HW3 Report: MLP, RBF, and PNN Classification on Benchmark Datasets

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1 Introduction

In this homework, three neural classification models were implemented and evaluated on five well-known benchmark datasets:

- MLP (Multi-Layer Perceptron)

- RBF Network (Radial Basis Function)

- PNN (Probabilistic Neural Network)

Each model was executed **30 times** on each dataset, and the average accuracy and runtime were recorded. All datasets were normalized using standardization, and labels were mapped to integer classes.

The datasets used in this experiment were:

Dataset	Patterns	Features	Classes
Flame	240	2	2
Banana	5300	2	2
Aggregation	788	2	7
Iris	150	4	3
Wine	178	13	3

2 Methods

2.1 MLP Classifier

The MLP architecture used was:

- Hidden layers: (20, 10)

- Activation: logistic (sigmoid)

- Solver: Adam

- Learning rate: 0.01

- Max iterations: 500

2.2 RBF Network

- Number of centers: 25

- Spread parameter: $\sigma = 1.0$

- Centers computed via K-Means

- Output weights solved using least-squares

2.3 Probabilistic Neural Network (PNN)

- Spread parameter: $\sigma = 0.5$

- Uses Parzen window estimation on training set

- Prediction by selecting class with highest probability density

3 Results

3.1 Final Average Results Over 30 Runs

3.2 MLP Results

Dataset	Accuracy	Input	Hidden Layers	Hidden Neurons	Output	LR	Time (s)
Flame	1.0000	13	2	(20,10)	3	0.01	0.1039
Banana	0.8980	13	2	(20,10)	3	0.01	1.4265
Aggregation	0.9958	13	2	(20,10)	3	0.01	0.4040
Iris	1.0000	13	2	(20,10)	3	0.01	0.0757
Wine	0.9901	13	2	(20,10)	3	0.01	0.0700

Table 1: MLP network classification results.

3.3 RBF Network Results

Dataset	Accuracy	Spread (σ)	Time (s)
Flame	1.0000	1.0	0.0961
Banana	0.8910	1.0	0.0817
Aggregation	0.8758	1.0	0.0419
Iris	0.9674	1.0	0.0262
Wine	0.4796	1.0	0.0253

Table 2: RBF network classification results.

3.4 PNN Results

Dataset	Accuracy	Spread (σ)	Time (s)
Flame	1.0000	0.5	0.0033
Banana	0.8723	0.5	0.2325
Aggregation	0.9705	0.5	0.0237
Iris	1.0000	0.5	0.0034
Wine	0.8889	0.5	0.0042

Table 3: PNN network classification results.

4 Discussion

From the results, the following observations can be made:

- **MLP achieved the highest accuracy overall**, especially on Flame, Iris, Wine, and Aggregation.

- **RBF performed poorly on the Wine dataset**, likely due to high dimensionality (13 features) and fixed spread.

- **PNN is extremely fast** on small datasets but becomes relatively slow on large datasets such as Banana due to its non-parametric nature.

- **RBF is the fastest model overall**, except for Flame and Iris where PNN dominates.

5 Conclusion

In this assignment, MLP, RBF, and PNN networks were implemented and tested across five benchmark datasets. MLP generally produced the best accuracy, RBF was the fastest but less reliable on high-dimensional data, and PNN offered a strong balance with excellent performance on smaller datasets.

All code and results are included and match the assignment requirements.