CSCI-4100 Assignment 12 Yichuan Wang 661414395

1. Neural Network

(a)Back propagation:

Identity result:

Layer 1:

$$\begin{bmatrix} -0.0322 & -0.0322 \\ -0.0322 & -0.0322 \\ -0.0322 & -0.0322 \end{bmatrix}$$

Layer 2:

$$\begin{bmatrix} -0.2162 \\ -0.1373 \\ -0.1373 \end{bmatrix}$$

tanh result:

Layer 1:

$$\begin{bmatrix} -0.0267 & -0.0267 \\ -0.0267 & -0.0267 \\ -0.0267 & -0.0267 \end{bmatrix}$$

Layer 2:

$$\begin{bmatrix} -0.1791 \\ -0.1137 \\ -0.1137 \end{bmatrix}$$

(b) Gradient approximation with weight nudging by 0.0001

Identity result:

Layer 1:

$$\begin{bmatrix} -0.0322 & -0.0322 \\ -0.0322 & -0.0322 \\ -0.0322 & -0.0322 \end{bmatrix}$$

Layer 2:

$$\begin{bmatrix} -0.2162 \\ -0.1373 \\ -0.1373 \end{bmatrix}$$

tanh result:
Layer 1:

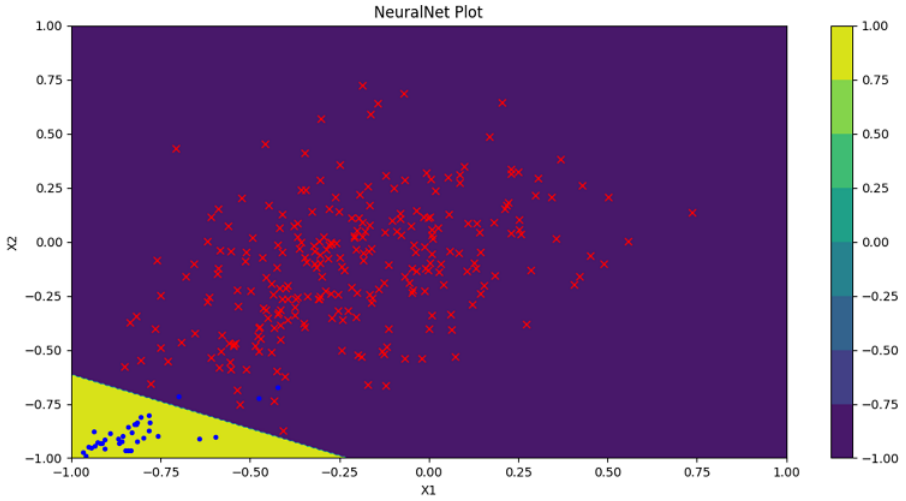
$$\begin{bmatrix} -0.0267 & -0.0267 \\ -0.0267 & -0.0267 \\ -0.0267 & -0.0267 \end{bmatrix}$$

Layer 2:

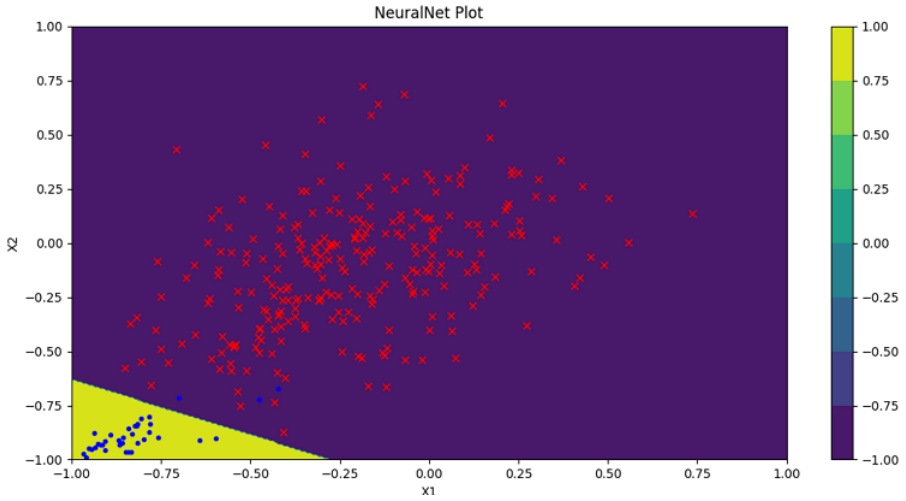
$$\begin{bmatrix} -0.1790 \\ -0.1137 \\ -0.1137 \end{bmatrix}$$

