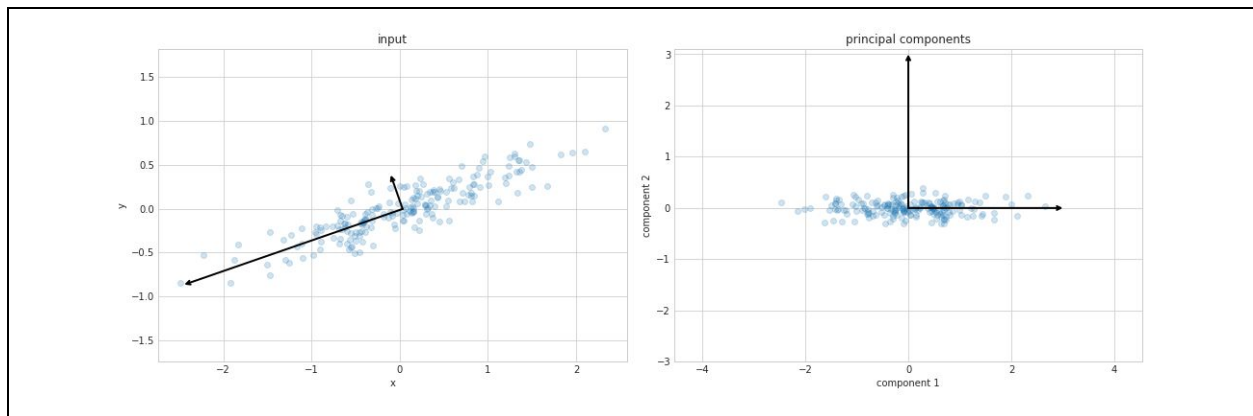
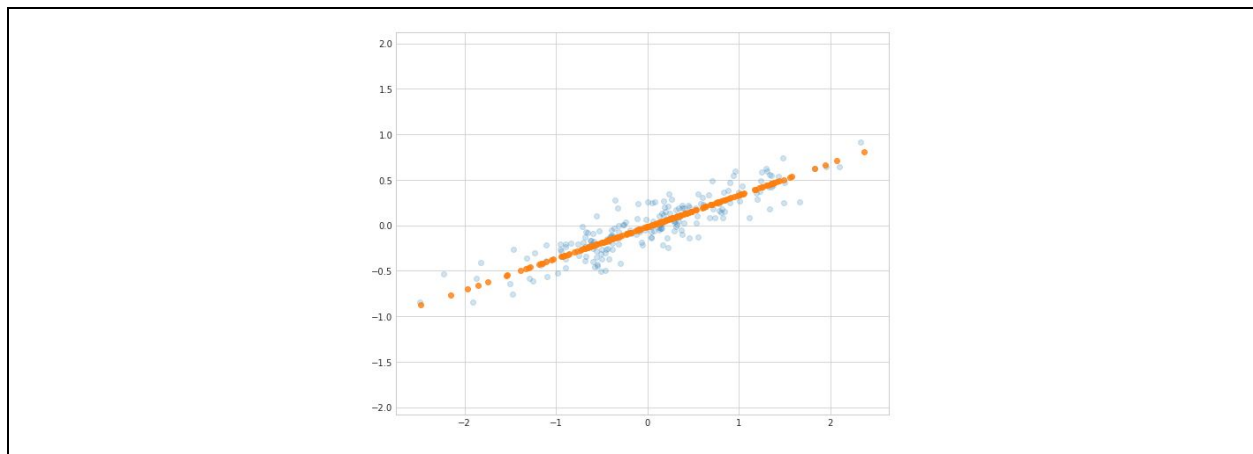


