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MyMainScript

```
clc; clear;
tic;
```

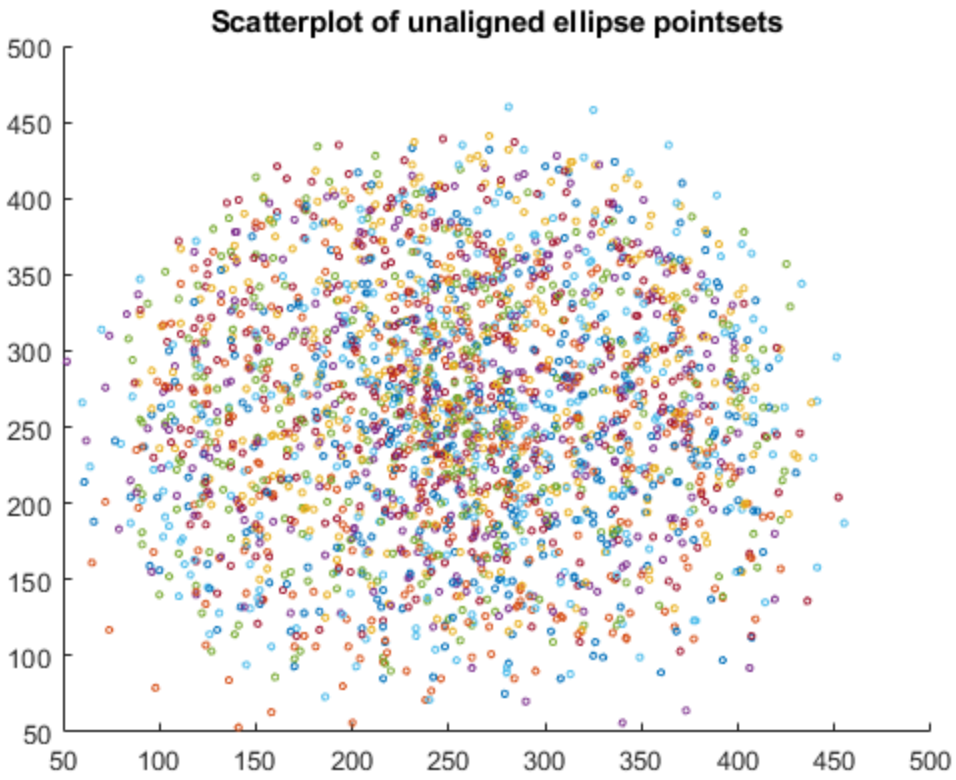
NOTE

```
% Please ensure that image processing toolbox is installed as well.
% The ellipses may not be closed due to the pointset generation
 procedure
% used.
% The .mat files for ellipse, leaf and brain dataset are generated
% manually using traceBoundaries.m which is included in the folder.
```

Reading ellipse data

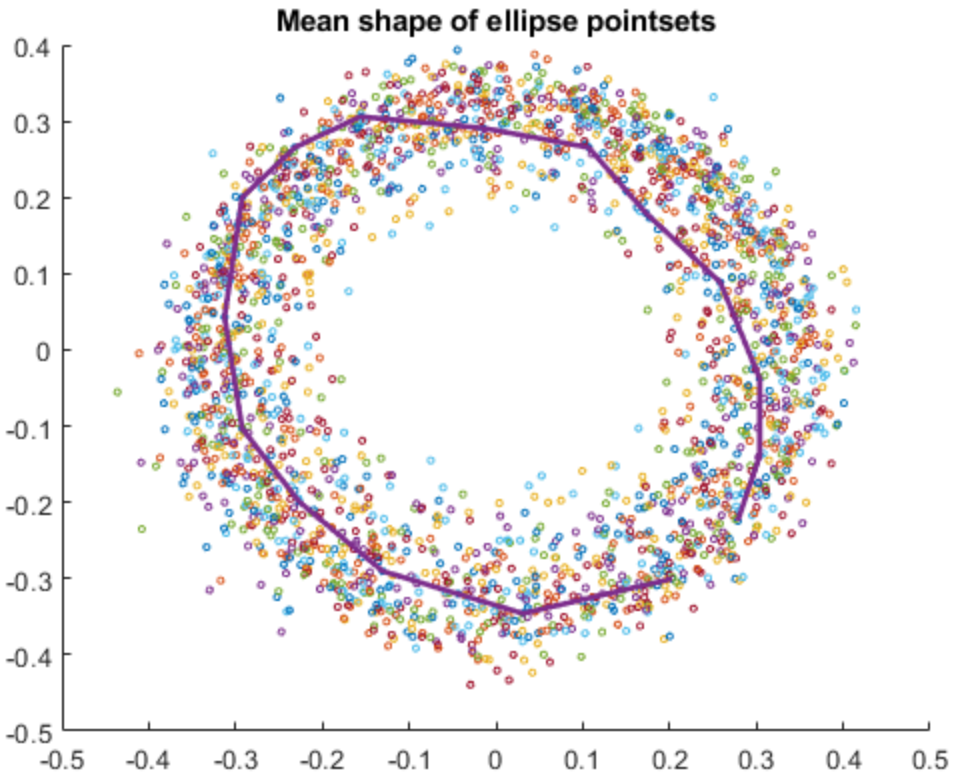
```
filePath = "../data/ellipse/data/";
%tracingBoundaries(".jpg", 150, 16, filePath);
data = load("../data/ellipse.mat");
imgs = data.shapes;

[dims, m, n] = size(imgs);
```

```
% plotting all the ellipses
figure
hold on
for i = 1:n
    scatter(imgs(1, :, i), imgs(2, :, i), 6);
end
title("Scatterplot of unaligned ellipse pointsets");
hold off
```



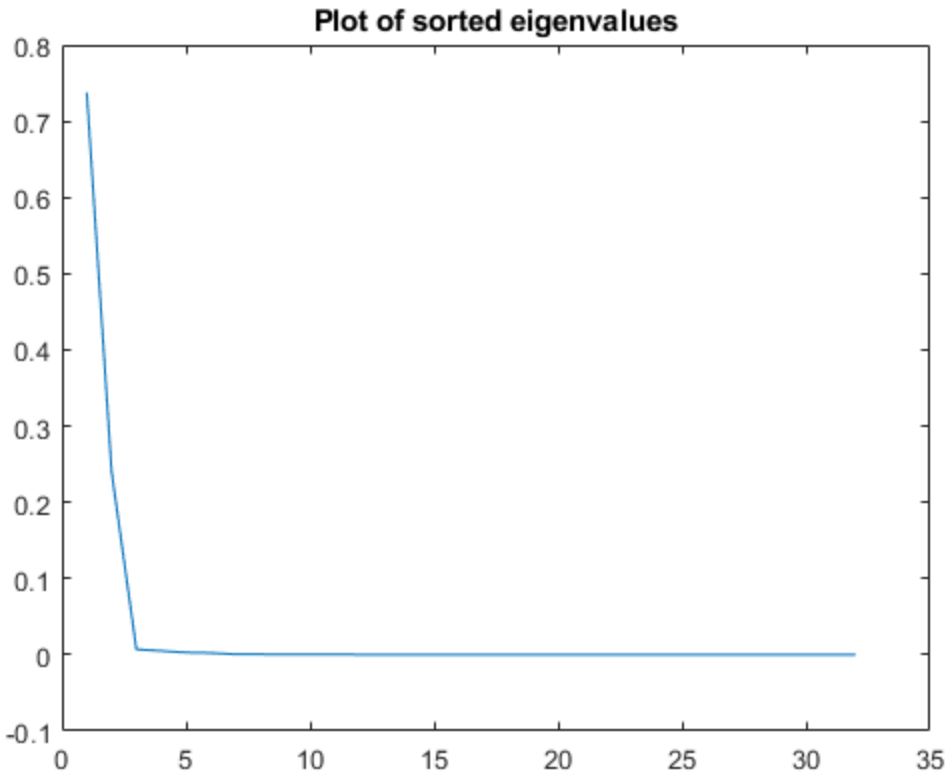
Mean shape of ellipse data

```
[ms, newPS] = meanShape(imgs);
figure
hold on
for i = 1:n
    scatter(newPS(1, :, i), newPS(2, :, i), 6);
end
plot(ms(1, :), ms(2, :), 'LineWidth', 2);
title("Mean shape of ellipse pointsets");
hold off
```



