Q1

March 12, 2019

1 Logistic Regression on Microchip Data

```
In [1]: import numpy as np
        import matplotlib.pyplot as plt
        import pandas as pd
        from sklearn.model_selection import train_test_split
        from sklearn.utils import shuffle
```

```
In [2]: df = pd.read_csv('microchip-data.csv', header=None, names=['test1','test2','result'])
        df = shuffle(df)
        df.head()
```

```
Out[2]:        test1    test2  result
        14   0.54666  0.48757       1
        72   0.82892 -0.52120       0
        28  -0.13882  0.54605       1
        104 -0.15035 -0.36769       0
        74   0.59274 -0.74050       0
```

```
In [3]: df.shape
```

```
Out[3]: (118, 3)
```

```
In [4]: Y = df['result']
        X = df.drop(['result'],axis=1)
```

```
In [5]: print(X.shape)
        print(Y.shape)
```

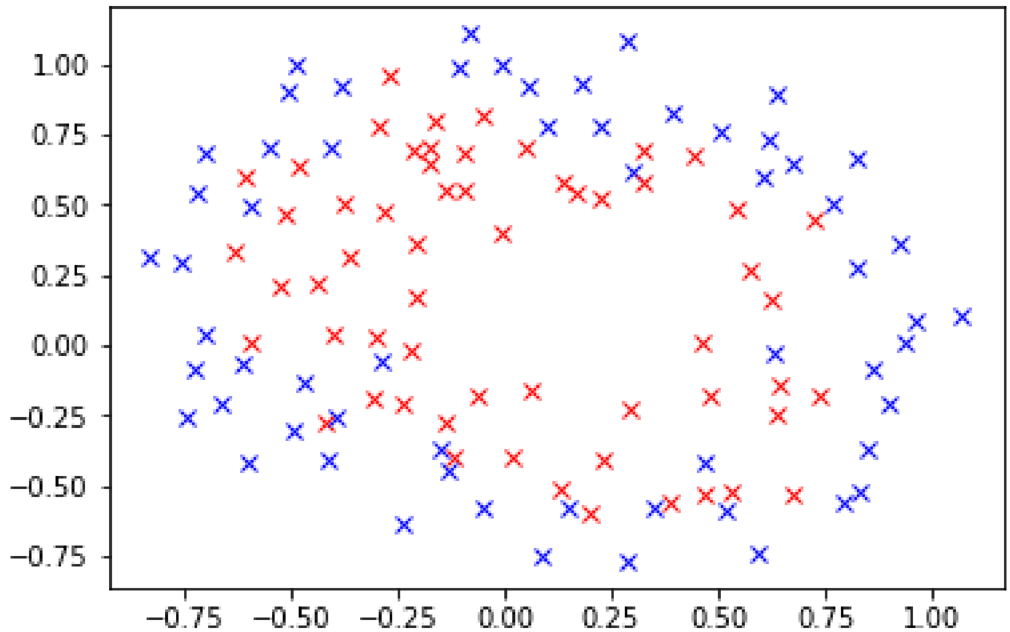
```
(118, 2)
(118,)
```

1.1 Data Preprocessing

```
In [6]: Y = (np.array(Y)).reshape(Y.shape[0],1)
        print(Y.shape)
        X = np.array(X)
        X = np.c_[np.ones(X.shape[0]),np.array(X)]
        print(X.shape)
```

```
(118, 1)
(118, 3)
```

```
In [7]: for i in range(X.shape[0]):
            if Y[i]==1:
                plt.plot(X[i,1],X[i,2],'rx')
            else:
                plt.plot(X[i,1],X[i,2],'bx')
        plt.show()
```




```
In [8]: # Splitting data in train and test sets
        X_train, X_test, y_train, y_test = train_test_split(X, Y, test_size=0.3)
        print(X_train.shape, y_train.shape)
        print(X_test.shape, y_test.shape)
```

```
(82, 3) (82, 1)
(36, 3) (36, 1)
```

```
In [9]: #Normalising Inputs(2D input)
        def normalise(inp):
            return np.array((inp-inp.mean())/inp.std())
        X = normalise(X)
```

1.2 Defining functions

In [10]:
```
# Sigmoid function
def sigmoid(z):
    return 1.0 / (1 + np.exp(-z))
```

In [11]:
```
# Cost Function with regularization
def cost(X,Y,theta,_lambda=0.1):
    m = len(Y)
    h = sigmoid(X.dot(theta))
    reg = (_lambda/(2 * m)) * np.sum(theta**2)
    return (1 / m) * (-Y.T.dot(np.log(h)) - (1 - Y).T.dot(np.log(1 - h))) + reg
```

In [12]:
```
# Regularized gradient function
def derivative(X,Y,theta,_lambda = 0.1):
    m, n = X.shape
    h = sigmoid(X.dot(theta))
    reg = _lambda * theta /m
    return ((1 / m) * X.T.dot(h - Y)) + reg
```

