# Assignment-3 Report

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## 1 Dataset 1

### 1.1 Function approximation using MLFFNN

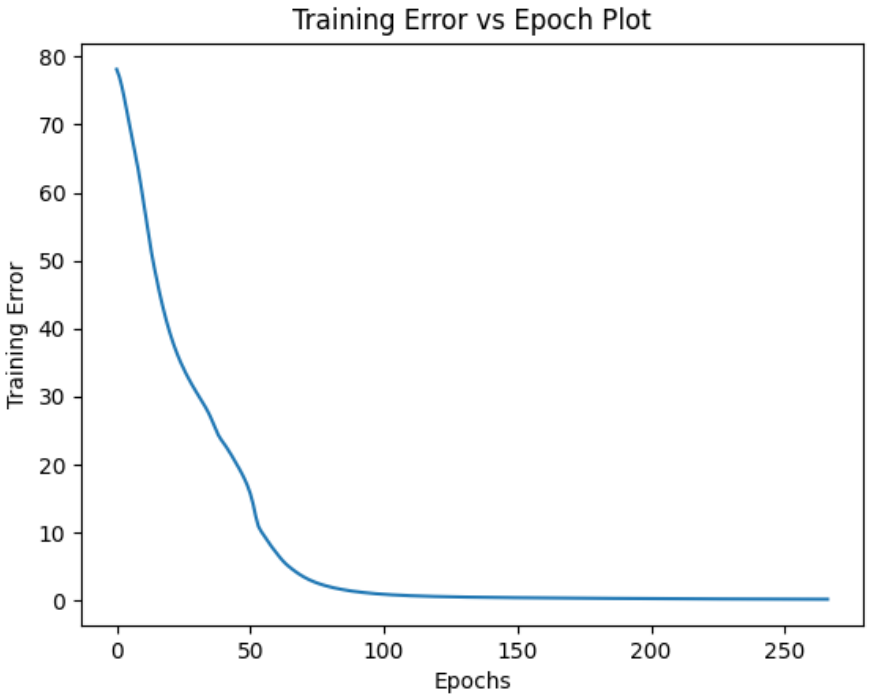


Figure 1: Training Error vs Epoch Plot

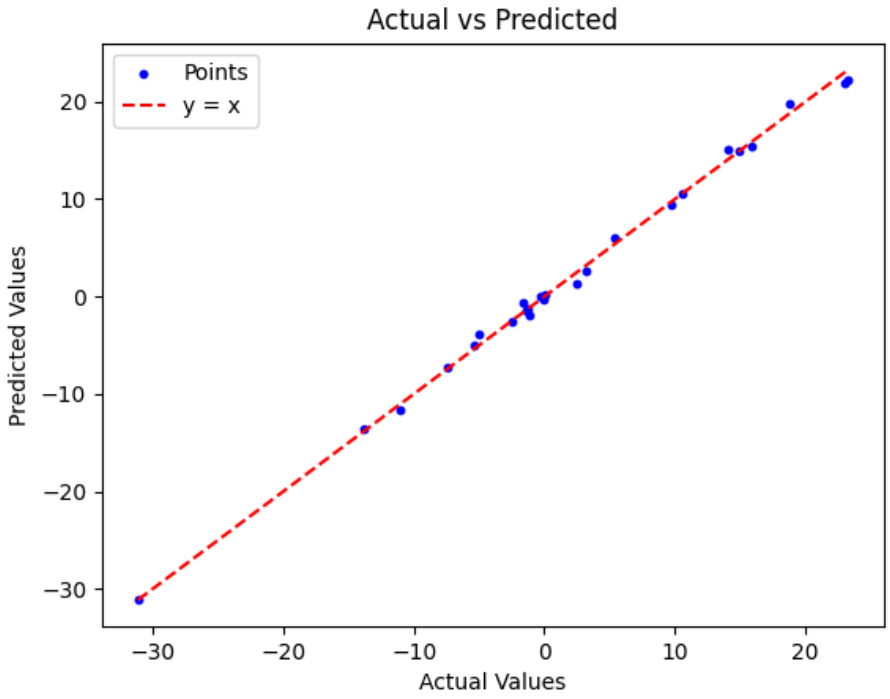


Figure 2: Scatter plot for training output of dataset 1

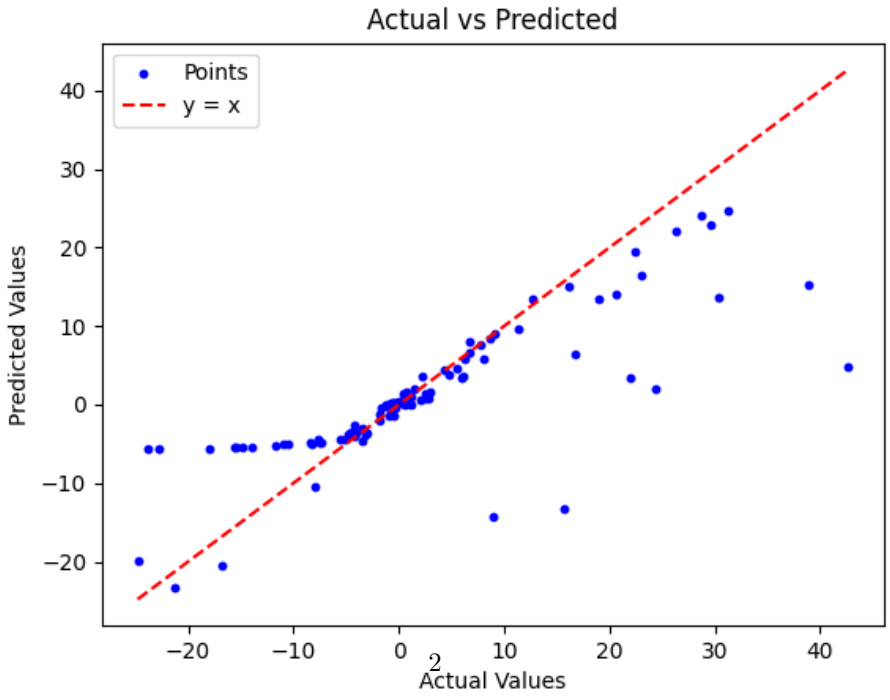


Figure 3: Scatter plot for test output of dataset 1

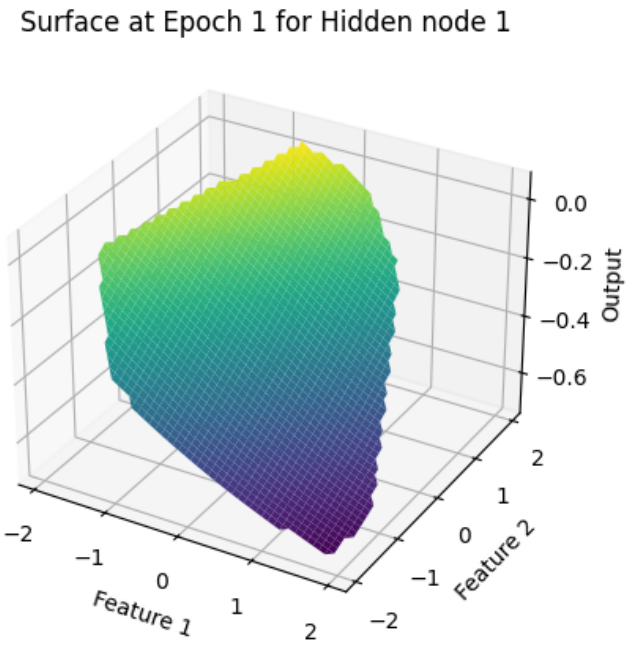


Figure 4: Surface Plot

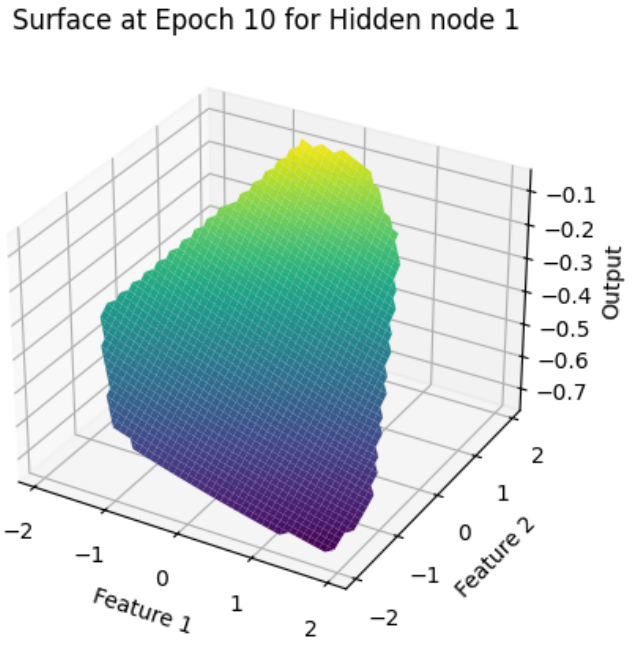




Figure 5: Surface Plot

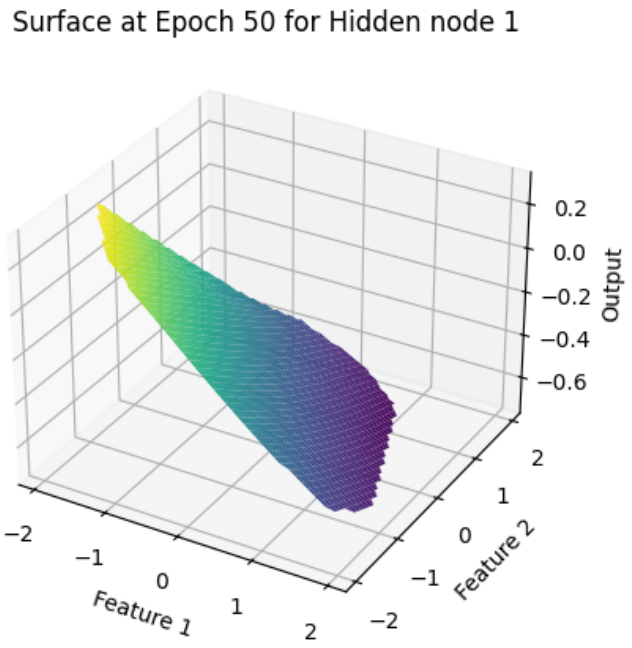


Figure 6: Surface Plot

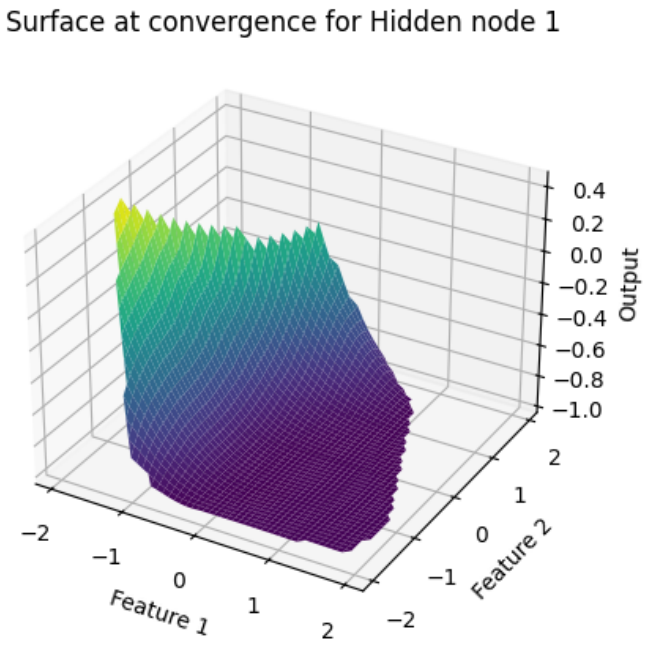




Figure 7: Surface Plot

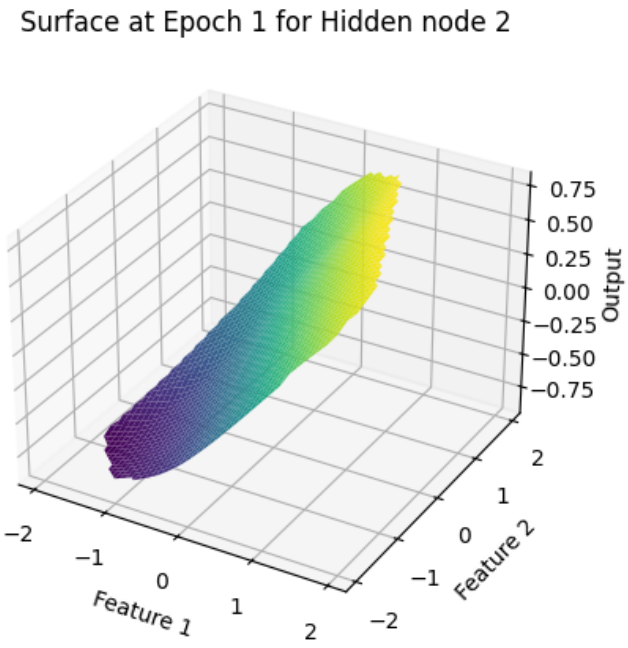


Figure 8: Surface Plot

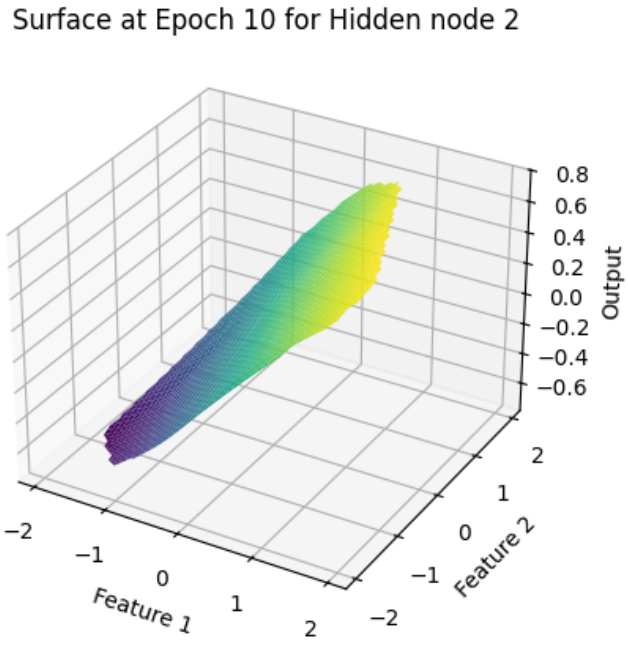