Eigenvalues calculation

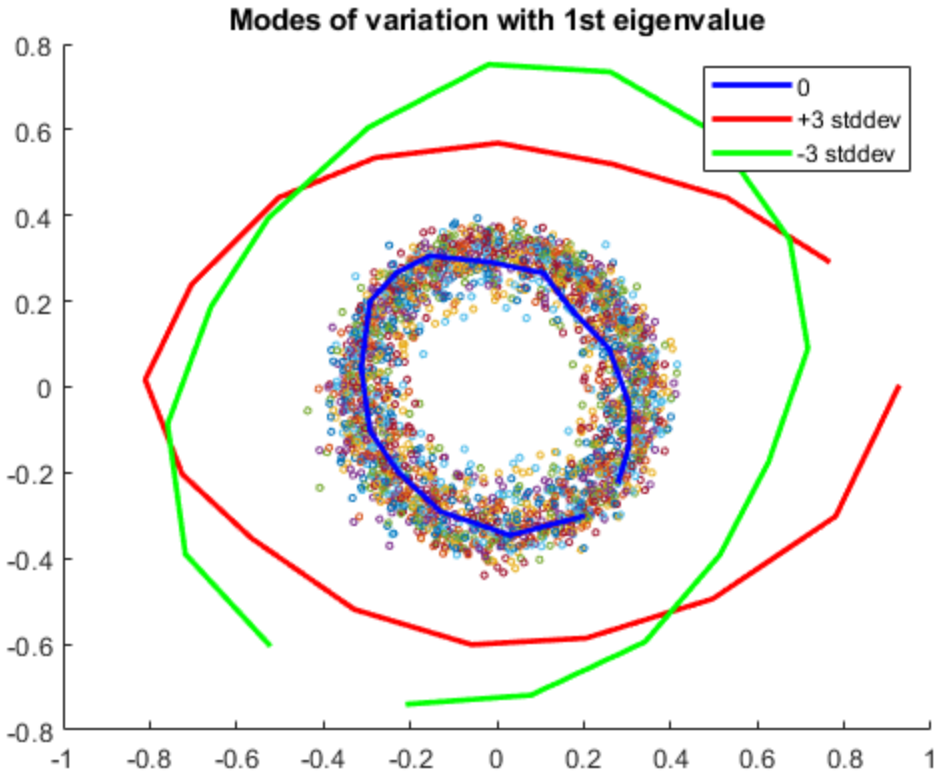
```
[D, W] = eigenCalc(newPS);
figure
plot(D);
title("Plot of sorted eigenvalues");
```

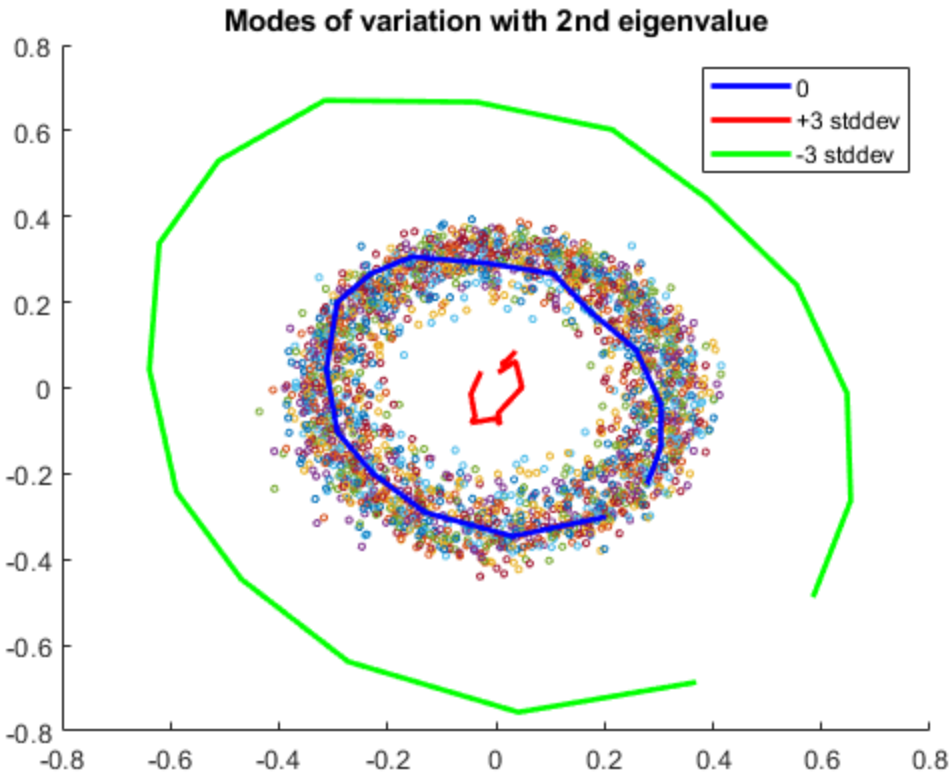


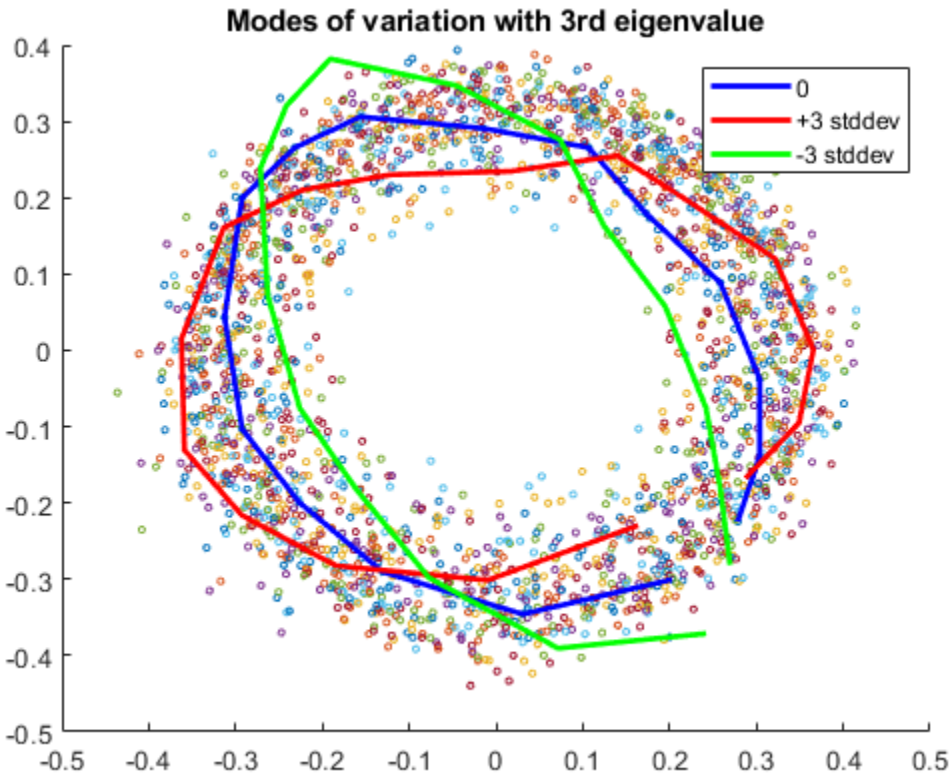
Top 3 modes of varations

```
% 1st eigenvalue
ms1 = ms + 3 * sqrt(D(1)) * reshape(W(:, 1), [2, m]);
ms2 = ms - 3 * sqrt(D(1)) * reshape(W(:, 1), [2, m]);
figure
hold on
for i = 1:n
    scatter(newPS(1, :, i), newPS(2, :, i), 6);
end
p1 = plot(ms(1, :), ms(2, :), 'Color', 'blue', 'LineWidth', 2);
p2 = plot(ms1(1, :), ms1(2, :), 'Color', 'red', 'LineWidth', 2);
p3 = plot(ms2(1, :), ms2(2, :), 'Color', 'green', 'LineWidth', 2);
title("Modes of variation with 1st eigenvalue");
legend([p1, p2, p3], "0", "+3 stddev", "-3 stddev");
hold off

% 2nd eigenvalue
ms1 = ms + 3 * sqrt(D(2)) * reshape(W(:, 2), [2, m]);
ms2 = ms - 3 * sqrt(D(2)) * reshape(W(:, 2), [2, m]);
figure
hold on
for i = 1:n
    scatter(newPS(1, :, i), newPS(2, :, i), 6);
end
```

```
p1 = plot(ms(1, :), ms(2, :), 'Color', 'blue', 'LineWidth', 2);
p2 = plot(ms1(1, :), ms1(2, :), 'Color', 'red', 'LineWidth', 2);
p3 = plot(ms2(1, :), ms2(2, :), 'Color', 'green', 'LineWidth', 2);
title("Modes of variation with 2nd eigenvalue");
legend([p1, p2, p3], "0", "+3 stddev", "-3 stddev");
hold off

% 3rd eigenvalue
ms1 = ms + 3 * sqrt(D(3)) * reshape(W(:, 3), [2, m]);
ms2 = ms - 3 * sqrt(D(3)) * reshape(W(:, 3), [2, m]);
figure
hold on
for i = 1:n
    scatter(newPS(1, :, i), newPS(2, :, i), 6);
end
p1 = plot(ms(1, :), ms(2, :), 'Color', 'blue', 'LineWidth', 2);
p2 = plot(ms1(1, :), ms1(2, :), 'Color', 'red', 'LineWidth', 2);
p3 = plot(ms2(1, :), ms2(2, :), 'Color', 'green', 'LineWidth', 2);
title("Modes of variation with 3rd eigenvalue");
legend([p1, p2, p3], "0", "+3 stddev", "-3 stddev");
hold off
```

