Machine Learning Homework 4

development environment：

```
Linux version 4.15.0-36-generic (buildd@lgw01-amd64-031)
Description:          Ubuntu 18.04.1 LTS
Architecture:         x86_64
CPU op-mode(s):       32-bit, 64-bit
Byte Order:           Little Endian
CPU(s):               Intel(R) Core(TM) i7-8700 CPU @ 3.20GHz x 12
GPU :                 GeForce GTX 1080 Ti
memory:               32G
L1d cache:            32K
L1i cache:            32K
L2 cache:             256K
L3 cache:             12288K
Python version:       Python 3.6.5
```

1.

(a) wide hidden layer

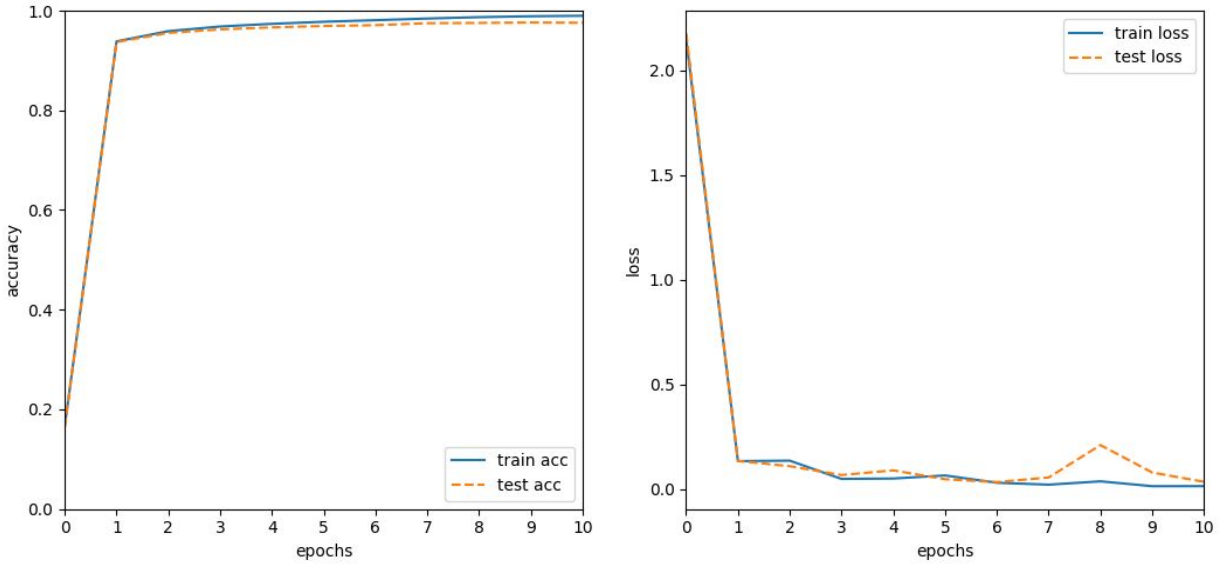
- Hyperparameters

```
input layer  neurons: 784
hidden layer neurons: 256
output layer neurons: 10
learning rate: 0.1
batch size : 64
```

- training, testing accuracy result (10 epochs, 1000 iterations per epoch)

```
Epoch[0/10]  train acc ,test acc | 0.1541 ,0.1505
Epoch[1/10]  train acc ,test acc | 0.9403 ,0.9388
Epoch[2/10]  train acc ,test acc | 0.9588 ,0.9533
Epoch[3/10]  train acc ,test acc | 0.9669 ,0.9612
Epoch[4/10]  train acc ,test acc | 0.9731 ,0.9667
Epoch[5/10]  train acc ,test acc | 0.9782 ,0.9697
Epoch[6/10]  train acc ,test acc | 0.9816 ,0.9712
Epoch[7/10]  train acc ,test acc | 0.9842 ,0.9731
Epoch[8/10]  train acc ,test acc | 0.9861 ,0.9739
Epoch[9/10]  train acc ,test acc | 0.9872 ,0.9742
Epoch[10/10] train acc ,test acc | 0.9898 ,0.9748
```