## 1) Principal Component Analysis

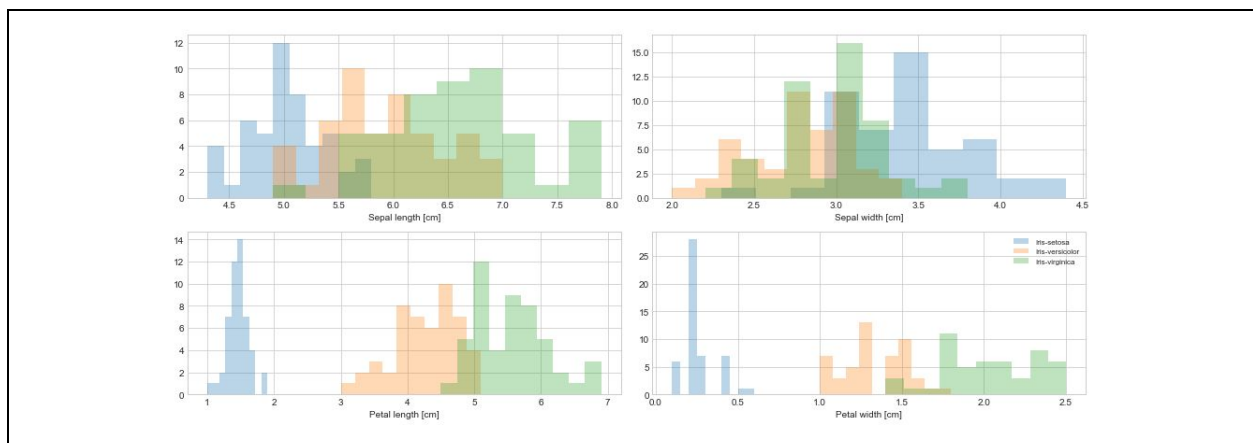
-Please see the notebook at the end of this document.

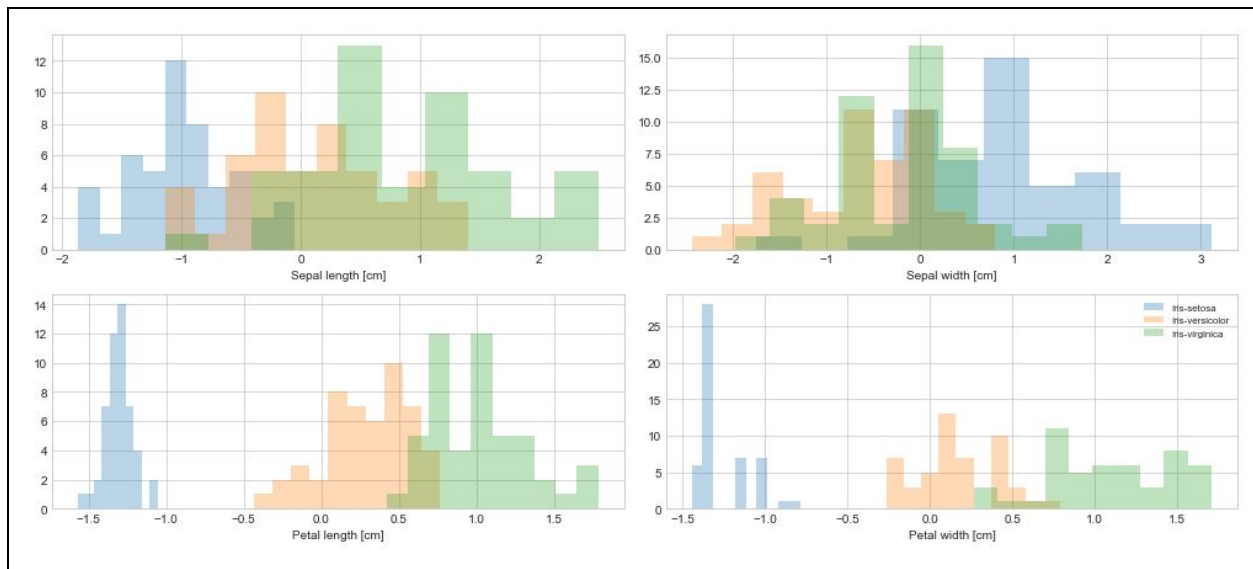


They are vectors with respect to datapoints.



They are in the same direction as the main data points. It seems that the variance of the point in regard to the principal components is preserved, but in regard to the other one, the variance of points is not preserved.





The shape of histograms remains the same; however, the intervals in the horizontal axis are different.

Covariance matrix:

```
[[ 1.      -0.10936925  0.87175416  0.81795363]
 [-0.10936925  1.      -0.4205161  -0.35654409]
 [ 0.87175416 -0.4205161  1.      0.9627571 ]
 [ 0.81795363 -0.35654409 0.9627571  1.      ]]
```

