PCA Assignment

May 2, 2021

0.1 PCA Assignment: Performing PCA on 42k Dataset

0.1.1 PCA without Sckiti-Learn

[1]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
%matplotlib inline
```

[2]:
```
data = pd.read_csv('train.csv')
data.head()
```

[2]:

	label	1x1	1x2	1x3	1x4	1x5	1x6	1x7	1x8	1x9	…	28x19	28x20	\
0	5	0	0	0	0	0	0	0	0	0	…	0	0	
1	0	0	0	0	0	0	0	0	0	0	…	0	0	
2	4	0	0	0	0	0	0	0	0	0	…	0	0	
3	1	0	0	0	0	0	0	0	0	0	…	0	0	
4	9	0	0	0	0	0	0	0	0	0	…	0	0	

	28x21	28x22	28x23	28x24	28x25	28x26	28x27	28x28
0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0

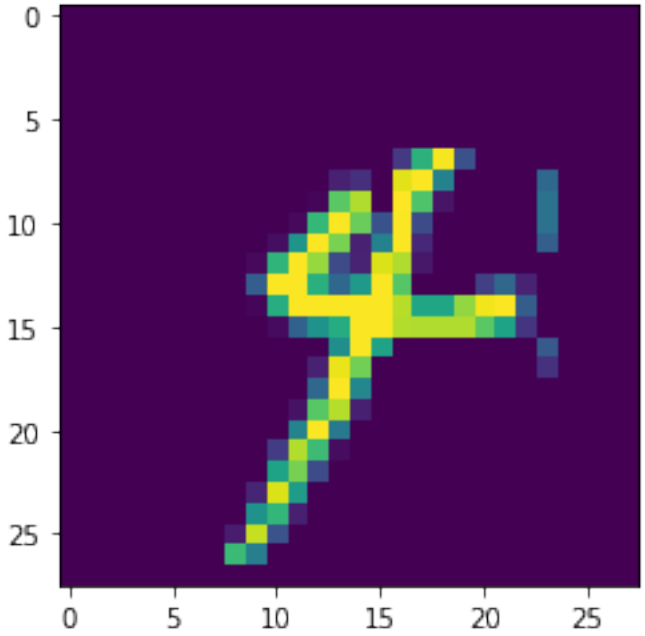
[5 rows x 785 columns]

[3]:
```
l = data['label']
f = data.drop('label', axis=1)
print(l.shape)
print(f.shape)
```

```
(60000,)
(60000, 784)
```

[4]:
```
id = 53
# id is index
# Since in one row there are 783 elemnts which is in 1-D
```

```
#to first we converting that into numpy array so that we can use reshape␣
 ↪function
# reshaping it into rows x columns i.e. 2-D.
# 28, 28 because 28*28 = 784 which is the total elements in a single row
plot_data = f.iloc[id].to_numpy().reshape(28,28)
plt.imshow(plot_data)
plt.show()
#Checking the value in the image and in our label matches or not.
print('The number in the above image is: ', l.iloc[id])
```




```
The number in the above image is:  4
```

0.1.2 2-D PCA

0.1.3 Task 1: Standardize your data

[5]:
```
from sklearn.preprocessing import StandardScaler
standardized_data = StandardScaler().fit_transform(f)
print(standardized_data.shape)
```

```
(60000, 784)
```

0.1.4 Task 2: Create Co-Variance Matrix of your Standardized data

Co Variance Matrix = A^T * A

[6]:
```
covar = np.dot(standardized_data.T, standardized_data)
#size of standardized data is (42k, 784)
#So (42k, 784) * (42k, 784) will return matrix of (784, 784)
print ( "The shape of variance matrix = ", covar.shape)
```

```
The shape of variance matrix =  (784, 784)
```

0.1.5 Task 3: Finding the top two eigen values and vectors

Since we are converting our 784 by 784 array into 2-D

[7]:
```
from scipy.linalg import eigh
# the parameter 'eigvals' is defined (low value to heigh value)
# eigh function will return the eigen values in asending order
# this code generates only the top 2 (782 and 783) eigenvalues.
#subset_by_index will take start to end value.
values, vectors = eigh(covar, subset_by_index=(782, 783))

print("Shape of eigen vectors = ",vectors.shape)
```

```
Shape of eigen vectors =  (784, 2)
```

[8]:
```
print(values)
print(vectors)
```

```
[1754472.60943943 2429217.61887289]
[[0. 0.]
 [0. 0.]
 [0. 0.]
 …
 [0. 0.]
 [0. 0.]
 [0. 0.]]
```

0.1.6 Task 4: Multiplying EV to Dataset to convert to 2-D

As we know to get maximum variance in a PCA, we need to multiply our top eigen vectos with the dataset. Now our dataset is 784 by 784. If we mutiply X to get X' (xi * EV1, xi * EV2) we get matric of (2, 42k). Thus we can transform our (784 by 784) matrix to 2-D

If you recall, after we find the eigen vectors, we need to create X' (a 2-D matrix) which we get by dot product of X * EV. Remember, our dataset is (42k, 784) and EV is (784, 2) so after X.EV we get X' of (42k, 2)

[9]:
```
new_cordinates = np.dot(standardized_data, vectors)
print (" resultanat new data points' shape ", standardized_data.shape, "X",␣
 ↪vectors.shape," = ", new_cordinates.shape)
```

