# Plot the learning curves

September 26, 2019

In [1]:
```
import matplotlib.pyplot as plt
import numpy as np
```

$i = 1, 2, \cdots, n$
$\hat{y}_i = \sigma(z_i)$
$z_i = w^T x_i + b$
$\sigma(z) = \frac{1}{1+\exp(-z)}$
$\mathcal{L} = \frac{1}{n} \sum_{i=1}^{n} f_i(w, b)$
$f_i(w, b) = -y_i \log \hat{y}_i - (1 - y_i) \log(1 - \hat{y}_i)$

1. Plot two clusters of points for training dateset

In [2]:
```
# u^prime = u - 10^(-5) * x
# v^prime = v - 10^(-5) * y
# b^prime = b - 10^(-5)

x_lim = 1000

X = np.empty(200, dtype=float)
Y = np.empty(200, dtype=float)
L = np.empty(200, dtype=float)

# Training Dataset

x_1 = np.random.randint(0, 450, 100)
y_1 = np.random.randint(1200, 1900, 100)

x_2 = np.random.randint(550, 1000, 100)
y_2 = np.random.randint(0, 700, 100)

for i in range(100):
    X[i] = x_1[i]
    X[100 + i] = x_2[i]
    Y[i] = y_1[i]
    Y[100 + i] = y_2[i]
```

```
        L[i] = 0
        L[100 + i] = 1

    plt.title('Training Dataset')
    for x in range(200):
        if x < 100:
            plt.scatter(X[x], Y[x], c='r', s=2)
        else:
            plt.scatter(X[x], Y[x], c='b', s=2)
```


2. Plot two clusters of points for testing dataset

```
In [3]: # Testing Dataset

    tX = np.empty(200, dtype=float)
    tY = np.empty(200, dtype=float)

    tx_1 = np.random.randint(0, 450, 100)
    ty_1 = np.random.randint(1200, 1900, 100)

    tx_2 = np.random.randint(550, 1000, 100)
    ty_2 = np.random.randint(0, 700, 100)
```

```
for i in range(100):
    tX[i] = tx_1[i]
    tX[100 + i] = tx_2[i]
    tY[i] = ty_1[i]
    tY[100 + i] = ty_2[i]

plt.title('Testing Dataset')
for x in range(200):
    if x < 100:
        plt.scatter(tX[x], tY[x], c='k', s=2)
    else:
        plt.scatter(tX[x], tY[x], c='y', s=2)
```


In [4]:
```
plt.title('Training and Testing Dataset')

for x in range(200):
    if x < 100:
        plt.scatter(X[x], Y[x], c='r', s=2)
    else:
        plt.scatter(X[x], Y[x], c='b', s=2)
for x in range(200):
    if x < 100:
        plt.scatter(tX[x], tY[x], c='k', s=2)
    else:
        plt.scatter(tX[x], tY[x], c='y', s=2)
```


