

Programming Assignment 2 - Report

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1 Backpropagation

Question 1.

I used the following for training the ANN:

- Squared error loss
- Softmax output function
- Exponentially decreasing learning rate

Exponentially decreasing learning rate helps the ANN converge by making the changes in the parameters negligibly small.

Class	Recall	Precision	f_1 measure
1	0.55	0.33333	0.41509
2	0.65	0.35135	0.45614
3	0.75	0.36585	0.4918
4	0.5	0.32258	0.39216

Table 1: Performance of ANN : 10000 iterations, 100 hidden nodes

Question 2.

According to The Elements of Statistical Learning, 2α & 2β get added to the update equations of α and β .

The test error is reduced due to prevention of overfitting by regularization.

The following evaluations were made for 100 hidden nodes and 10000 iterations:

Class	Recall	Precision	f_1 measure
1	0.7	0.4375	0.53846
2	0.75	0.44118	0.55556
3	0.85	0.44737	0.58621
4	0.5	0.41667	0.45455

Table 2: Performance of ANN for $\gamma = 1$

Class	Recall	Precision	f_1 measure
1	0.55	0.31429	0.4
2	0.7	0.34146	0.45902
3	0.75	0.34884	0.47619
4	0.35	0.25926	0.29787

Table 3: Performance of ANN for $\gamma = 0.1$

Class	Recall	Precision	f_1 measure
1	0.6	0.4	0.48
2	0.9	0.42857	0.58065
3	0.55	0.39286	0.45833
4	0.65	0.40625	0.5

Table 4: Performance of ANN for $\gamma = 10$

Class	Recall	Precision	f_1 measure
1	0.55	0.31429	0.4
2	0.7	0.34146	0.45902
3	0.75	0.34884	0.47619
4	0.35	0.25926	0.29787

Table 5: Performance of ANN for $\gamma = 0.01$

2 LDA

QDA, LDA and RDA were done using the specified library, and the boundaries were plotted.

3 Logistic Regression

Non-regularized and L1 Regularized Logistic Regression were performed on the given data set.

The following were recorded for non-regularized Logistic Regression:

	Class 1	Class 2	Class 3	Class 4
Recall	0.6000	0.8000	0.5000	0.6500
Precision	0.3636	0.3902	0.3448	0.3714
F1	0.4528	0.5246	0.4082	0.4727

Table 6: Performance of unregularized Logistic Regression

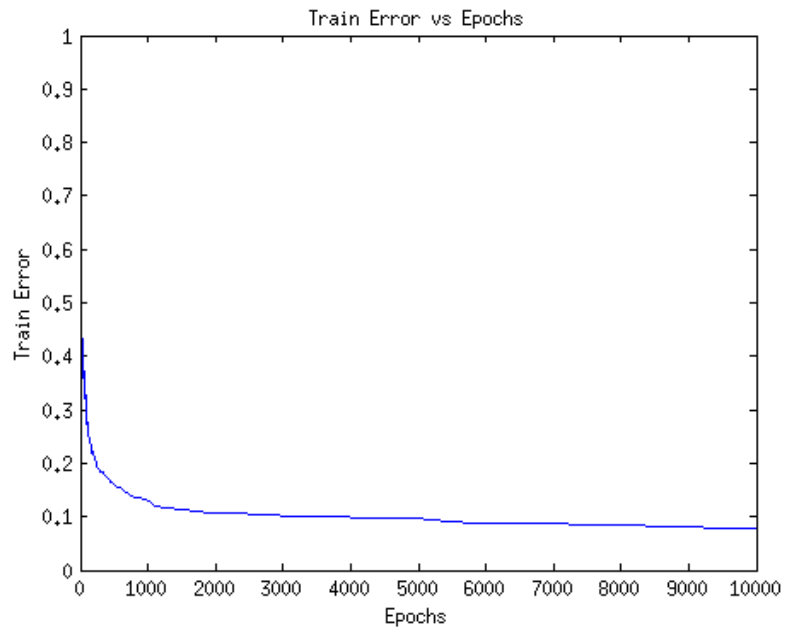


Figure 1: Train Error vs. Epoch plot.