- accuracy and loss curve



(b) deep hidden layer

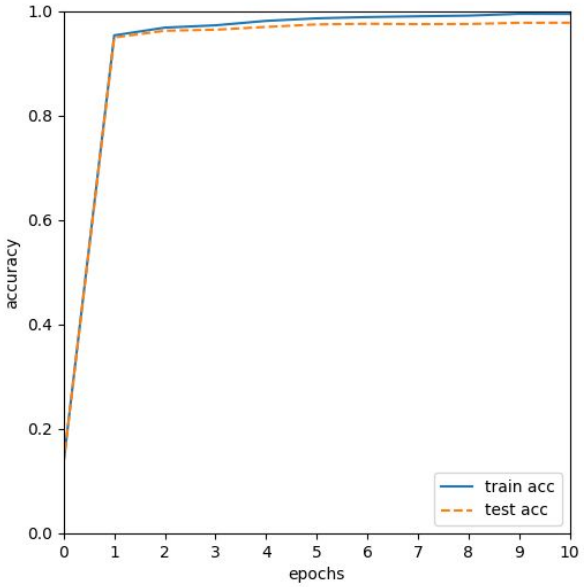
- Hyperparameters

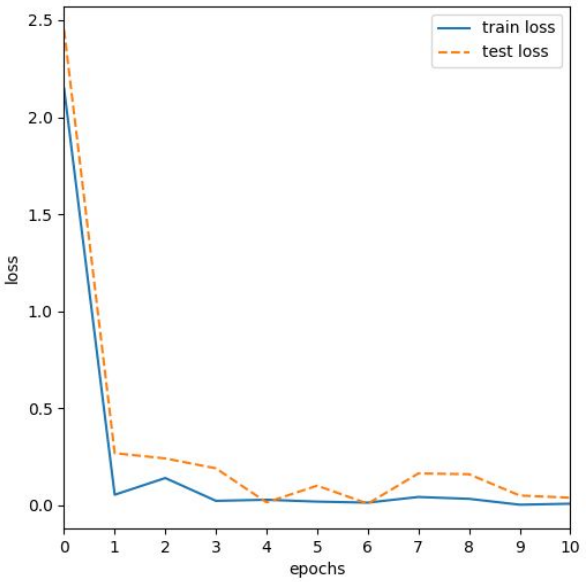
```
input layer  neurons: 784
hidden layer1 neurons: 204
hidden layer2 neurons: 202
output layer neurons: 10
learning rate: 0.1
batch size : 64
```

- training, testing accuracy (10 epochs, 1000 iterations per epoch)

```
Epoch[0/10]  train acc ,test acc | 0.1363 ,0.1348
Epoch[1/10]  train acc ,test acc | 0.9540 ,0.9499
Epoch[2/10]  train acc ,test acc | 0.9688 ,0.9629
Epoch[3/10]  train acc ,test acc | 0.9733 ,0.9648
Epoch[4/10]  train acc ,test acc | 0.9818 ,0.9702
Epoch[5/10]  train acc ,test acc | 0.9867 ,0.9750
Epoch[6/10]  train acc ,test acc | 0.9891 ,0.9762
Epoch[7/10]  train acc ,test acc | 0.9906 ,0.9755
Epoch[8/10]  train acc ,test acc | 0.9919 ,0.9758
Epoch[9/10]  train acc ,test acc | 0.9953 ,0.9781
Epoch[10/10] train acc ,test acc | 0.9951 ,0.9782
```