```
 resultanat new data points' shape  (60000, 784) X (784, 2)  =  (60000, 2)
```

[10]:
```
print(new_cordinates)
print(new_cordinates.shape)
```

```
[[-4.81479035 -0.92215881]
 [-7.75440302  8.70897698]
 [ 9.43133817  2.32838932]
 …
 [-3.23056436 -3.77721201]
 [-4.94812525  1.72236917]
 [-6.17538558 -1.42725062]]
(60000, 2)
```

Adding label column so that we can visualize the our number labels. Since new_cordinate size is (42k, 2) and label has (42k,) so if we do new_cordinate.T dot product label i.e (2, 42k) * (42k,) we get (3, 42k)

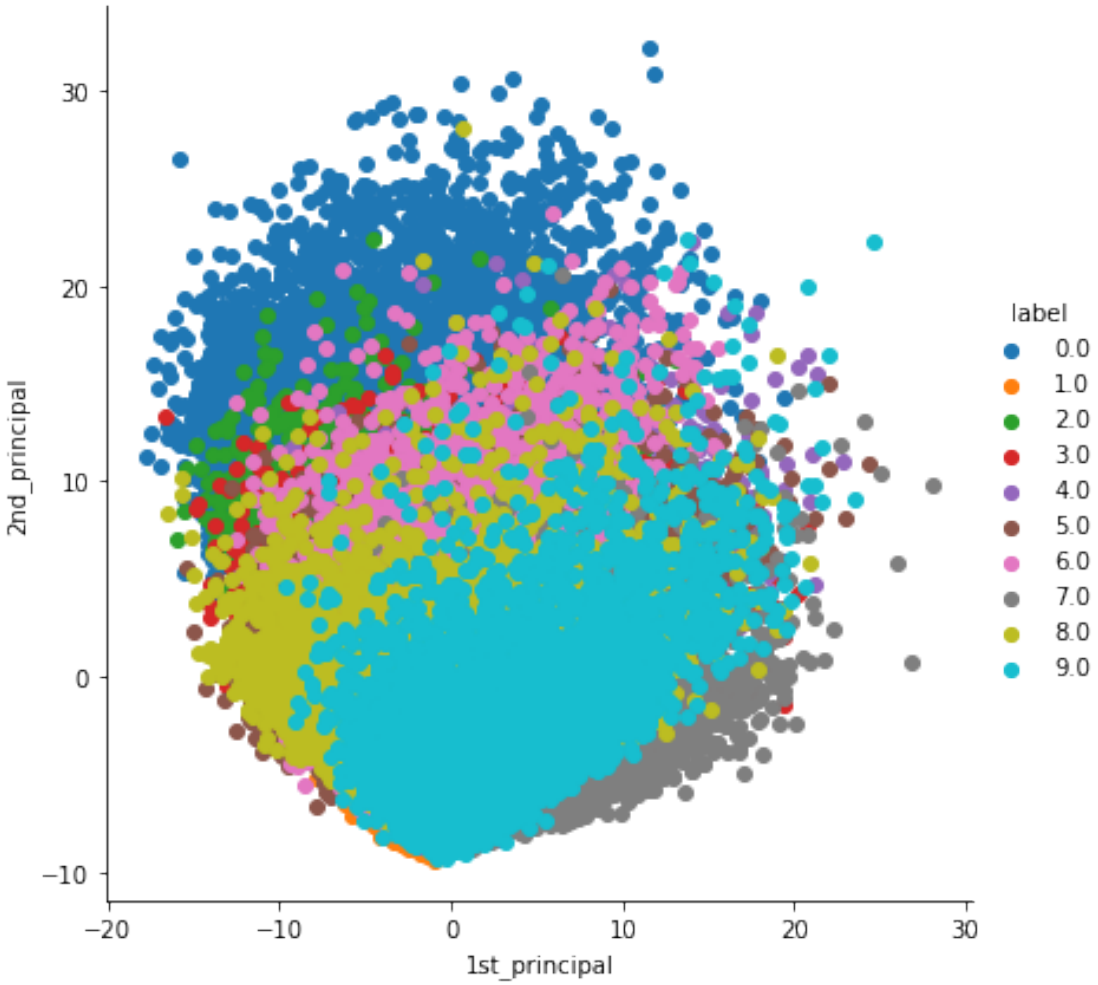
[11]:
```
new_cordinates = np.vstack((new_cordinates.T, l))
new_cordinates.shape
#transpose because we want 42k rows and 3 columns and not 3 rows and 42k columns
new_cordinates = new_cordinates.T
```

[12]:
```
# creating a new data frame for ploting the labeled points.
dataframe = pd.DataFrame(data=new_cordinates, columns=("1st_principal",␣
 ↪"2nd_principal", "label"))
print(dataframe.head())