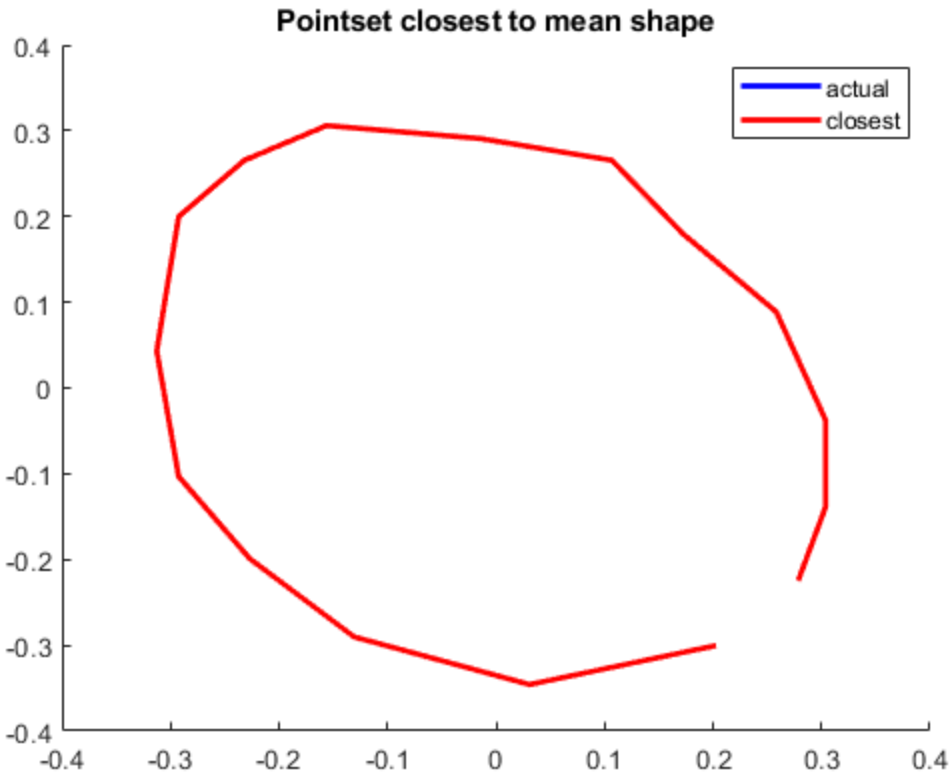


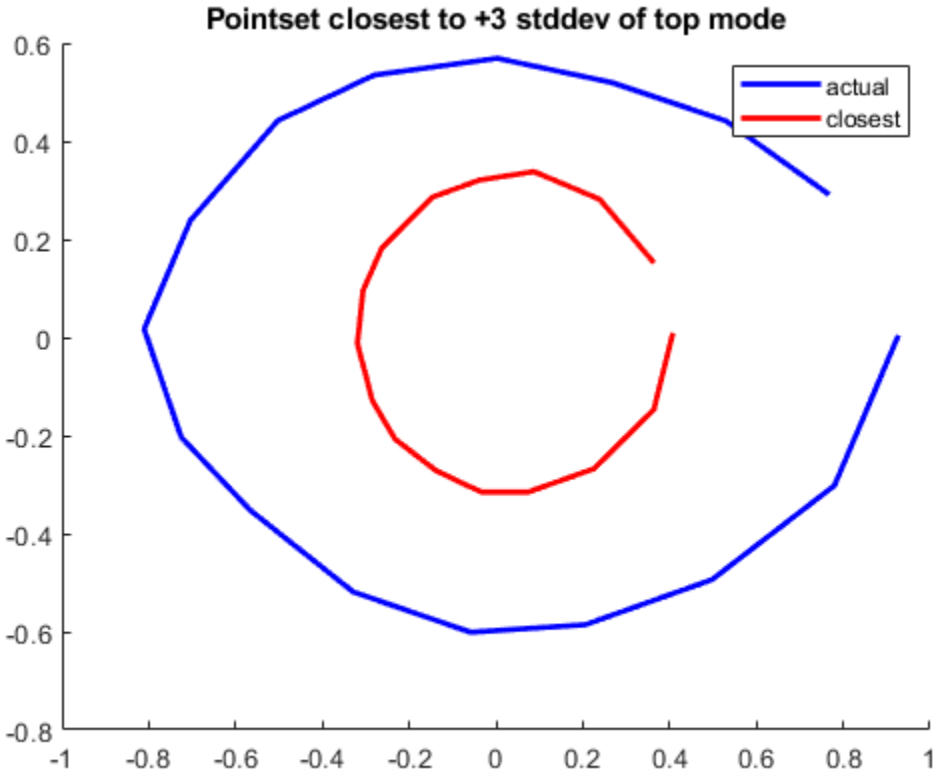

Modes of variation with 2nd eigenvalue
0
+3 stddev
-3 stddev
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8

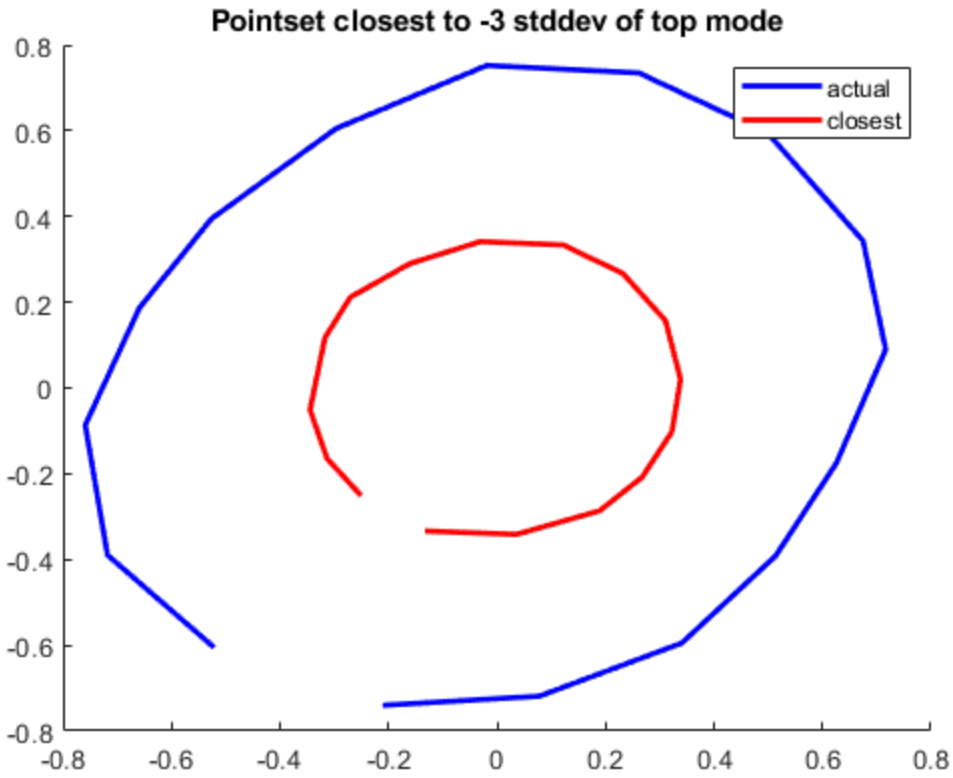

Modes of variation with 3rd eigenvalue
0
+3 stddev
-3 stddev
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.5
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
0.4
0.5

Closest pointsets

```
ms1 = ms + 3 * sqrt(D(1)) * reshape(W(:, 1), [2, m]);
ms2 = ms - 3 * sqrt(D(1)) * reshape(W(:, 1), [2, m]);

% Closest to mean shape
ps = findMinErrorPS(newPS, ms);
figure
hold on
p1 = plot(ms(1, :), ms(2, :), 'Color', 'blue', 'LineWidth', 2);
p2 = plot(ps(1, :), ps(2, :), 'Color', 'red', 'LineWidth', 2);
title("Pointset closest to mean shape");
legend([p1, p2], "actual", "closest");
hold off

% Closest to +3 stddev
ps = findMinErrorPS(newPS, ms1);
figure
hold on
p1 = plot(ms1(1, :), ms1(2, :), 'Color', 'blue', 'LineWidth', 2);
p2 = plot(ps(1, :), ps(2, :), 'Color', 'red', 'LineWidth', 2);
title("Pointset closest to +3 stddev of top mode");
legend([p1, p2], "actual", "closest");
hold off

% Closest to -3 stddev
ps = findMinErrorPS(newPS, ms2);
figure
hold on
p1 = plot(ms2(1, :), ms2(2, :), 'Color', 'blue', 'LineWidth', 2);
p2 = plot(ps(1, :), ps(2, :), 'Color', 'red', 'LineWidth', 2);
title("Pointset closest to -3 stddev of top mode");
legend([p1, p2], "actual", "closest");
hold off
```

