



# CS 736 Programming Assignment 1

## Shape Analysis

Submitted By

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# 1 Objective

The objective of this assignment was to perform shape analysis using correspondence based pointsets for different datasets. This involved aligning two shape images, computing optimal shape mean, finding the modes of variations and plot different characteristics and evaluated mean and modes of variations.

## 2 Code Structure

We have used python (Version 3.7.4) for coding.

1. python files:

- i `functions.py`: Computation of pre-shape space, optimal rotation for alignment of 2 images, mean computation, covariance matrix computation and finding the closest pointset for the given mean or mode of variation shape
- ii `solver.py`: Computation of mean, modes of variation and plotting of all parts for the given data of pointsets
- iii `main.py`: Computation and plotting of all the data points
- iv `annotate_pointset.py`: Script for manually annotating the pointsets for data and saving the pointsets
- v `visualize_pointset.py`: For plotting the pointsets on the original images

2. Other scripts

- i `requirements.txt`: Contains the libraries used

**Instructions to run** (will generate results for all the datasets):

```
$ python main.py
```

### 3 Analysis And Results

#### 3.1 Ellipse

##### 3.1.1 Part A

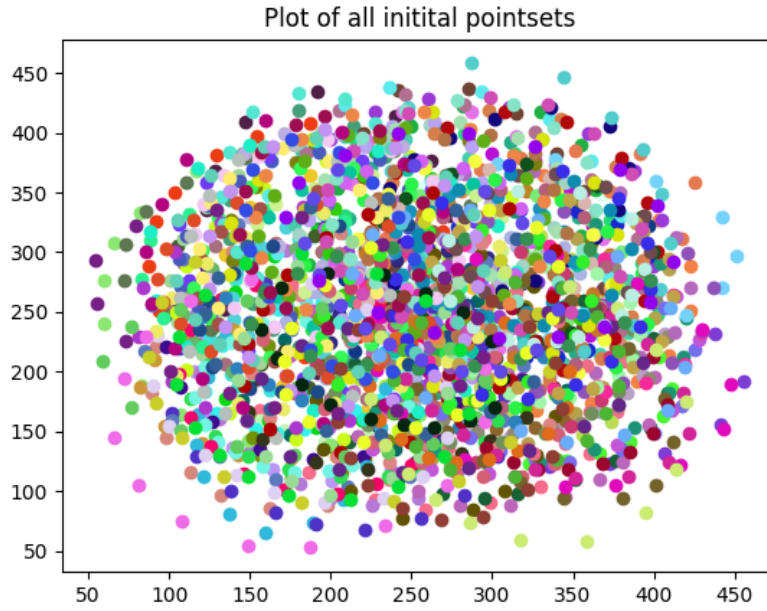


Figure 1: Scatter Plot

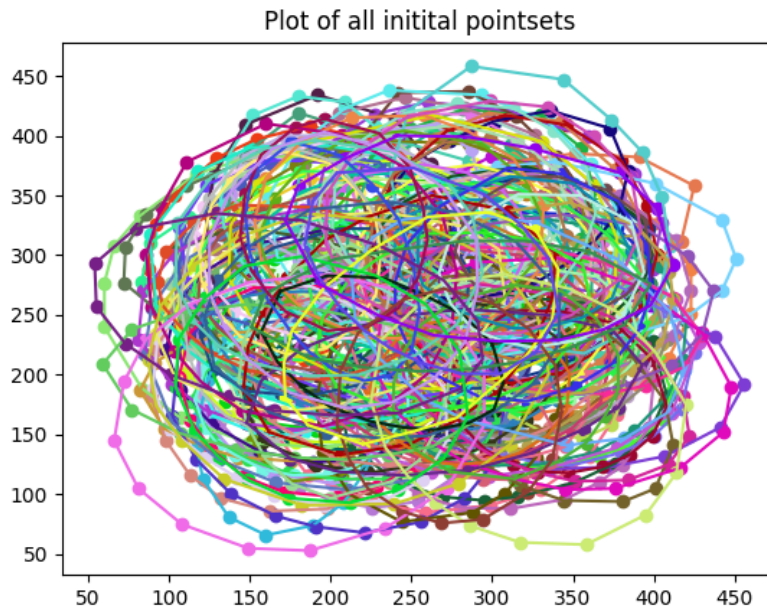


Figure 2: Each pointset represented by polylines

### 3.1.2 Part B

Computed shape mean (in black), together with all the aligned pointsets

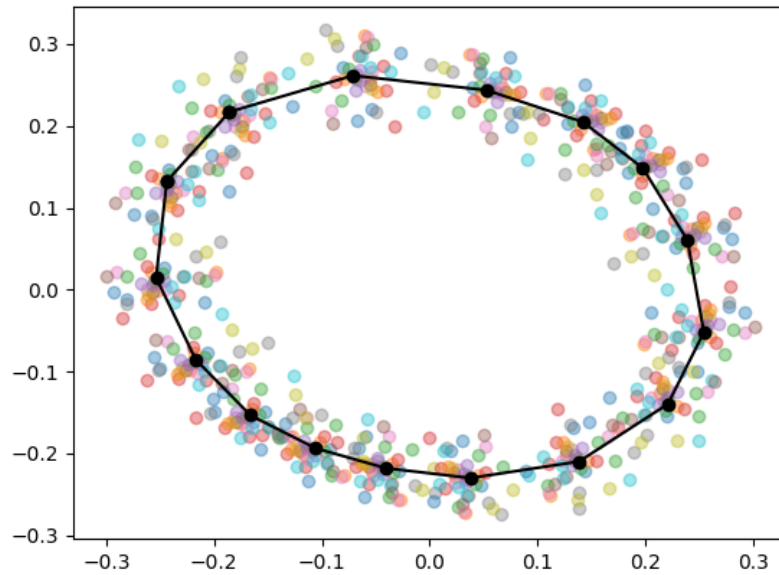


Figure 3:

### 3.1.3 Part C

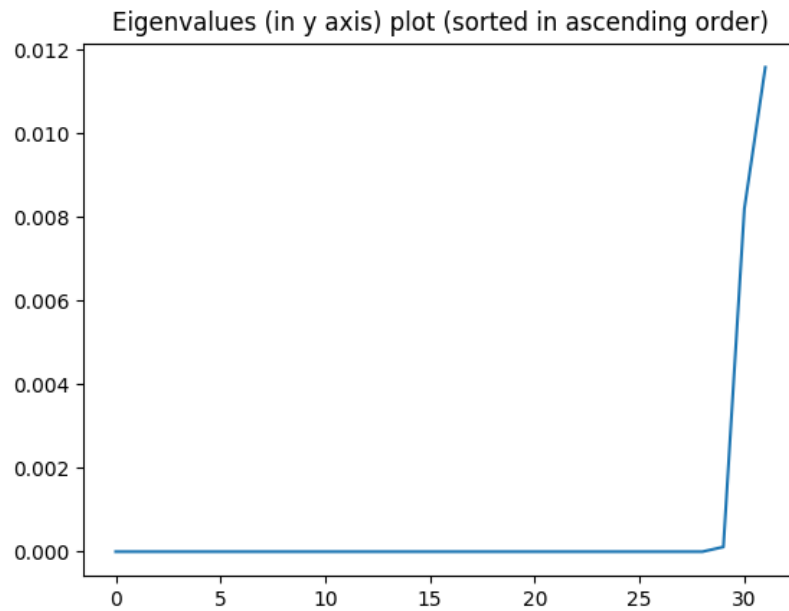


Figure 4: First two eigen values are significantly greater than other eigen values which are close to zero