```

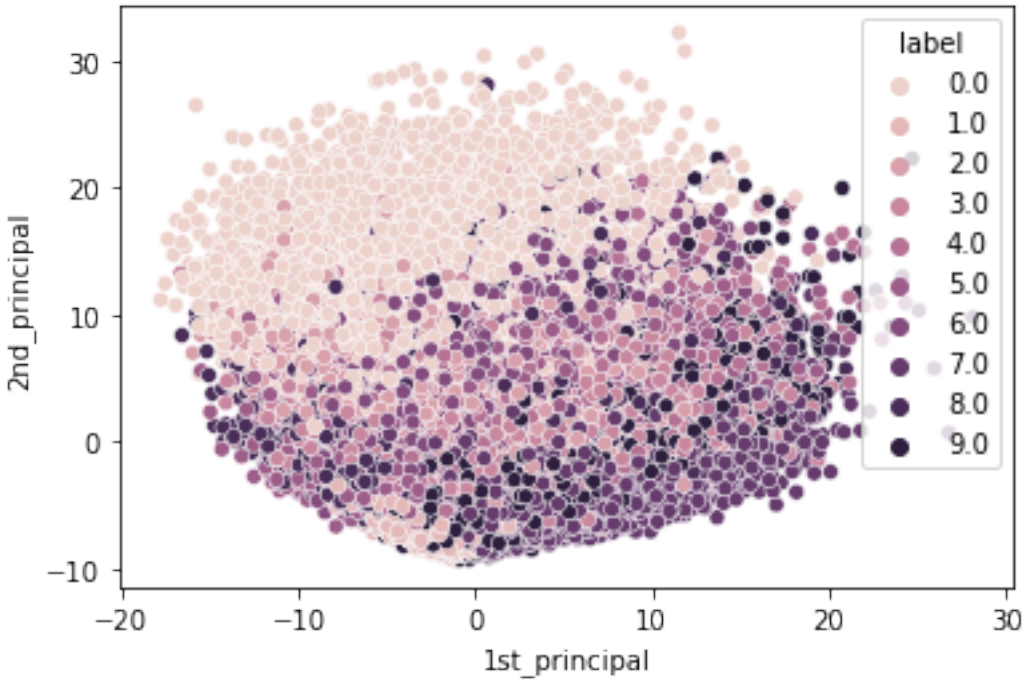
```
   1st_principal  2nd_principal  label
0      -4.814790      -0.922159    5.0
1      -7.754403       8.708977    0.0
2       9.431338       2.328389    4.0
3      -3.746318      -6.582173    1.0
4       3.133297      -5.183251    9.0
```

0.1.7 Task 5: Visualizing our PCA Dataset

[13]:
```
import seaborn as sns
sns.FacetGrid(dataframe, hue='label', height=6).map(plt.scatter,␣
 ↪"1st_principal", "2nd_principal").add_legend()
plt.show()
```



[14]:
```
sns.scatterplot(x="1st_principal", y="2nd_principal", hue='label',␣
↪data=dataframe, legend='full')
plt.show()
```



0.1.8 PCA with Scikit-Learn

[15]:
```
from sklearn import decomposition
pca = decomposition.PCA()
```

[16]:
```
# configuring the parameteres
# the number of components = 2
#no of component means in which D you want to convert your dataset. Here 2-D so␣
 ↪component is 2
pca.n_components = 2
pca_data = pca.fit_transform(standardized_data)