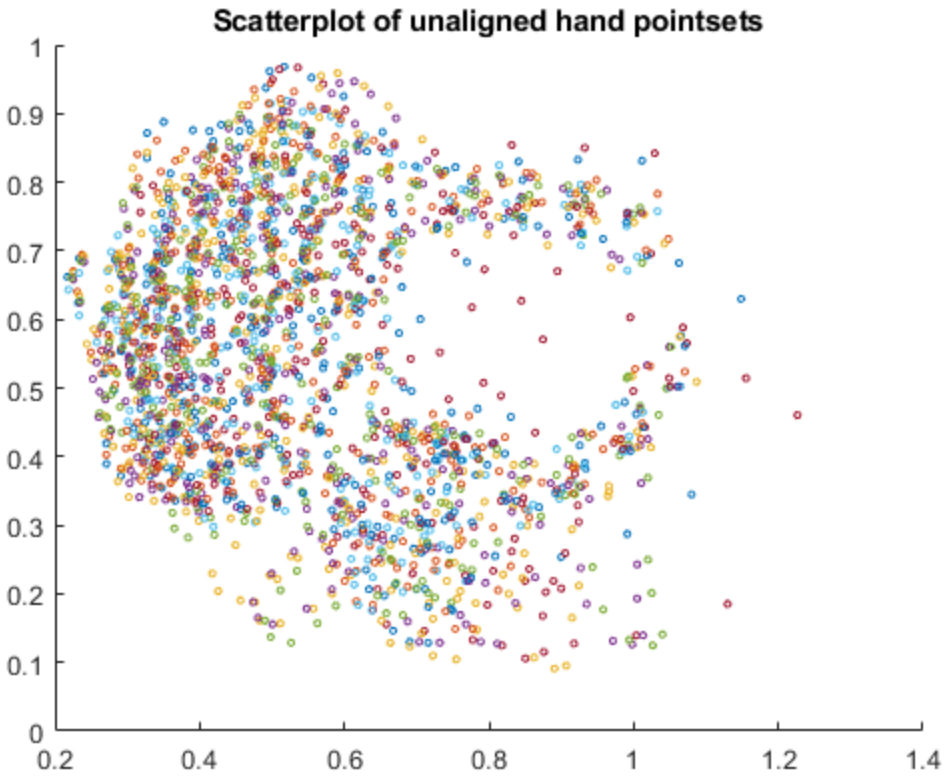

Pointset closest to mean shape
actual
closest
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
0.4


Pointset closest to +3 stddev of top mode
actual
closest
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1



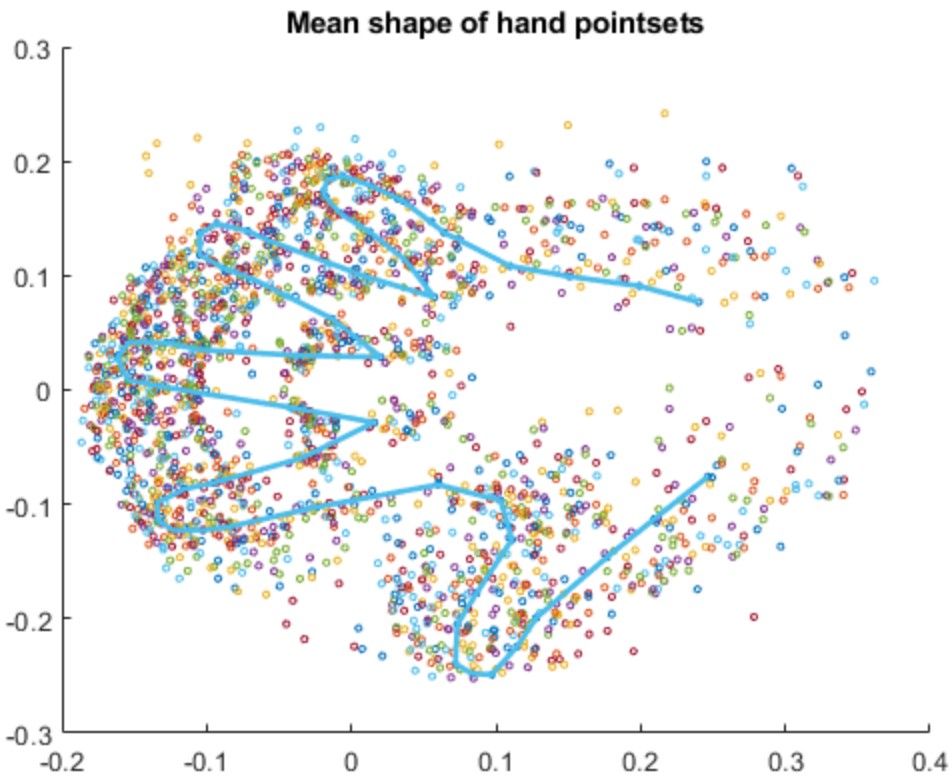
Reading hand data

```
data = load("../data/hand/data.mat");
imgs = data.shapes;

[dims, m, n] = size(imgs);

% plotting all the hands
figure
hold on
for i = 1:n
    scatter(imgs(1, :, i), imgs(2, :, i), 6);
end
title("Scatterplot of unaligned hand pointsets");
hold off
```



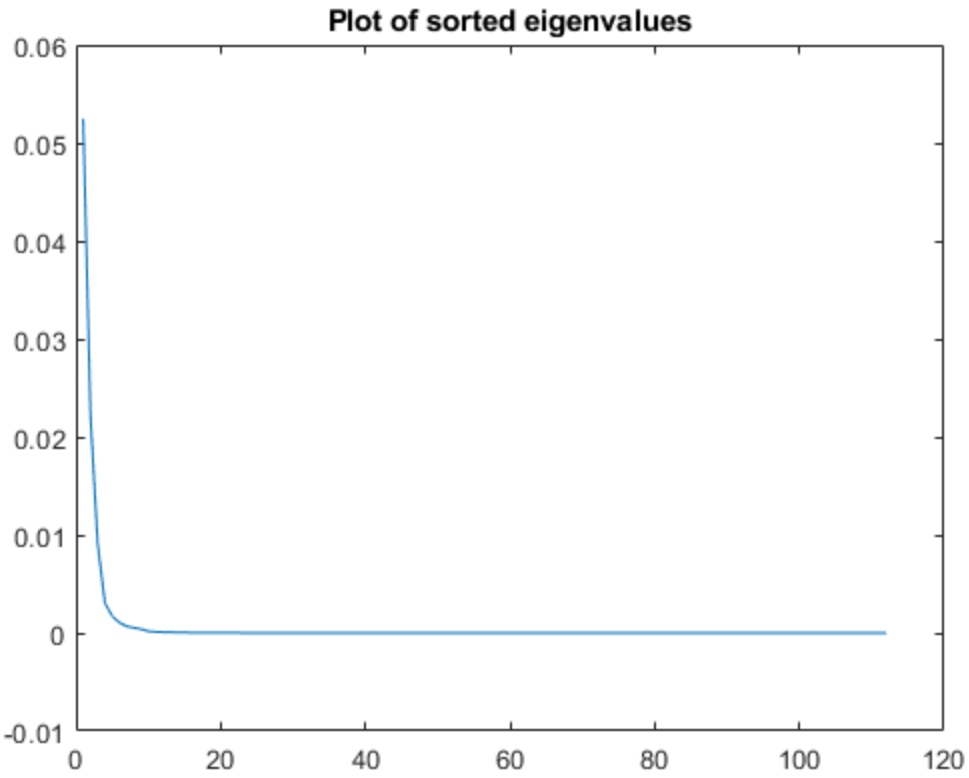
Mean shape of hand data

```
[ms, newPS] = meanShape(imgs);
figure
hold on
for i = 1:n
    scatter(newPS(1, :, i), newPS(2, :, i), 6);
end
plot(ms(1, :), ms(2, :), 'LineWidth', 2);
title("Mean shape of hand pointsets");
hold off
```