Eigenvectors

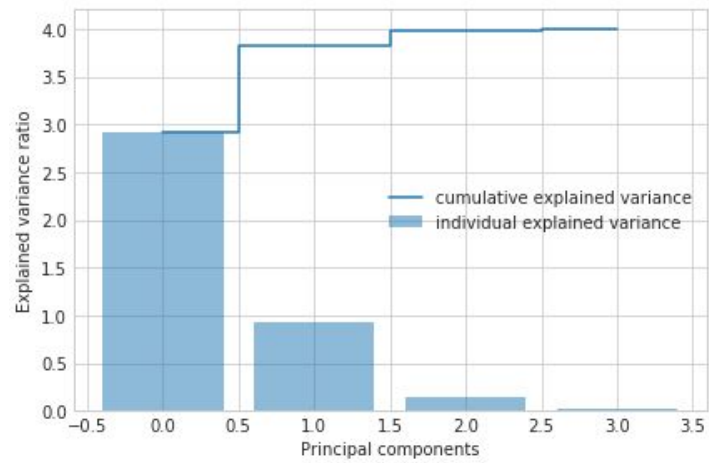
```
[[ 0.52237162 -0.37231836 -0.72101681  0.26199559]
 [-0.26335492 -0.92555649  0.24203288 -0.12413481]
 [ 0.58125401 -0.02109478  0.14089226 -0.80115427]
 [ 0.56561105 -0.06541577  0.6338014  0.52354627]]
```

Eigenvalues

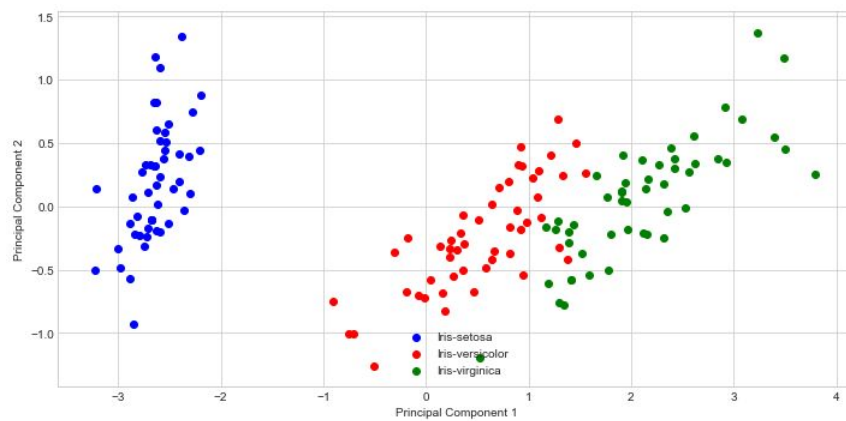
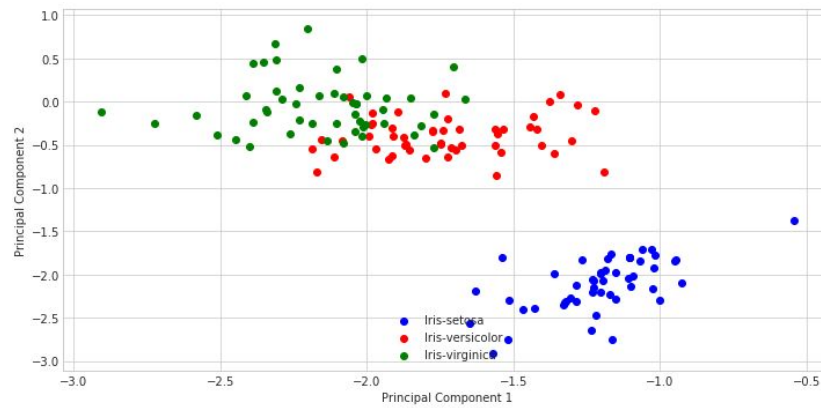
```
[2.91081808 0.92122093 0.14735328 0.02060771]
```

Eigenvalues in descending order:

```
2.9108180837520528
0.9212209307072242
0.14735327830509573
0.020607707235625487
```



The variance for the two first principal components are large; the other two are not considerable.