# pca_reduced will contain the 2-d projects of simple data
print("shape of pca_reduced.shape = ", pca_data.shape)
```

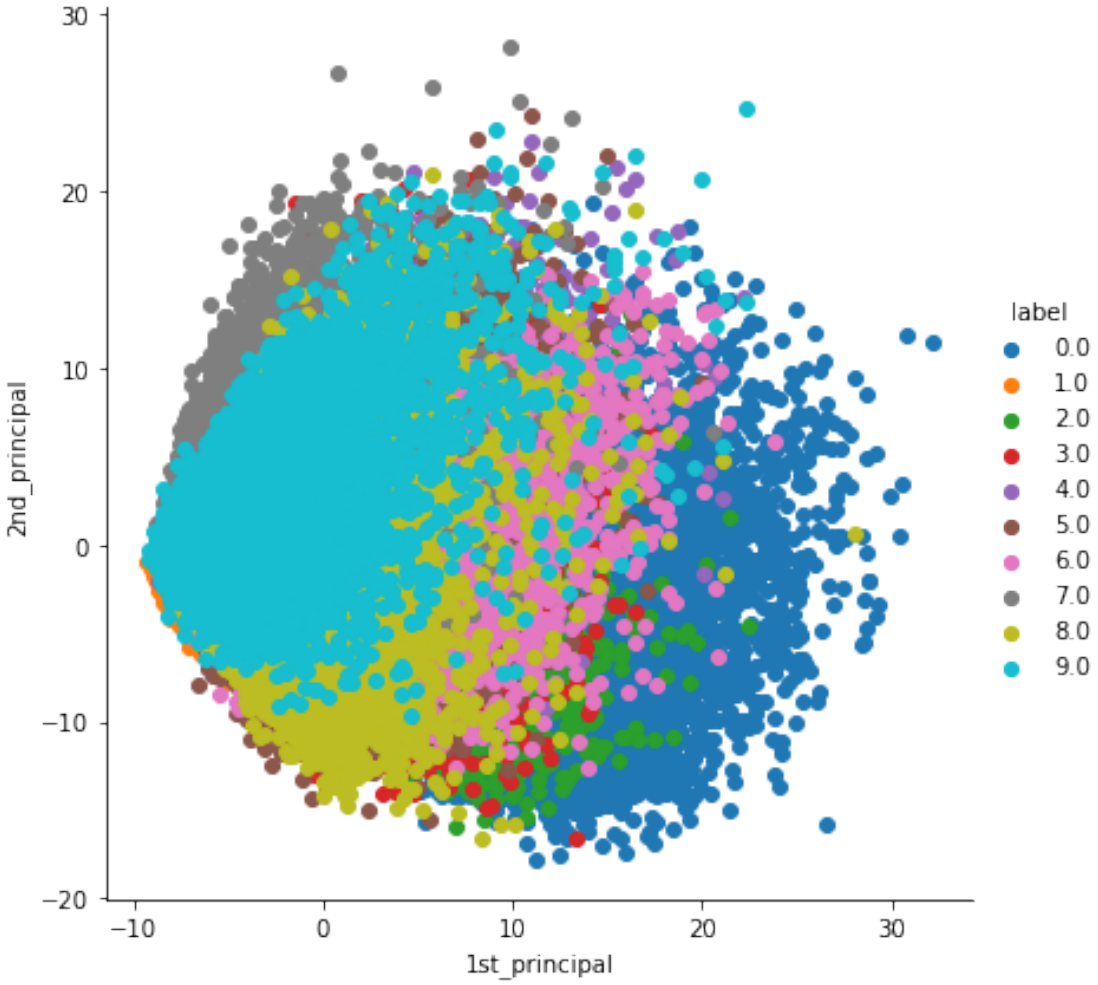
```
shape of pca_reduced.shape =  (60000, 2)
```

[17]:
```
pca_data = np.vstack((pca_data.T, l))
pca_data = pca_data.T
pca_data.shape
```

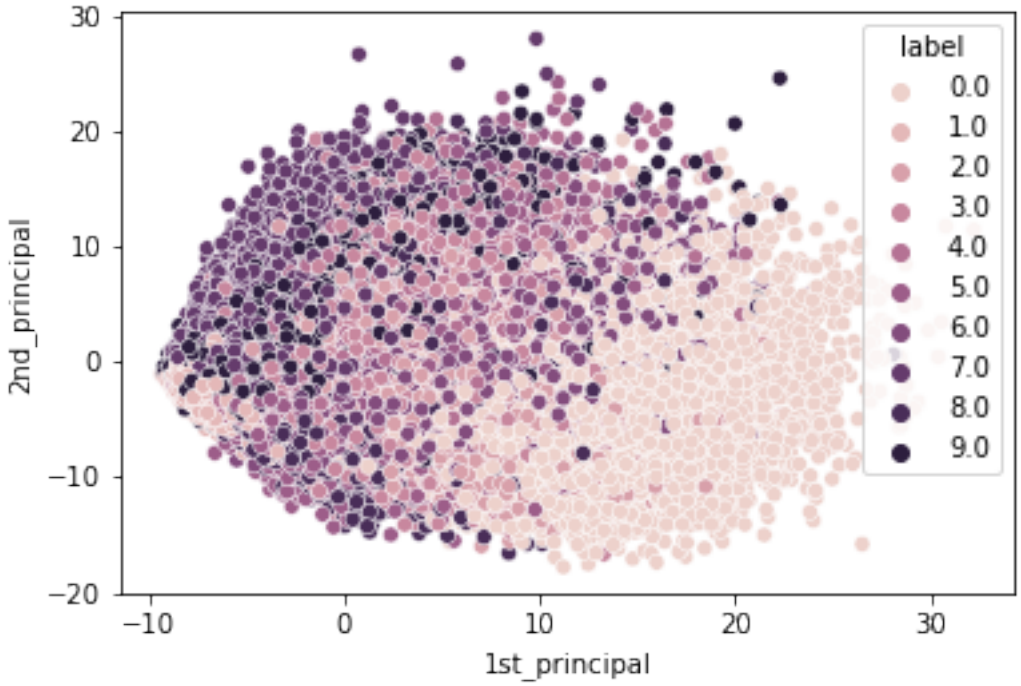
[17]:
```
(60000, 3)
```

[18]:
```
# creating a new data fram which help us in ploting the result data
```