Conclusion: There is nearly no difference between forward propagation gradient estimation and back propagation method.

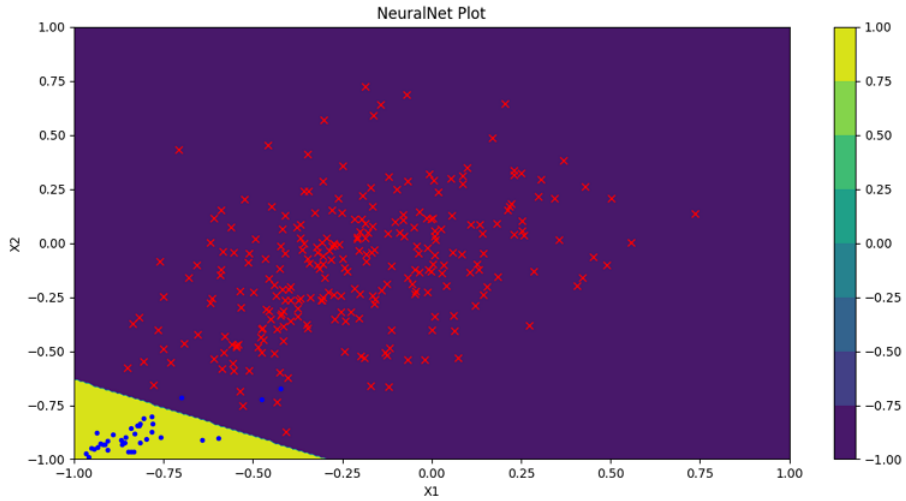
2. Neural Network with number digits
(a)
Error vs iteration:
Classifier: $E_{test} = 0.0136$



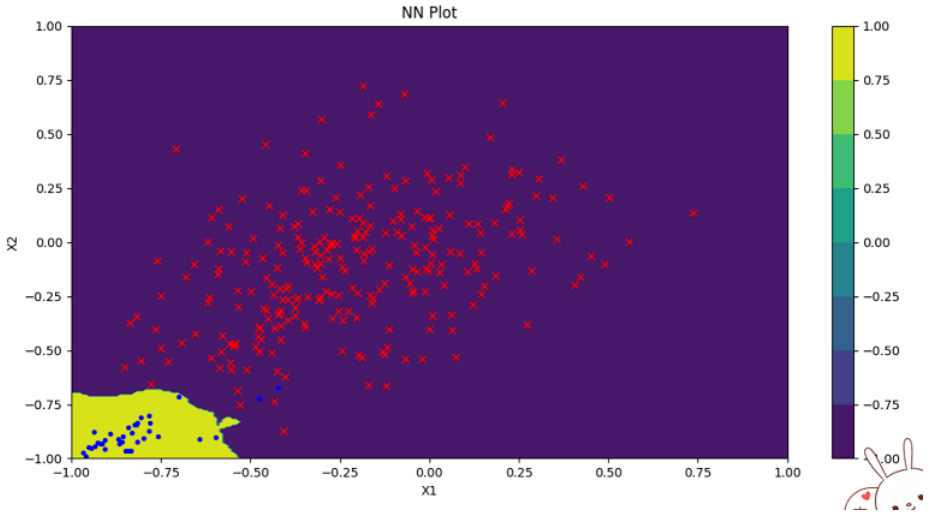
(b) Weight Decay with variable learning rate
Classifier: $E_{test} = 0.0127$