Figure 9: Surface Plot

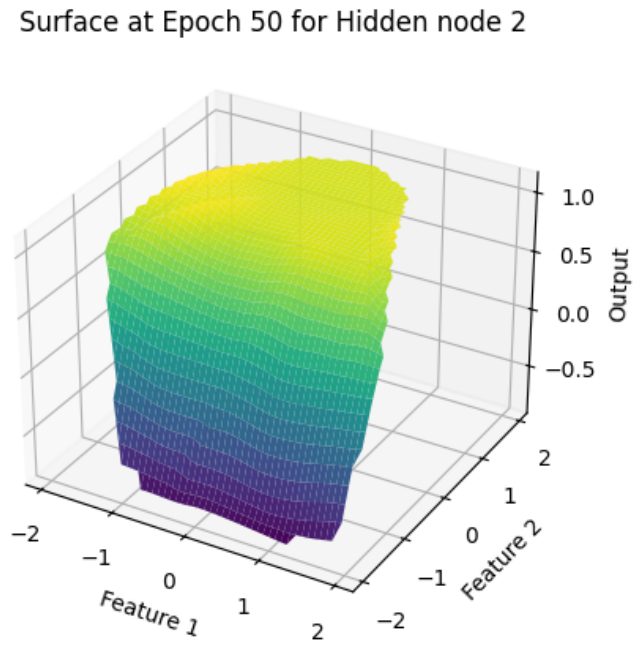


Figure 10: Surface Plot

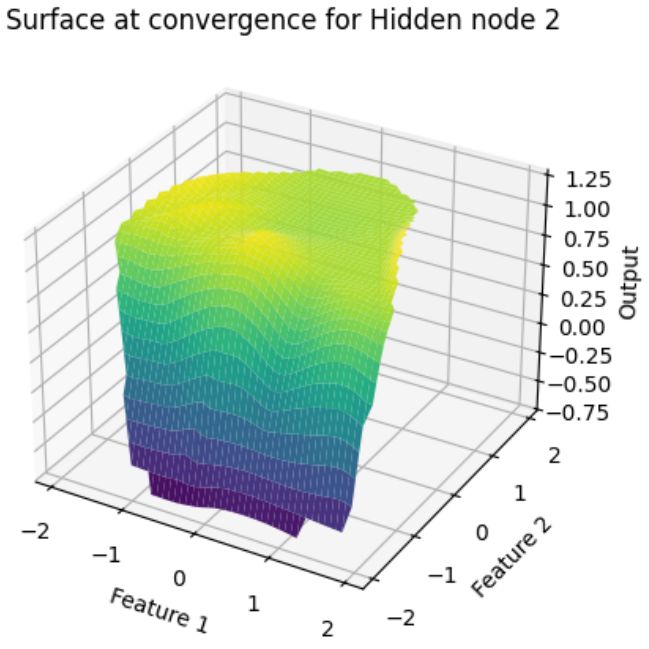




Figure 11: Surface Plot

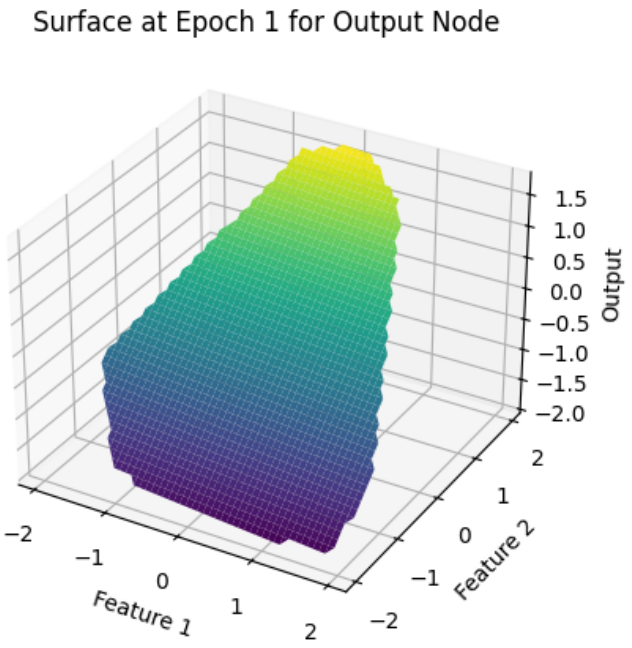


Figure 12: Surface Plot

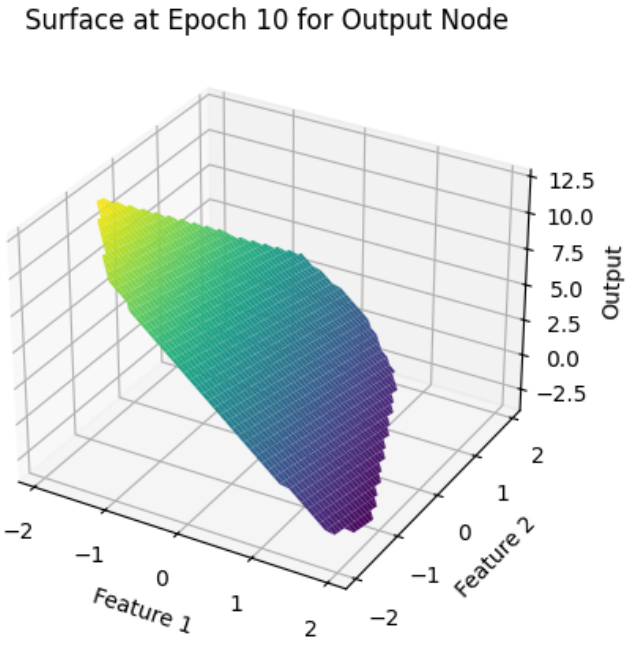




Figure 13: Surface Plot

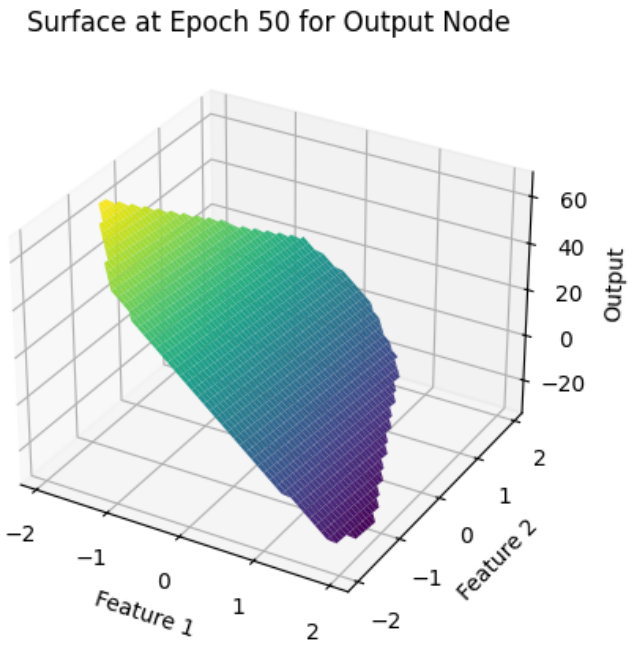


Figure 14: Surface Plot

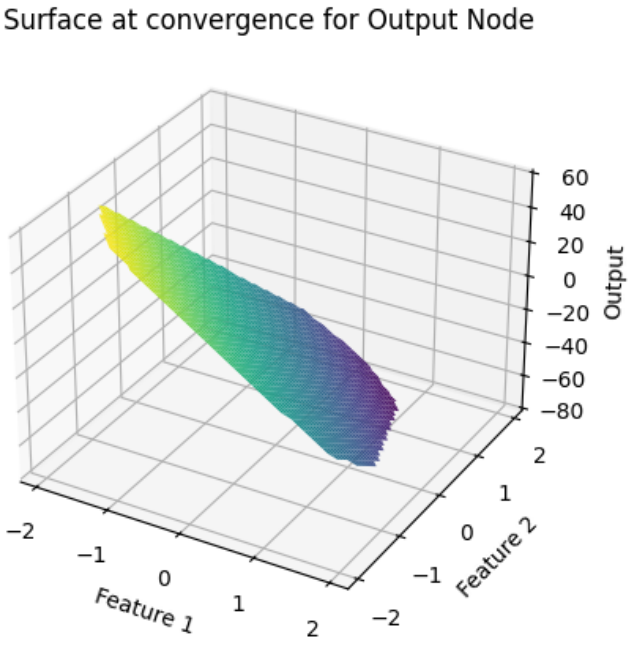




Figure 15: Surface Plot

# 2 Dataset 2

## 2.1 Function approximation using MLFFNN

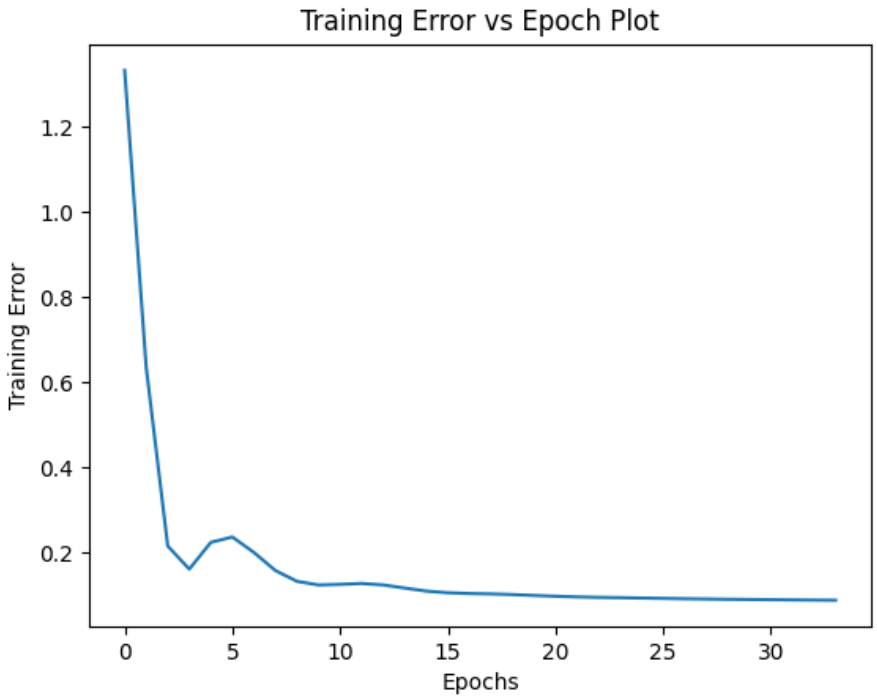


Figure 16: Training Error vs Epoch Plot

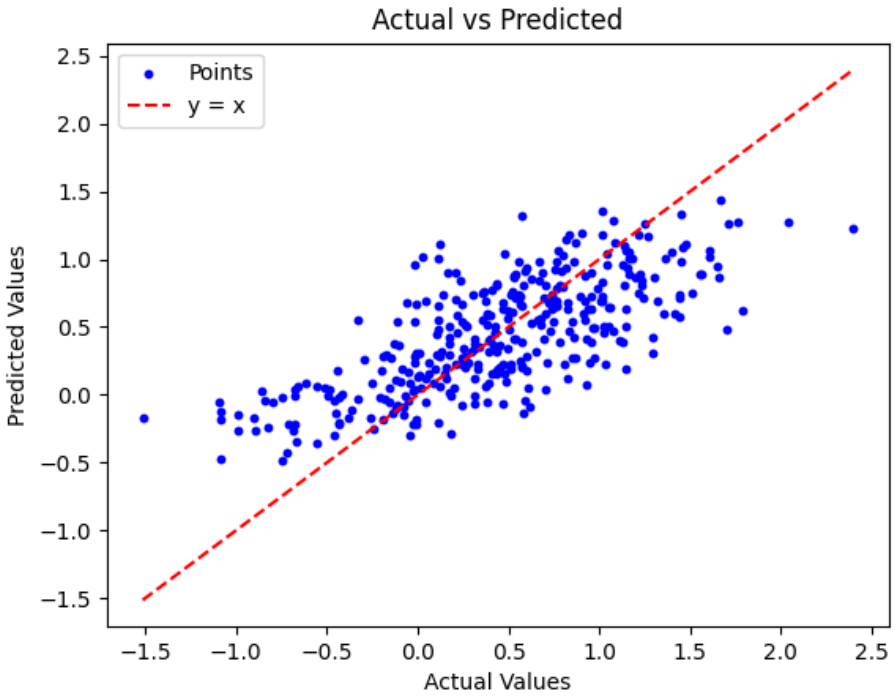


Figure 17: Scatter plot for training output 1 of dataset 2

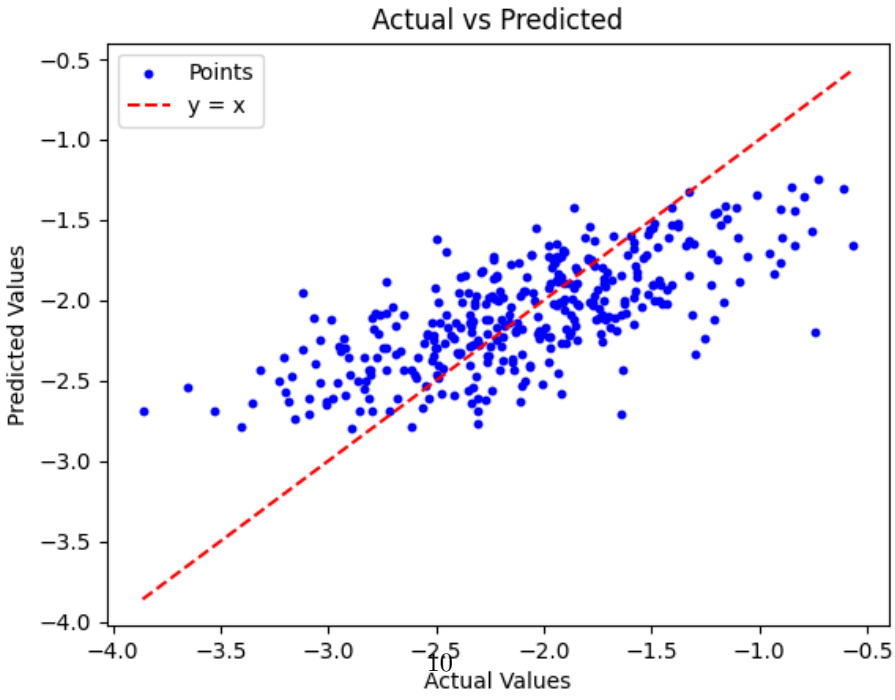




Figure 18: Scatter plot for training output 2 of dataset 2