```
pca_df = pd.DataFrame(data=pca_data, columns=("1st_principal", "2nd_principal",␣
↪"label"))
sns.FacetGrid(pca_df, hue="label", height=6).map(plt.scatter, '1st_principal',␣
↪'2nd_principal').add_legend()
plt.show()
```



[19]:
```
sns.scatterplot(x="1st_principal", y="2nd_principal", hue='label', data=pca_df,␣
↪legend='full')
plt.show()
```



[ ]:

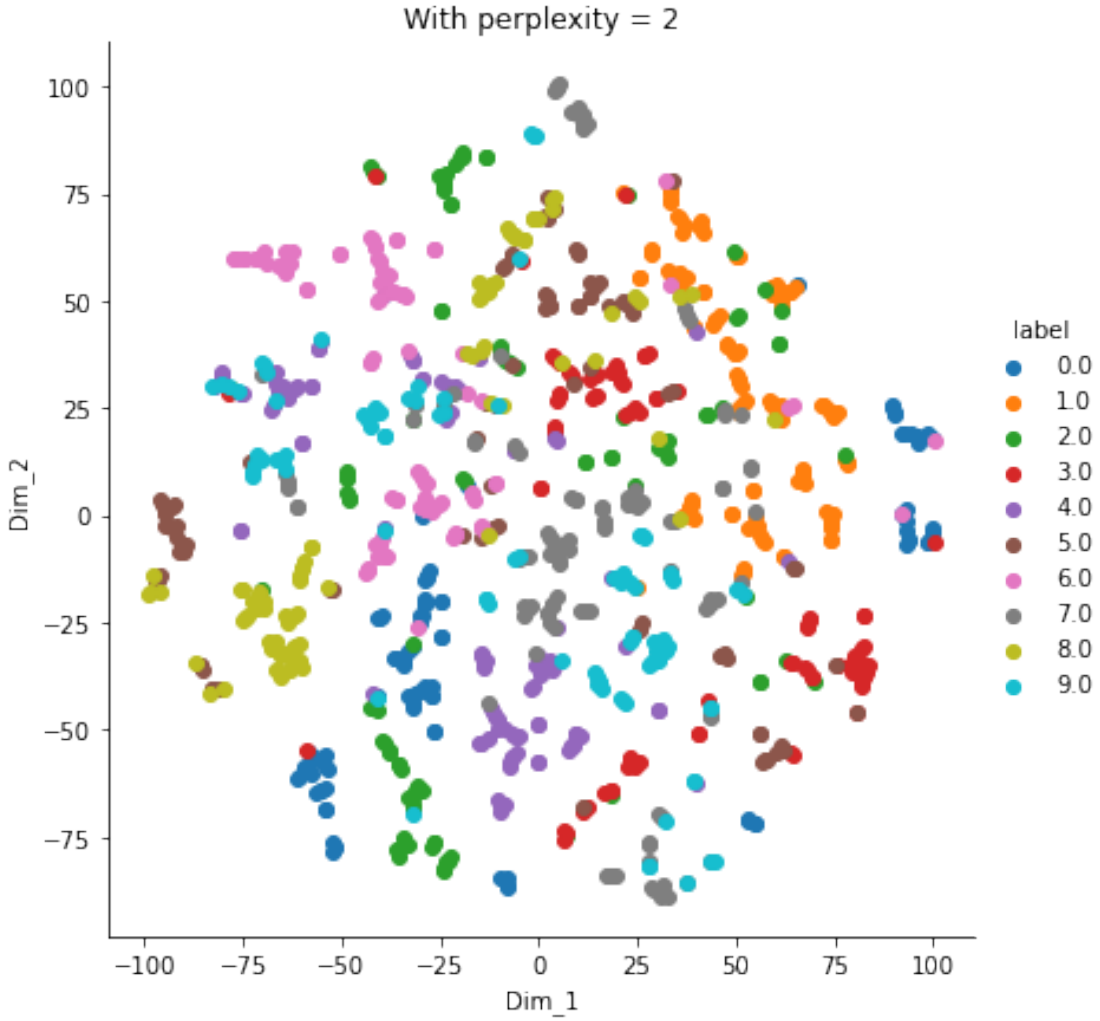
[20]:
```
# TSNE