Eigenvalues calculation

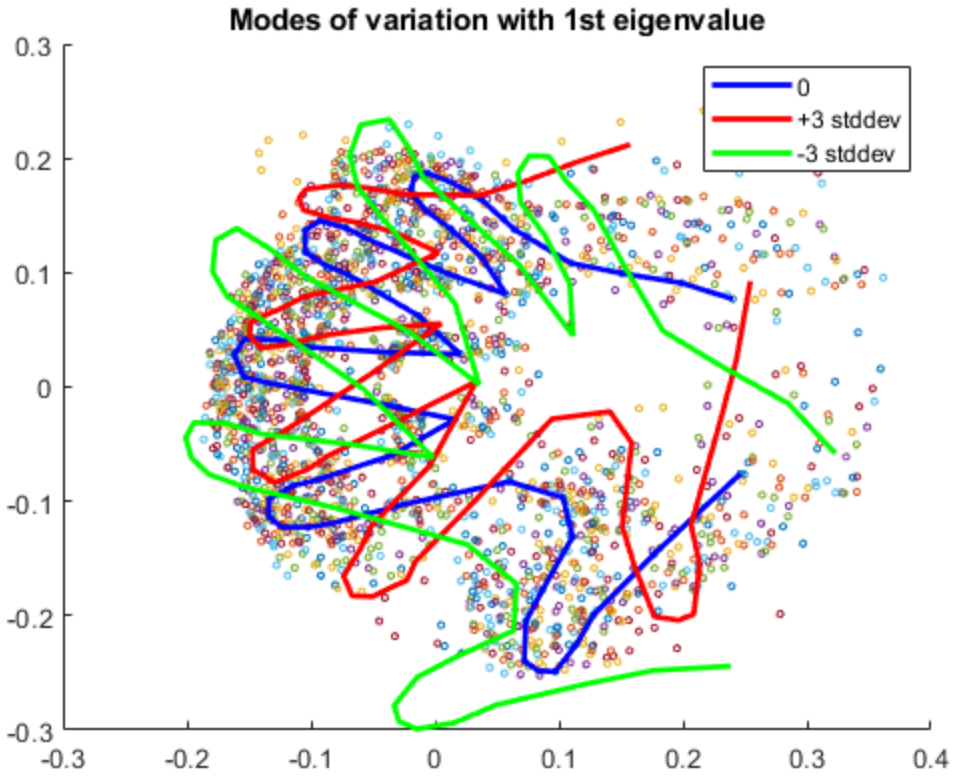
```
[D, W] = eigenCalc(newPS);
figure
plot(D);
title("Plot of sorted eigenvalues");
```

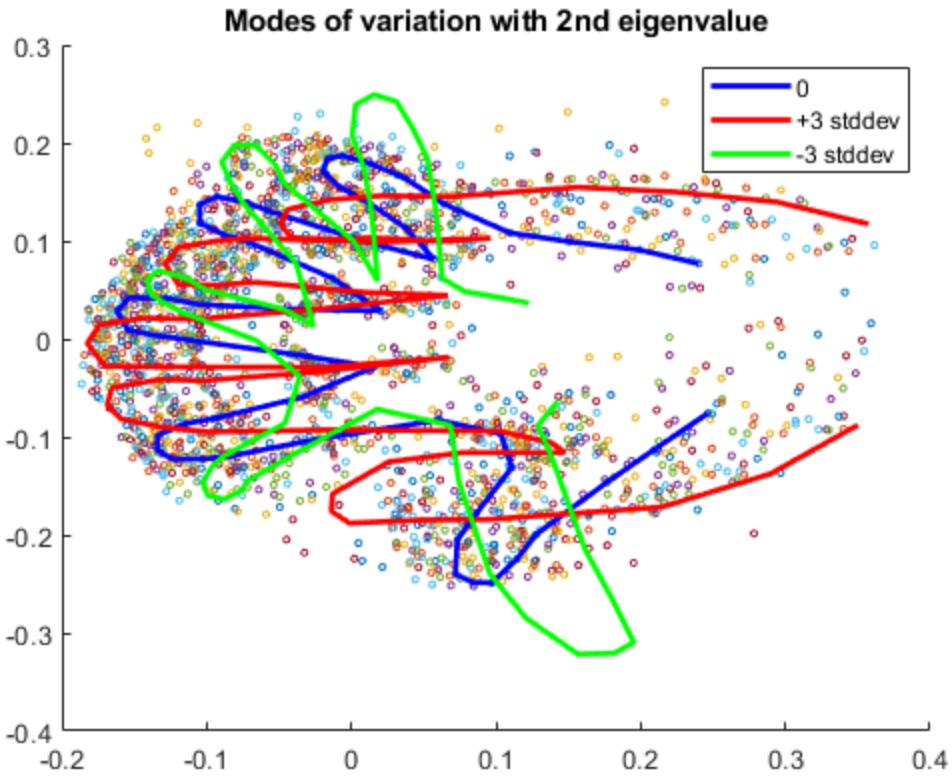


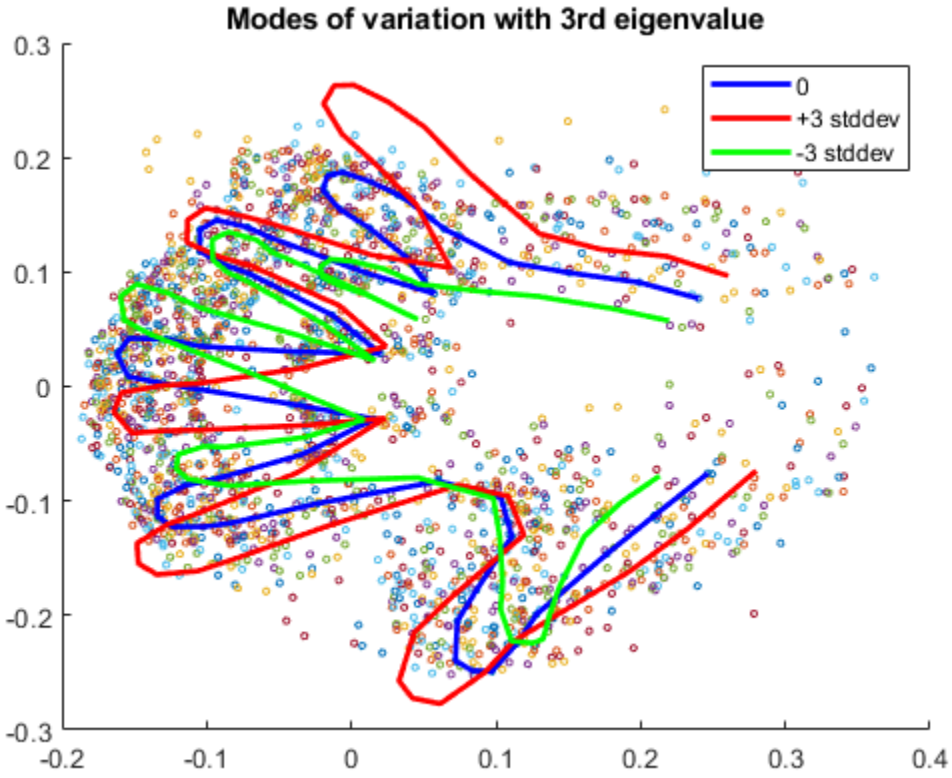
Top 3 modes of varations

```
% 1st eigenvalue
ms1 = ms + 3 * sqrt(D(1)) * reshape(W(:, 1), [2, m]);
ms2 = ms - 3 * sqrt(D(1)) * reshape(W(:, 1), [2, m]);
figure
hold on
for i = 1:n
    scatter(newPS(1, :, i), newPS(2, :, i), 6);
end
p1 = plot(ms(1, :), ms(2, :), 'Color', 'blue', 'LineWidth', 2);
p2 = plot(ms1(1, :), ms1(2, :), 'Color', 'red', 'LineWidth', 2);
p3 = plot(ms2(1, :), ms2(2, :), 'Color', 'green', 'LineWidth', 2);
title("Modes of variation with 1st eigenvalue");
legend([p1, p2, p3], "0", "+3 stddev", "-3 stddev");
hold off

% 2nd eigenvalue
ms1 = ms + 3 * sqrt(D(2)) * reshape(W(:, 2), [2, m]);
ms2 = ms - 3 * sqrt(D(2)) * reshape(W(:, 2), [2, m]);
figure
hold on
for i = 1:n
    scatter(newPS(1, :, i), newPS(2, :, i), 6);
end
```

```
p1 = plot(ms(1, :), ms(2, :), 'Color', 'blue', 'LineWidth', 2);
p2 = plot(ms1(1, :), ms1(2, :), 'Color', 'red', 'LineWidth', 2);
p3 = plot(ms2(1, :), ms2(2, :), 'Color', 'green', 'LineWidth', 2);
title("Modes of variation with 2nd eigenvalue");
legend([p1, p2, p3], "0", "+3 stddev", "-3 stddev");
hold off

% 3rd eigenvalue
ms1 = ms + 3 * sqrt(D(3)) * reshape(W(:, 3), [2, m]);
ms2 = ms - 3 * sqrt(D(3)) * reshape(W(:, 3), [2, m]);
figure
hold on
for i = 1:n
    scatter(newPS(1, :, i), newPS(2, :, i), 6);
end
p1 = plot(ms(1, :), ms(2, :), 'Color', 'blue', 'LineWidth', 2);
p2 = plot(ms1(1, :), ms1(2, :), 'Color', 'red', 'LineWidth', 2);
p3 = plot(ms2(1, :), ms2(2, :), 'Color', 'green', 'LineWidth', 2);
title("Modes of variation with 3rd eigenvalue");
legend([p1, p2, p3], "0", "+3 stddev", "-3 stddev");
hold off
```

