Report for CS215 Assignment 2

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October 12, 2021

Question No - 4

Part 1

Calculating the number of principle modes of variation:

If we define the number of principle modes of variation as the number of nodes of variation that capture atleast 90 percent of the variance of the data i.e n such that

$$\frac{\sum_{i=1}^{n} D_{ii}}{\sum_{i=1}^{N} D_{ii}}$$

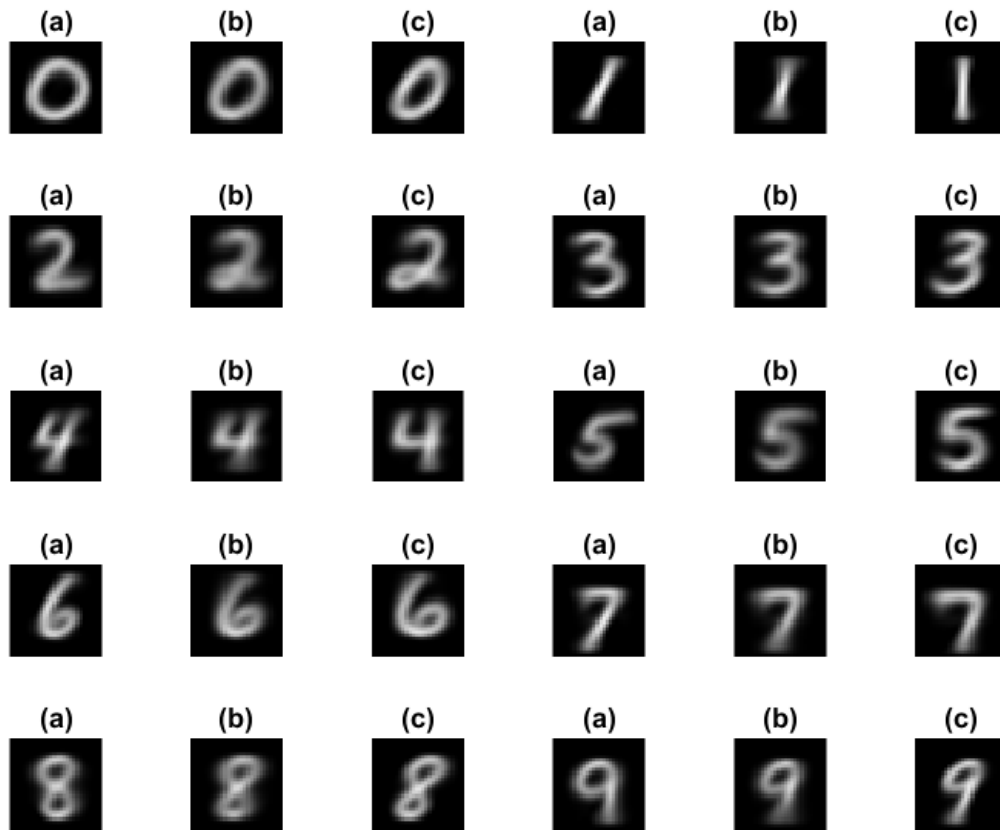then we get the following data shown in the table below:

Digit	Number of principle modes of variation
0	62
1	36
2	81
3	80
4	76
5	75
6	62
7	66
8	82
9	62

From the above table, it can be clearly seen that the number of principle modes of variation is far less than $784(28^2)$ for each of the digit. This is because in real world images, the neighbouring pixels usually have a high correlation among themselves and hence the actual degrees of freedom is far less than the actual number of pixels.

Part 2

The middle figures for each digit represented by **(b)** represent the mean of all the images of a particular digit, i.e. it represents on an average the way how most of the people write a particular digit. The left and right images for each digit represented by **(b)** and **(c)** respectively represent the deviations from the average way of writing a digit along the direction of maximum deviation. For the digit 1, it can be easily observed that amongst the various ways that people write the digit, the most significant variation is in the tilt of the digit and on the two extremes, people write it as tilted towards the right or vertical. Thus, the principal mode represents how tilted is 1 written, and the two images show the range of angles between which most people write the digit 1. Similarly for other digits...

3 Images for each Digit side by side

(a)	(b)	(c)	(a)	(b)	(c)
0	0	0	1	1	1

(a)	(b)	(c)	(a)	(b)	(c)
2	2	2	3	3	3

(a)	(b)	(c)	(a)	(b)	(c)
4	4	4	5	5	5

(a)	(b)	(c)	(a)	(b)	(c)
6	6	6	7	7	7

(a)	(b)	(c)	(a)	(b)	(c)
8	8	8	9	9	9

Graph of Sorted Eigenvalues for each Digit

Sorted Eigenvalues