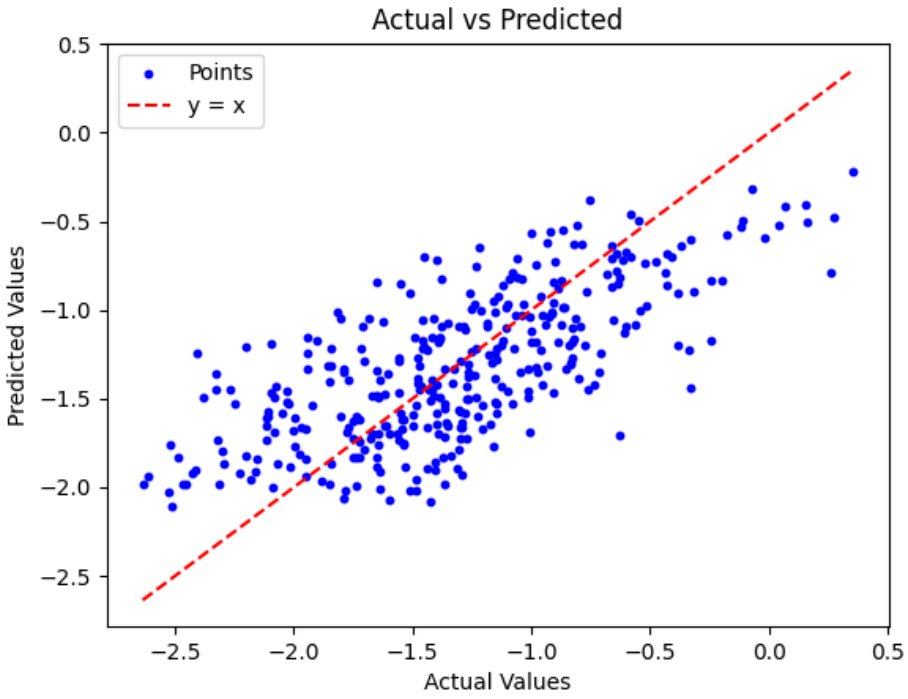


Figure 19: Scatter Plot for training output 3 of dataset 2

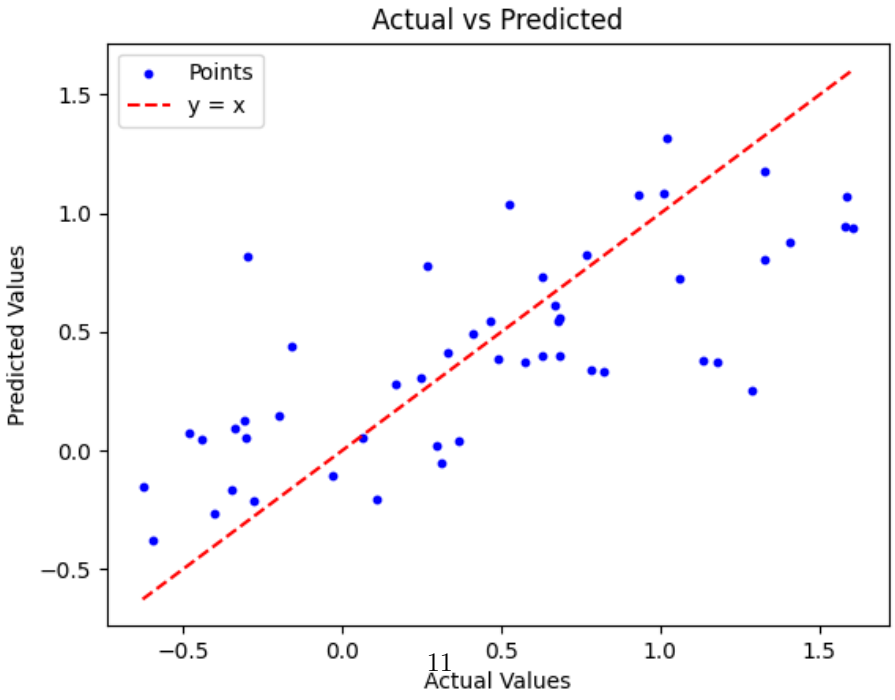


Figure 20: Scatter Plot for test output 1 of dataset 2

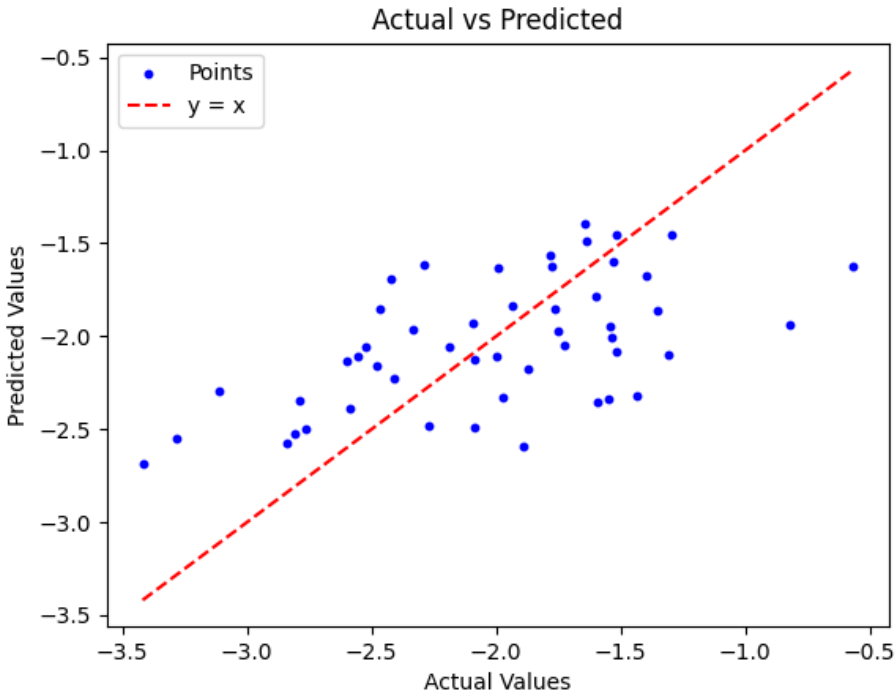


Figure 21: Scatter Plot for test output 2 of dataset 2

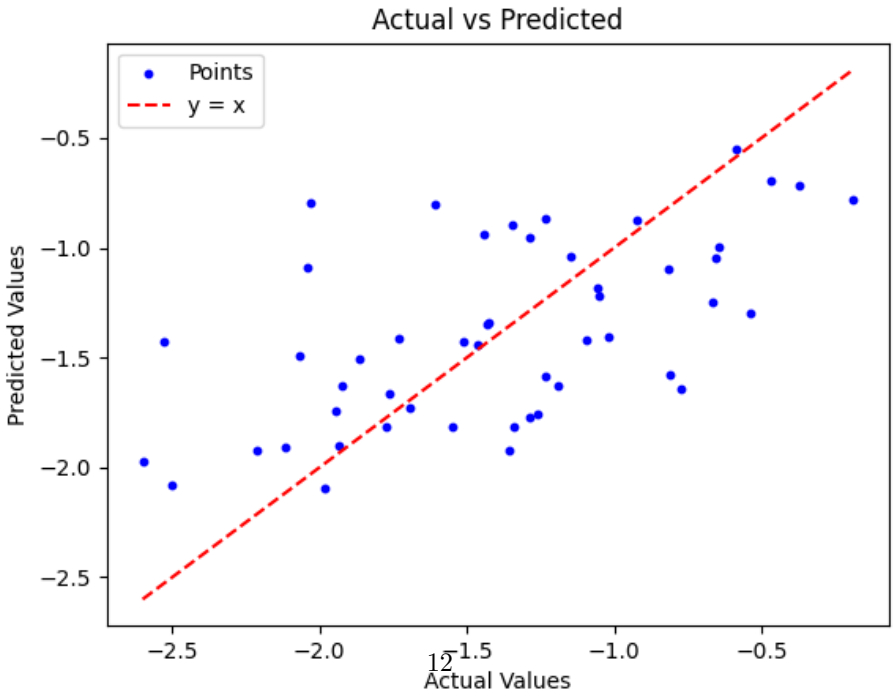


Figure 22: Scatter Plot for test output 3 of dataset 2

# 3 Dataset 3

## 3.1 Classifier using MLFFNN

Table 1: Classification accuracies on training and test data

| Training Accuracy | Test Accuracy |
|---|---|
| 0.9572192513368984 | 0.975 |

Table 2: Confusion matrix for training and test data

| Training Data | Test Data |
|---|---|
| $\begin{pmatrix} 273 & 11 \\ 13 & 264 \end{pmatrix}$ | $\begin{pmatrix} 79 & 3 \\ 8 & 69 \end{pmatrix}$ |

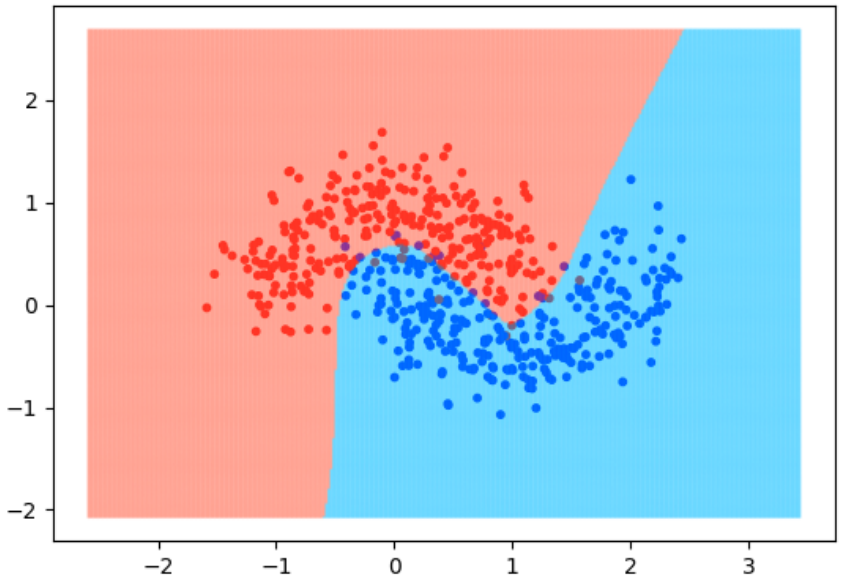