from sklearn.manifold import TSNE
```

0.1.9 PCA with Perplexity: 2, No of Iteration: 1000

[21]:
```
data_1000 = standardized_data[0:1000,:]
labels_1000 = l[0:1000]

model = TSNE(n_components=2, random_state=0, perplexity=2)
tsne_data = model.fit_transform(data_1000)

# creating a new data fram which help us in ploting the result data
tsne_data = np.vstack((tsne_data.T, labels_1000)).T
tsne_df = pd.DataFrame(data=tsne_data, columns=("Dim_1", "Dim_2", "label"))

# Ploting the result of tsne
sns.FacetGrid(tsne_df, hue="label", size=6).map(plt.scatter, 'Dim_1', 'Dim_2').
 ↪add_legend()
plt.title('With perplexity = 2')
plt.show()
```

```
C:\Users\nooru\anaconda3\lib\site-packages\seaborn\axisgrid.py:316: UserWarning:
```

```
The `size` parameter has been renamed to `height`; please update your code.
  warnings.warn(msg, UserWarning)
```

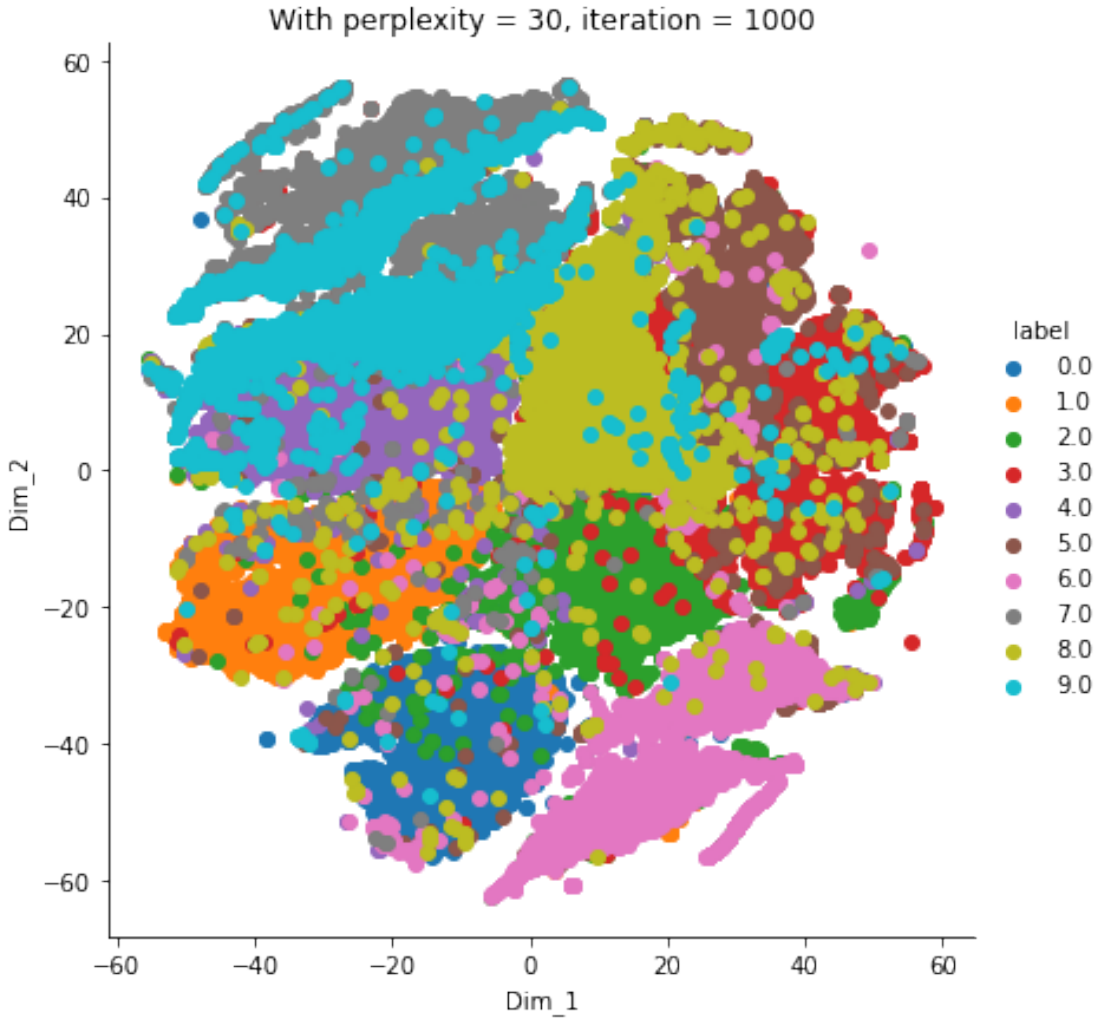


0.1.10 PCA with Perplexity: 30, No of Iteration: 1000

[22]:
```
model = TSNE(n_components=2, random_state=0, perplexity=30)
tsne_data = model.fit_transform(standardized_data)

# creating a new data fram which help us in ploting the result data
tsne_data = np.vstack((tsne_data.T, l)).T
tsne_df = pd.DataFrame(data=tsne_data, columns=("Dim_1", "Dim_2", "label"))