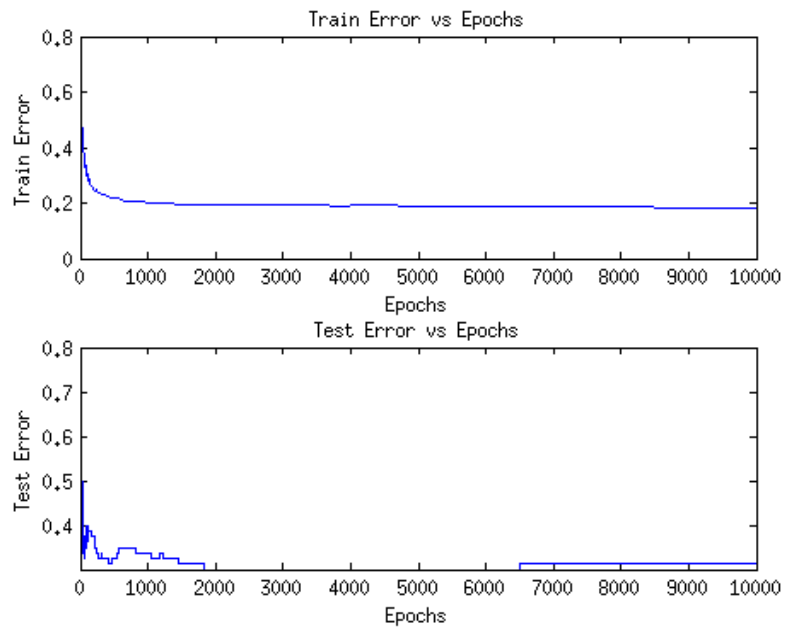


Figure 2: Train error & test error vs epoch for $\gamma = 1$.

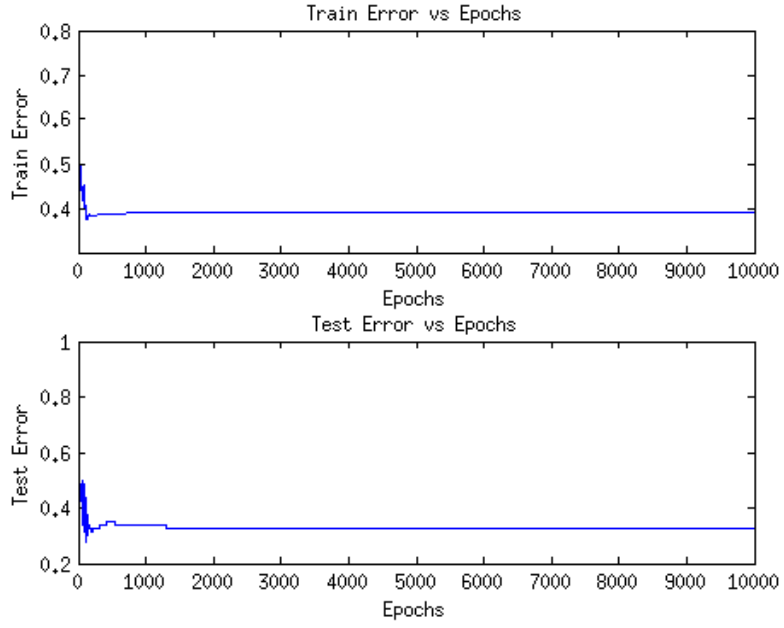


Figure 3: Train error & test error vs epoch for $\gamma = 10$.