Figure 23: Decision regions plot

### 3.1.1 Epoch 1

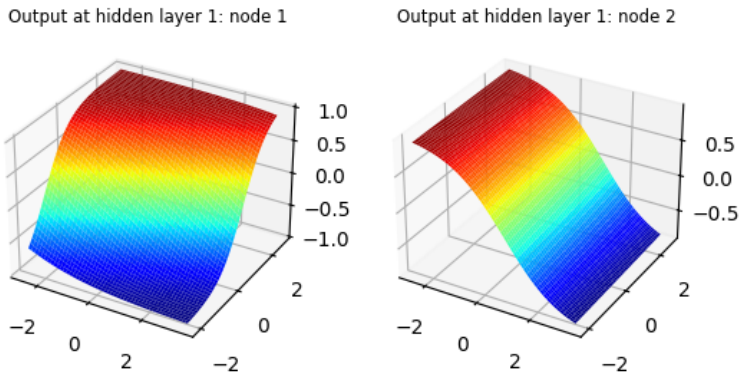


Figure 24: Output plots for hidden layer 1.

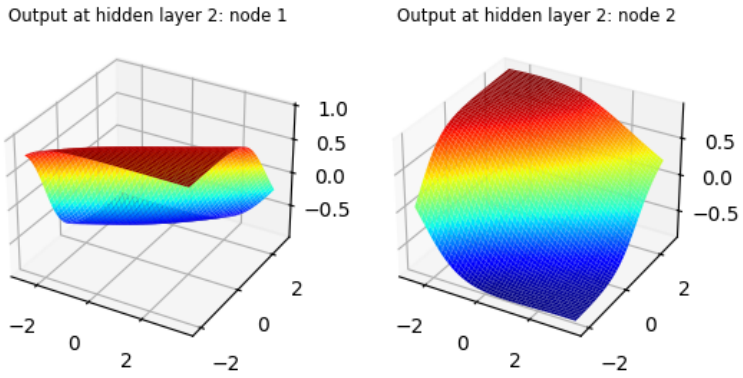


Figure 25: Output plots for hidden layer 2.

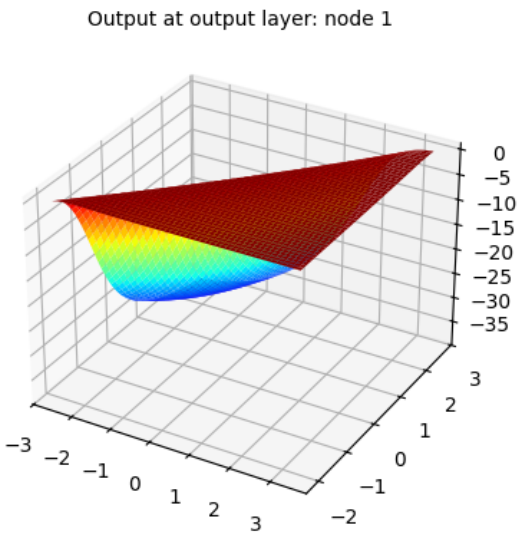


Figure 26: Output plot for the output layer

### 3.1.2 Epoch 10

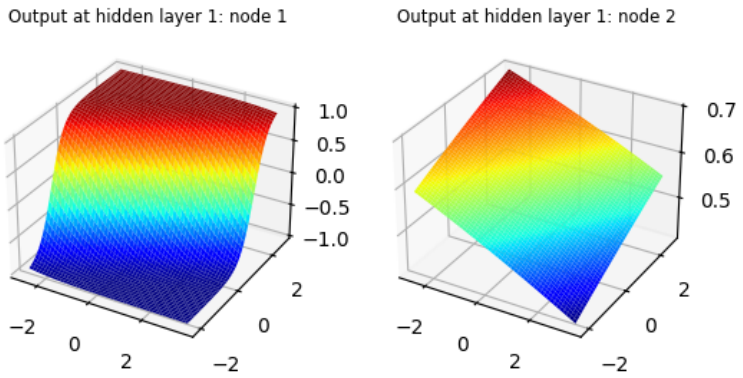


Figure 27: Output plots for hidden layer 1.

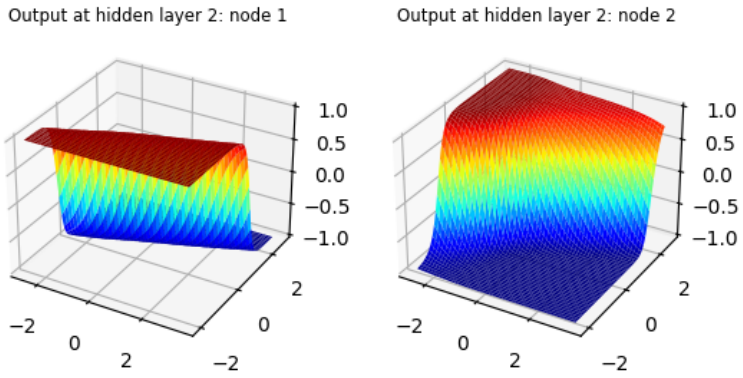


Figure 28: Output plots for hidden layer 2.

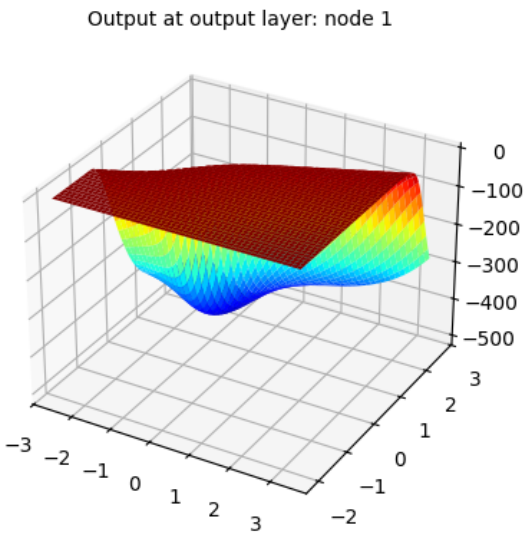


Figure 29: Output plot for the output layer

### 3.1.3 Epoch 50

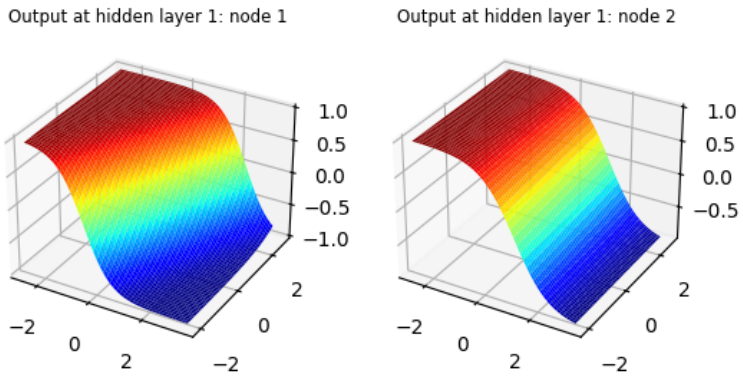


Figure 30: Output plots for hidden layer 1.

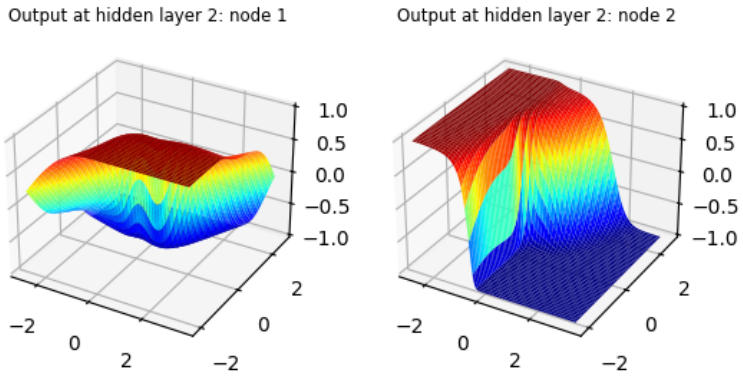


Figure 31: Output plots for hidden layer 2.

