ML Homework4

Due Date: 2020/05/04 (MON.) 23:55

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Description :

1. Logistic regression

- Input:
  1. N (number of data points)
  2. mx_1, vx_1, my_1, vy_1 mx_2, vx_2, my_2, vy_2 (m: mean, v: variance)
- Function:
  1. Generate n data point: $D1 = (x_1, y_1), (x_2, y_2), \ldots, (x_n, y_n)$, where x and y are independently sampled from $N(mx_1, vx_1)$ and $N(my_1, vy_1)$ respectively.
  2. Generate n data point: $D2 = (x_1, y_1), (x_2, y_2), \ldots, (x_n, y_n)$, where x and y are independently sampled from $N(mx_2, vx_2)$ and $N(my_2, vy_2)$ respectively.
  3. Use Logistic regression to separate $D1$ and $D2$. You should implement both Newton's and steepest gradient descent method during optimization.
     - In other words, when the Hessian is singular, use steepest descent for instead. You should come up with a reasonable rule to determine convergence.(a simple run out of the loop should be used as the ultimatum)
- Output:
  1. The confusion matrix and the **sensitivity** and **specificity** of the logistic regression applied to the training data D.
  2. Visualization
     - Plot the ground truth
     - Plot the predict result
       - Gradient descent
       - Newton's method

> **Use the Gaussian random number generator in homework 3.**

- Sample input & output (**for reference only**)
  - Case 1: $N = 50, mx_1 = my_1 = 1, mx_2 = my_2 = 10, vx_1 = vy_1 = vx_2 = vy_2 = 2$

```
Gradient descent:

w:
```

```
 -78.1766393662
    6.7233419236
   11.2430677919

Confusion Matrix:
                 Predict cluster 1 Predict cluster 2
Is cluster 1         50                0
Is cluster 2         0                 50

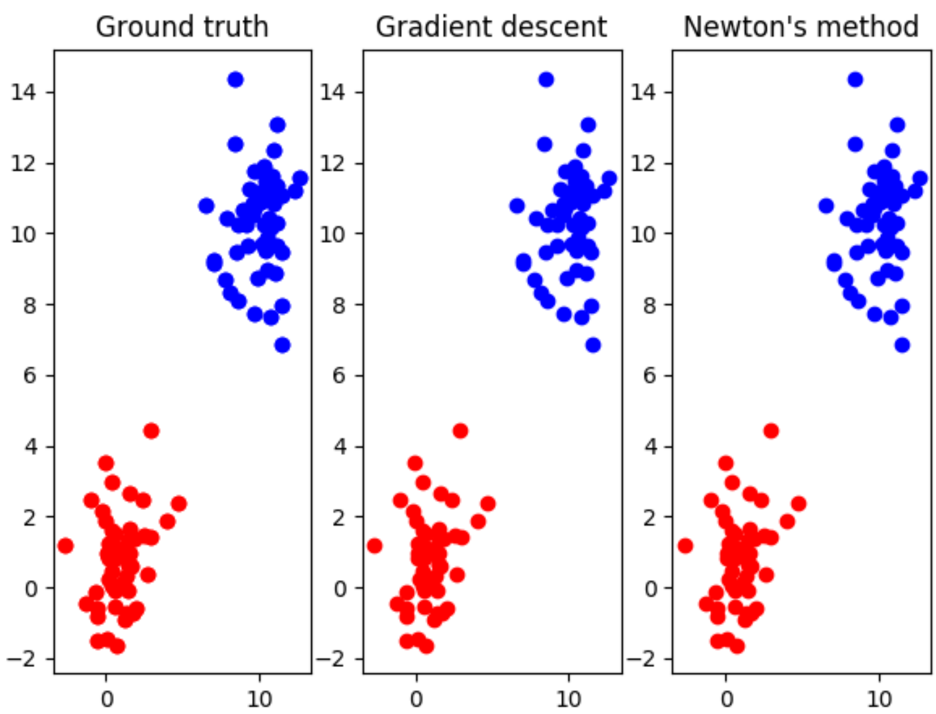
Sensitivity (Successfully predict cluster 1): 1.00000
Specificity (Successfully predict cluster 2): 1.00000

----------------------------------------
Newton's method:

w:
-118.3601516394
    8.7747332848
   10.1954120077

Confusion Matrix:
                 Predict cluster 1 Predict cluster 2
Is cluster 1         50                0
Is cluster 2         0                 50

Sensitivity (Successfully predict cluster 1): 1.00000
Specificity (Successfully predict cluster 2): 1.00000
```