In [13]:
```
# Training function
def train(X, Y, alpha, iterations = 100000, _lambda=0.1):
    costs = np.empty([iterations])
    i = 0
    m = X.shape[0]
    theta = np.random.randn(X.shape[1],1)

    while i < iterations:
        costs[i] = cost(X, Y, theta, _lambda)
        theta = theta - (alpha / m) * (derivative(X, Y, theta, _lambda))
        i = i + 1
    return theta, costs
```

In [14]:
```
def test(X,Y,theta):
    pred = sigmoid(X.dot(theta))
    counts = 0
    a, b = X.shape
    for i in range(a):
        if pred[i] > 0.5:
            if int(Y[i]) == 1:
                counts = counts + 1
        else:
            if int(Y[i]) == 0 :
                counts = counts + 1

    print('Accuracy:',counts/a * 100)
```

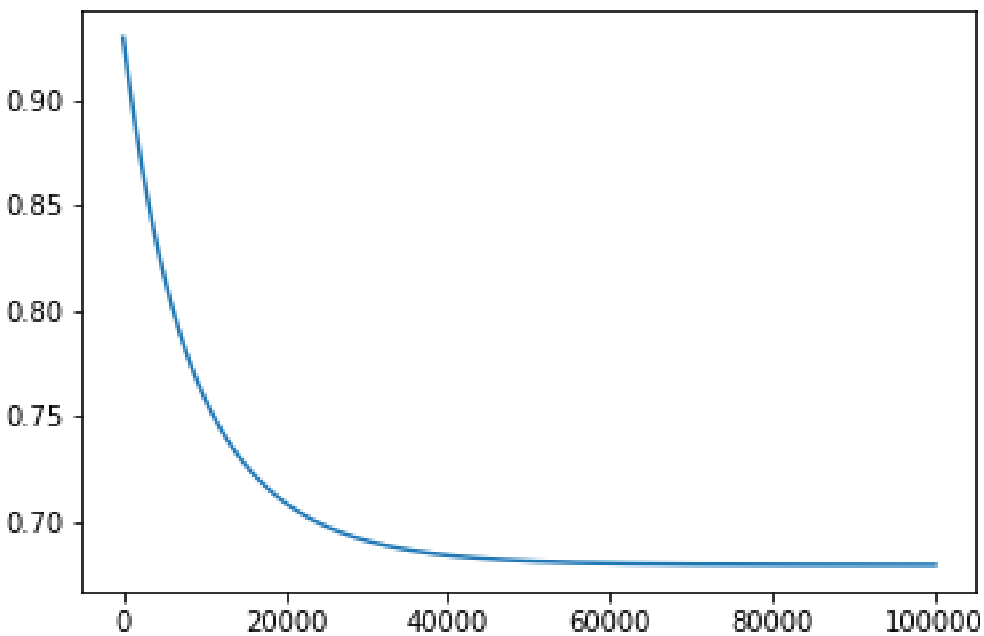
1.3 Training without Regularization (lambda = 0)

```
In [15]: theta, costs = train(X_train, y_train, 0.05, _lambda=0)
         print(theta)
```

```
[[-0.10435592]
 [-0.5438233 ]
 [ 0.16656105]]
```

```
In [16]: plt.plot(range(len(costs)),costs)
```

```
Out[16]: [<matplotlib.lines.Line2D at 0x7f5fb4875080>]
```




```
In [17]: test(X_test,y_test,theta)
```

```
Accuracy: 47.22222222222222
```

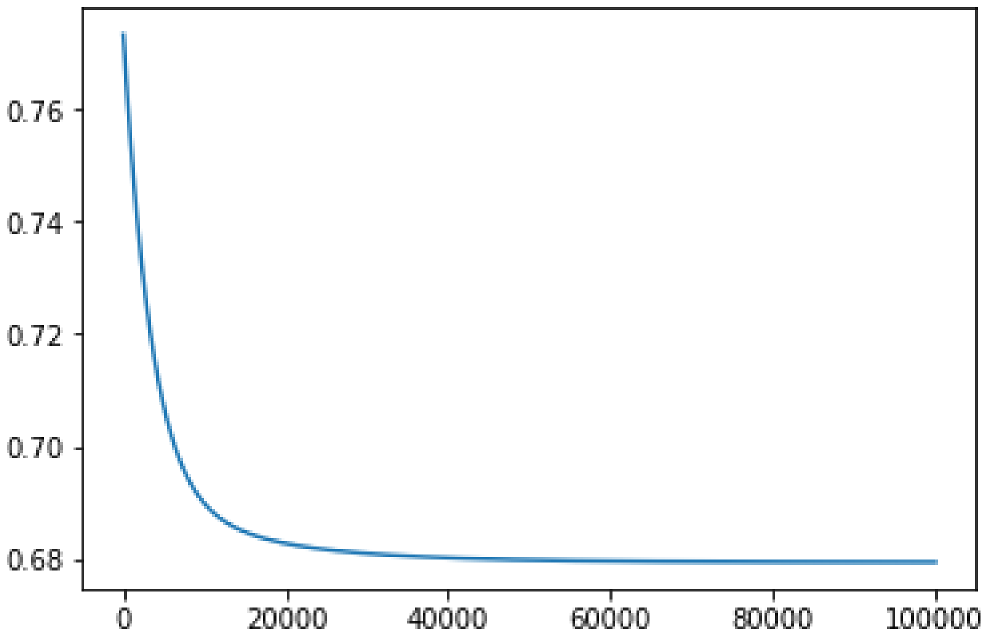
1.4 lambda = 0.1

```
In [18]: theta, costs = train(X_train, y_train, 0.05, _lambda=0)
         print(theta)
```

```
[[-0.10795917]
 [-0.55070798]
 [ 0.18339786]]
```

In [19]:
```
plt.plot(range(len(costs)),costs)
```

Out[19]: [<matplotlib.lines.Line2D at 0x7f5fb47ca6a0>]



In [20]:
```
test(X_test,y_test,theta)
```

Accuracy: 47.22222222222222

2 Addition of Non-linear features

In [21]:
```
# Adding non linear features
df['test1**2'] = df.apply (lambda row: row.test1 * row.test1, axis=1)
df['test2**2'] = df.apply (lambda row: row.test2 * row.test2, axis=1)
df.head()
```

Out[21]:

	test1	test2	result	test1**2	test2**2
14	0.54666	0.48757	1	0.298837	0.237725
72	0.82892	-0.52120	0	0.687108	0.271649
28	-0.13882	0.54605	1	0.019271	0.298171
104	-0.15035	-0.36769	0	0.022605	0.135196
74	0.59274	-0.74050	0	0.351341	0.548340

In [22]:
```
Y = df['result']
X = df.drop(['result'],axis=1)
```

In [23]:
```
print(X.shape)
print(Y.shape)
```

```
(118, 4)
(118,)
```

In [24]:
```
Y = (np.array(Y)).reshape(Y.shape[0],1)
print(Y.shape)
X = np.array(X)
X = np.c_[np.ones(X.shape[0]),np.array(X)]
print(X.shape)
X = normalise(X)
```

```
(118, 1)
(118, 5)
```

In [25]:
```
# Splitting data in train and test sets
X_train, X_test, y_train, y_test = train_test_split(X, Y, test_size=0.3)
print(X_train.shape, y_train.shape)
print(X_test.shape, y_test.shape)
```

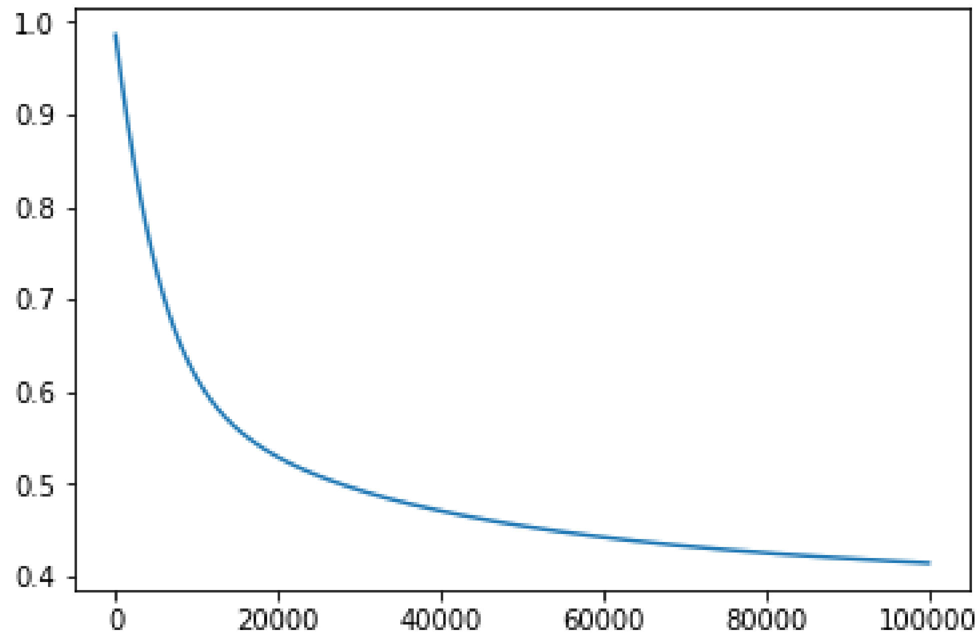
```
(82, 5) (82, 1)
(36, 5) (36, 1)
```

In [26]:
```
theta, costs = train(X_train, y_train, 0.05, _lambda=0.1)
print(theta)
```

```
[[-0.23683709]
 [ 0.54715789]
 [ 0.71398527]
 [-2.76901115]
 [-2.51671882]]
```

In [27]:
```
plt.plot(range(len(costs)),costs)
```

Out[27]:
```
[<matplotlib.lines.Line2D at 0x7f5fb80d7390>]
```




```
In [28]: test(X_test,y_test,theta)
```

```
Accuracy: 72.22222222222221
```