Apply the gradient descent algorithm

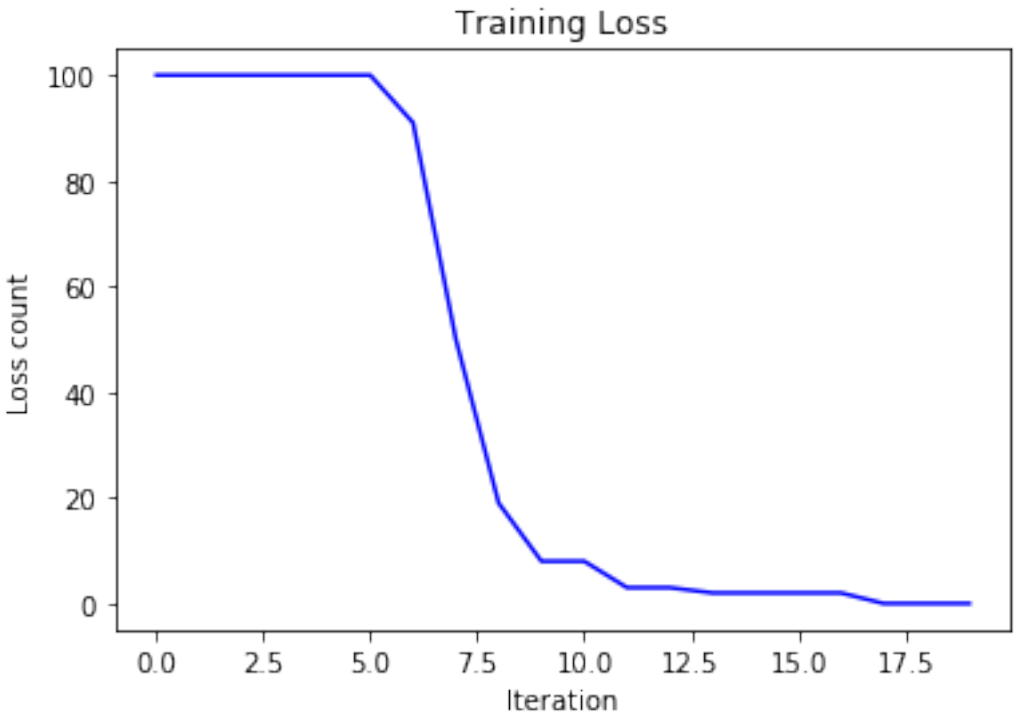
```
In [36]: dj = np.empty(200, dtype=float)
         loss_arr = np.zeros(200, dtype=float)
         t_loss_arr = np.zeros(200, dtype=float)

         # initialize
         u = 5
         v = 5
         b = 5

         runningRate = 10**(-5)

         def sigmoid(x):
             return 1/(1 + np.exp(x))

         iteration = 20

         for iter in range(iteration):
             for i in range(200):
                 dj[i] = sigmoid(u*X[i] + v*Y[i] + b) - L[i]

             u = u - runningRate*np.sum(dj[:]*X[:])*(-1)
             v = v - runningRate*np.sum(dj[:]*Y[:])*(-1)
             b = b - runningRate*np.sum(dj[:])*(-1)
```

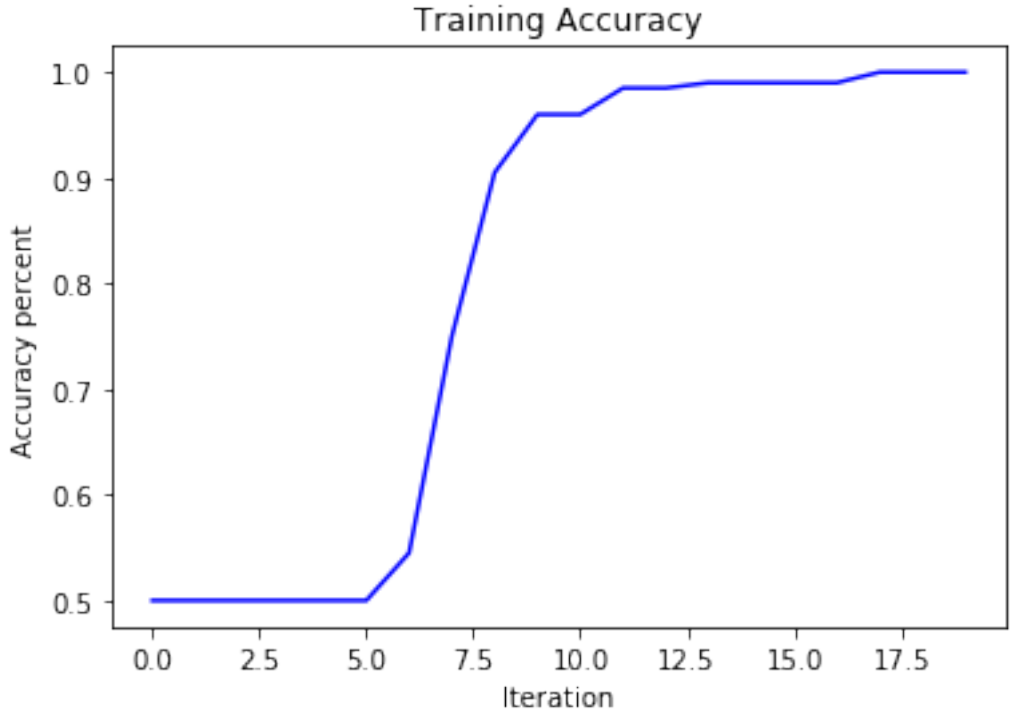
```
        training_loss = 0
        testing_loss = 0

        for i in range(200):
            if L[i] == 1:
                if sigmoid(u*X[i] + v*Y[i] + b) <= 0.5: # loss count
                    training_loss += 1

            else:
                if sigmoid(u*X[i] + v*Y[i] + b) > 0.5: # loss count
                    training_loss += 1

        for i in range(200):
            if L[i] == 1:
                if sigmoid(u*tX[i] + v*tY[i] + b) <= 0.5: # loss count
                    testing_loss += 1

            else:
                if sigmoid(u*tX[i] + v*tY[i] + b) > 0.5: # loss count
                    testing_loss += 1

        loss_arr[iter] = training_loss
        t_loss_arr[iter] = testing_loss
```

