.

10. Iris Dataset Analysis

Using the Iris dataset, calculate the following for each feature:

1. Mean
2. Variance
3. Kurtosis
4. Skewness

Plot the graphs of these metrics for the dataset.

11. Heart Disease Dataset Analysis

Using the Heart Disease dataset, calculate the following for each feature:

1. Mean
2. Variance
3. Kurtosis
4. Skewness

Plot the graphs of these metrics for the dataset.

Machine Learning Problems

AUTUMN-2024 LAB Assignment Examination

Group Problems (GR)

GR1

Consider a random vector, a collection of random values of n-dimension [**min** $n = 100$]:

- Fit Poisson's distribution and Gaussian distribution for these collected values.

GR2

Use the **Iris** and **Heart Disease** databases to perform the following:

1. Perform classification tasks with 50%-50% training and testing using the SVM classifier.
2. Apply PCA to the dataset.
3. Perform classification with 50%-50% training and testing on:
    - 1st PCA component
    - 2nd PCA component

GR3

Use the **Heart Disease** database:

1. Perform classification with 50%-50% training and testing before data normalization.
2. Apply the Min-Max and Z-score normalization techniques, and then perform classification with 50%-50% training and testing using the SVM classifier.

GR4

Use the **Heart Disease** database:

- Apply Singular Value Decomposition (SVD) to analyze the decomposed features.
- Apply data visualization to the outcomes of SVD.

GR5

Use the **Chronic Kidney Disease** database:

- Perform factor analysis to distinguish between the features.
- Arrange the features based on their importance.

GR6

Use the **Optical Recognition of Handwritten Disease** database:

1. Apply classifiers such as Naive Bayes, KNN, Random Forest, and Decision Tree.
2. List the performance of these classifiers in tabular form, including:

   Precision, Recall, F1_Score, Accuracy

3. Compare the F1_Score to justify the best classifier for the problem.

GR7

Using the **Optical Recognition of Handwritten Disease** database, suppose the SVM classifier gives better performance. Create a table with the following structure:

Nature	Learning Rate	F1_Score
Linear	0.1	-
	0.3	-
	0.5	-
Poly	0.1	-
	0.3	-
	0.5	-
Radial	0.1	-
	0.3	-
	0.5	-

Justify the best nature of the SVM classifier for this database.

GR8

Use the **Real Estate Valuation** database:

- Apply linear regression and logistic regression to justify the outcomes.

GR9

Use the **Diabetes 180 US Hospital** database:

- Apply classification and clustering techniques.
- Use reinforcement learning to analyze and justify the features.

GR10

Suppose there are 3 disease detection systems:

- Diabetes system generates a score d.
- Heart Disease system generates a score h.
- Thyroid Disease system generates a score t.

1. Use a Fuzzy Inference System with (small, medium, large) or (low, moderate, high) to derive a final score by combining the scores.
2. Build a fuzzy fusion system for this purpose.

GR11

Use the **Thyroid Disease** database:

1. Perform classification using different classifiers and list the results in tabular form.
2. Visualize the clustering of all 5 features with their differences in a single plot.

GR12

Use different loss functions to classify the nature of features in the **Magic Gamma Telescope** database.

GR13

Use the **Magic Gamma Telescope** database:

1. Apply an Artificial Neural Network (ANN) classifier with:
    - A (1-1-1) NN architecture.
    - A (1-2-1) NN architecture.

GR14

Use the **Magic Gamma Telescope** database:

- Apply an ANN with 1 input layer, 2 hidden layers, and 1 output layer.
- Report the performance using various activation functions:
    1. Sigmoid
    2. Tanh
    3. ReLU
    4. Leaky ReLU