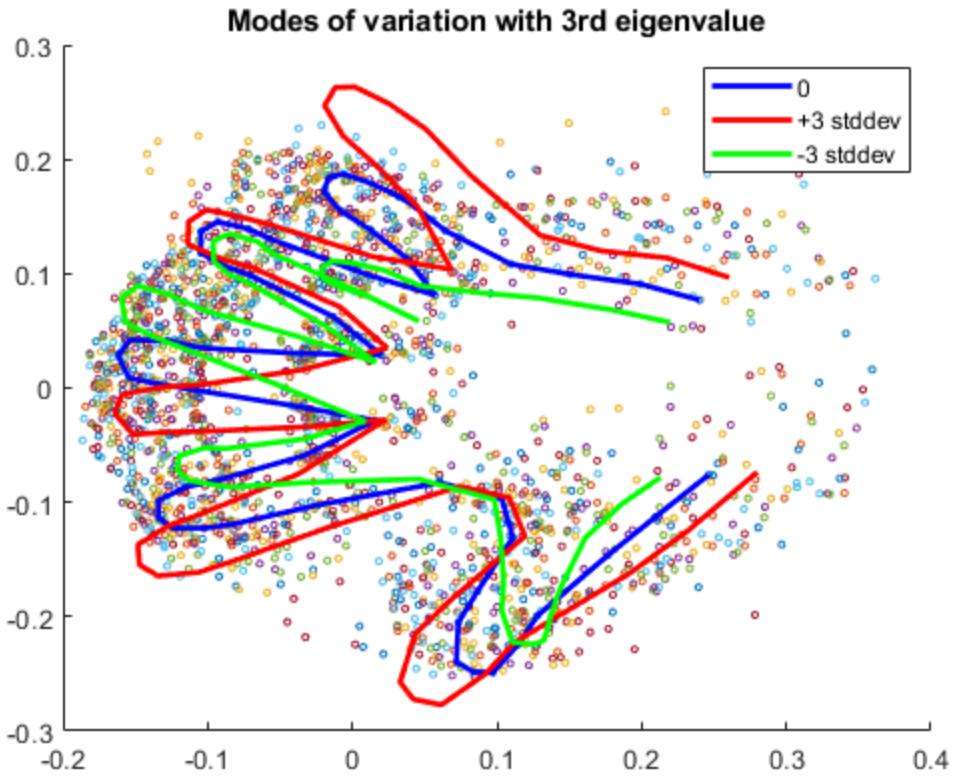


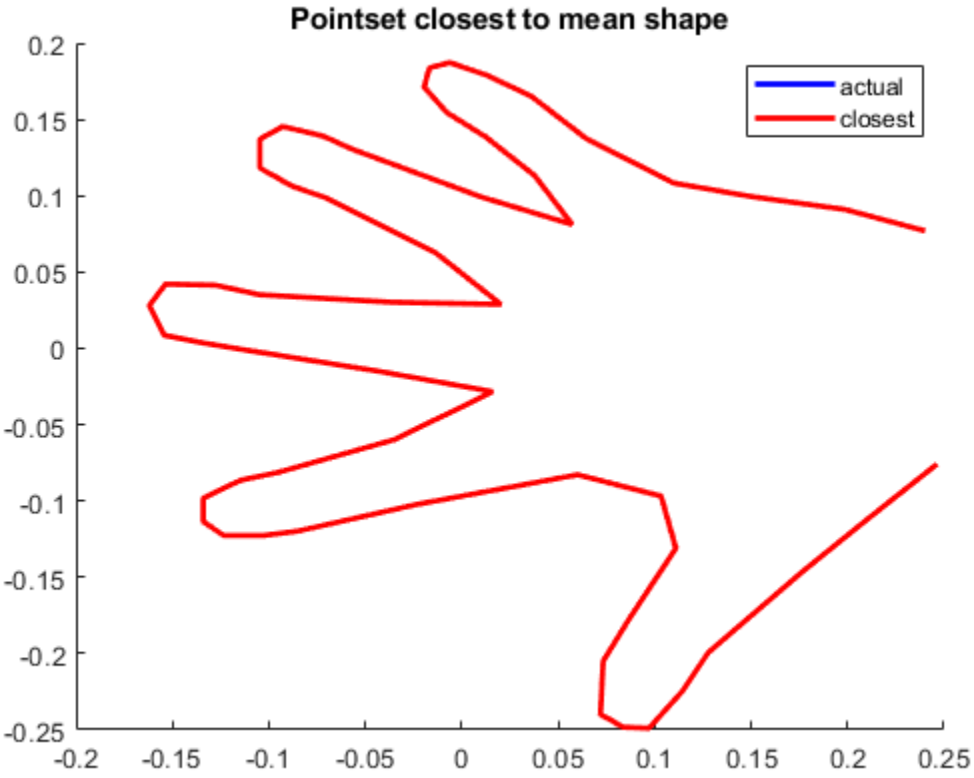

Modes of variation with 2nd eigenvalue
0
+3 stddev
-3 stddev
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.2
-0.1
0
0.1
0.2
0.3
0.4

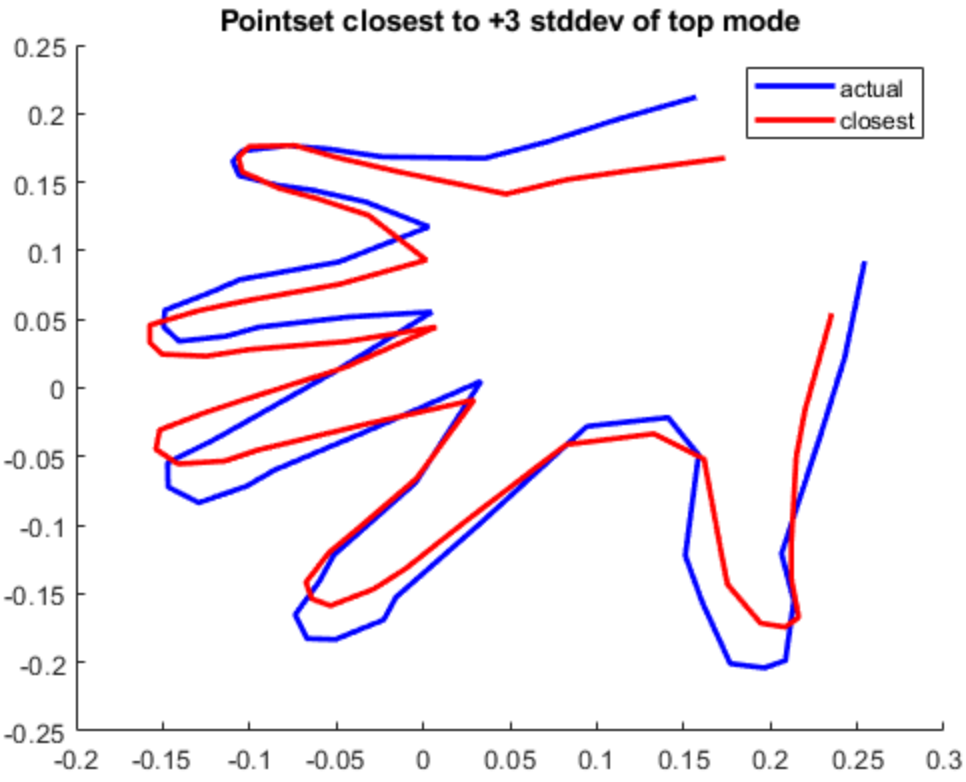

Modes of variation with 3rd eigenvalue
0
+3 stddev
-3 stddev
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
0.4