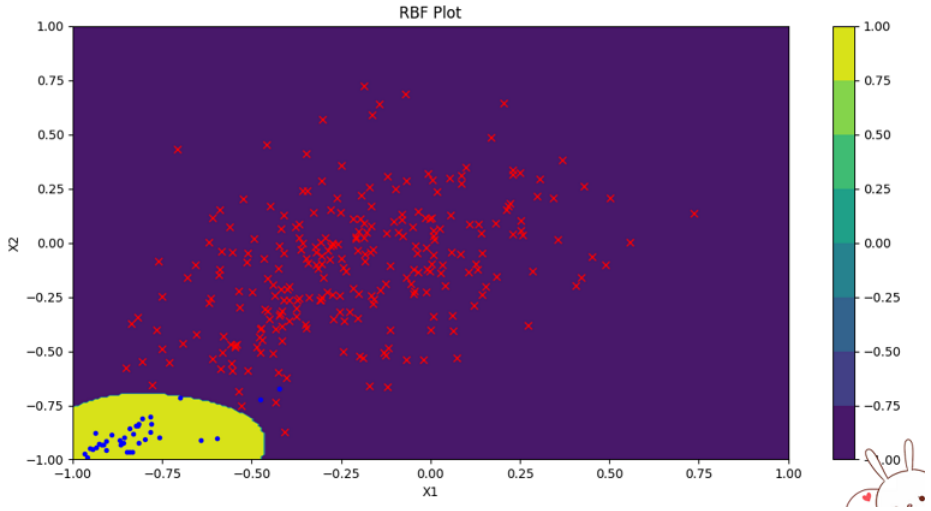
(c) Early stop
Classifier: $E_{test} = 0.0126$



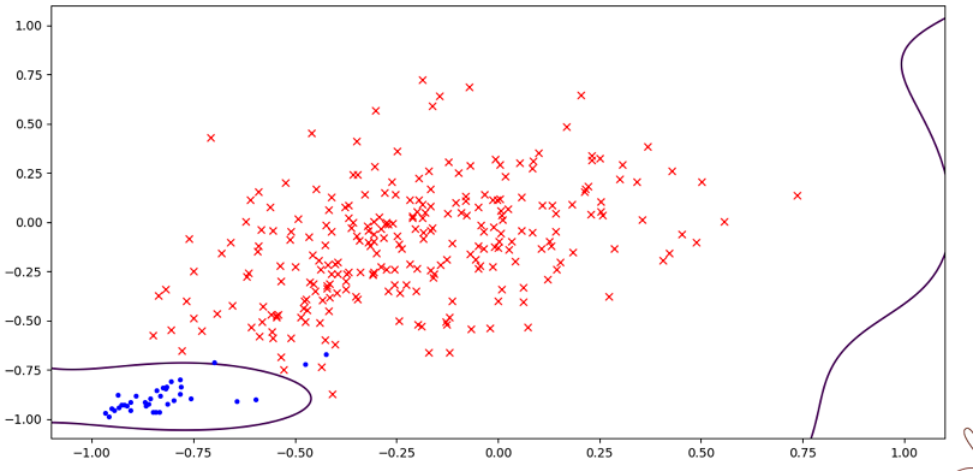
Since the data used last time is not saved, old models with new data (those used on NN) was run and data is provided below:
KNN: $E_{test} = 0.0174$



RBF: $E_{test} = 0.0144$



Linear Model: $E_{test} = 0.0284$

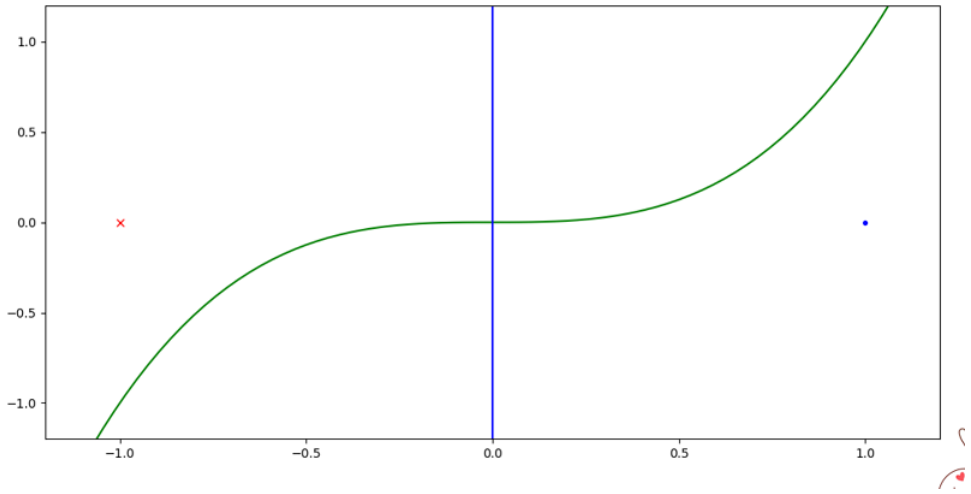


3. SVM

(a) The optimal separator is $x_1 = 0$. Since two data points lay symmetrically about y axis, the y-axis gives the most cushion.

(b) After transformation, the data points lay symmetrically about the z1 axis, so $z_1 = 0$, the hyperplane in the middle, gives the maximum cushion.

(c) After transformation the decision boundary becomes $z_1^3 - z_2 = 0$, plot as following:



(d)

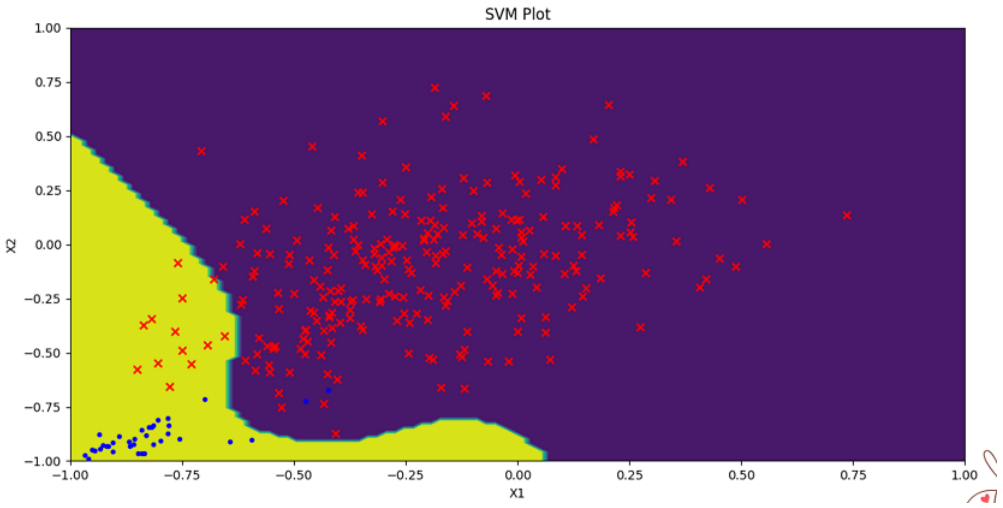
The data point after transformation is $(x_0^3 - x_1, x_0 x_1)$, $(y_0^3 - y_1, y_0 y_1)$

Taking the dot product of these two we get following result:

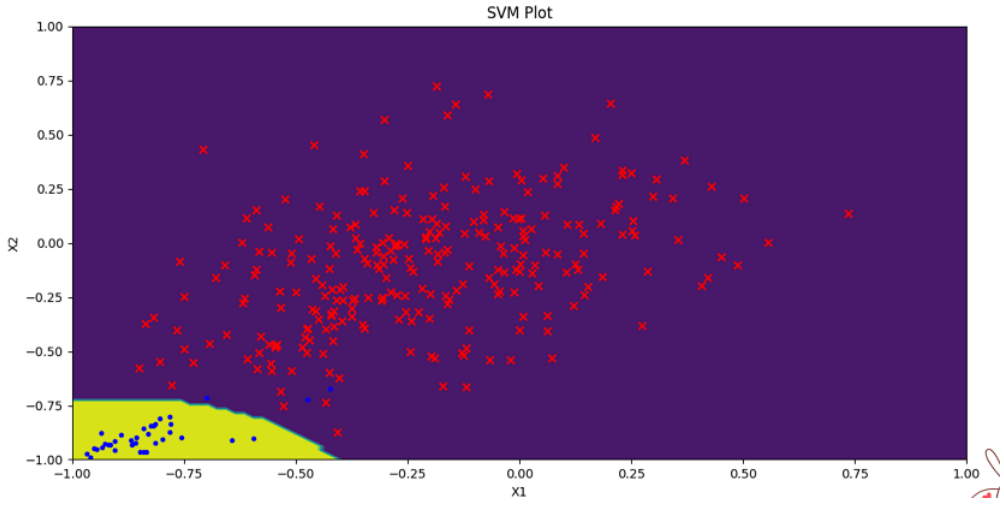
$$x_0^3 y_0^3 - x_0^3 y_1 - y_0^3 x_1 + x_1 y_1 + x_0 x_1 y_0 y_1$$

(e)The kernel function in function form is $h(x) = sign(x^3 - y)$

4. SVM for digits
Small C is 0.1: $E_{test} = 0.0468$, image given below

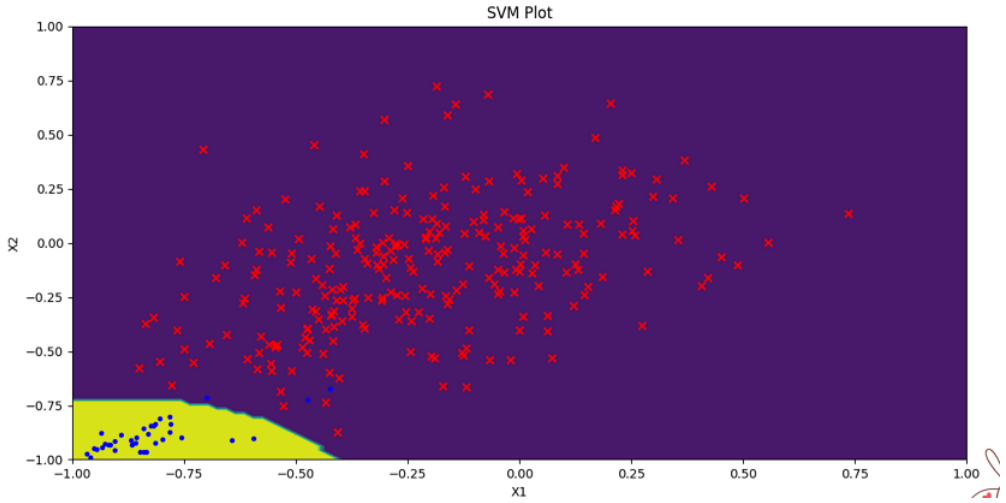


Large C is 100: $E_{test} = 0.0154$, image given below



For cross validation choosing C from 0.1 to 100, $C = 100$ has the best per-

formance: ($E_{test} = 0.0154$)



5. Comments
Test error comparison first:
Linear Model: 0.0284
KNN: 0.0174
RBF: 0.0144
Neural Network: 0.0126
SVM: 0.0154

Neural Network has the best result, and it's probably because it's high ability to fit the model, even though the final output classifier takes a linear fashion. SVM runs very fast, with an average performance; its ability to use cushion and use C to deal with inseparable data makes it more noise-resistant and that's probably why it's better than the linear model.