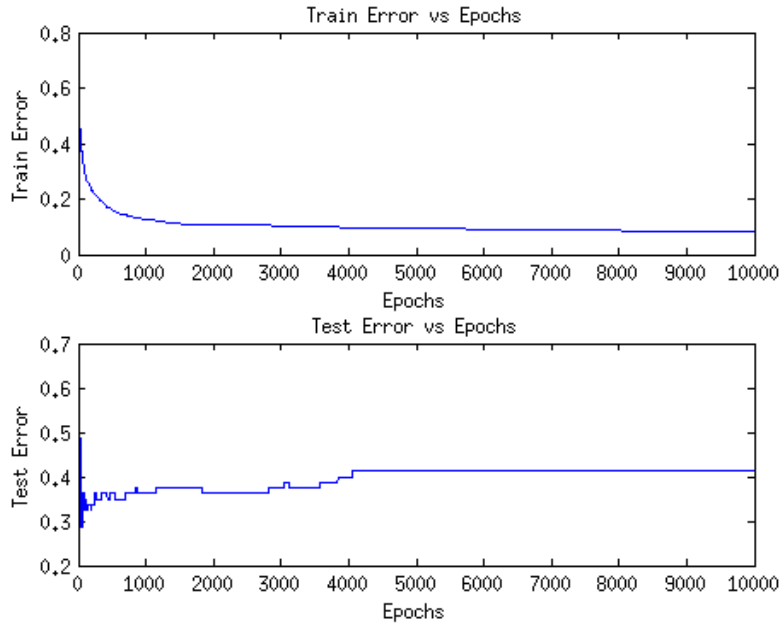


Figure 4: Train error & test error vs epoch for $\gamma = 0.01$.

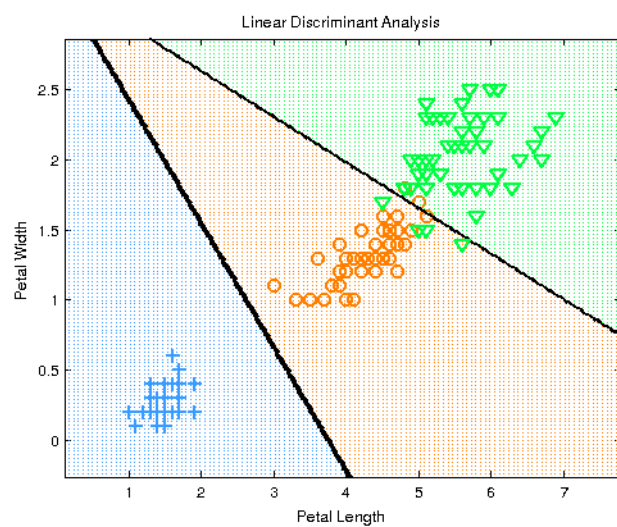


Figure 5: Decision boundary for LDA.

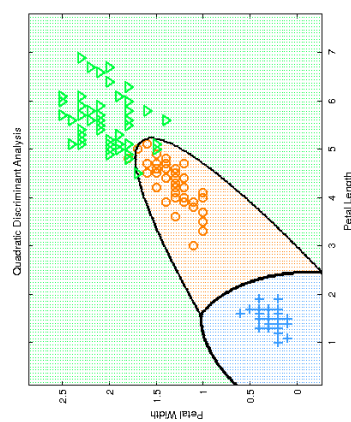


Figure 6: Decision boundary for QDA.