3.Plot the learning curves

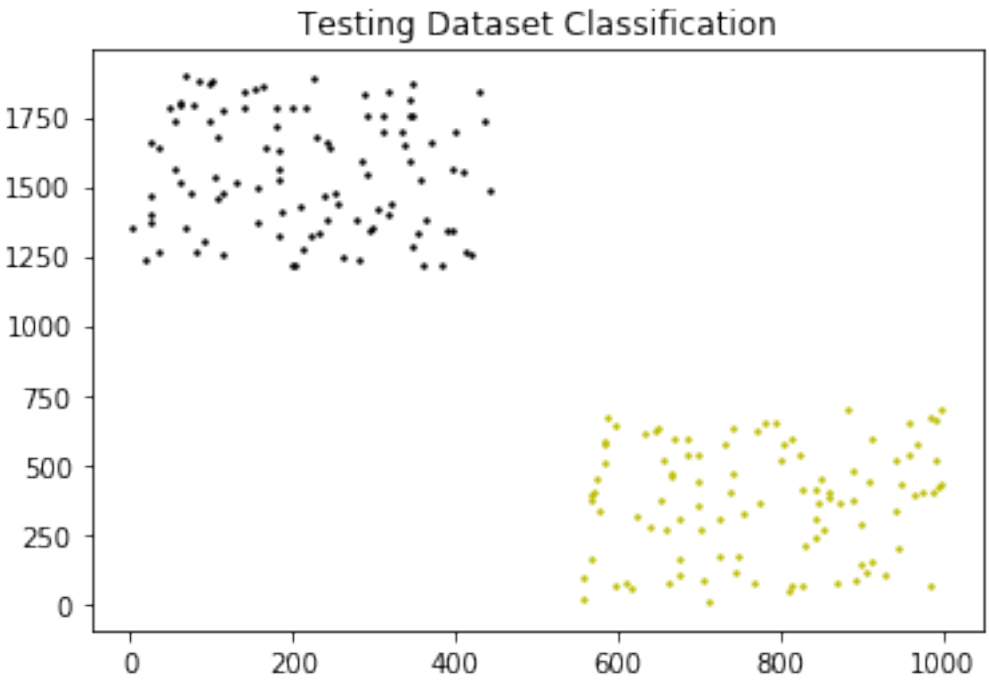
```
In [43]: plt.title('Training Dataset Classification')

        for i in range(200):
            res = sigmoid(u*X[i] + v*Y[i] + b)
            if res > 0.5:
                plt.scatter(X[i], Y[i], c='b', s=2)
            else:
                plt.scatter(X[i], Y[i], c='r', s=2)
```


In [39]:
```
x = range(iteration)
y = loss_arr[x]

plt.plot(x, y, "BLUE")
plt.title('Training Loss')
plt.xlabel('Iteration')
plt.ylabel('Loss count')
plt.show()

x = range(iteration)
y = (200 - loss_arr[x])/200

plt.plot(x, y, "BLUE")
plt.title('Training Accuracy')
plt.xlabel('Iteration')
plt.ylabel('Accuracy percent')
plt.show()
```


Training Loss
Loss count
100
80
60
40
20
0
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
Iteration

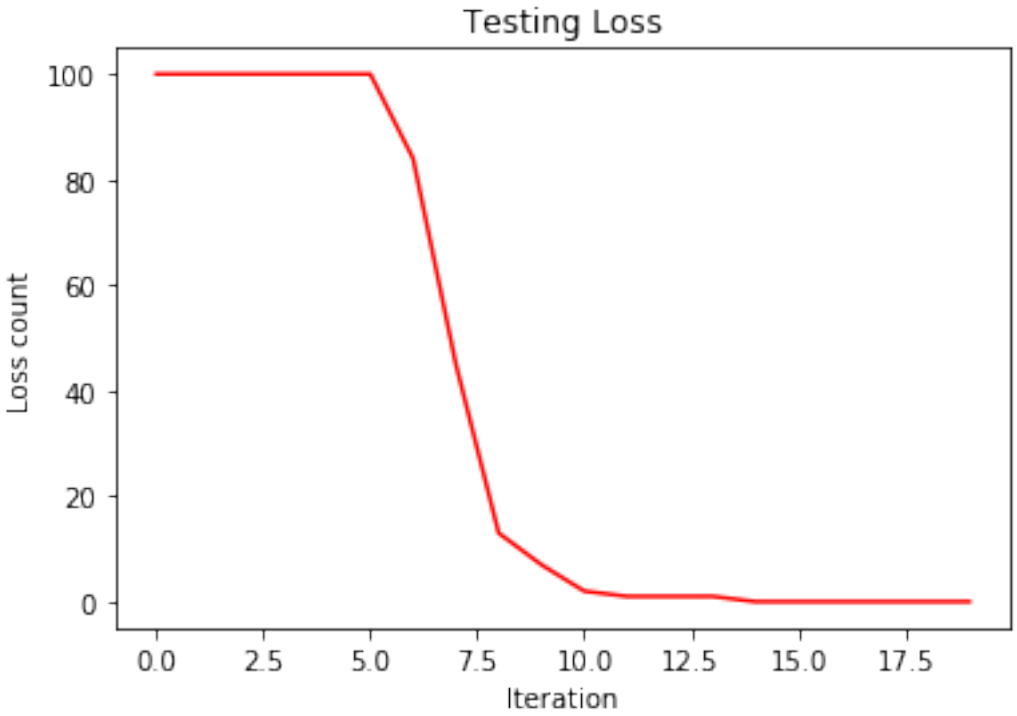

Training Accuracy
Accuracy percent
1.0
0.9
0.8
0.7
0.6
0.5
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
Iteration

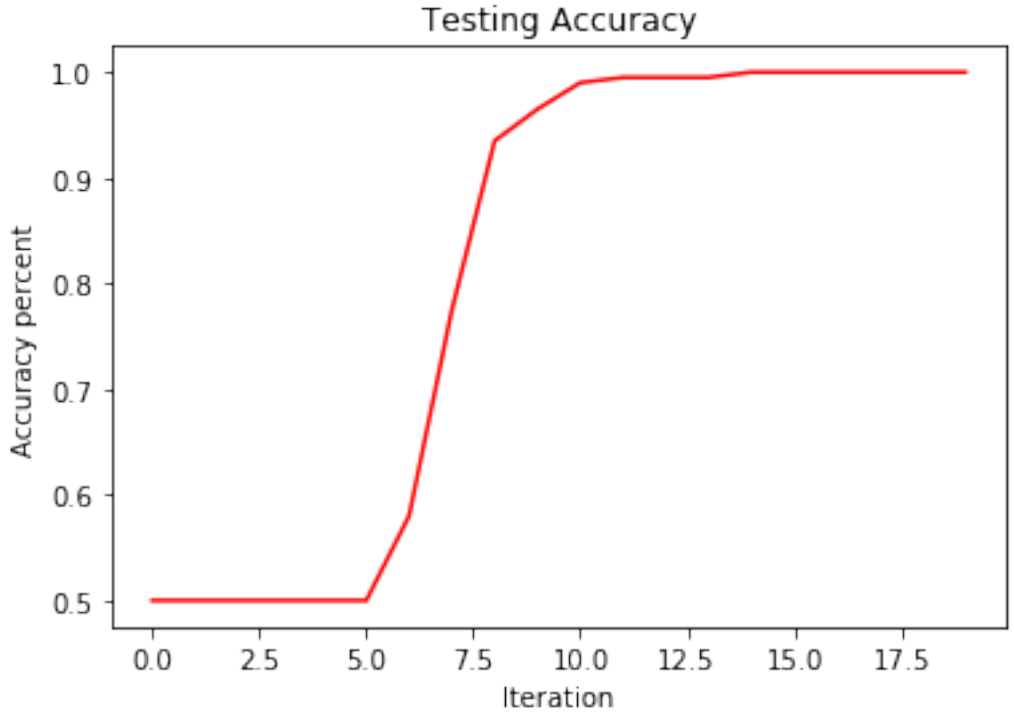
In [44]:
```
plt.title('Testing Dataset Classification')

for i in range(200):
    res = sigmoid(u*tX[i] + v*tY[i] + b)
    if res > 0.5:
        plt.scatter(tX[i], tY[i], c='y', s=2)
    else:
        plt.scatter(tX[i], tY[i], c='k', s=2)
```




In [40]:
```
x = range(iteration)
y = t_loss_arr[x]

plt.plot(x, y, "RED")
plt.title('Testing Loss')
plt.xlabel('Iteration')
plt.ylabel('Loss count')
plt.show()

x = range(iteration)
y = (200 - t_loss_arr[x])/200

plt.plot(x, y, "RED")
plt.title('Testing Accuracy')
plt.xlabel('Iteration')
```

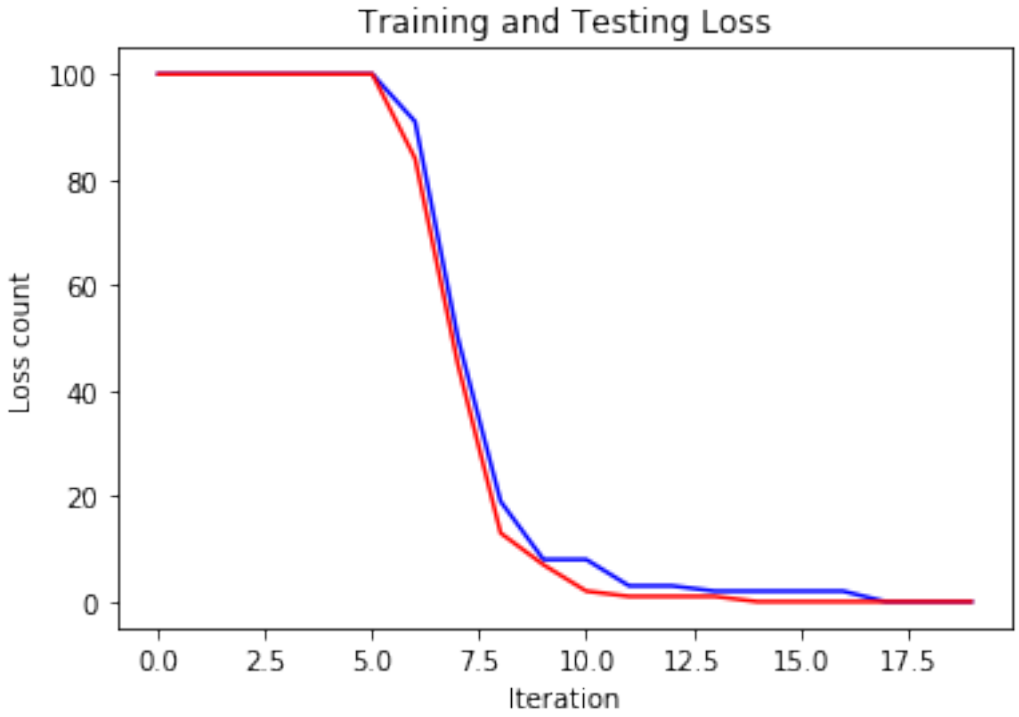
```
plt.ylabel('Accuracy percent')
plt.show()
```



Training loss and testing loss at every iteration

```
In [41]: x = range(iteration)
         y1 = loss_arr[x]
         y2 = t_loss_arr[x]

         plt.plot(x, y1, "BLUE")
         plt.plot(x, y2, "RED")
         plt.title('Training and Testing Loss')
         plt.xlabel('Iteration')
         plt.ylabel('Loss count')
         plt.show()
```




Training accuracy and testing accuracy at every iteration

```
In [42]: x = range(iteration)
         y1 = (200 - loss_arr[x])/200
         y2 = (200 - t_loss_arr[x])/200

         plt.plot(x, y1, "BLUE")
         plt.plot(x, y2, "RED")
```

```
plt.title('Training and Testing Loss')
plt.xlabel('Iteration')
plt.ylabel('Loss count')
plt.show()
```