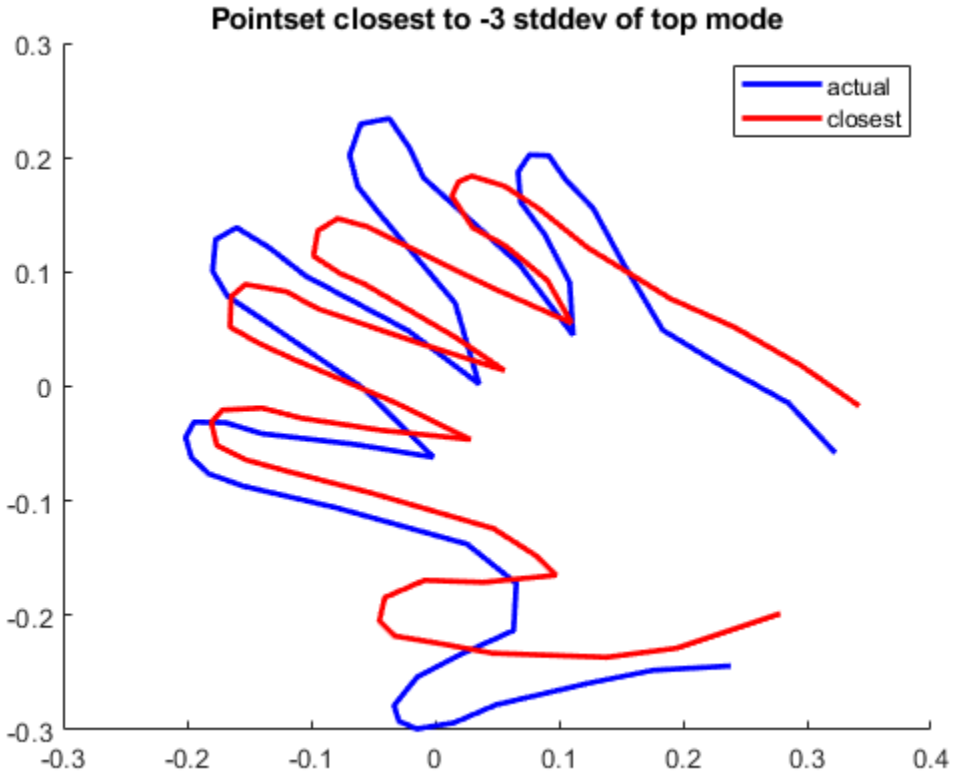
Closest pointsets

```
ms1 = ms + 3 * sqrt(D(1)) * reshape(W(:, 1), [2, m]);
ms2 = ms - 3 * sqrt(D(1)) * reshape(W(:, 1), [2, m]);

% Closest to mean shape
ps = findMinErrorPS(newPS, ms);
figure
hold on
p1 = plot(ms(1, :), ms(2, :), 'Color', 'blue', 'LineWidth', 2);
p2 = plot(ps(1, :), ps(2, :), 'Color', 'red', 'LineWidth', 2);
title("Pointset closest to mean shape");
legend([p1, p2], "actual", "closest");
hold off

% Closest to +3 stddev
ps = findMinErrorPS(newPS, ms1);
figure
hold on
p1 = plot(ms1(1, :), ms1(2, :), 'Color', 'blue', 'LineWidth', 2);
p2 = plot(ps(1, :), ps(2, :), 'Color', 'red', 'LineWidth', 2);
title("Pointset closest to +3 stddev of top mode");
legend([p1, p2], "actual", "closest");
hold off

% Closest to -3 stddev
ps = findMinErrorPS(newPS, ms2);
figure
hold on
p1 = plot(ms2(1, :), ms2(2, :), 'Color', 'blue', 'LineWidth', 2);
p2 = plot(ps(1, :), ps(2, :), 'Color', 'red', 'LineWidth', 2);
title("Pointset closest to -3 stddev of top mode");
legend([p1, p2], "actual", "closest");
hold off
```


Modes of variation with 3rd eigenvalue
0
+3 stddev
-3 stddev
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
0.4

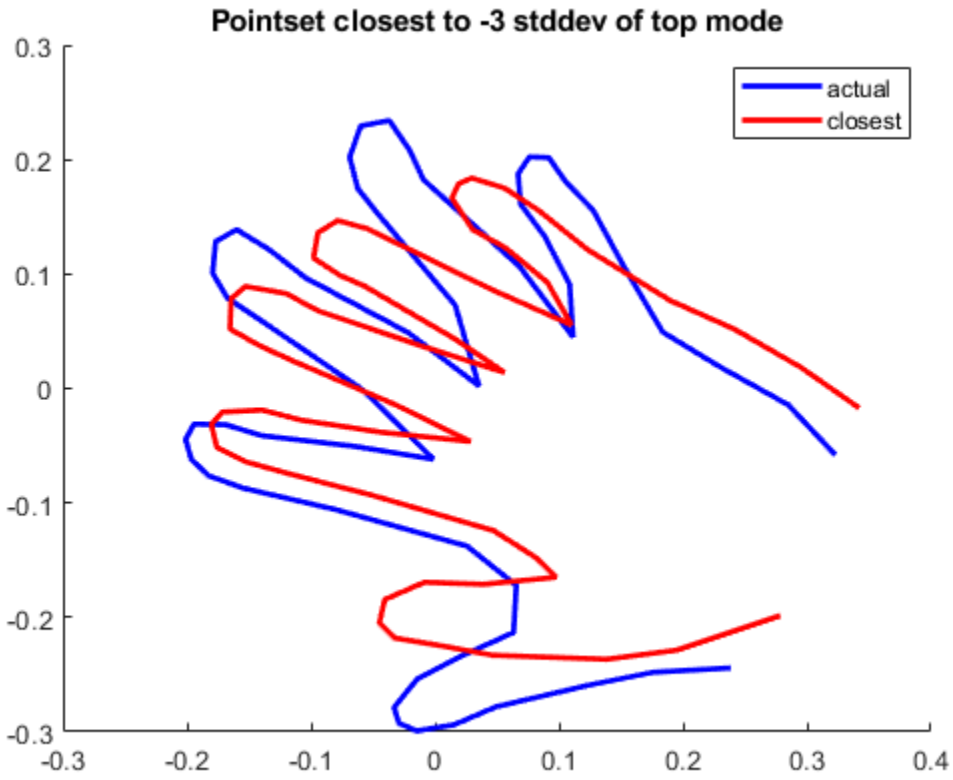

Pointset closest to mean shape
actual
closest
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.2
-0.15
-0.1
-0.05
0
0.05
0.1
0.15
0.2
0.25

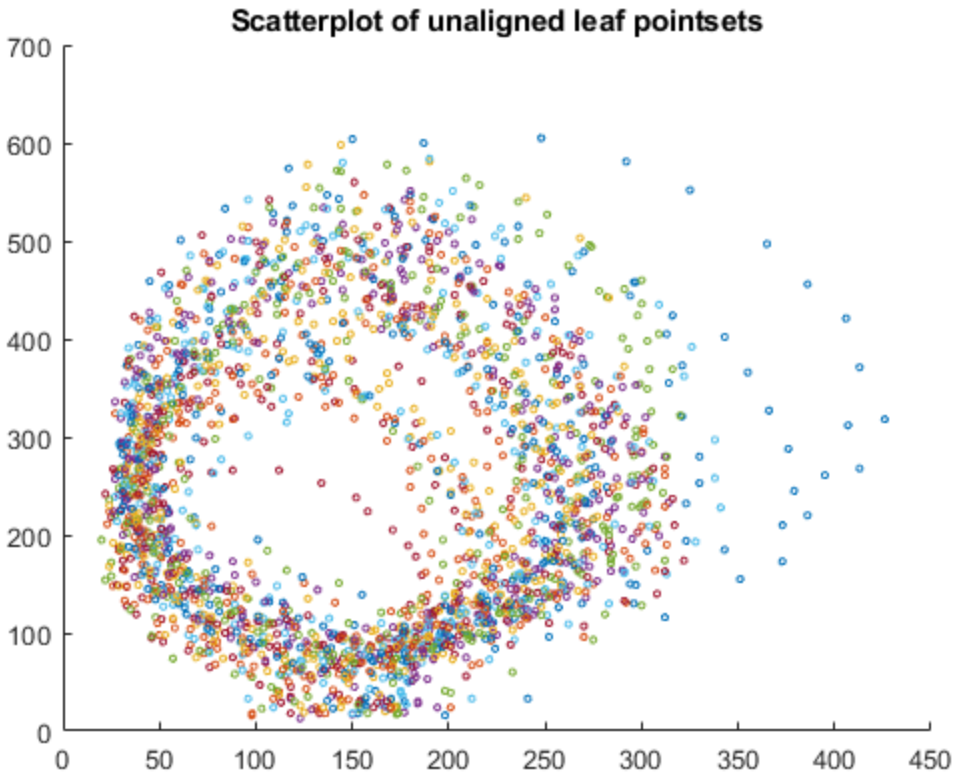

Pointset closest to +3 stddev of top mode
actual
closest
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.2
-0.15
-0.1
-0.05
0
0.05
0.1
0.15
0.2
0.25
0.3


Pointset closest to -3 stddev of top mode
actual
closest
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
0.4

Reading leaf data

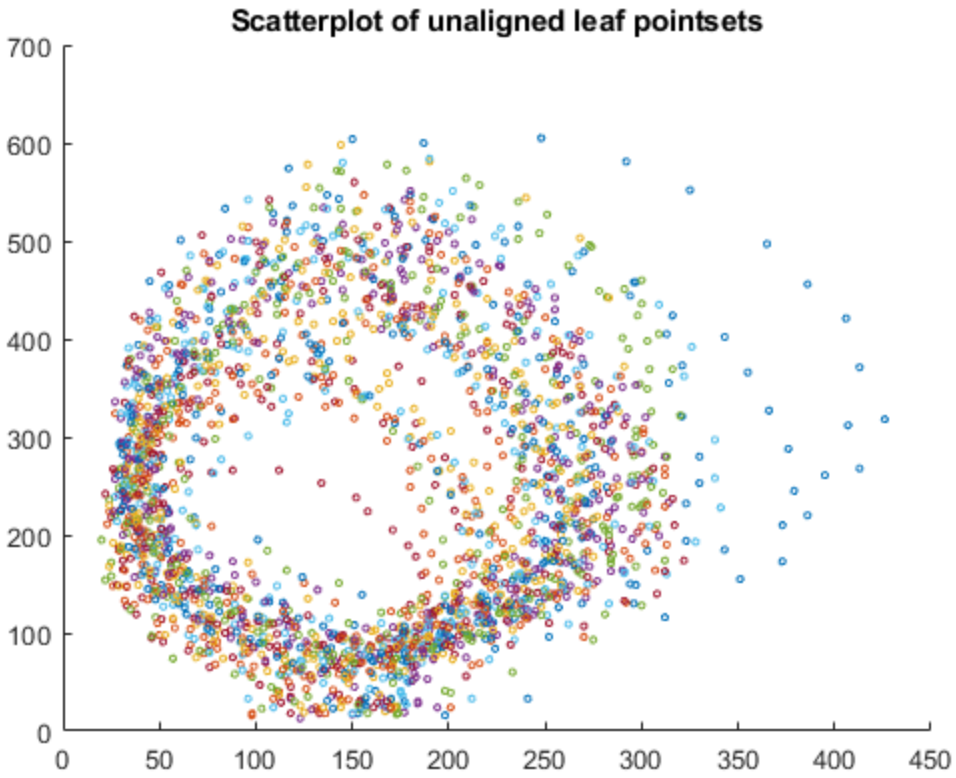
```
filePath = "../data/leaf/data/leaf_";
%tracingBoundaries(".png", 75, 32, filePath);
data = load("../data/leaf.mat");
imgs = data.shapes;

[dims, m, n] = size(imgs);

% plotting all the hands
figure
hold on
for i = 1:n
    scatter(imgs(1, :, i), imgs(2, :, i), 6);
end
title("Scatterplot of unaligned leaf pointsets");
hold off
```