### 3.1.4 Part D

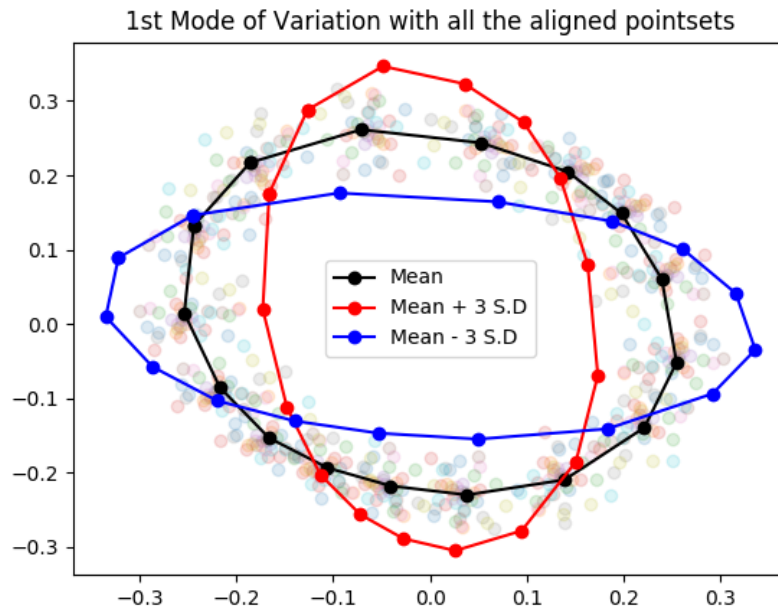


Figure 5: First Mode of variation seems to capture the ellipse shape dimensions in both the dimensions. Mean+3 standard deviations ellipse shape is longer in vertical direction while Mean-3 standard deviations ellipse shape is longer horizontally

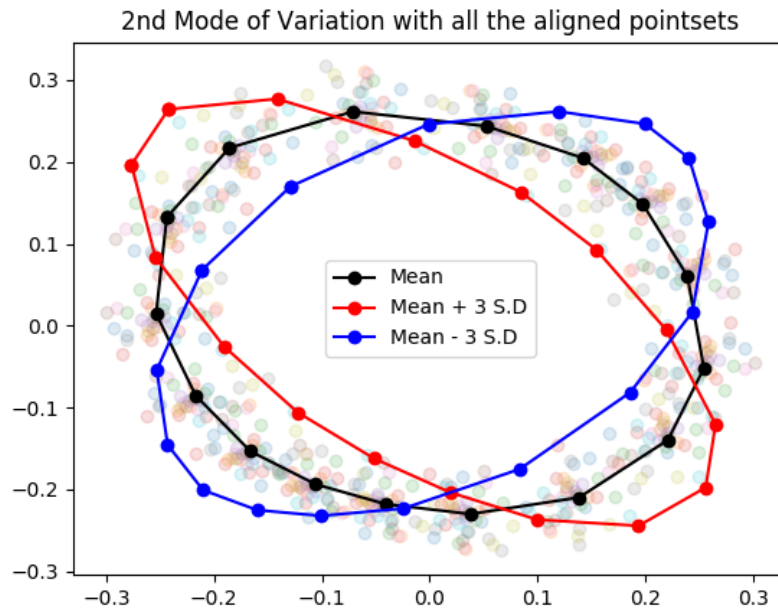


Figure 6: Second Mode of variation seems to capture the ellipse rotation. Mean+3 standard deviations shape rotated towards left (anticlockwise) while Mean-3 standard deviations shape is rotated towards right (clockwise).

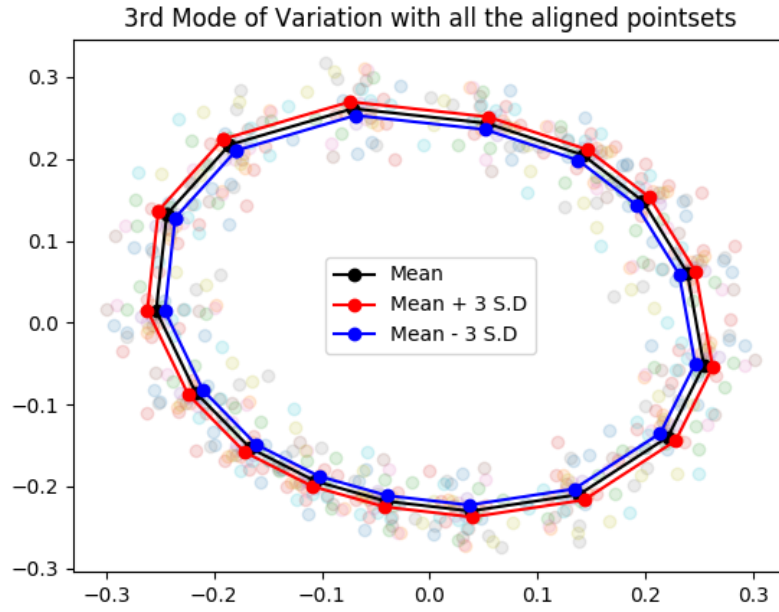


Figure 7: The variation is small in this case but the third mode seems for control the ellipse size. Mean+3 standard deviations shape is slightly larger in area while Mean-3 standard deviations shape is slightly smaller in area.

### 3.1.5 Part E

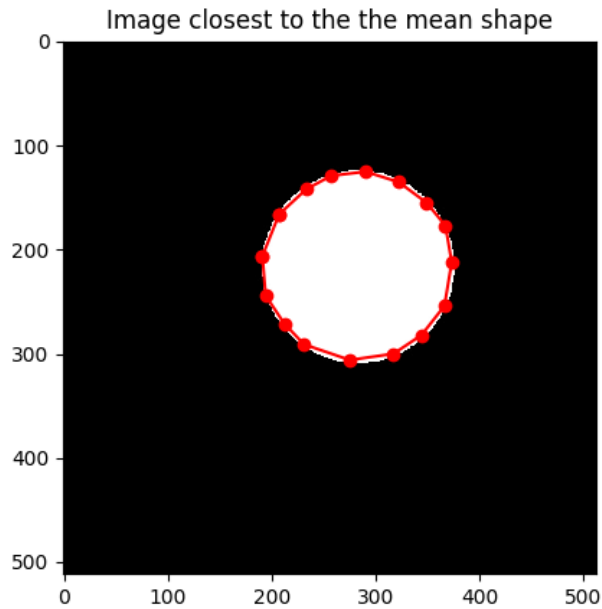


Figure 8:

Image closest to Mean shape +3 S.D along the top mode of variation

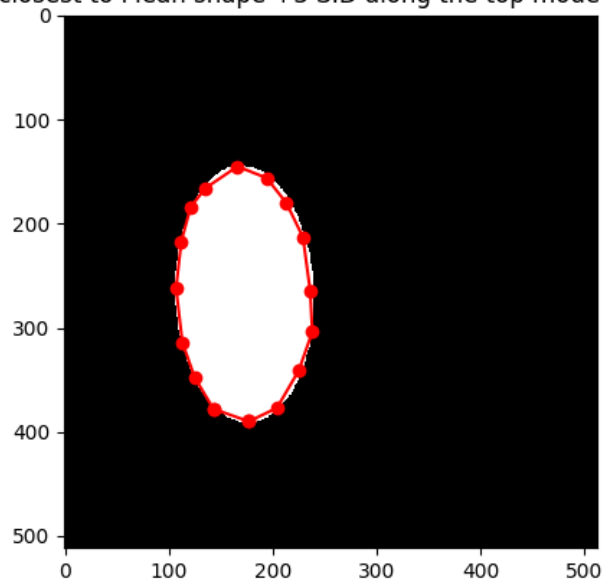


Figure 9: Vertically longer than mean shape

Image closest to Mean shape -3 S.D along the top mode of variation

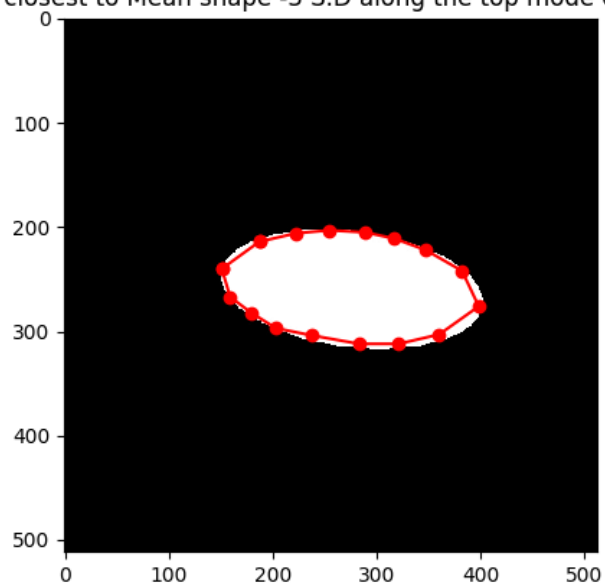


Figure 10: Horizontally wider than mean shape



## 3.2 Human Hand Shapes

### 3.2.1 Part A

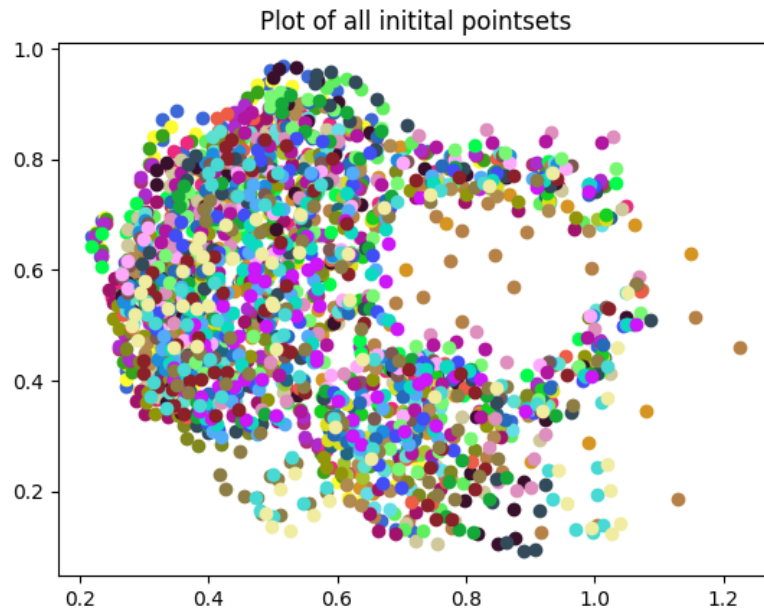


Figure 11: Scatter Plot

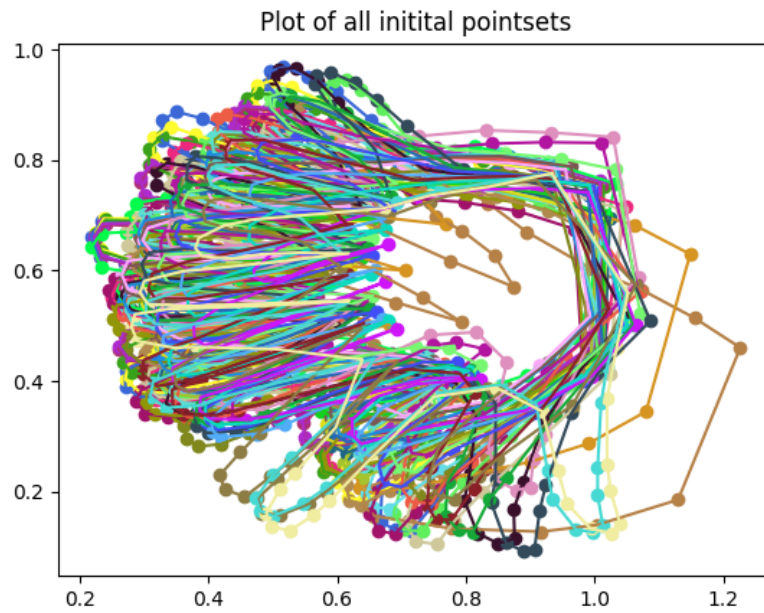


Figure 12: Each pointset represented by polylines

### 3.2.2 Part B

Computed shape mean (in black), together with all the aligned pointsets

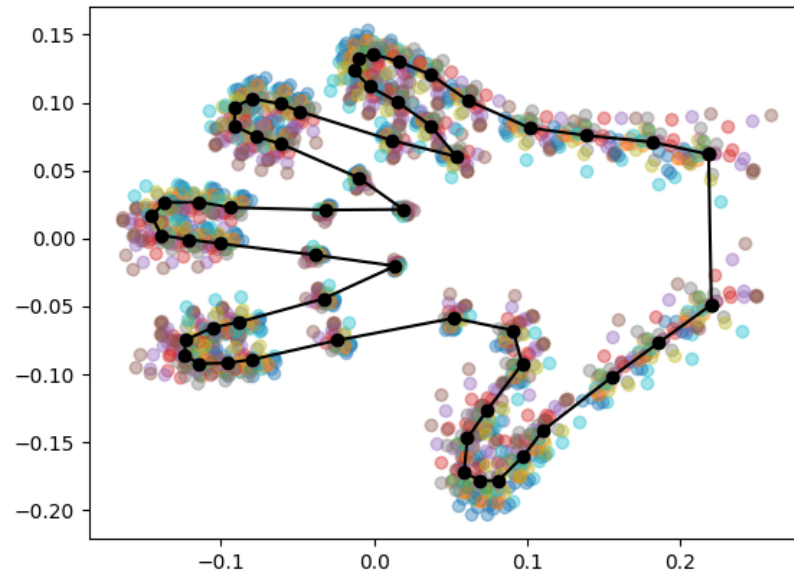


Figure 13:

### 3.2.3 Part C

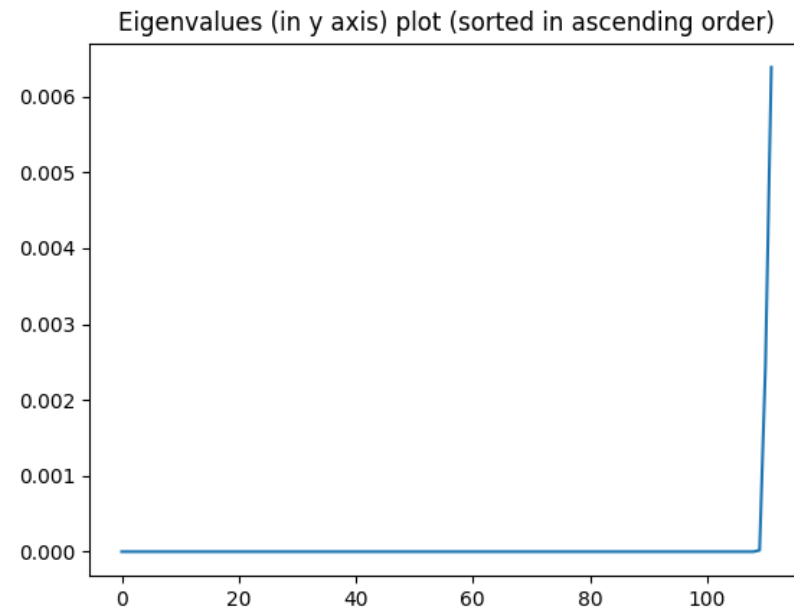


Figure 14: First two eigen values are significantly greater than other eigen values which are close to zero

### 3.2.4 Part D

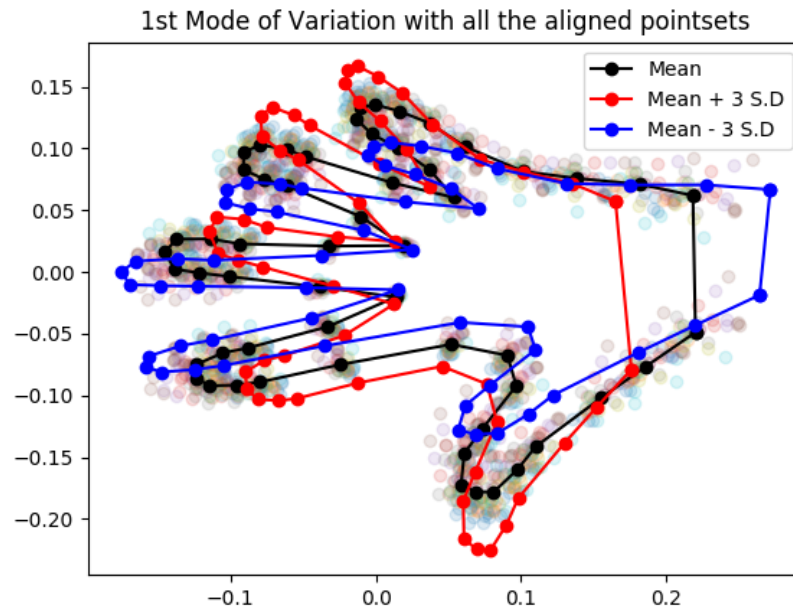


Figure 15: First Mode of variation seems to capture the hand shape thickness (Thickness of fingers and palm). Mean+3 standard deviations hand is thinner while Mean-3 standard deviations is thicker.

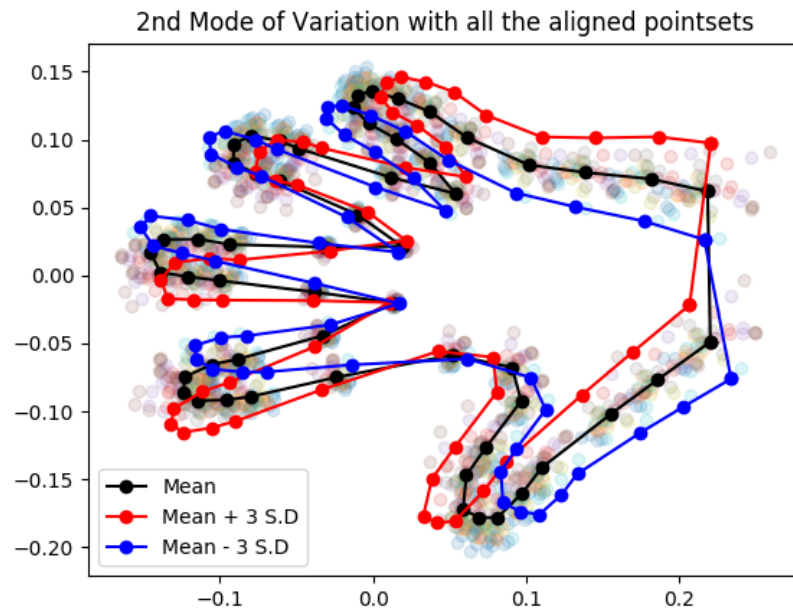


Figure 16: Second Mode of variation seems to capture the hand shape rotation. Mean+3 standard deviations hand is rotated downwards (anticlockwise) while Mean-3 standard deviations hand is rotated upwards (clockwise)

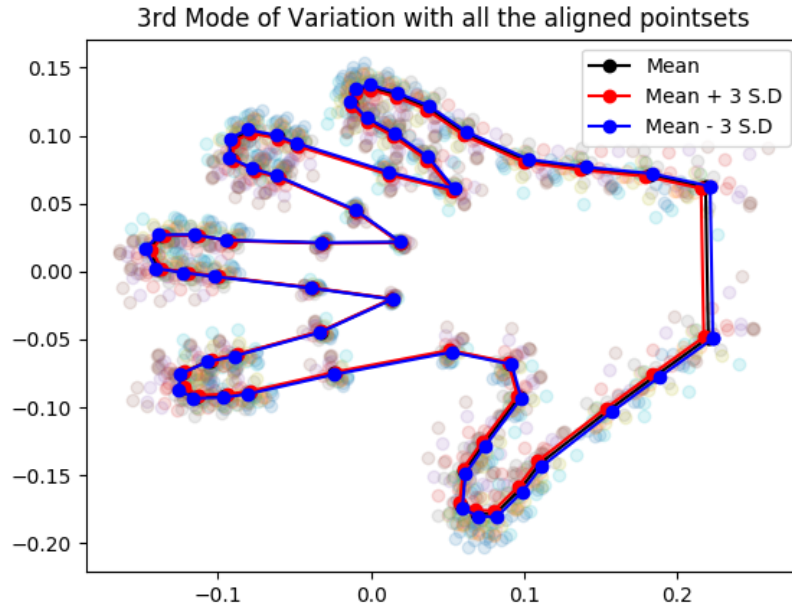


Figure 17: As the 3rd greatest eigenvalue is very small, the third mode of variation does not seem to capture anything and all the three shapes almost overlap.

### 3.2.5 Part E

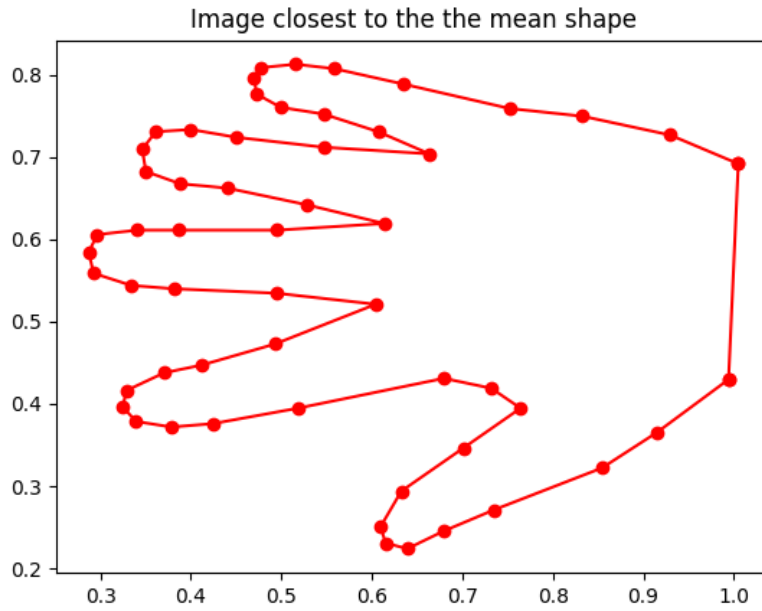


Figure 18:

Image closest to Mean shape +3 S.D along the top mode of variation

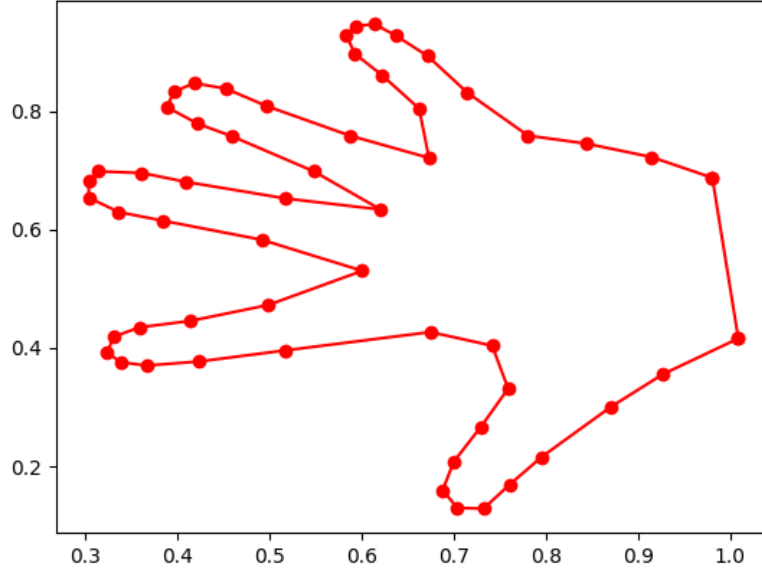


Figure 19: Thinner than mean shape

Image closest to Mean shape -3 S.D along the top mode of variation

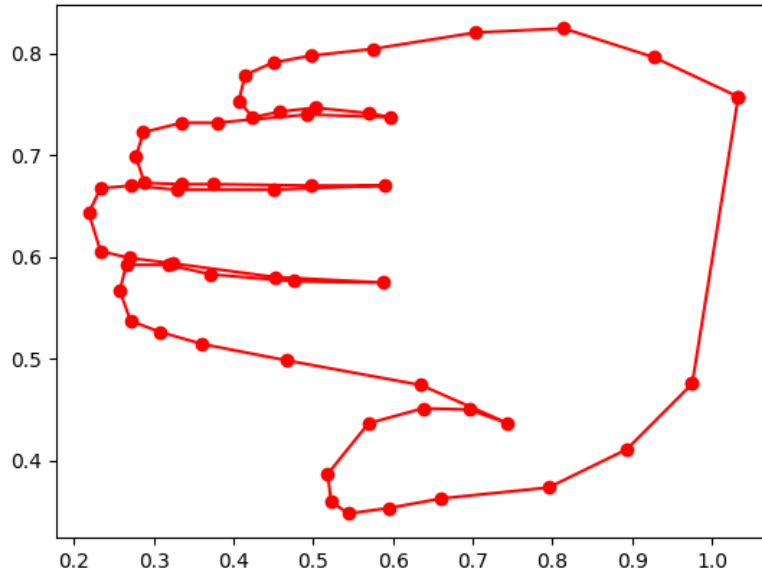


Figure 20: Thicker than mean shape

### 3.3 Leaf Shapes

The pointset (consisting of 32 points) for each image was developed by manually placing the 32 points on leaf boundaries. The script `annotate_pointset.py` was used for this purpose. The 32 points were placed on each of the 75 images and the resultant pointset (75x32x2) was stored as a numpy array.

### 3.3.1 Part A

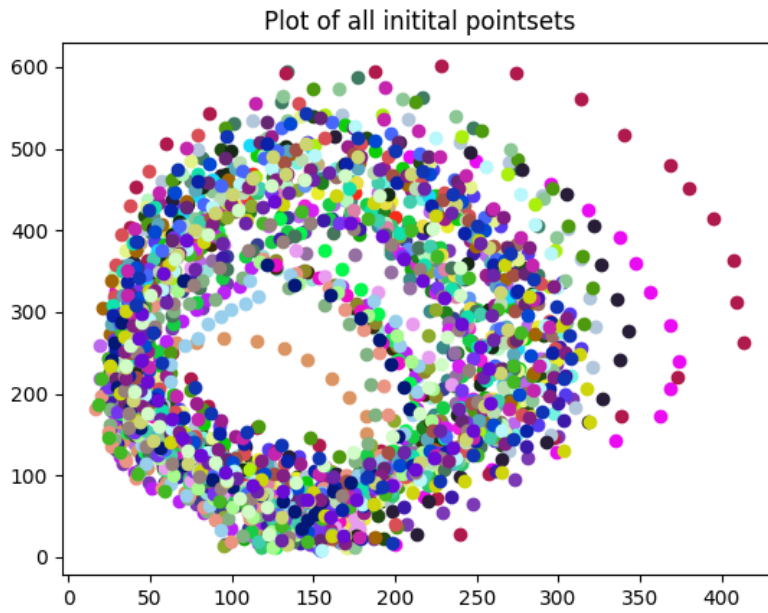


Figure 21: Scatter Plot

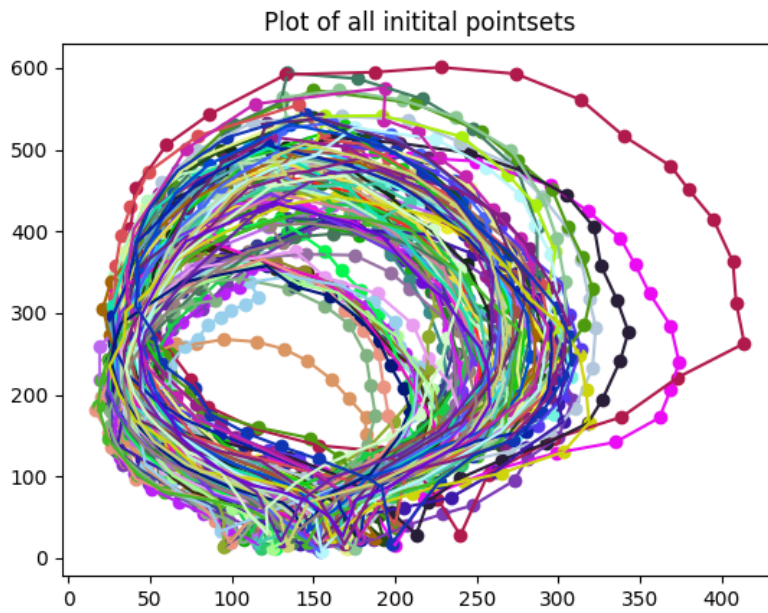


Figure 22: Each pointset represented by polylines

### 3.3.2 Part B

Computed shape mean (in black), together with all the aligned pointsets

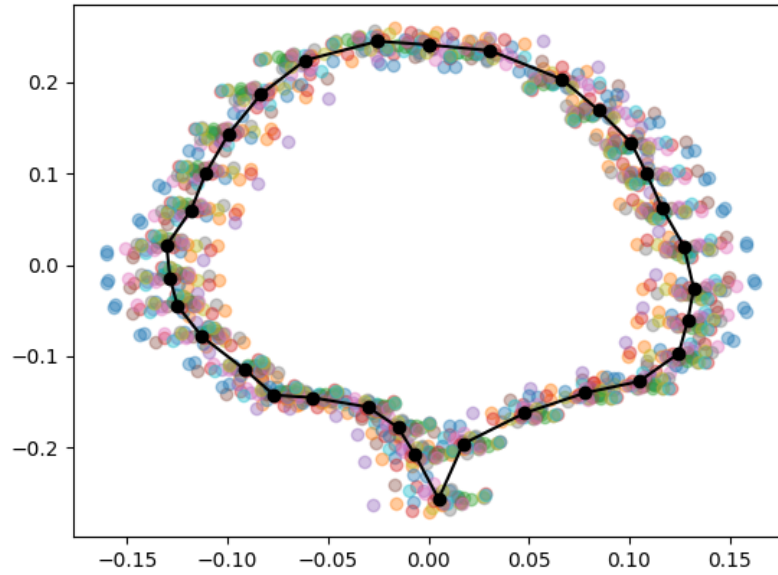


Figure 23:

### 3.3.3 Part C

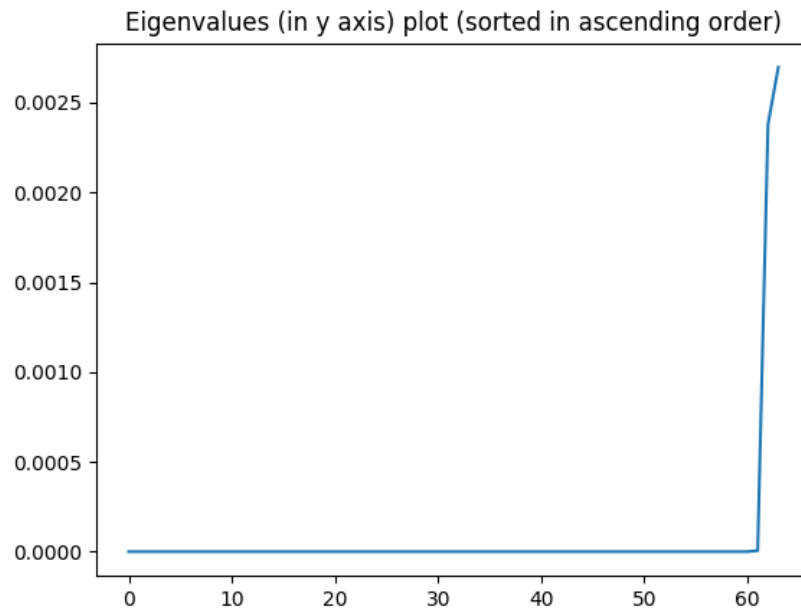


Figure 24: First two eigen values are significantly greater than other eigen values which are close to zero



### 3.3.4 Part D

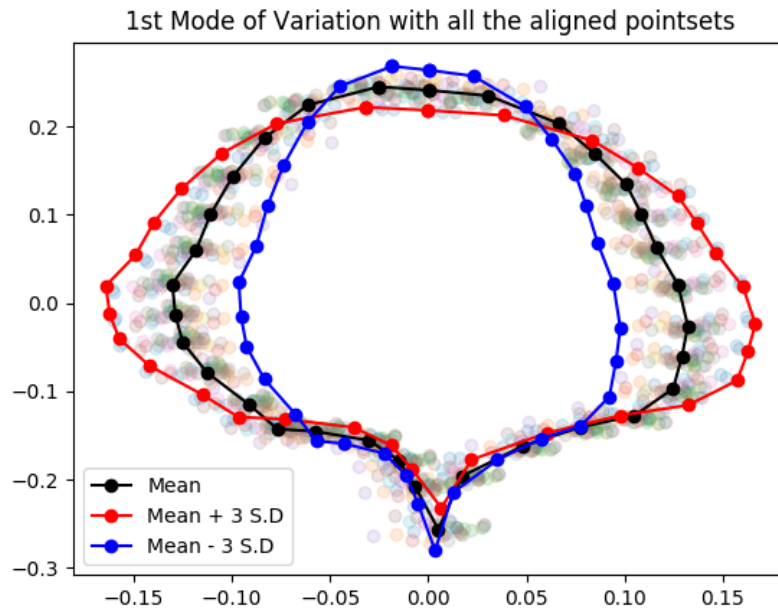


Figure 25: First Mode of variation seems to capture the leaf shape thickness. Mean+3 standard deviations leaf is thicker and shorter while Mean-3 standard deviations leaf is thinner and longer.

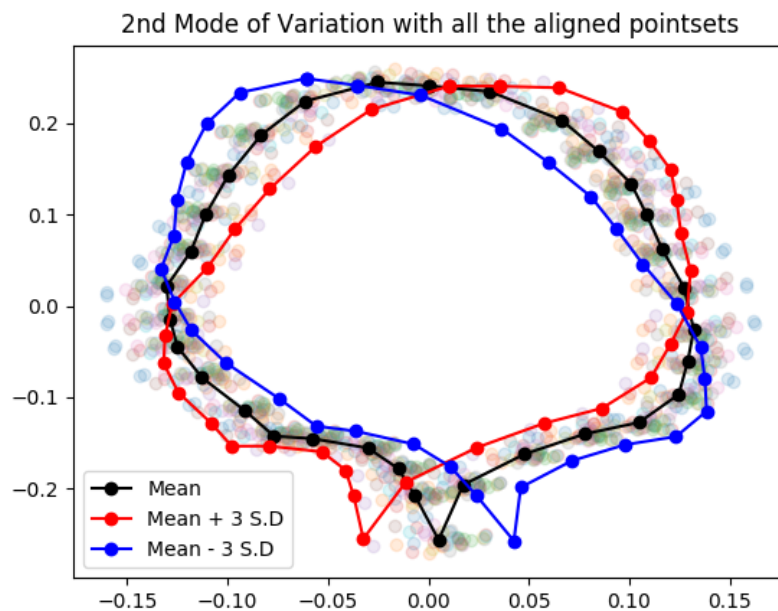


Figure 26: Second Mode of variation seems to capture the hand shape rotation. Mean+3 standard deviations hand is rotated downwards (anticlockwise) while Mean-3 standard deviations hand is rotated upwards (clockwise)



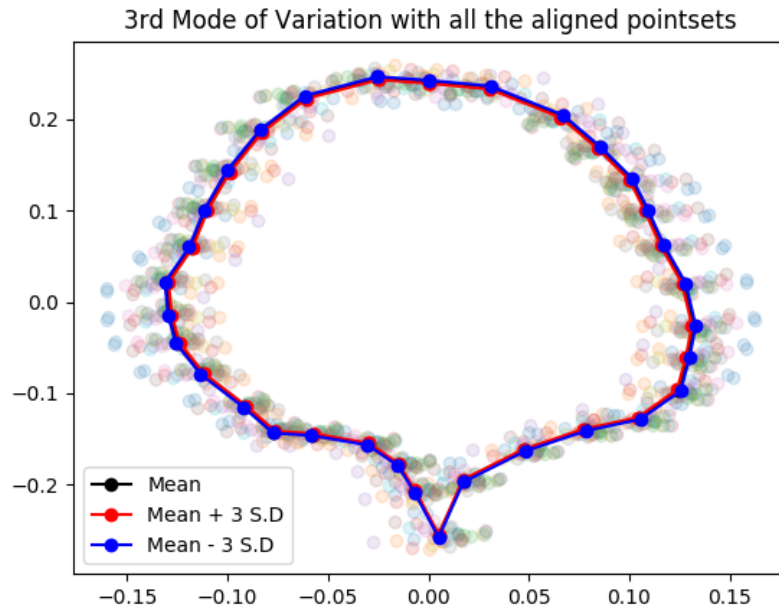


Figure 27: As the 3rd greatest eigenvalue is very small, the third mode of variation does not seem to capture anything and all the three shapes almost overlap.

### 3.3.5 Part E

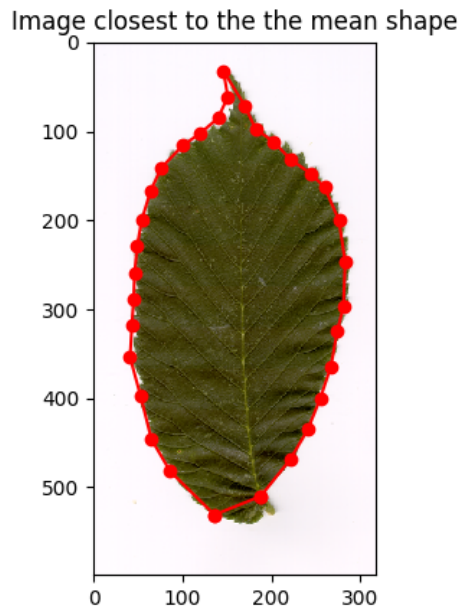


Figure 28:

Image closest to Mean shape +3 S.D along the top mode of variation

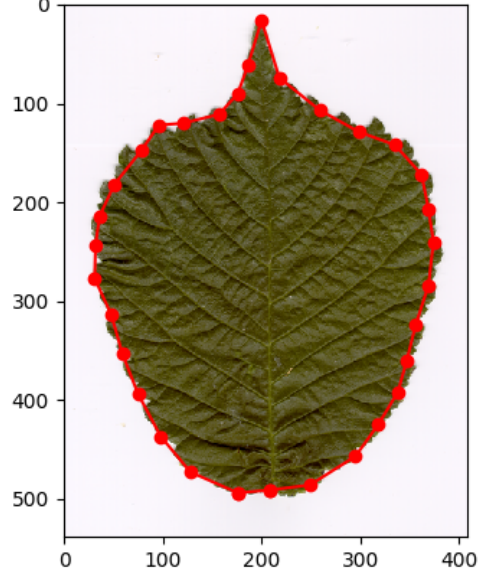


Figure 29: Thicker and shorter than mean shape

Image closest to Mean shape -3 S.D along the top mode of variation

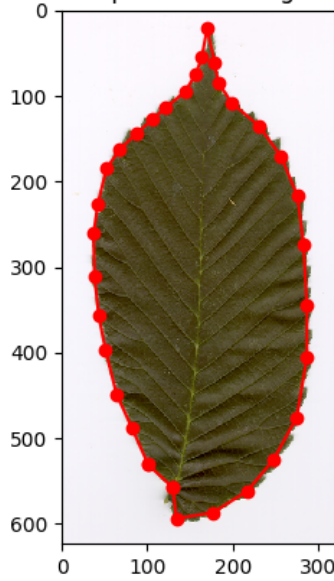


Figure 30: Thinner and longer than mean shape

### 3.4 MRI images of the Human Head.

The pointset (consisting of 32 points) for each image was developed by manually placing the 32 points on brain scan boundaries. The script `annotate_pointset.py` was used for this purpose. The 32 points were placed on each of the 40 images and the resultant pointset (40x32x2) was stored as a numpy array.

### 3.4.1 Part A

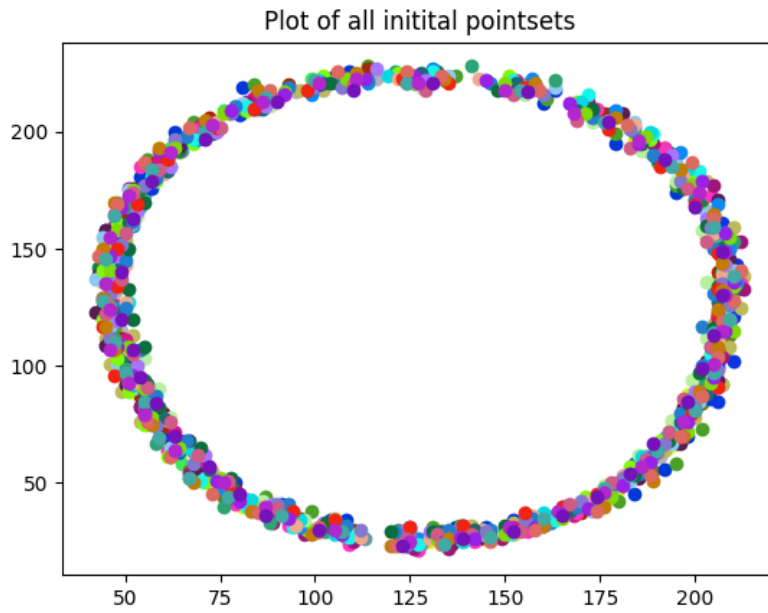


Figure 31: Scatter Plot

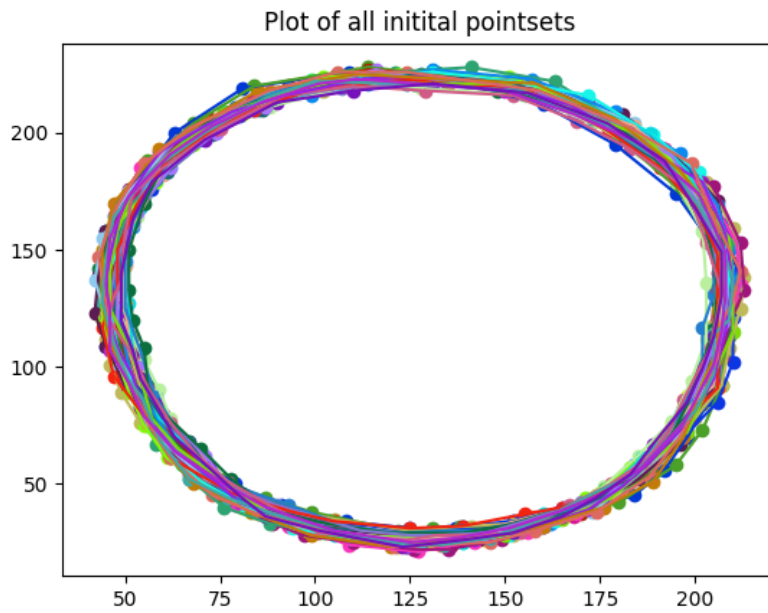


Figure 32: Each pointset represented by polylines

### 3.4.2 Part B

Computed shape mean (in black), together with all the aligned pointsets

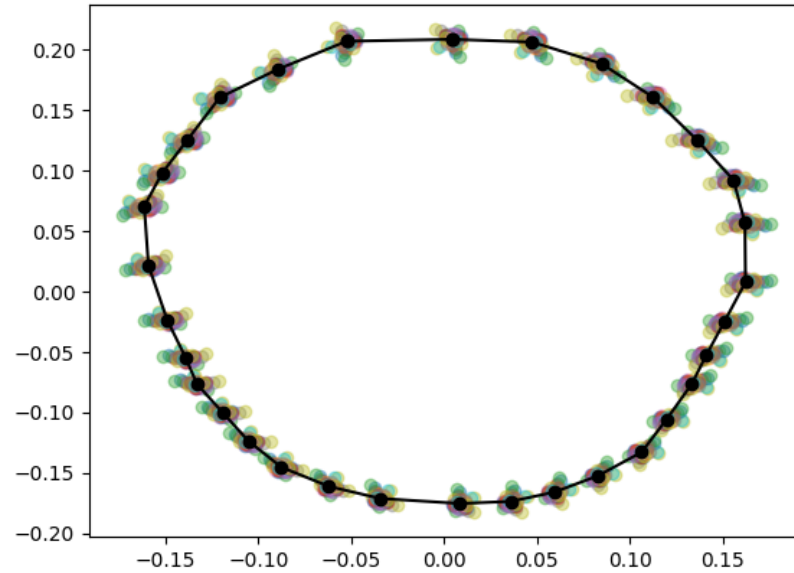


Figure 33:

### 3.4.3 Part C

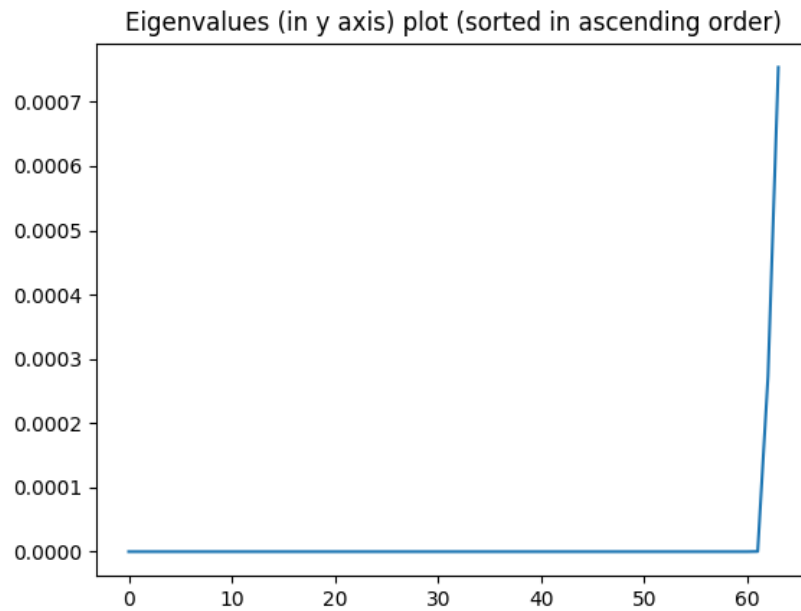


Figure 34: First two eigen values are significantly greater than other eigen values which are close to zero

### 3.4.4 Part D

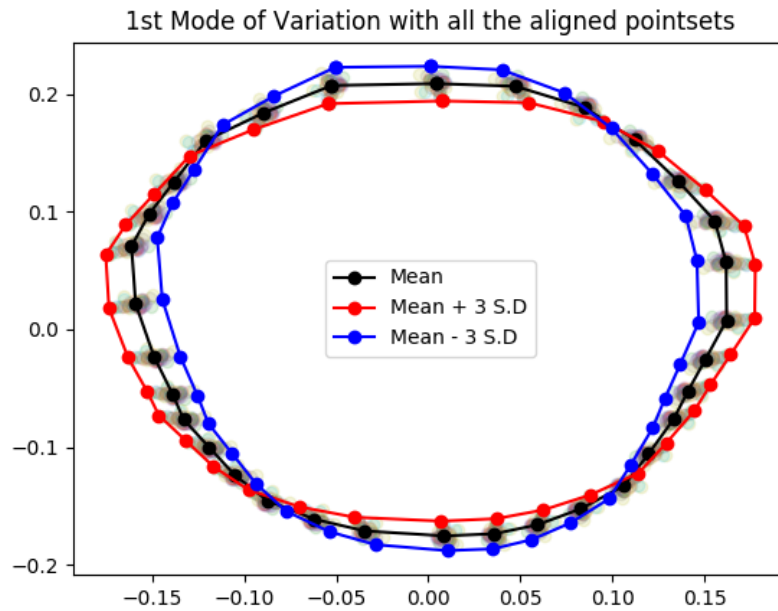


Figure 35: First Mode of variation seems to capture the brain shape thickness. Mean+3 standard deviations brain shape is shorter in vertical direction and longer in horizontal direction and vice-versa for Mean-3 standard deviations brain shape.

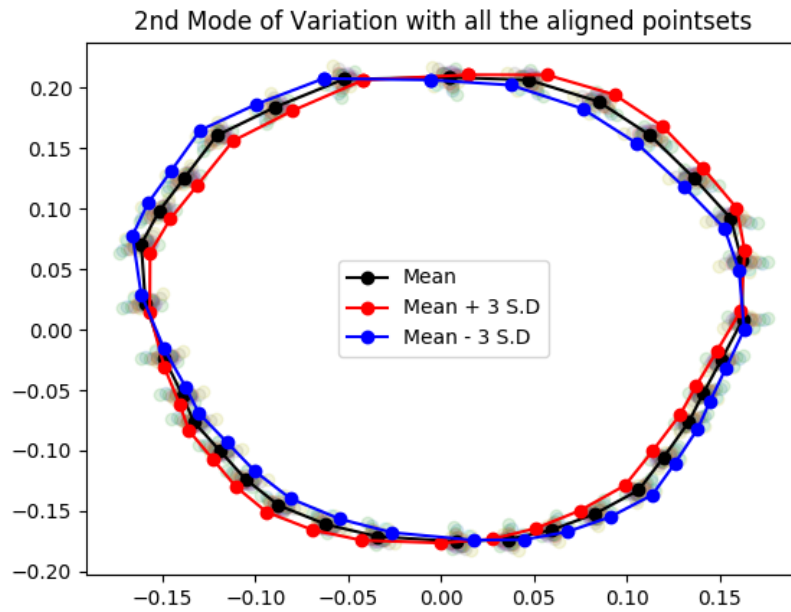


Figure 36: Second Mode of variation seems to capture the brain rotation. Mean+3 standard deviations hand is slightly tilted towards right while Mean-3 standard deviations hand is slightly tilted towards left

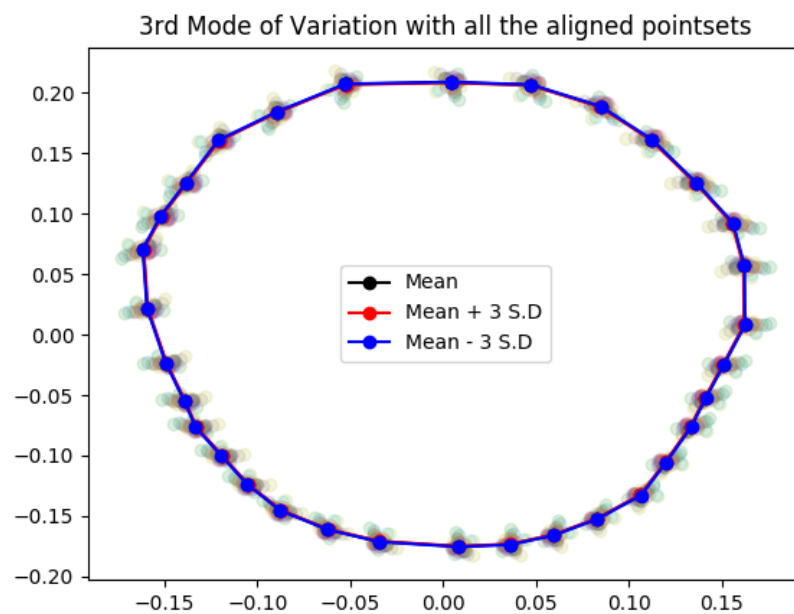


Figure 37: As the 3rd greatest eigenvalue is very small, the third mode of variation does not seem to capture anything and all the three shapes almost overlap.

### 3.4.5 Part E

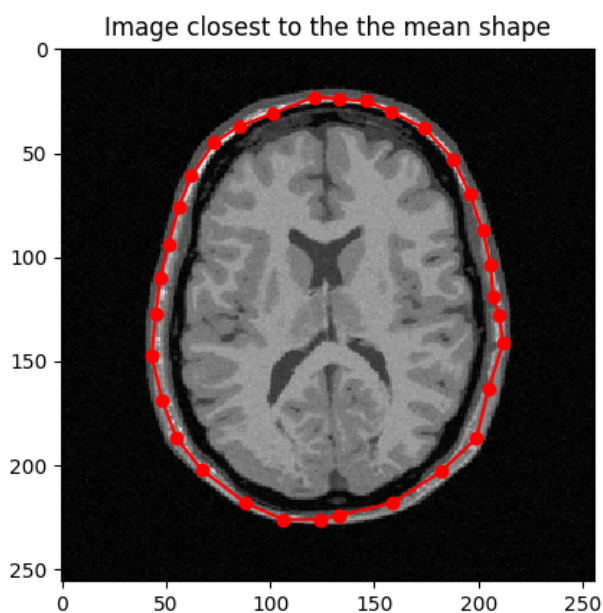


Figure 38:

Image closest to Mean shape +3 S.D along the top mode of variation

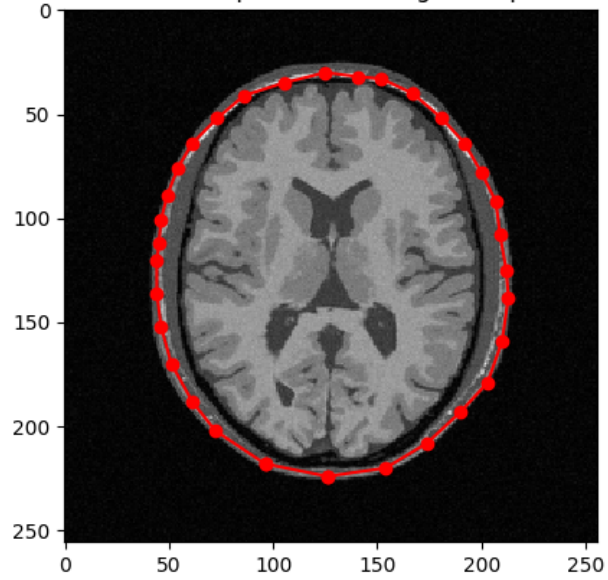


Figure 39: Thinner and shorter than mean shape

Image closest to Mean shape -3 S.D along the top mode of variation

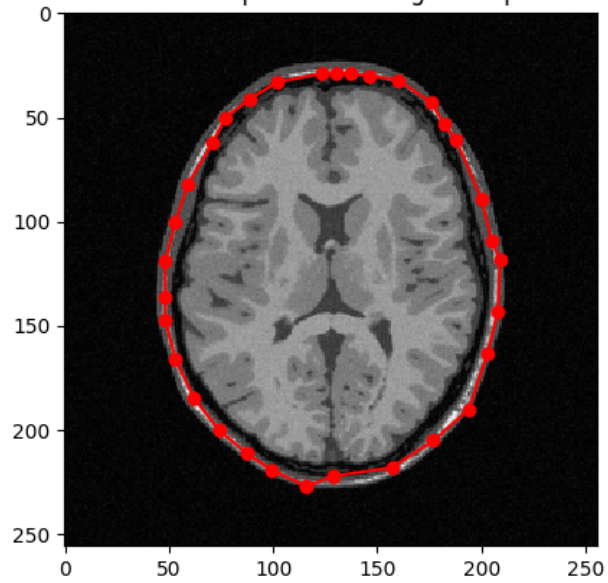


Figure 40: Thinner and longer than mean shape