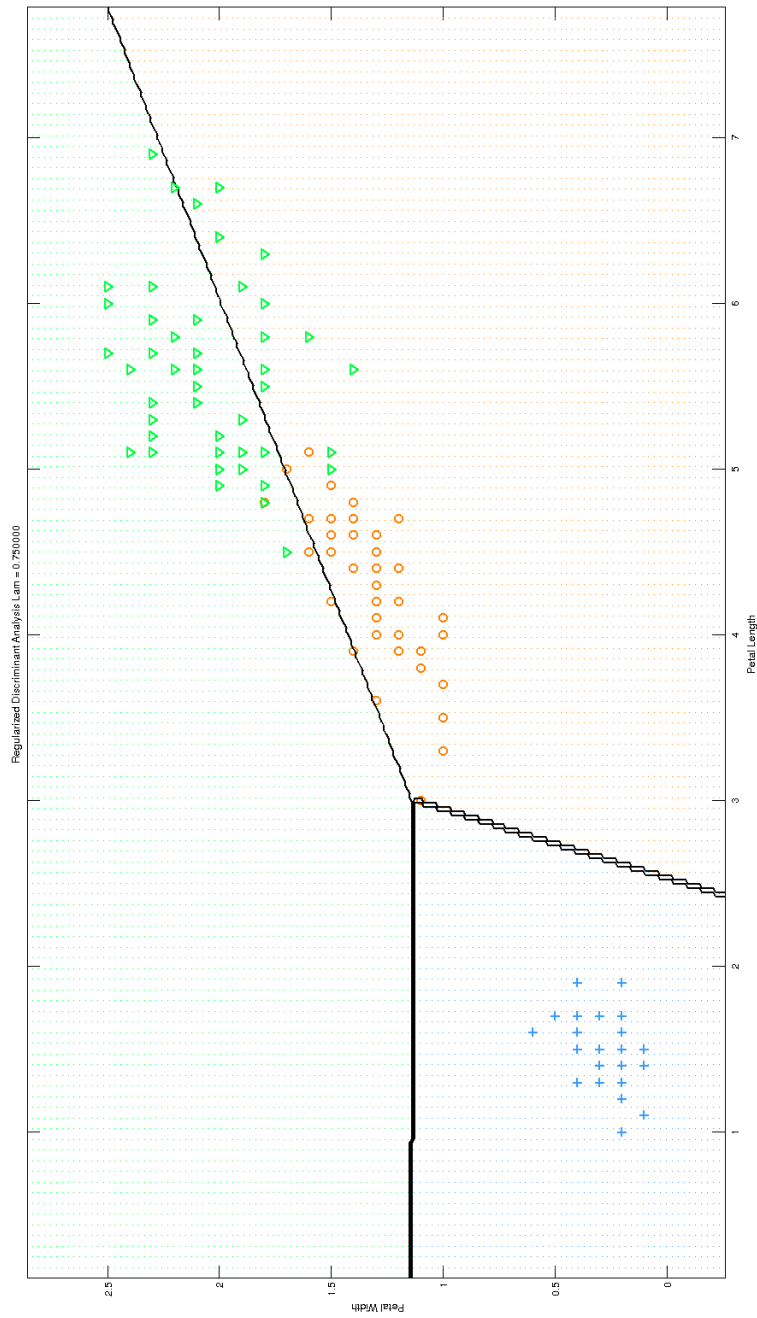


Figure 7: Decision boundary for RDA.