- Case 2: $N = 50, mx_1 = my_1 = 1, mx_2 = my_2 = 3, vx_1 = vy_1 = 2, vx_2 = vy_2 = 4$

```
Gradient descent:

w:
 -71.1902536008
  46.0123814025
  54.6803199701

Confusion Matrix:
             Predict cluster 1 Predict cluster 2
Is cluster 1        16                34
Is cluster 2        3                 47

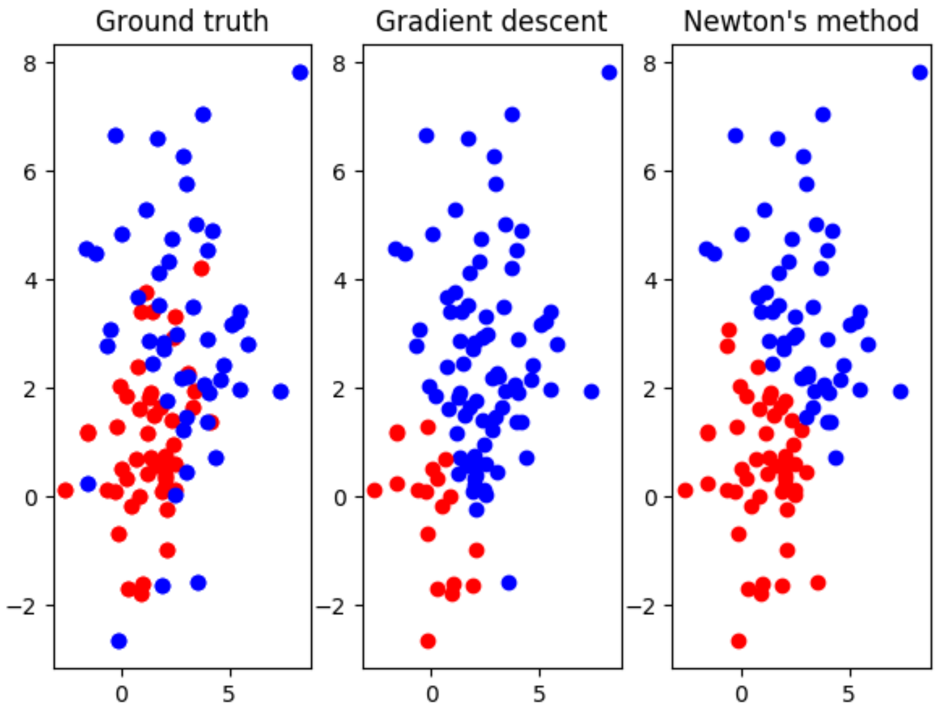
Sensitivity (Successfully predict cluster 1): 0.32000
Specificity (Successfully predict cluster 2): 0.94000

----------------------------------------
Newton's method:

w:
  -1.9045831451
   0.3940876974
   0.5695243849

Confusion Matrix:
             Predict cluster 1 Predict cluster 2
Is cluster 1        40                10
Is cluster 2        10                40

Sensitivity (Successfully predict cluster 1): 0.80000
Specificity (Successfully predict cluster 2): 0.80000
```



2. EM algorithm

- Input: MNIST **training** data and label sets. (Same as HW02)
- Function:
  1. Binning the gray level value into **two bins**. Treating all pixels as random variables following Bernoulli distributions. Note that each pixel follows a different Binomial distribution independent to others.
  2. Use EM algorithm to cluster each image into ten groups. You should come up with a reasonable rule to determine convergence. (a simple run out of the loop should be used as the ultimatum)
- Output:
  1. For each digit, output a confusion matrix and the **sensitivity** and **specificity** of the clustering applied to the training data.
  2. Print out the imagination of numbers in your classifier
     - Just like before, about the details please refer to HW02
- Hint: The algorithm is a kind of unsupervised learning, so the labels are not used during training. But you can use these labels to help you to figure out which class belongs to which number.

  In other words, you should find a way to assign label to each class which you classified **before you compute the confusion matrix**
- Sample input & output (**for reference only**)

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class 0:
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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class 1:
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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... all other unlabeled imagination of numbers goes here ...

class 9:
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No. of Iteration: 1, Difference: 3176.579389514846

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class 0:
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... all other iterations goes here ...

class 9:
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No. of Iteration: 10, Difference: 19.89546432548733

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labeled class 0:
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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labeled class 1:
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0
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... all other labeled imagination of numbers goes here ...

labeled class 9:
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

------------------------------------------------------------

Confusion Matrix 0:
                Predict number 0 Predict not number 0
Is number 0          3023              2900
Isn't number 0        113              53964

Sensitivity (Successfully predict number 0)    : 0.51038
Specificity (Successfully predict not number 0): 0.99791

------------------------------------------------------------

Confusion Matrix 1:
                Predict number 1 Predict not number 1
Is number 1          5986               756
Isn't number 1        800              52458

Sensitivity (Successfully predict number 1)    : 0.88787
Specificity (Successfully predict not number 1): 0.98498

------------------------------------------------------------

... all other confusion matrix goes here ...

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Confusion Matrix 9:
                Predict number 9 Predict not number 9
Is number 9          2718              3231
Isn't number 9       5147              48904

Sensitivity (Successfully predict number 9)    : 0.45688
Specificity (Successfully predict not number 9): 0.90478

Total iteration to converge: 10
Total error rate: 0.5081666666666667
```