# Ploting the result of tsne
sns.FacetGrid(tsne_df, hue="label", size=6).map(plt.scatter, 'Dim_1', 'Dim_2').
 ↪add_legend()
```

```
plt.title('With perplexity = 30, iteration = 1000')
plt.show()
```

```
C:\Users\nooru\anaconda3\lib\site-packages\seaborn\axisgrid.py:316: UserWarning:
The `size` parameter has been renamed to `height`; please update your code.
  warnings.warn(msg, UserWarning)
```

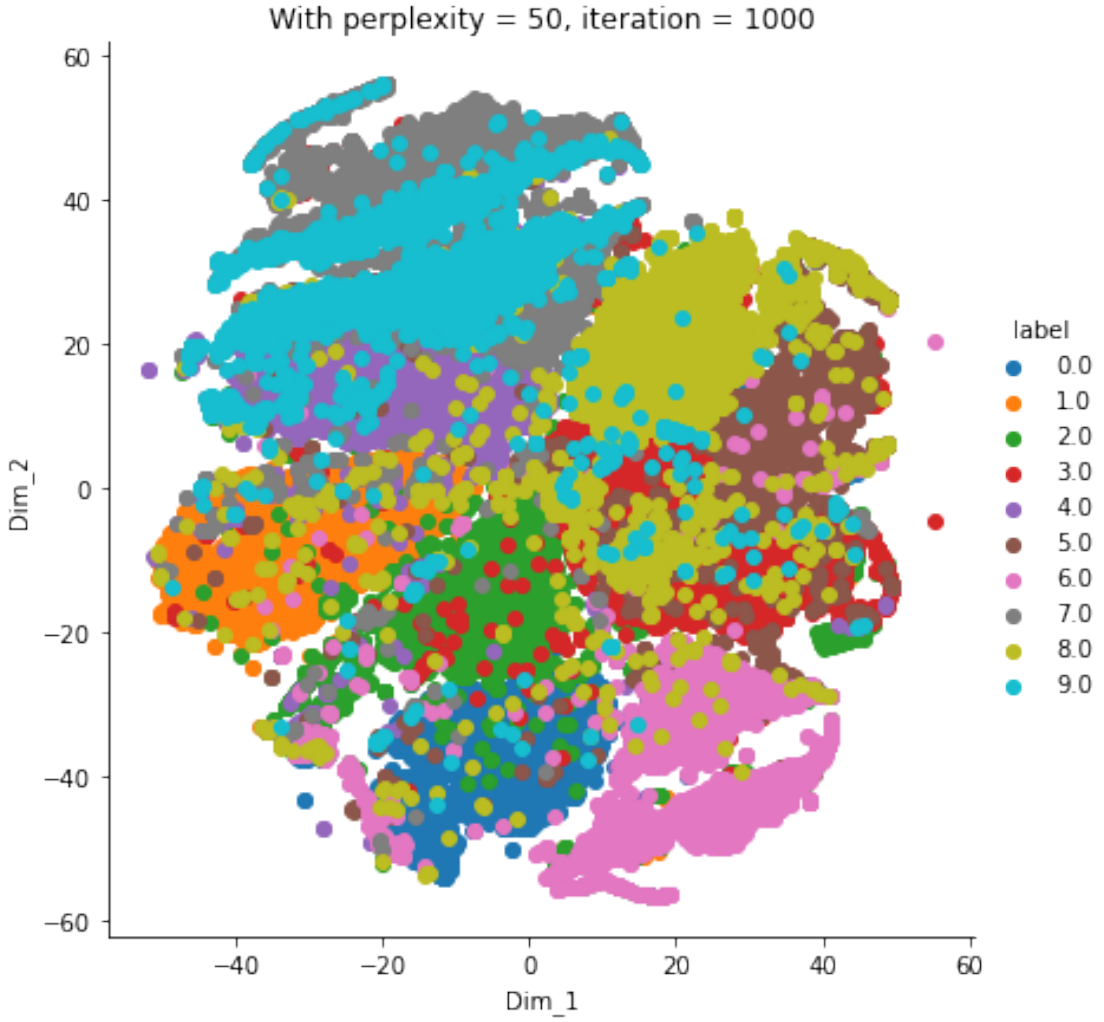


0.1.11 PCA with Perplexity: 50, No of Iteration: 1000

[23]:
```
model = TSNE(n_components=2, random_state=0, perplexity=50)
tsne_data = model.fit_transform(standardized_data)

# creating a new data fram which help us in ploting the result data
tsne_data = np.vstack((tsne_data.T, l)).T
tsne_df = pd.DataFrame(data=tsne_data, columns=("Dim_1", "Dim_2", "label"))
```