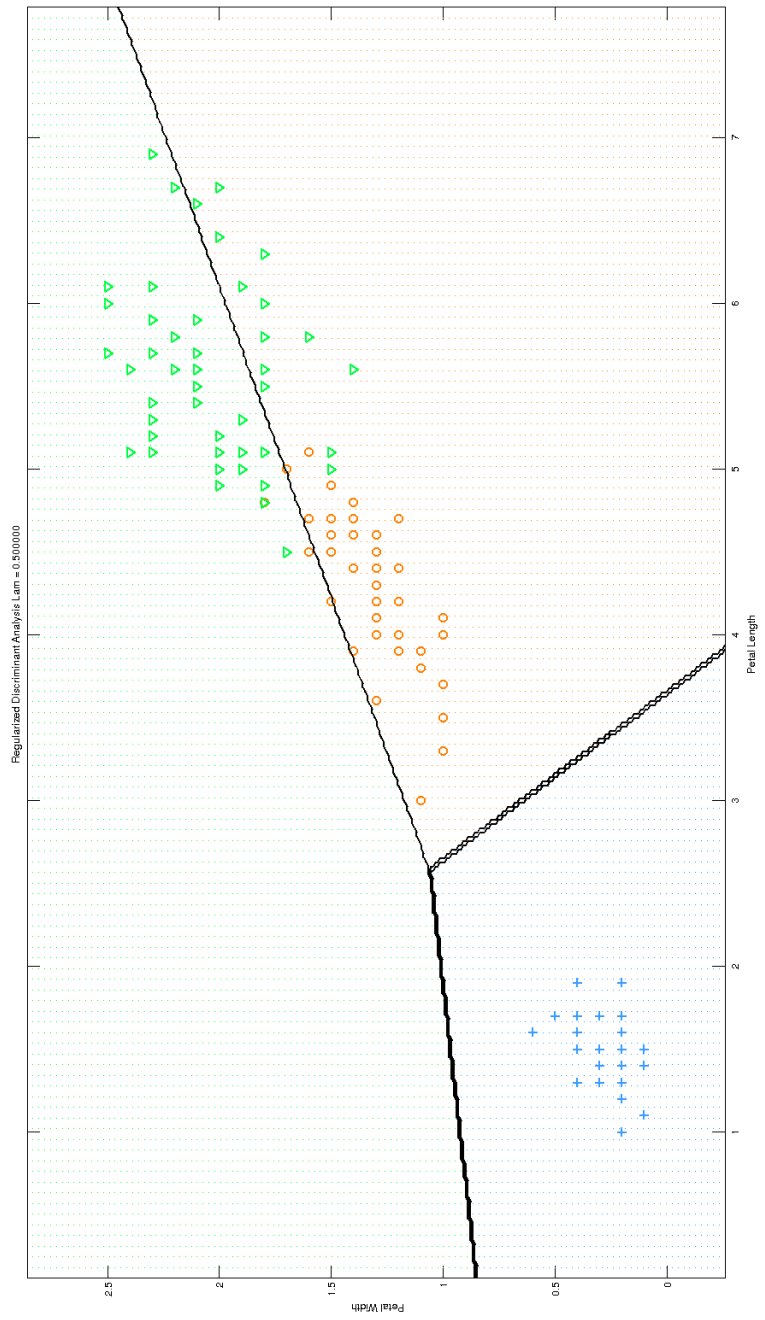


Figure 8: Decision boundary for RDA.

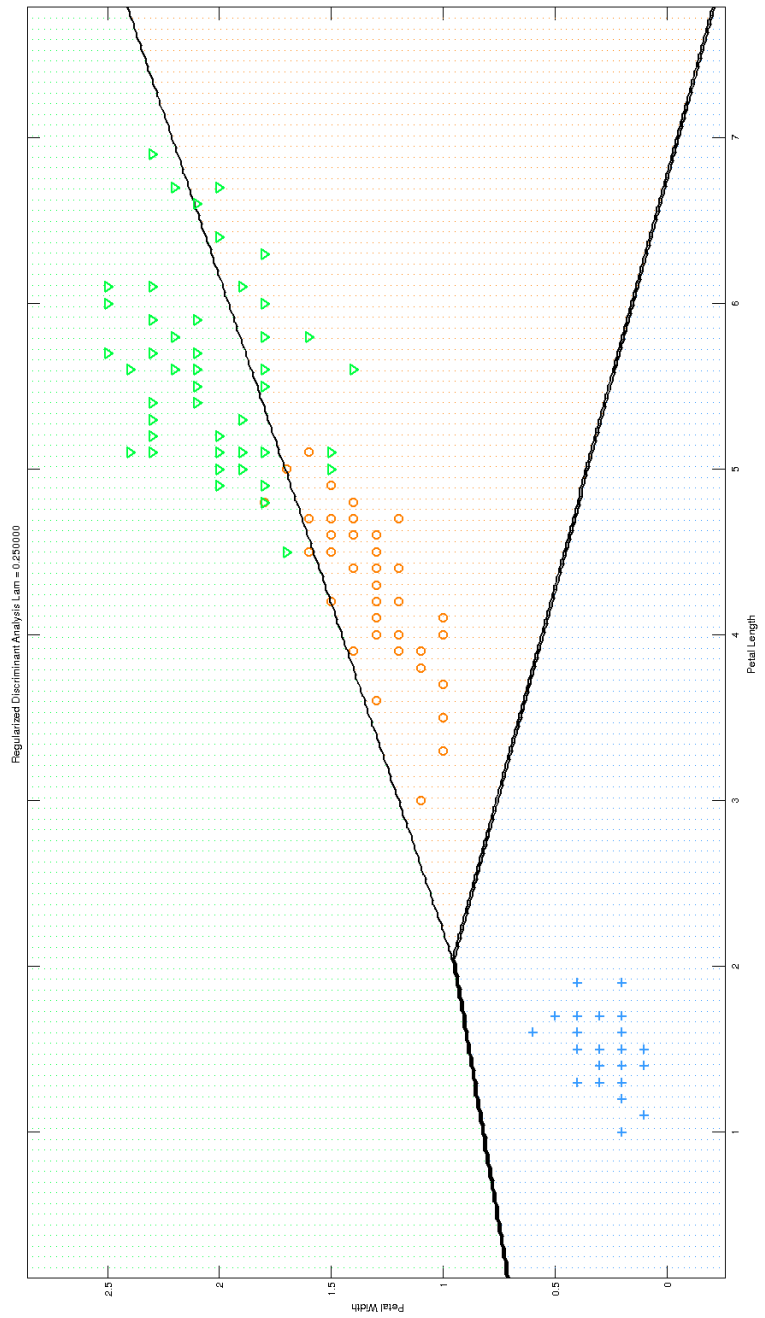


Figure 9: Decision boundary for RDA.

We have obtained the following for various values of λ :

	Class 1	Class 2	Class 3	Class 4
Recall	0.6000	0.8000	0.5000	0.7000
Precision	0.3750	0.4000	0.3571	0.3889
F1	0.4615	0.5333	0.4167	0.5000

Table 7: Performance of regularised Logistic Regression for $\lambda = 0.0001$

	Class 1	Class 2	Class 3	Class 4
Measure	Class1	Class2	Class3	Class4
Recall	0.6500	0.8000	0.5500	0.7500
Precision	0.4194	0.4324	0.4074	0.4286
F1	0.5098	0.5614	0.4681	0.5455

Table 8: Performance of regularised Logistic Regression for $\lambda = 0.0005$

	Class 1	Class 2	Class 3	Class 4
Recall	0.6000	0.8000	0.5500	0.7000
Precision	0.3871	0.4103	0.3793	0.4000
F1	0.4706	0.5424	0.4490	0.5091

Table 9: Performance of regularised Logistic Regression for $\lambda = 0.001$

	Class 1	Class 2	Class 3	Class 4
Measure	Class1	Class2	Class3	Class4
Recall	0.6500	0.8000	0.6000	0.7500
Precision	0.4333	0.4444	0.4286	0.4412
F1	0.5200	0.5714	0.5000	0.5556

Table 10: Performance of regularised Logistic Regression for $\lambda = 0.005$

	Class 1	Class 2	Class 3	Class 4
Measure	Class1	Class2	Class3	Class4
Recall	0.6000	0.8000	0.5500	0.7000
Precision	0.3871	0.4103	0.3793	0.4000
F1	0.4706	0.5424	0.4490	0.5091

Table 11: Performance of regularised Logistic Regression for $\lambda = 0.01$

	Class 1	Class 2	Class 3	Class 4
Measure	Class1	Class2	Class3	Class4
Recall	0.5000	0.9500	0.5000	0.2000
Precision	0.2703	0.3455	0.2703	0.1600
F1	0.3509	0.5067	0.3509	0.1778

Table 12: Performance of regularised Logistic Regression for $\lambda = 10.05$

	Class 1	Class 2	Class 3	Class 4
Recall	0	0	1.0000	0
Precision	0	0	0.2500	0
F1	NaN	NaN	0.4000	NaN

Table 13: Performance of regularised Logistic Regression for $\lambda = 1$