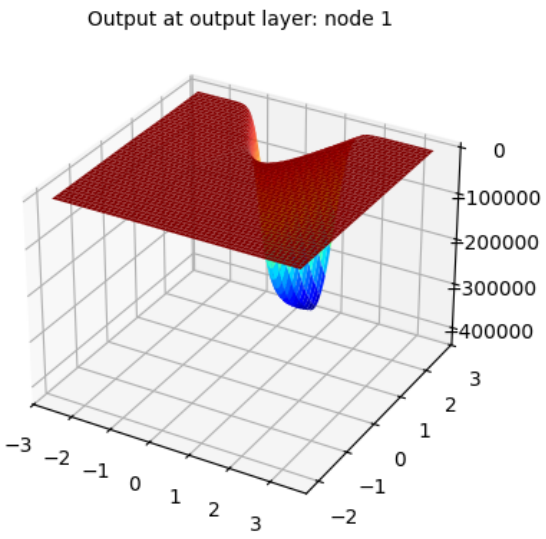


Figure 32: Output plot for the output layer

### 3.1.4 Convergence

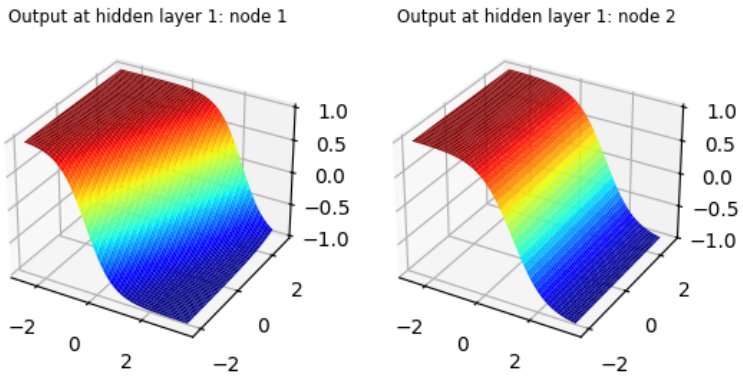


Figure 33: Output plots for hidden layer 1.

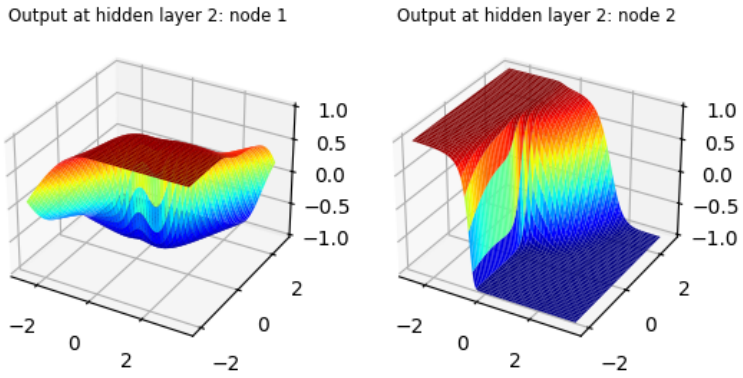


Figure 34: Output plots for hidden layer 2.

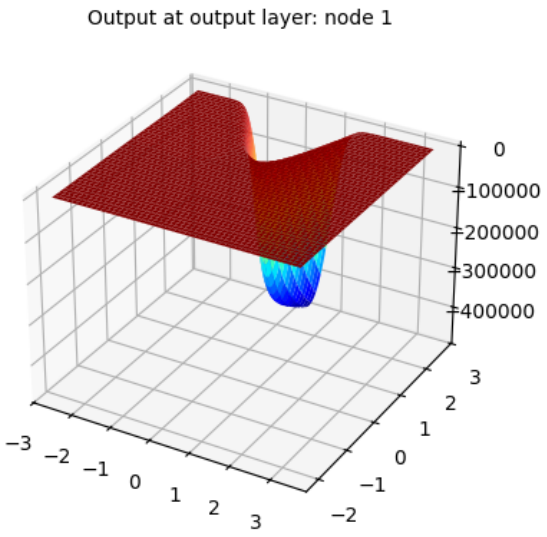


Figure 35: Output plot for the output layer

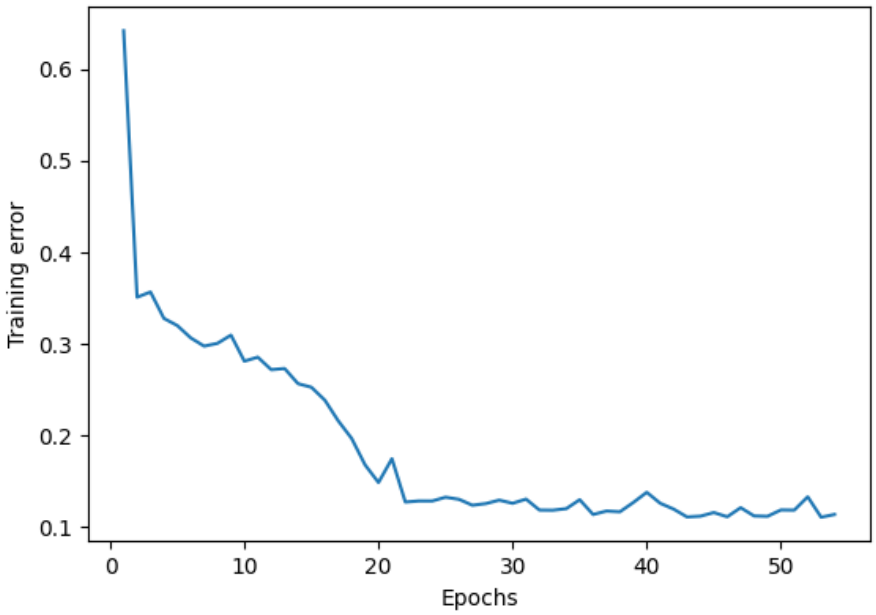


Figure 36: Training Error vs Epoch Plot

### 3.2 Logistic regression classifier

### 3.3 K = 5

Table 3: Classification accuracies on training and test data

| Training Accuracy | Test Accuracy |
|---|---|
| 0.9554367201426025 | 0.975 |

Table 4: Confusion matrix for training and test data

| Training Data | Test Data |
|---|---|
| $\begin{pmatrix} 271 & 13 \\ 12 & 265 \end{pmatrix}$ | $\begin{pmatrix} 34 & 0 \\ 2 & 44 \end{pmatrix}$ |

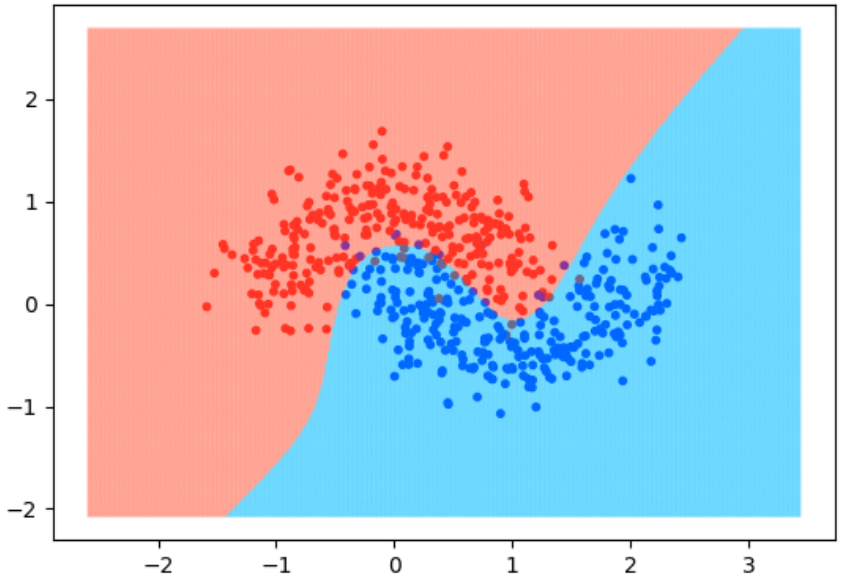


Figure 37: Decision regions plot

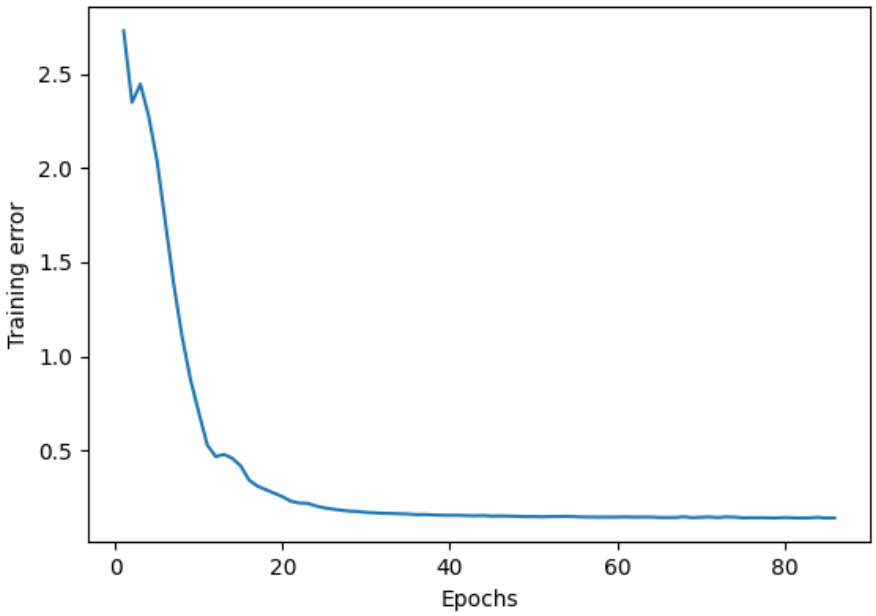


Figure 38: Training Error vs Epoch Plot

### 3.4 K = 7

Table 5: Classification accuracies on training and test data

| **Training Accuracy** | **Test Accuracy** |
|---|---|
| 0.948306595365419 | 0.9625 |

Table 6: Confusion matrix for training and test data

| **Training Data** | **Test Data** |
|---|---|
| $\begin{pmatrix} 270 & 14 \\ 15 & 262 \end{pmatrix}$ | $\begin{pmatrix} 33 & 1 \\ 2 & 44 \end{pmatrix}$ |

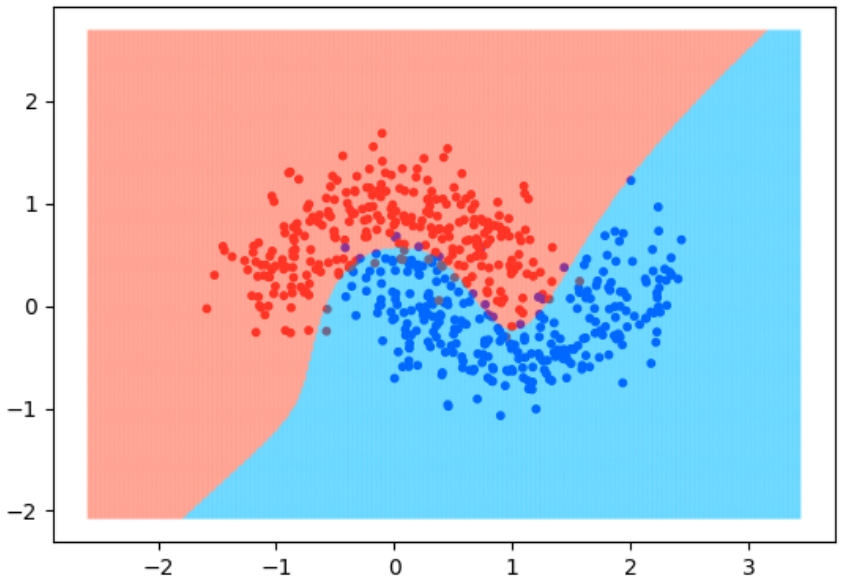


Figure 39: Decision regions plot

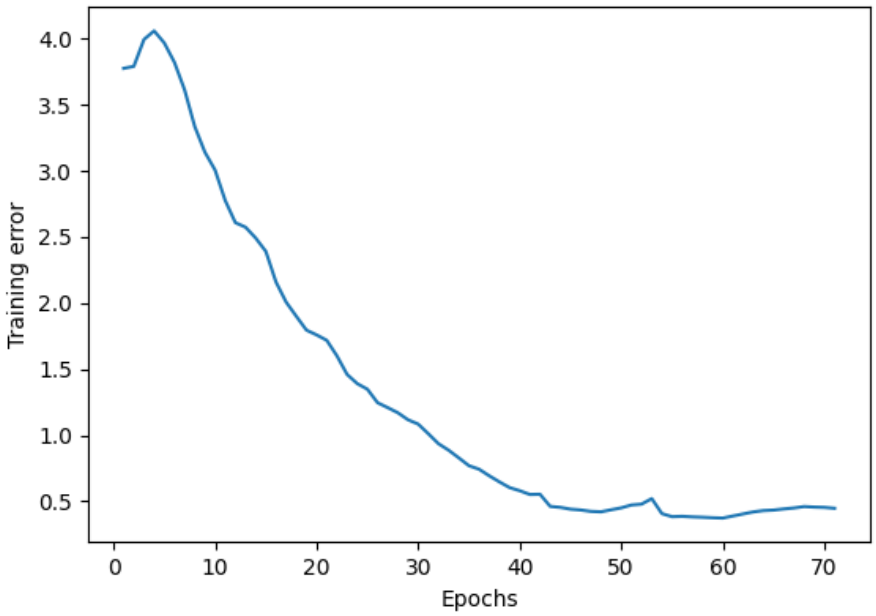


Figure 40: Training Error vs Epoch Plot

### 3.5 K = 9

Table 7: Classification accuracies on training and test data

| Training Accuracy | Test Accuracy |
|---|---|
| 0.786096256684492 | 0.725 |

Table 8: Confusion matrix for training and test data

| Training Data | Test Data |
|---|---|
| $\begin{pmatrix} 227 & 57 \\ 63 & 214 \end{pmatrix}$ | $\begin{pmatrix} 23 & 11 \\ 11 & 35 \end{pmatrix}$ |

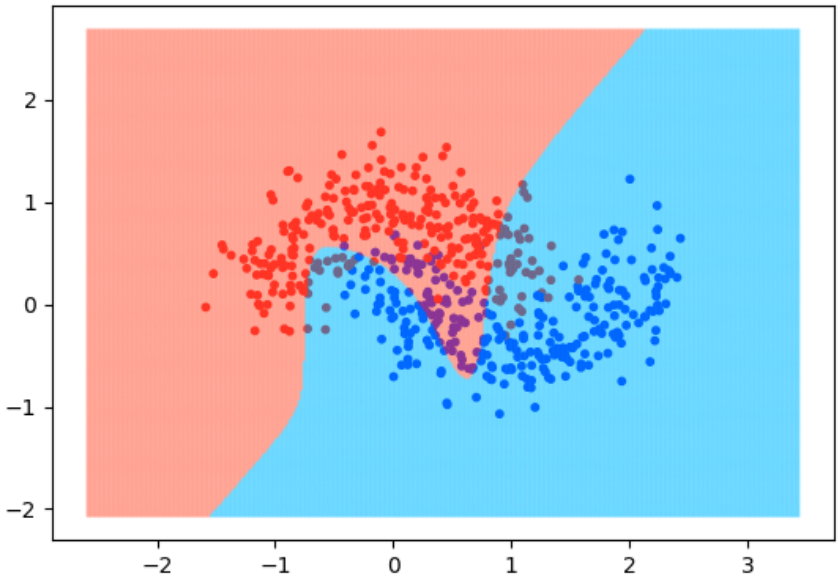


Figure 41: Decision regions plot

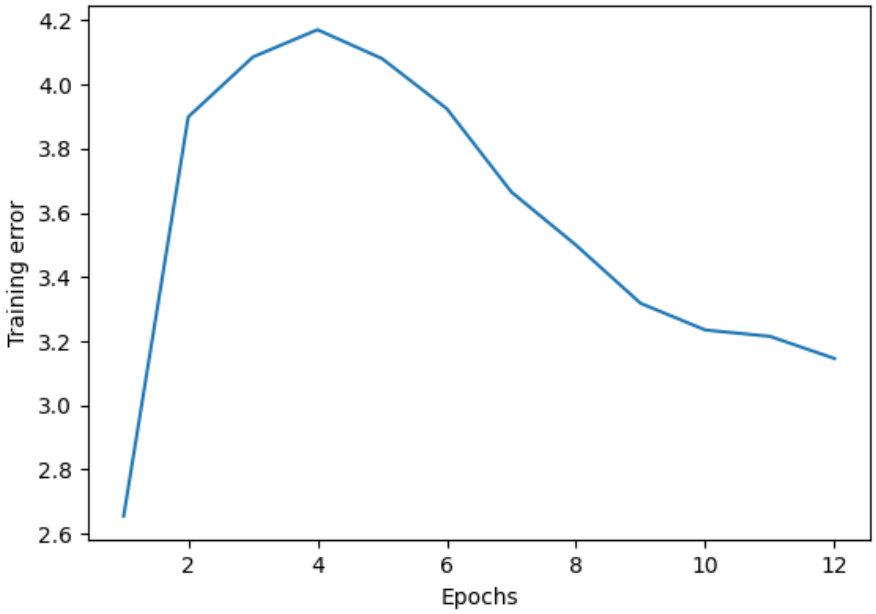


Figure 42: Training Error vs Epoch Plot

# 4 Dataset 4

## 4.1 Classifier using MLFFNN

Table 9: Classification accuracies on training and test data

| Training Accuracy | Test Accuracy |
|---|---|
| 0.7205 | 0.582 |

Table 10: Confusion matrix for training and test data

| Training Data | Test Data |
|---|---|
| $\begin{pmatrix} 266 & 21 & 44 & 35 & 34 \\ 37 & 273 & 17 & 13 & 60 \\ 32 & 5 & 311 & 29 & 23 \\ 37 & 3 & 17 & 315 & 28 \\ 40 & 36 & 19 & 29 & 276 \end{pmatrix}$ | $\begin{pmatrix} 50 & 7 & 17 & 14 & 12 \\ 15 & 50 & 10 & 7 & 18 \\ 13 & 5 & 60 & 13 & 9 \\ 13 & 9 & 9 & 60 & 9 \\ 12 & 13 & 11 & 10 & 54 \end{pmatrix}$ |

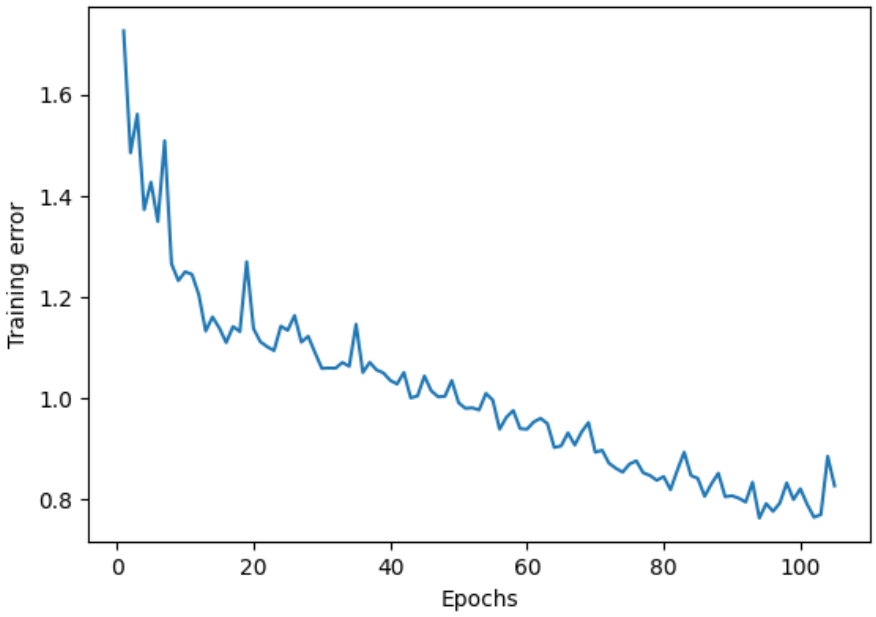


Figure 43: Training Error vs Epoch Plot

## 4.2 Logistic regression classifier

Table 11: Classification accuracies on training and test data for $K = 50$ and $\sigma = 0.3$

| **Training Accuracy** | **Test Accuracy** |
|---|---|
| 0.531 | 0.286 |

Table 12: Confusion matrix for training and test data for $K = 50$ and $\sigma = 0.3$

| **Training Data** | **Test Data** |
|---|---|
| $\begin{pmatrix} 203 & 23 & 61 & 64 & 49 \\ 50 & 194 & 41 & 25 & 90 \\ 40 & 18 & 244 & 61 & 37 \\ 88 & 11 & 48 & 185 & 68 \\ 33 & 60 & 18 & 53 & 236 \end{pmatrix}$ | $\begin{pmatrix} 1 & 43 & 37 & 0 & 19 \\ 0 & 82 & 6 & 0 & 12 \\ 0 & 47 & 32 & 0 & 21 \\ 0 & 39 & 19 & 0 & 42 \\ 0 & 57 & 15 & 0 & 28 \end{pmatrix}$ |

Table 13: Classification accuracies on training and test data for $K = 50$ and $\sigma = 0.5$

| **Training Accuracy** | **Test Accuracy** |
|---|---|
| 0.527 | 0.278 |

Table 14: Confusion matrix for training and test data for $K = 50$ and $\sigma = 0.5$

| **Training Data** | **Test Data** |
|---|---|
| $\begin{pmatrix} 197 & 18 & 65 & 63 & 57 \\ 54 & 168 & 46 & 26 & 106 \\ 38 & 15 & 245 & 60 & 42 \\ 83 & 6 & 52 & 187 & 72 \\ 32 & 38 & 22 & 51 & 257 \end{pmatrix}$ | $\begin{pmatrix} 0 & 71 & 23 & 0 & 6 \\ 0 & 91 & 4 & 0 & 5 \\ 0 & 51 & 32 & 0 & 17 \\ 0 & 65 & 15 & 0 & 20 \\ 0 & 68 & 16 & 0 & 16 \end{pmatrix}$ |

Table 15: Classification accuracies on training and test data for $K = 50$ and $\sigma = 0.8$

| **Training Accuracy** | **Test Accuracy** |
|---|---|
| 0.507 | 0.26 |

Table 16: Confusion matrix for training and test data for $K = 50$ and $\sigma = 0.8$

| **Training Data** | **Test Data** |
|---|---|
| $\begin{pmatrix} 193 & 15 & 63 & 67 & 62 \\ 60 & 126 & 63 & 26 & 125 \\ 42 & 11 & 247 & 51 & 49 \\ 86 & 5 & 54 & 178 & 77 \\ 29 & 25 & 23 & 53 & 270 \end{pmatrix}$ | $\begin{pmatrix} 0 & 80 & 18 & 0 & 2 \\ 0 & 91 & 6 & 0 & 3 \\ 0 & 56 & 32 & 0 & 12 \\ 0 & 78 & 11 & 0 & 11 \\ 0 & 84 & 9 & 0 & 7 \end{pmatrix}$ |

Table 17: Classification accuracies on training and test data for $K = 75$ and $\sigma = 0.3$

| **Training Accuracy** | **Test Accuracy** |
|---|---|
| 0.542 | 0.248 |

Table 18: Confusion matrix for training and test data for $K = 75$ and $\sigma = 0.3$

| **Training Data** | **Test Data** |
|---|---|
| $\begin{pmatrix} 203 & 25 & 57 & 61 & 54 \\ 51 & 189 & 39 & 26 & 95 \\ 38 & 23 & 237 & 62 & 40 \\ 68 & 9 & 43 & 215 & 65 \\ 36 & 57 & 16 & 51 & 240 \end{pmatrix}$ | $\begin{pmatrix} 0 & 29 & 71 & 0 & 0 \\ 0 & 77 & 23 & 0 & 0 \\ 0 & 51 & 47 & 0 & 2 \\ 0 & 37 & 62 & 0 & 1 \\ 0 & 60 & 40 & 0 & 0 \end{pmatrix}$ |

