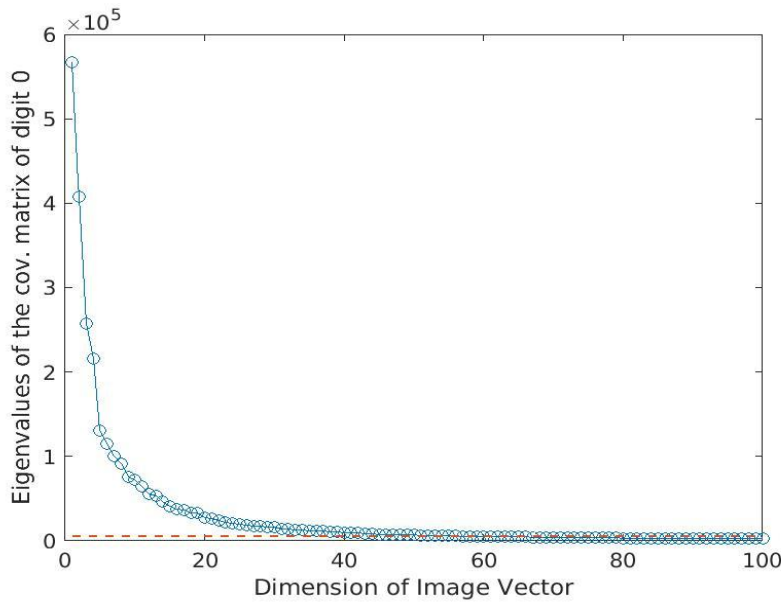


Problem 4

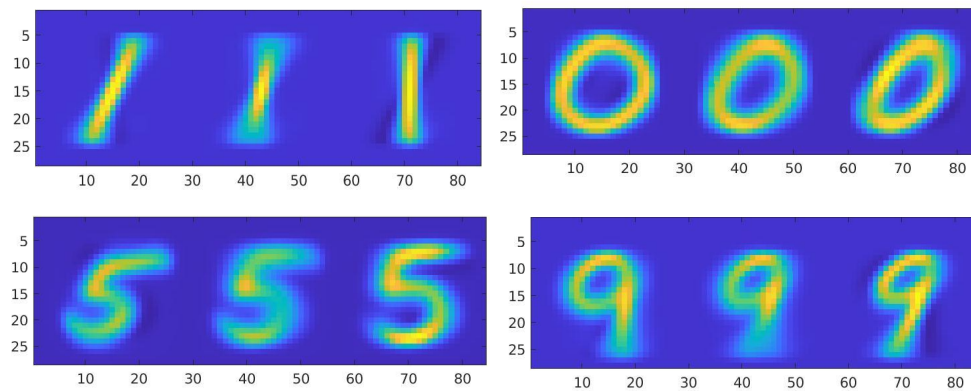


Other plots are in the results folder

- NOTE: The graph has large eigenvalues of order 10^5 because the pixels were in $[0 \ 255]$ if we scale it to $[0 \ 1]$ the graph would be of order 1.
- Observation: Most of the eigenvalues were not significant (i.e, less than 1% of the maximum eigenvalue) and the eigenvalues dropped steeply for the initial values.
- This observation is seen because very few dimensions captures most of the variability (total dispersion) in the data
- Following are the significant modes of variation. This is far less than 28^2 because the number of pixels which vary while writing a particular digit say 1 is far less than 28^2 as most of the pixels are black irrespective of the fact that people have written straight or tilted 1. Variance is seen only in some significant pixels which are black in some images and white in others (due to tilt of 1)
- Moreover the lower value of no. of significant mode for 1 (27) depicts that people don't mess much while writing digit 1 than they do while writing other digits like say 8 or 3 (89)

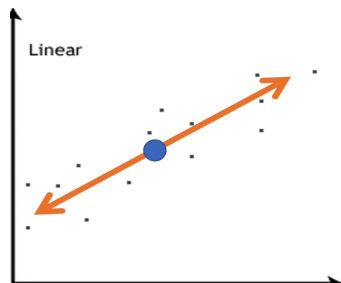
Digits	λ_1	Number of Significant mode of variation
0	5.6716e+05	56
1	5.1199e+05	27
2	3.9687e+05	86
3	3.6442e+05	86

4	3.1714e+05	83
5	5.1741e+05	69
6	4.8539e+05	60
7	3.9185e+05	63
8	3.6633e+05	89
9	4.0329e+05	63



Other images are in the results folder

- The left image is $\mu - \sqrt{\lambda_1} v_1$, the middle one is μ and the right one is $\mu + \sqrt{\lambda_1} v_1$.
- The three images depict different ways in which digits are written by people. Left and right images are two extremes in the direction of the principal mode of variation.
- 1 written in a tilted fashion in the left and in a straight way in the right depicts the variation in the way people write the digit 1. This variation is seen in these images because we have subtracted the principal mode in the first figure and added the principal mode in the third image similar to what was shown in this graph in slides.



- Furthermore If people would have written some 6s inverted like 9 then this analysis would have captured this variation with the right image looking like 9 left like 6 and mean would have looked like 8.