- accuracy and loss curve



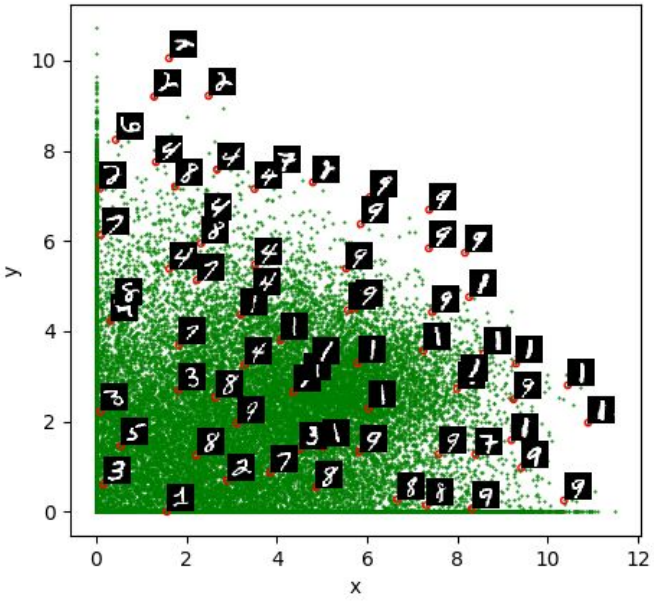


2. Implement an autoencoder (AE) to learn the representation of the MNIST datasets.

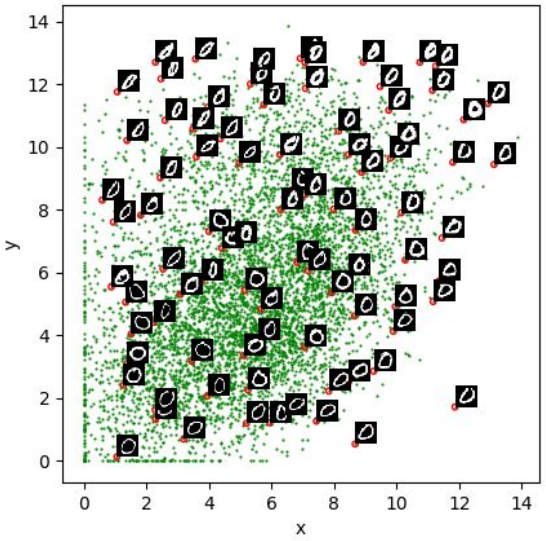
(a) Show the results of the AE-based dimension reduction such as HW3-A.

training set

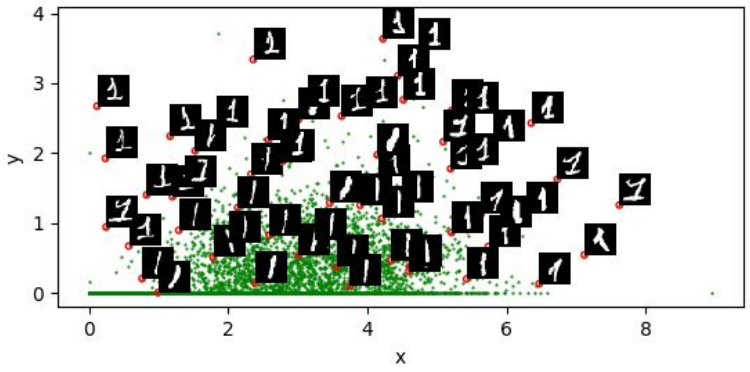
- all digit of top 10000 in training set



- digit 0

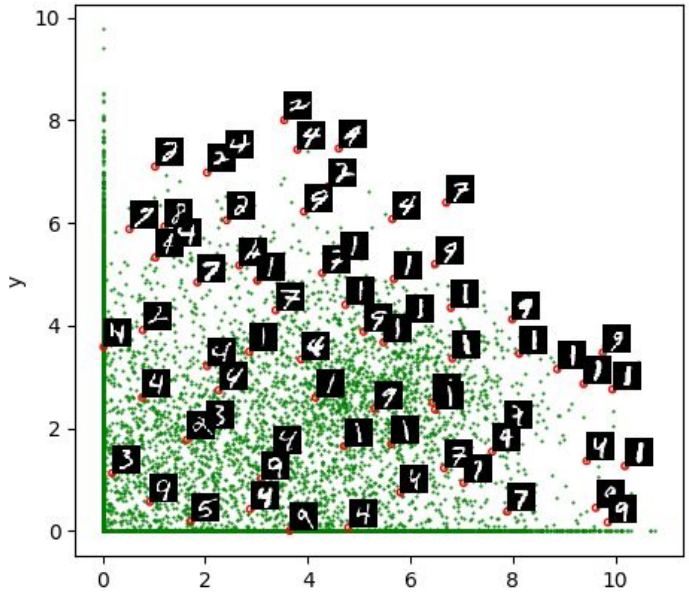


- digit 1

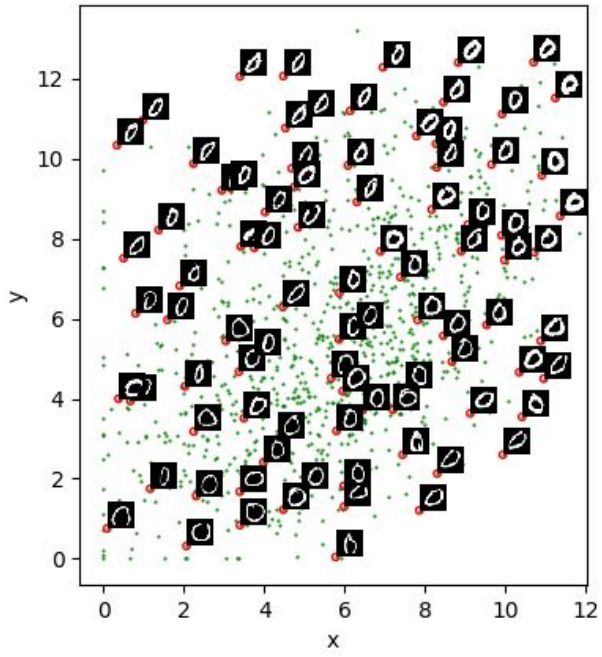


testing set

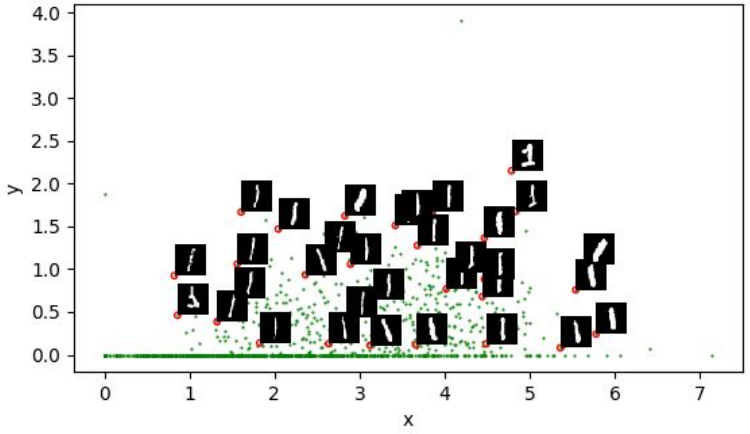
- all



- digit 0



- digit 1



(b) Visualize the reconstruction results and the filters.

- Hyperparameters

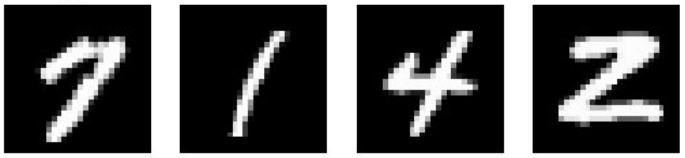
```
input layer  neurons: 784
hidden layer neurons: 128
output layer neurons: 784
learning rate: 0.01
batch size : 64
```

- Result (5 epochs, 500 iterations per epoch)

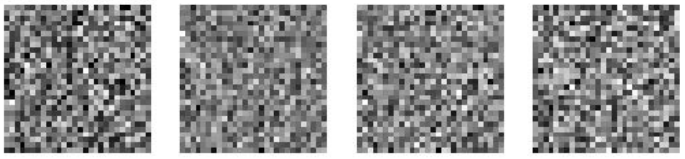
```
Epoch[0/5]  |  label=[7 1 4 2]
train loss, test loss  |  266.5626, 267.8676
Epoch[1/5]  |  label=[7 3 2 9]
train loss, test loss  |  48.1467, 49.5476
Epoch[2/5]  |  label=[5 8 8 1]
train loss, test loss  |  40.5914, 41.3452
Epoch[3/5]  |  label=[0 6 0 4]
train loss, test loss  |  36.6603, 37.0315
Epoch[4/5]  |  label=[3 9 1 9]
train loss, test loss  |  34.2981, 34.9079
Epoch[5/5]  |  label=[2 2 5 9]
train loss, test loss  |  33.2759, 33.7161
```

- Epoch[0/5]

original



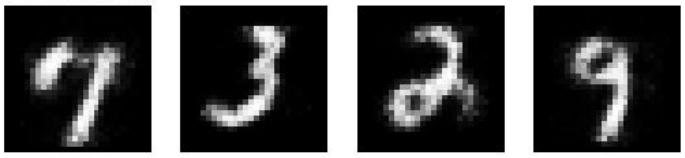
reconstructed



- Epoch[1/5]

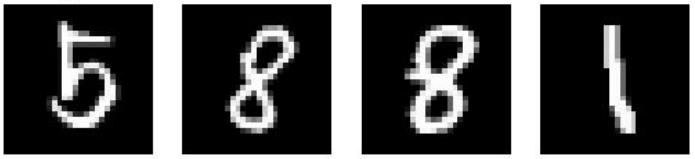
original

reconstructed

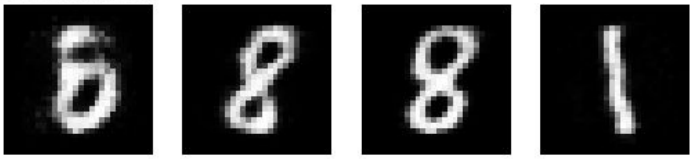


- Epoch[2/5]

original



reconstructed



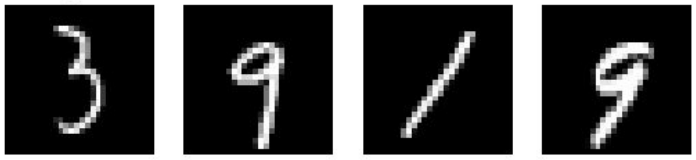
- Epoch[3/5]

original

reconstructed

- Epoch[4/5]

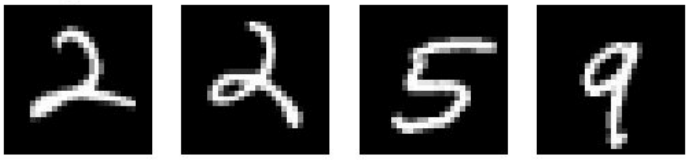
original



reconstructed

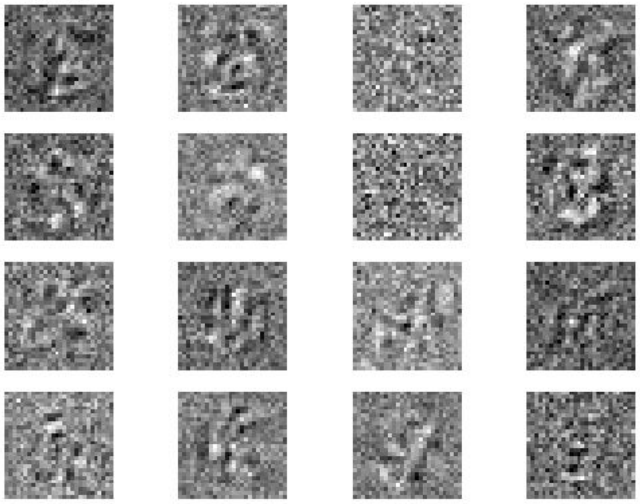
- Epoch[5/5]

original



reconstructed

- Filters

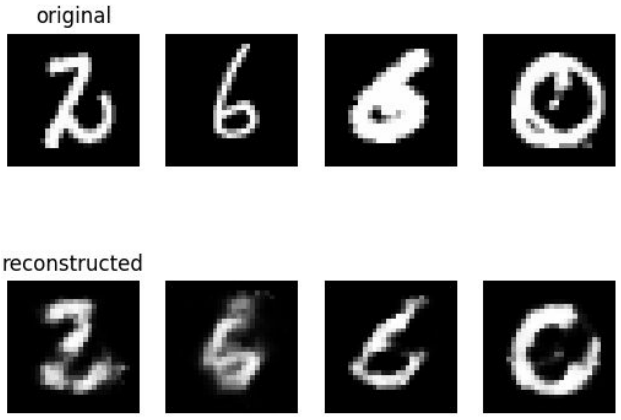


（c）Apply denoise and dropout mechanism, and visualize the reconstruction results and the filters. (10%, Bonus)

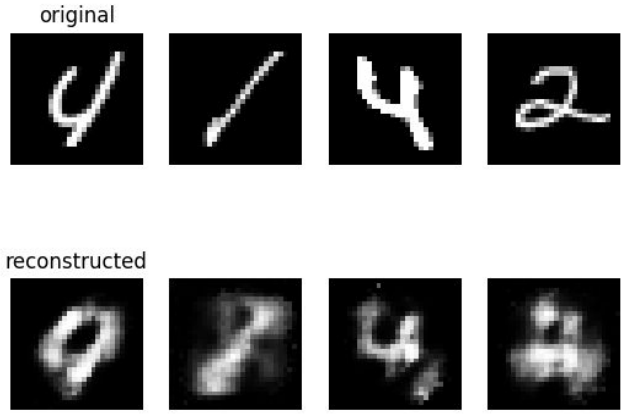
- Result (5 epochs, 500 iterations per epoch)

```
(env) forest@server:~/env/mlhw4$ py autoencoder.py
Apply denoise and dropout?
Input 1 for True, 2 for False : 1
Epoch[0/5]  |  label=[9 6 9 1]
train loss, test loss  |  274.4898, 275.0325
Epoch[1/5]  |  label=[2 8 1 5]
train loss, test loss  |  58.2506, 66.8891
Epoch[2/5]  |  label=[8 5 4 3]
train loss, test loss  |  60.0102, 64.2880
Epoch[3/5]  |  label=[2 0 3 6]
train loss, test loss  |  64.3706, 68.0223
Epoch[4/5]  |  label=[2 6 6 0]
train loss, test loss  |  66.2162, 69.2971
Epoch[5/5]  |  label=[4 1 4 2]
train loss, test loss  |  54.8299, 60.2125
```

- Epoch[4/5]



- Epoch[5/5]



- Filters