Table 19: Classification accuracies on training and test data for $K = 75$ and $\sigma = 0.5$

| **Training Accuracy** | **Test Accuracy** |
|---|---|
| 0.538 | 0.242 |

Table 20: Confusion matrix for training and test data for $K = 75$ and $\sigma = 0.5$

| **Training Data** | **Test Data** |
|---|---|
| $\begin{pmatrix} 204 & 20 & 64 & 53 & 59 \\ 57 & 168 & 48 & 23 & 104 \\ 39 & 15 & 248 & 55 & 43 \\ 75 & 5 & 53 & 198 & 69 \\ 37 & 37 & 23 & 45 & 258 \end{pmatrix}$ | $\begin{pmatrix} 0 & 41 & 59 & 0 & 0 \\ 0 & 82 & 18 & 0 & 0 \\ 0 & 61 & 39 & 0 & 0 \\ 0 & 54 & 46 & 0 & 0 \\ 0 & 69 & 31 & 0 & 0 \end{pmatrix}$ |

Table 21: Classification accuracies on training and test data for $K = 75$ and $\sigma = 0.8$

| **Training Accuracy** | **Test Accuracy** |
|---|---|
| 0.5245 | 0.228 |

Table 22: Confusion matrix for training and test data for $K = 75$ and $\sigma = 0.8$

| **Training Data** | **Test Data** |
|---|---|
| $\begin{pmatrix} 210 & 17 & 63 & 47 & 63 \\ 69 & 139 & 55 & 20 & 117 \\ 46 & 13 & 249 & 46 & 46 \\ 87 & 5 & 52 & 182 & 74 \\ 38 & 28 & 24 & 41 & 269 \end{pmatrix}$ | $\begin{pmatrix} 0 & 70 & 30 & 0 & 0 \\ 0 & 90 & 10 & 0 & 0 \\ 0 & 76 & 24 & 0 & 0 \\ 0 & 85 & 15 & 0 & 0 \\ 0 & 88 & 12 & 0 & 0 \end{pmatrix}$ |

Table 23: Classification accuracies on training and test data for $K = 100$ and $\sigma = 0.3$

| **Training Accuracy** | **Test Accuracy** |
|---|---|
| 0.551 | 0.274 |

Table 24: Confusion matrix for training and test data for $K = 100$ and $\sigma = 0.3$

| **Training Data** | **Test Data** |
|---|---|
| $\begin{pmatrix} 203 & 24 & 60 & 57 & 56 \\ 46 & 198 & 39 & 28 & 89 \\ 35 & 24 & 241 & 61 & 39 \\ 70 & 9 & 44 & 219 & 58 \\ 44 & 52 & 18 & 45 & 241 \end{pmatrix}$ | $\begin{pmatrix} 0 & 28 & 72 & 0 & 0 \\ 0 & 67 & 33 & 0 & 0 \\ 0 & 30 & 70 & 0 & 0 \\ 0 & 20 & 80 & 0 & 0 \\ 0 & 51 & 49 & 0 & 0 \end{pmatrix}$ |

Table 25: Classification accuracies on training and test data for $K = 100$ and $\sigma = 0.5$

| **Training Accuracy** | **Test Accuracy** |
|---|---|
| 0.5445 | 0.276 |

Table 26: Confusion matrix for training and test data for $K = 100$ and $\sigma = 0.5$

| **Training Data** | **Test Data** |
|---|---|
| $\begin{pmatrix} 217 & 20 & 53 & 53 & 57 \\ 60 & 172 & 43 & 25 & 100 \\ 46 & 18 & 233 & 61 & 42 \\ 81 & 3 & 41 & 214 & 61 \\ 48 & 39 & 16 & 44 & 253 \end{pmatrix}$ | $\begin{pmatrix} 0 & 45 & 55 & 0 & 0 \\ 0 & 76 & 24 & 0 & 0 \\ 0 & 38 & 62 & 0 & 0 \\ 0 & 47 & 53 & 0 & 0 \\ 0 & 56 & 44 & 0 & 0 \end{pmatrix}$ |

Table 27: Classification accuracies on training and test data for $K = 100$ and $\sigma = 0.8$

| **Training Accuracy** | **Test Accuracy** |
|---|---|
| 0.532 | 0.26 |

Table 28: Confusion matrix for training and test data for $K = 100$ and $\sigma = 0.8$

| **Training Data** | **Test Data** |
|---|---|
| $\begin{pmatrix} 193 & 17 & 72 & 59 & 59 \\ 58 & 150 & 61 & 27 & 104 \\ 34 & 15 & 252 & 60 & 39 \\ 69 & 4 & 57 & 206 & 64 \\ 37 & 33 & 24 & 43 & 263 \end{pmatrix}$ | $\begin{pmatrix} 0 & 56 & 44 & 0 & 0 \\ 0 & 77 & 23 & 0 & 0 \\ 0 & 47 & 53 & 0 & 0 \\ 0 & 63 & 37 & 0 & 0 \\ 0 & 60 & 40 & 0 & 0 \end{pmatrix}$ |

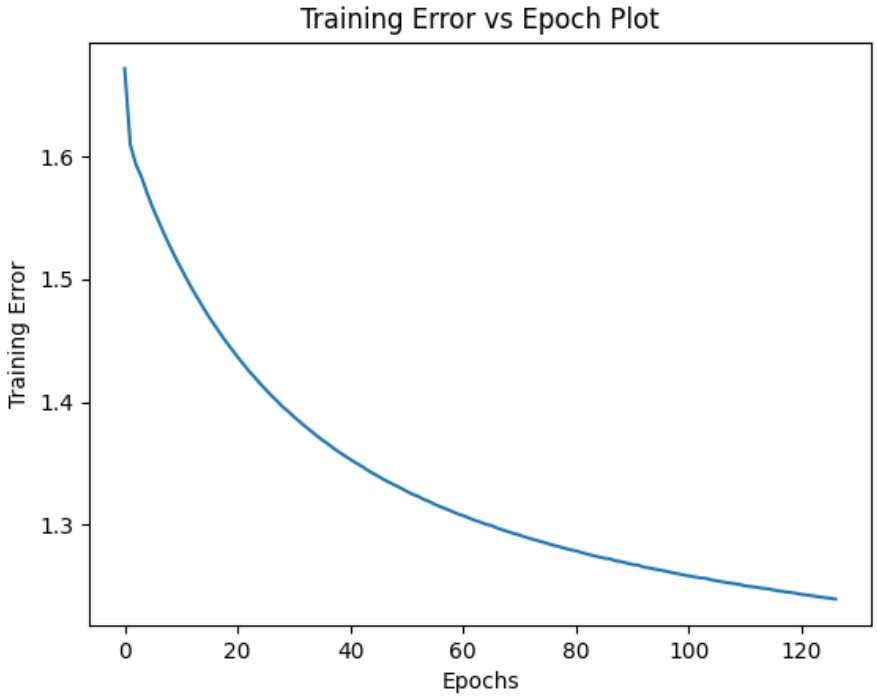


Figure 44: Training Error vs Epoch Plot for $K = 50$ and $\sigma = 0.3$

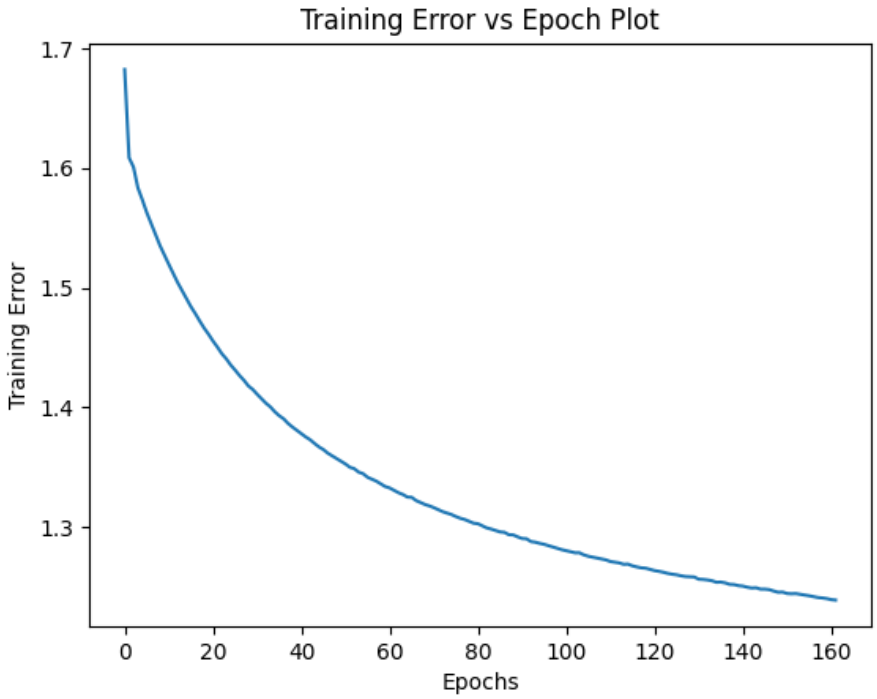


Figure 45: Training Error vs Epoch Plot for $K = 50$ and $\sigma = 0.5$

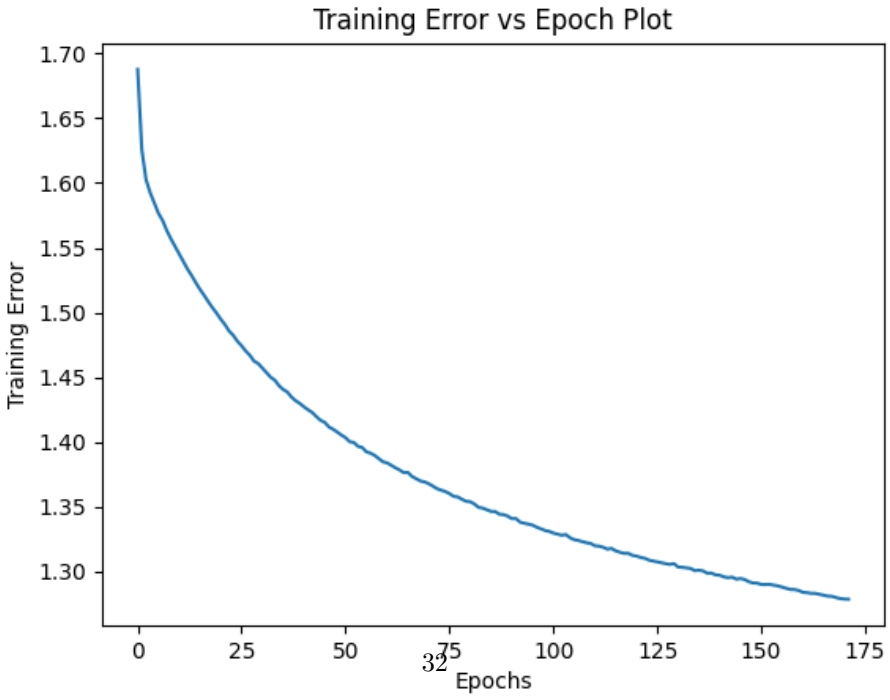


Figure 46: Training Error vs Epoch Plot for $K = 50$ and $\sigma = 0.8$

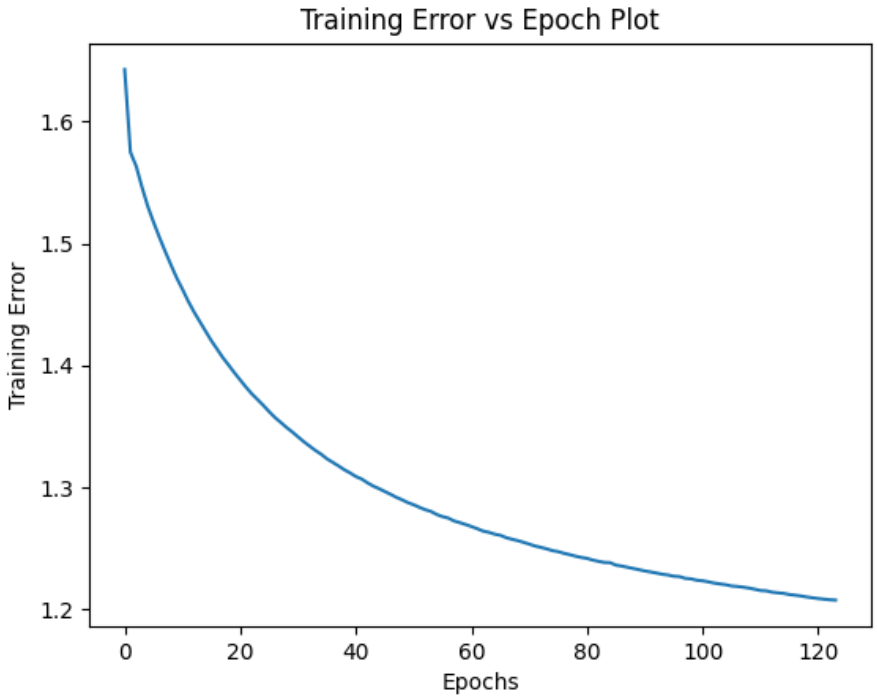


Figure 47: Training Error vs Epoch Plot for $K = 75$ and $\sigma = 0.3$

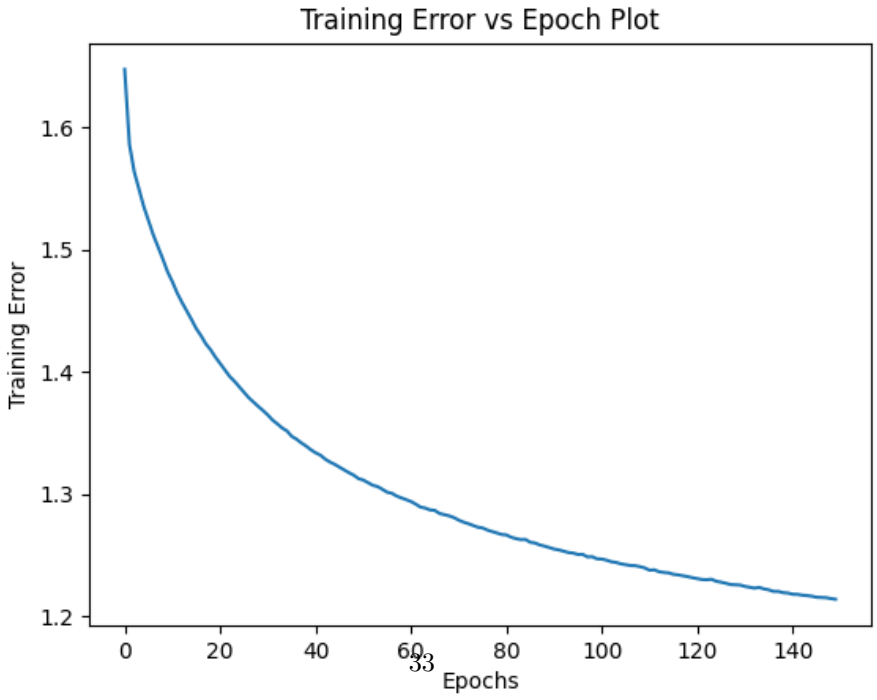




Figure 48: Training Error vs Epoch Plot for $K = 75$ and $\sigma = 0.5$

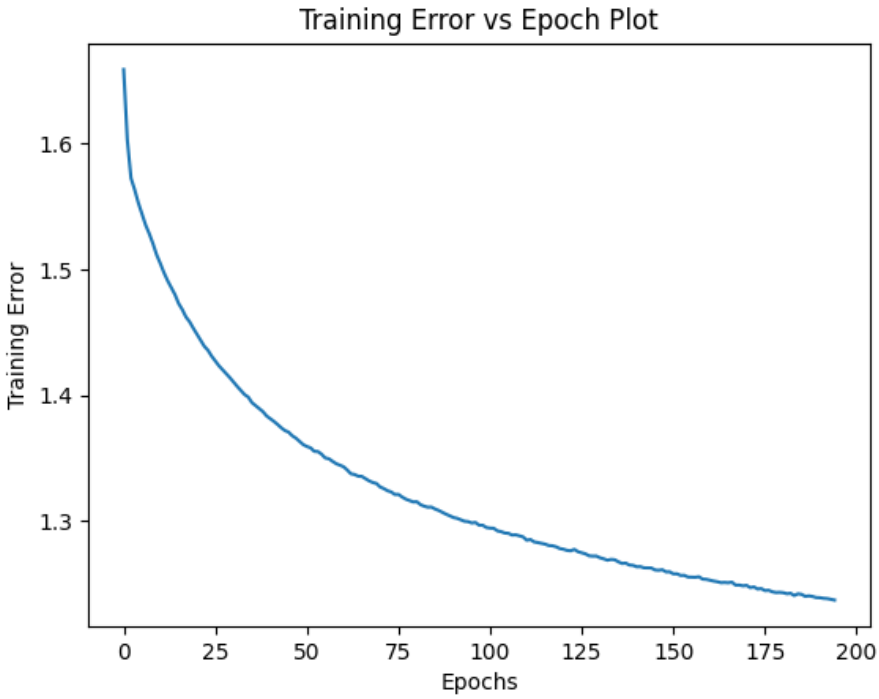


Figure 49: Training Error vs Epoch Plot for $K = 75$ and $\sigma = 0.8$

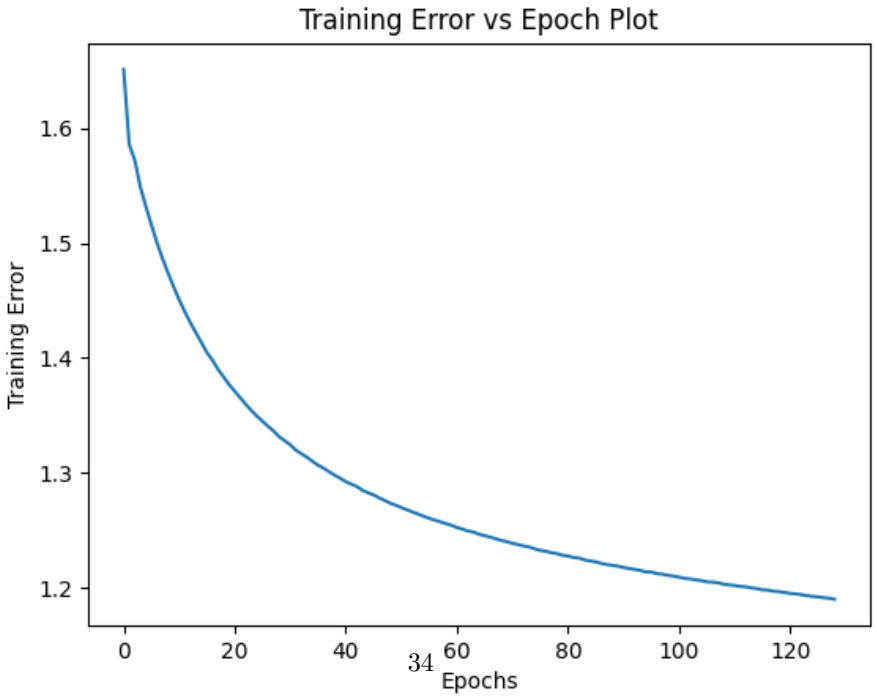


Figure 50: Training Error vs Epoch Plot for $K = 100$ and $\sigma = 0.3$

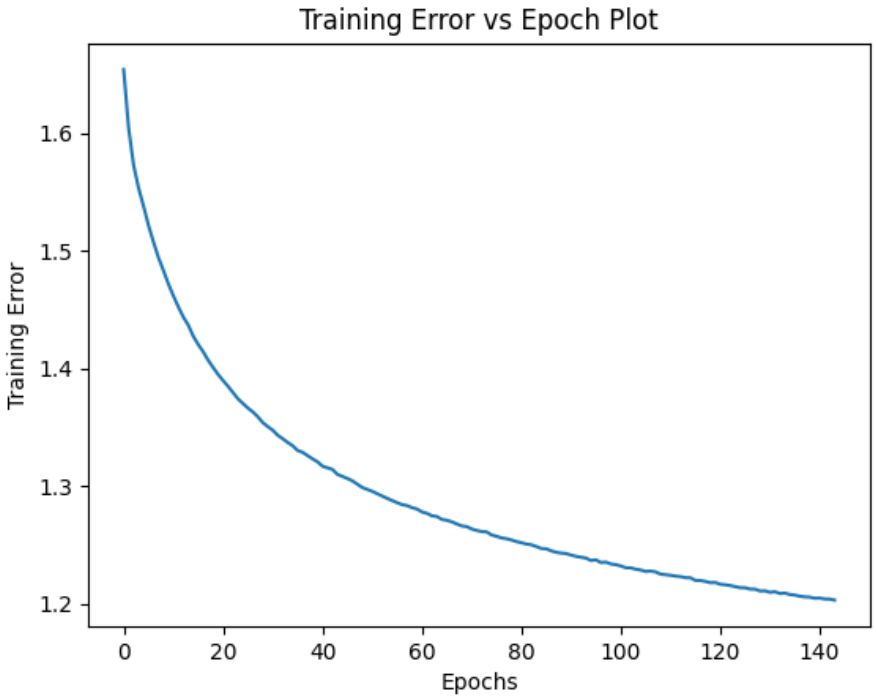


Figure 51: Training Error vs Epoch Plot for $K = 100$ and $\sigma = 0.5$

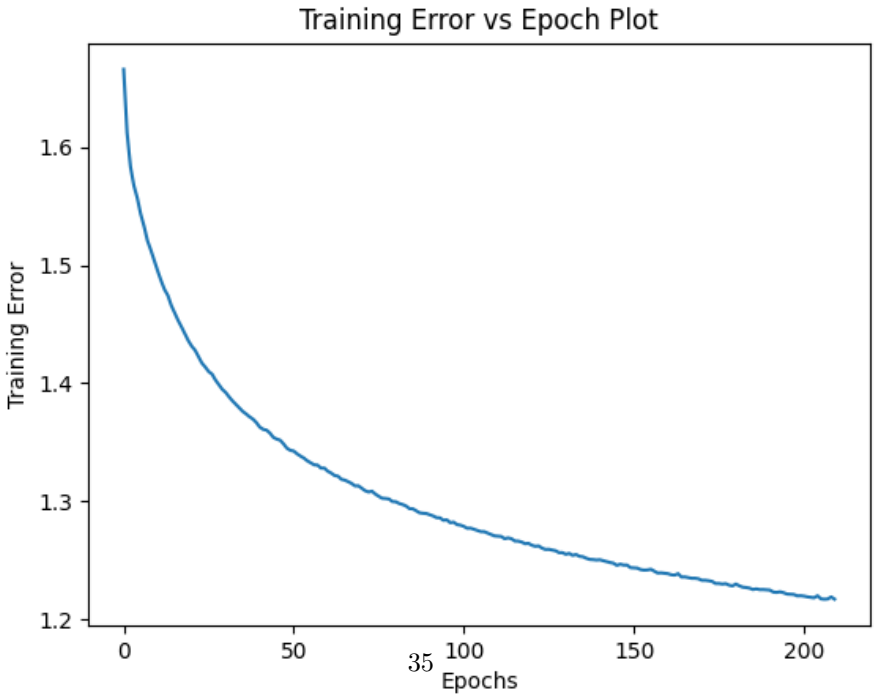




Figure 52: Training Error vs Epoch Plot for $K = 100$ and $\sigma = 0.8$