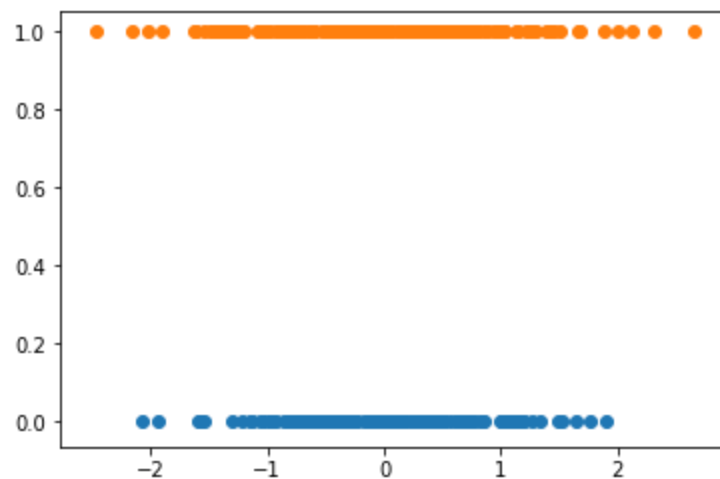


Eigenvectors

$\begin{bmatrix} 0.94446029 & -0.32862557 \end{bmatrix}$

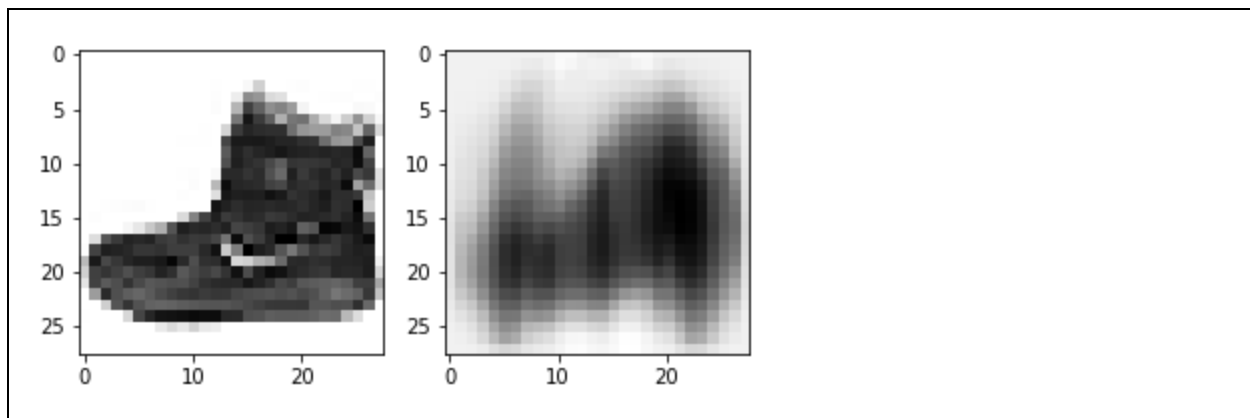
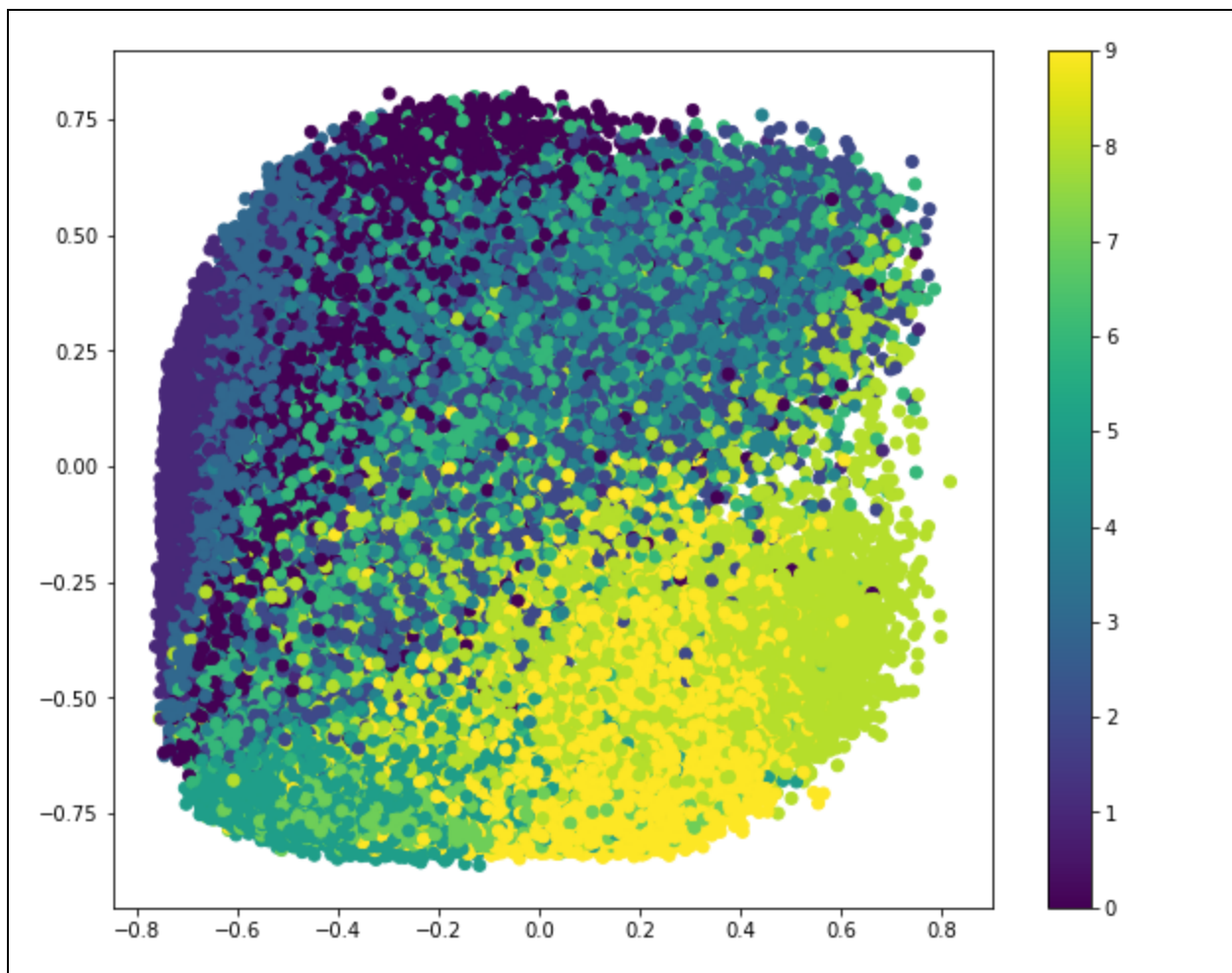
$\begin{bmatrix} 0.32862557 & 0.94446029 \end{bmatrix}$

Eigenvalues  
[0.75871884 0.01838551]  
Matrix W:  
[[ 0.94446029  
[-0.32862557]]  
X\_pca and Z\_My\_PCA are equal!



## 2) Autoencoders for Dimensionality Reduction

Epoch 1/5  
60000/60000 [=====] - 2s 37us/step - loss: 0.0626  
Epoch 2/5  
60000/60000 [=====] - 2s 37us/step - loss: 0.0473: 0s - loss:  
0.04  
Epoch 3/5  
60000/60000 [=====] - ETA: 0s - loss: 0.046 - 2s 34us/step -  
loss: 0.0466  
Epoch 4/5  
60000/60000 [=====] - 3s 42us/step - loss: 0.0464  
Epoch 5/5  
60000/60000 [=====] - 2s 39us/step - loss: 0.0463



Epoch 1/5  
60000/60000 [=====] - 8s 138us/step - loss: 0.0186  
Epoch 2/5

```

60000/60000 [=====] - 8s 126us/step - loss: 0.0111
Epoch 3/5
60000/60000 [=====] - 5s 77us/step - loss: 0.0104
Epoch 4/5
60000/60000 [=====] - 6s 94us/step - loss: 0.0101
Epoch 5/5
60000/60000 [=====] - 6s 107us/step - loss: 0.0099

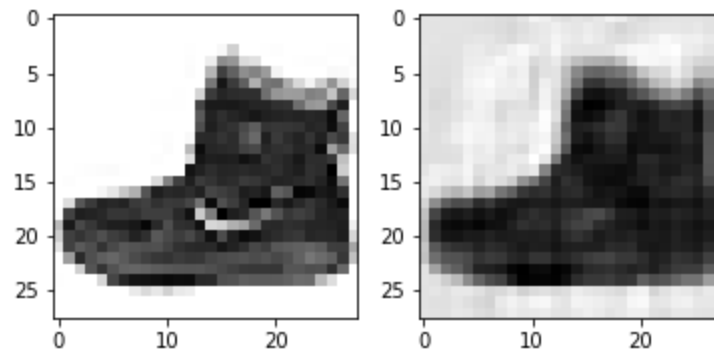
```

Out[28]:

```

<matplotlib.image.AxesImage at 0x1db41e04160>
<Figure size 720x720 with 0 Axes>

```



It is much better.

- KNN on raw data:

```

Time Elapsed for Learning: 0.5202689170837402
Time Elapsed for Prediction: 23.02728009223938
Accuracy: 0.8264

```

training for 2 dimensions

```

Epoch 1/5
7500/7500 [=====] - 0s 46us/step - loss: 0.1195
Epoch 2/5
7500/7500 [=====] - 0s 38us/step - loss: 0.0727
Epoch 3/5
7500/7500 [=====] - 0s 43us/step - loss: 0.0596
Epoch 4/5
7500/7500 [=====] - 0s 40us/step - loss: 0.0535
Epoch 5/5
7500/7500 [=====] - 0s 39us/step - loss: 0.0508
for 2 dims scores are : [0.48369927 0.46333333 0.50500334 0.48098732 0.47765177]
=====

```

training for 5 dimensions

```

Epoch 1/5
7500/7500 [=====] - 0s 44us/step - loss: 0.0966
Epoch 2/5

```

```
7500/7500 [=====] - 0s 44us/step - loss: 0.0550
Epoch 3/5
7500/7500 [=====] - 0s 36us/step - loss: 0.0449
Epoch 4/5
7500/7500 [=====] - 0s 42us/step - loss: 0.0412
Epoch 5/5
7500/7500 [=====] - 0s 47us/step - loss: 0.0390
for 5 dims scores are : [0.66666667 0.66666667 0.69513009 0.68112075 0.67311541]
```

=====

training for 7 dimensions

```
Epoch 1/5
7500/7500 [=====] - 0s 55us/step - loss: 0.0865
Epoch 2/5
7500/7500 [=====] - 0s 41us/step - loss: 0.0481
Epoch 3/5
7500/7500 [=====] - 0s 47us/step - loss: 0.0408
Epoch 4/5
7500/7500 [=====] - 1s 75us/step - loss: 0.0370
Epoch 5/5
7500/7500 [=====] - 1s 82us/step - loss: 0.0346
for 7 dims scores are : [0.71457086 0.73      0.71847899 0.74382922 0.73048699]
```

=====

training for 10 dimensions

```
Epoch 1/5
7500/7500 [=====] - 0s 59us/step - loss: 0.0795
Epoch 2/5
7500/7500 [=====] - 0s 50us/step - loss: 0.0432
Epoch 3/5
7500/7500 [=====] - 0s 50us/step - loss: 0.0357
Epoch 4/5
7500/7500 [=====] - 0s 48us/step - loss: 0.0320
Epoch 5/5
7500/7500 [=====] - 0s 53us/step - loss: 0.0301
for 10 dims scores are : [0.75582169 0.71866667 0.74583055 0.77051368 0.74916611]
```

=====

training for 15 dimensions

```
Epoch 1/5
7500/7500 [=====] - 0s 62us/step - loss: 0.0710
Epoch 2/5
7500/7500 [=====] - 0s 60us/step - loss: 0.0383
Epoch 3/5
7500/7500 [=====] - 0s 57us/step - loss: 0.0313
Epoch 4/5
7500/7500 [=====] - 0s 58us/step - loss: 0.0284
Epoch 5/5
7500/7500 [=====] - 0s 54us/step - loss: 0.0264
for 15 dims scores are : [0.77844311 0.774      0.77451634 0.79719813 0.78585724]
```

=====

training for 20 dimensions

```
Epoch 1/5
7500/7500 [=====] - 0s 52us/step - loss: 0.0659
Epoch 2/5
7500/7500 [=====] - 0s 47us/step - loss: 0.0348
Epoch 3/5
7500/7500 [=====] - 0s 49us/step - loss: 0.0290
Epoch 4/5
7500/7500 [=====] - 1s 85us/step - loss: 0.0263
Epoch 5/5
7500/7500 [=====] - 0s 59us/step - loss: 0.0247
for 20 dims scores are : [0.79041916 0.78533333 0.78519013 0.79052702 0.79853235]
=====
best_dim: 20
```

```
Epoch 1/5
7500/7500 [=====] - 0s 50us/step - loss: 0.0653
Epoch 2/5
7500/7500 [=====] - 0s 45us/step - loss: 0.0347
Epoch 3/5
7500/7500 [=====] - 0s 53us/step - loss: 0.0289
Epoch 4/5
7500/7500 [=====] - 0s 66us/step - loss: 0.0261
Epoch 5/5
7500/7500 [=====] - 0s 58us/step - loss: 0.0245
Time Elapsed for Learning: 0.3628087043762207
Time Elapsed for Prediction: 24.658313274383545
Accuracy: 0.8264
```