```
# Ploting the result of tsne
sns.FacetGrid(tsne_df, hue="label", size=6).map(plt.scatter, 'Dim_1', 'Dim_2').
 ↪add_legend()
plt.title('With perplexity = 50, iteration = 1000')
plt.show()
```

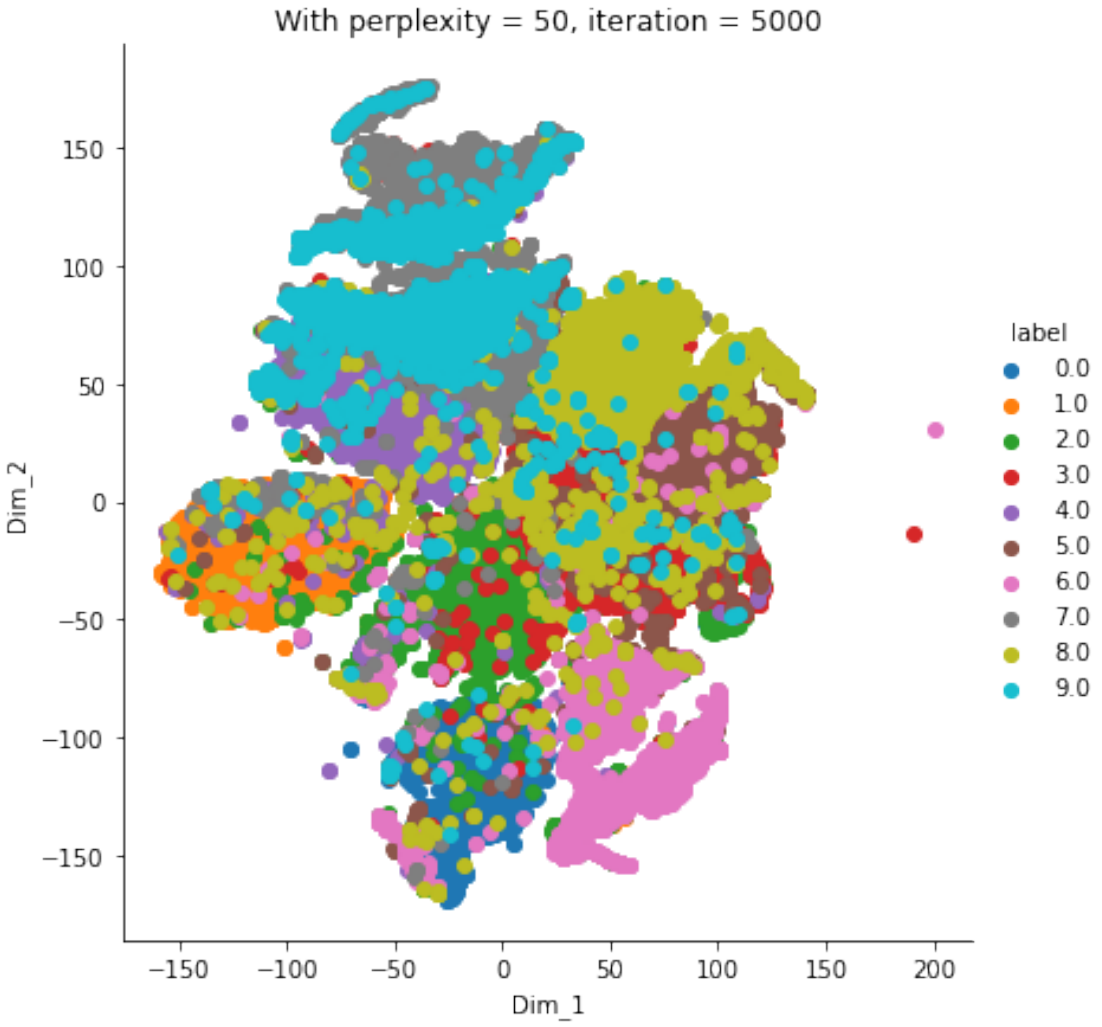
```
C:\Users\nooru\anaconda3\lib\site-packages\seaborn\axisgrid.py:316: UserWarning:
The `size` parameter has been renamed to `height`; please update your code.
  warnings.warn(msg, UserWarning)
```



0.1.12 PCA with Perplexity: 50, No of Iteration: 5000 1:01

[24]:
```
model = TSNE(n_components=2, random_state=0, perplexity=50, n_iter=5000)
tsne_data = model.fit_transform(standardized_data)

# creating a new data fram which help us in ploting the result data
tsne_data = np.vstack((tsne_data.T, l)).T
tsne_df = pd.DataFrame(data=tsne_data, columns=("Dim_1", "Dim_2", "label"))

# Ploting the result of tsne
sns.FacetGrid(tsne_df, hue="label", size=6).map(plt.scatter, 'Dim_1', 'Dim_2').
 ↪add_legend()
plt.title('With perplexity = 50, iteration = 5000')
plt.show()
```

```
C:\Users\nooru\anaconda3\lib\site-packages\seaborn\axisgrid.py:316: UserWarning:
The `size` parameter has been renamed to `height`; please update your code.
  warnings.warn(msg, UserWarning)
```



[ ]: