Homework 2

Collaborators:

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Problem 2-1. A Walk Through Linear Models

(a) Perceptron

Answer:

1. The results are shown as following:

```
E_train is 0.0, E_test is 0.11134060000000025
Average number of iterations is 7.4.
```

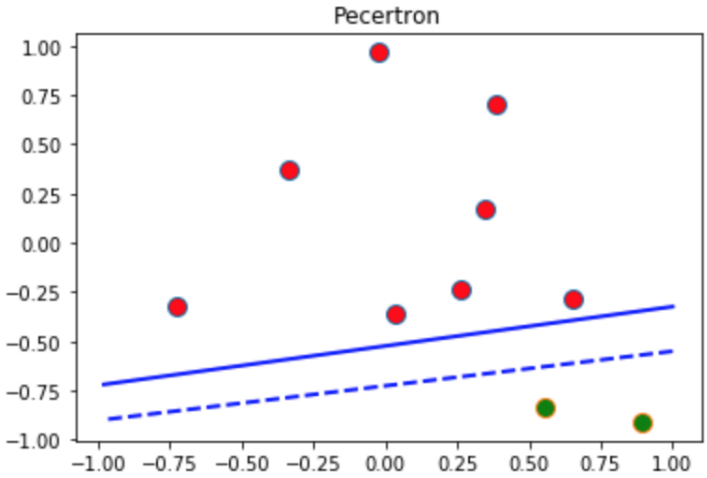

Figure 1: The plotting result for perceptron when nTrain = 10.

```
E_train is 0.0, E_test is 0.013448000000000003
Average number of iterations is 38.163.
```

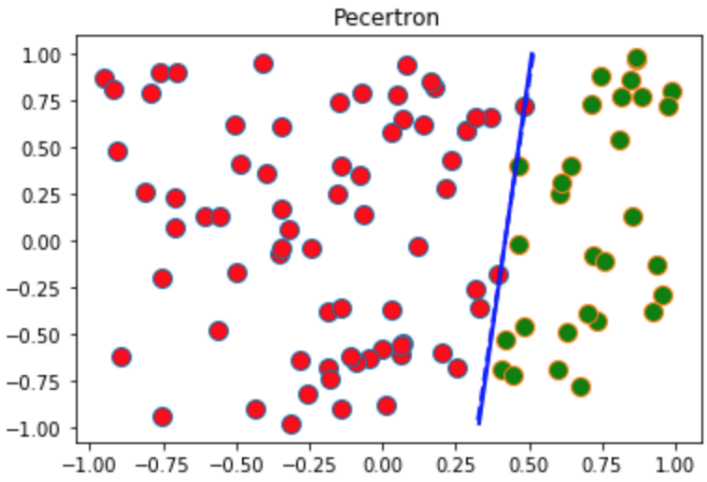

Figure 2: The plotting result for perceptron when nTrain = 100.

2. 7.4 when nTrain = 10
   38.163 when nTrain = 100
3. Algorithm stuck in an infinite loop

(b) Linear Regression

Answer:

1. The results are shown as following:

```
E_train is 0.03961000000000004, E_test is 0.049058500000000026
```

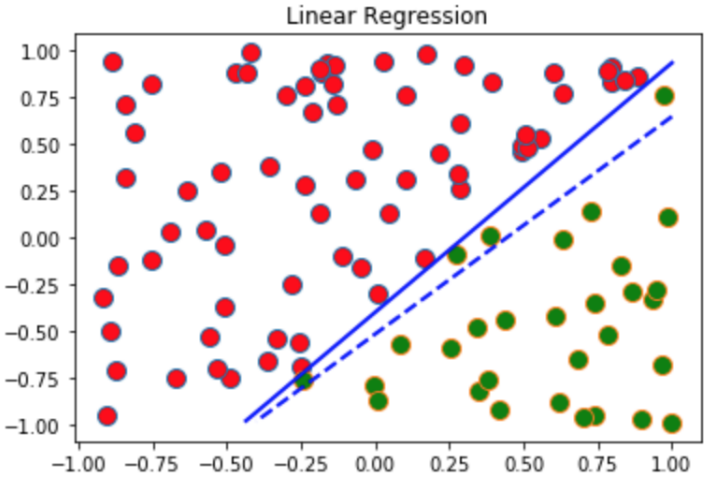

Figure 3: linear

2. The results are shown as following:

```
E_train is 0.13310000000000002, E_test is 0.14387830000000001
```

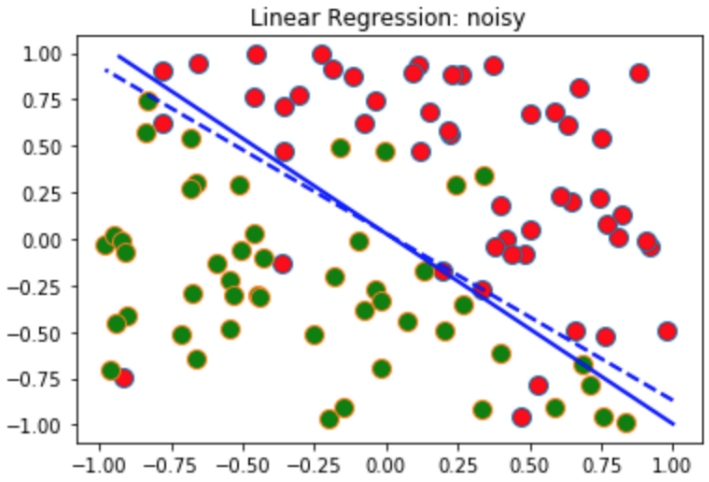

Figure 4: unlinear

3. $E_train = 0.49, E_test = 0.5496$
4. $E_train = 0.05, E_test = 0.066$

(c) Logistic Regression

Answer:

1. The results are shown as following:

```
E_train is 0.04479999999999998, E_test is 0.05282900000000002
```

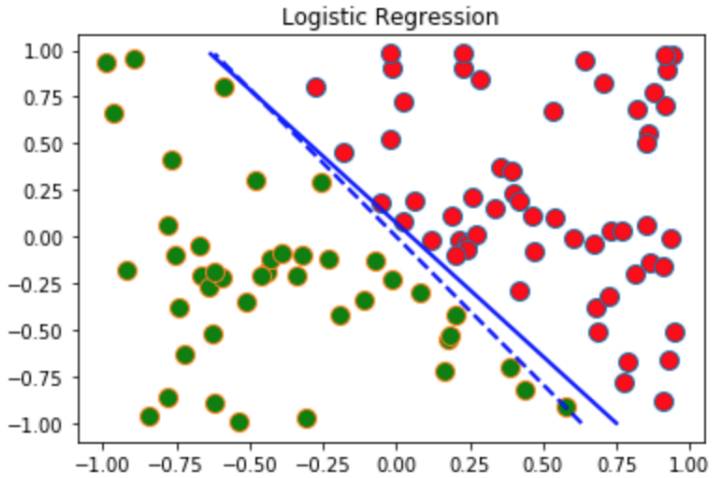

Figure 5: logistic regression

2. The results are shown as following:

```
E_train is 0.1471000000000001, E_test is 0.16119799999999998
```

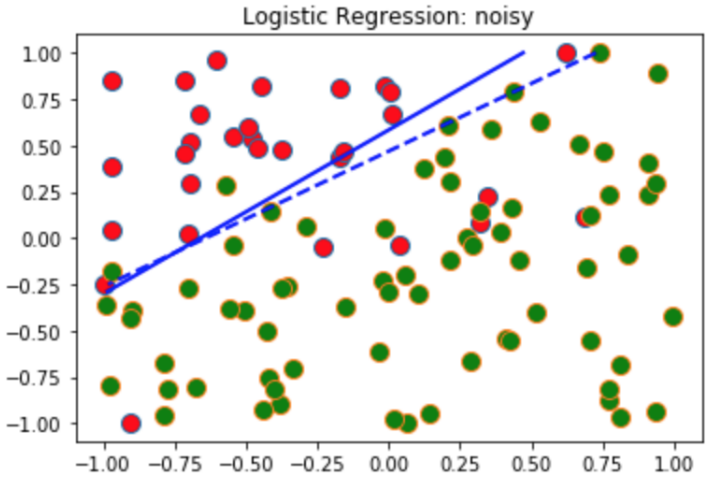

Figure 6: noisy

(d) Support Vector Machine

Answer:

1. The results are shown as following

```
E_train is 0.0, E_test is 0.03403640000000003
Average number of support vectors is 3.546.
```

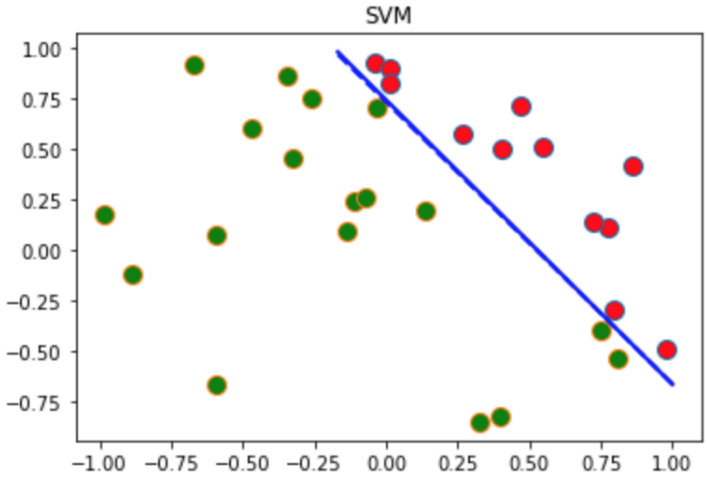

Figure 7: nTrain = 30

2. The results are shown as following

```
E_train is 0.0, E_test is 0.010898499999999986
Average number of support vectors is 3.095.
```

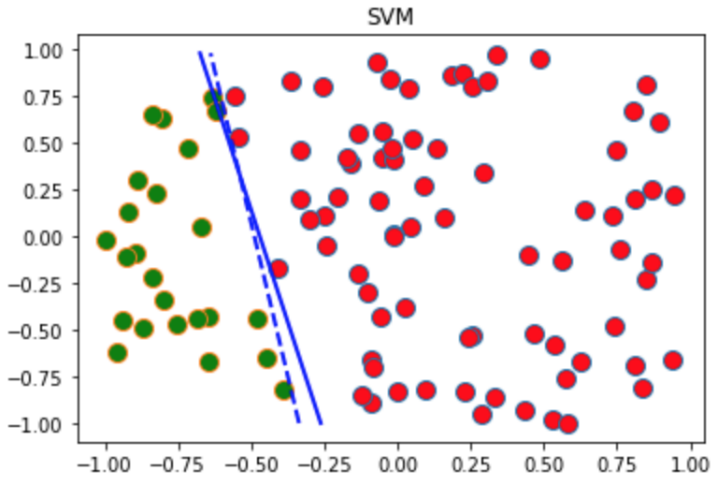

Figure 8: nTrain = 100

3. The average support vector number is 3.095

Problem 2-2. Regularization and Cross-Validation

(a) Implement Ridge Regrssion, and use LOOCV to tune the regularization parameter λ.

Answer:

1. The best lambda is 1000

```
0.001 0.08
0.01 0.08
0.1 0.07
0.0 0.08
1.0 0.07
10.0 0.05
100.0 0.04
1000.0 0.035
w^2 with reg 0.028695897111754368
```

Figure 9: cross-validate

2. The w^2 is shown as following:

```
w^2 without reg 1.2954738826969892
w^2 with reg 0.028695897111754364
```

Figure 10: The w

3. The train error and test error with or without regularization is shown as following:

```
E_train, E_test without reg 0.0 0.10547463586137619
E_train, E_test with reg 0.015 0.0622802611752888
```

Figure 11: The train and test error

(b) Implement Logistic Regrssion, and use LOOCV to tune the regularization parameter λ.

Answer: $\lambda = 10$

```
0.001 0.045
0.01 0.045
0.1 0.055
0.0 0.045
1.0 0.045
10.0 0.035
100.0 0.04
/Users/Alan/workspace/homework/ml/hw2/ml201
overflow encountered in exp
  return 1.0 / (1 + np.exp(-x))
/Users/Alan/anaconda3/lib/python3.6/site-pa
in reduce
  return ufunc.reduce(obj, axis, dtype, out
/Users/Alan/anaconda3/lib/python3.6/site-pa
reduce
  ret = umr_sum(arr, axis, dtype, out, keep
/Users/Alan/workspace/homework/ml/hw2/ml201
invalid value encountered in matmul
  yy = sigmoid(np.matmul(w.T, x))
1000.0 1.0
```

Figure 12: The cross-validate

The train error and test error with or without regularization is shown as following:

```
E_train, E_test without reg 0.0 0.06177800100452034
E_train, E_test with reg 0.0 0.05675539929683576
```

Figure 13: The train and test error

Problem 2-3. Bias Variance Trade-off

Let's review the bias-variance decomposition first. Now please answer the following questions:

(a) True of False

Answer:

1. F
2. F
3. T
4. F
5. F