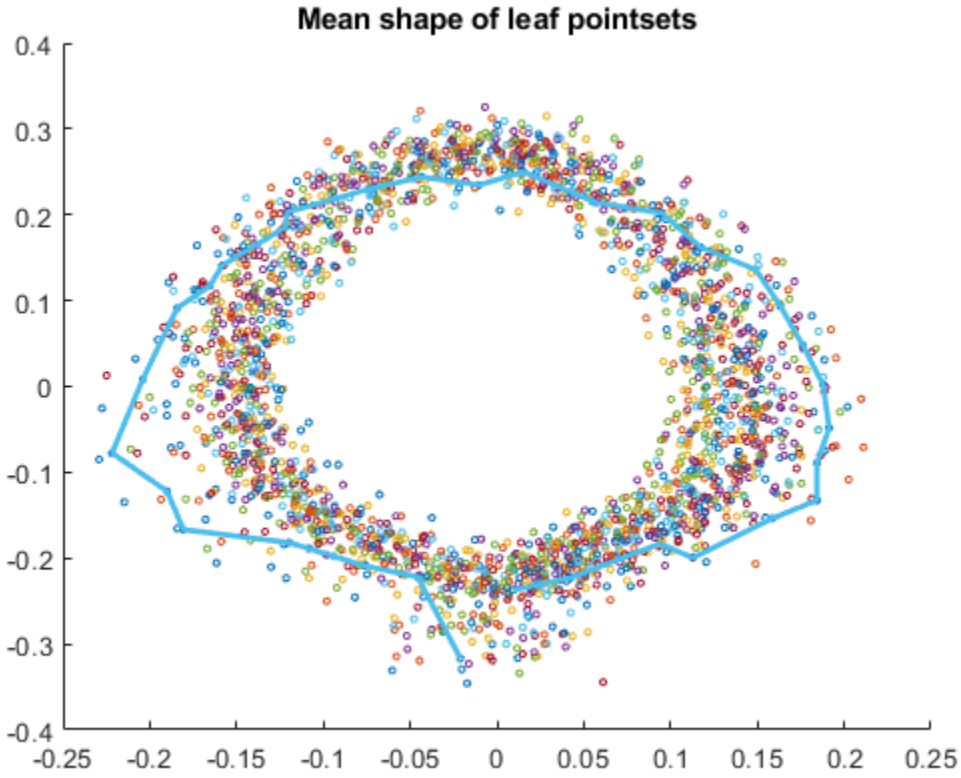




Mean shape of leaf data

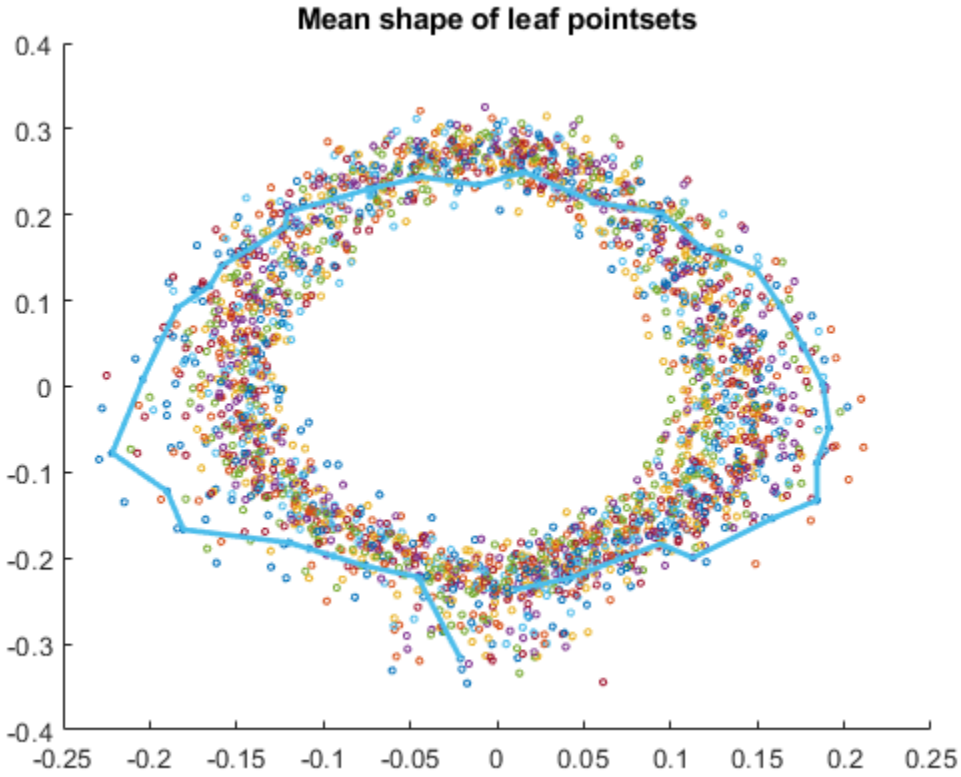
```
[ms, newPS] = meanShape(imgs);
figure
hold on
for i = 1:n
    scatter(newPS(1, :, i), newPS(2, :, i), 6);
end
plot(ms(1, :), ms(2, :), 'LineWidth', 2);
title("Mean shape of leaf pointsets");
hold off
```

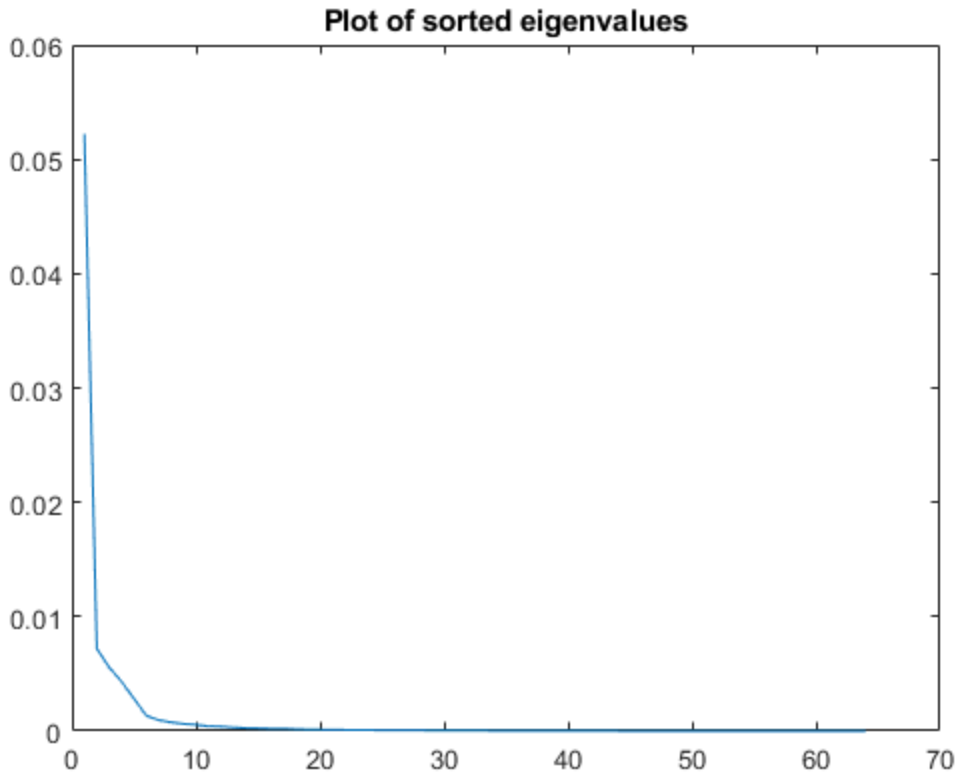

Scatterplot of unaligned leaf pointsets
700
600
500
400
300
200
100
0
0
50
100
150
200
250
300
350
400
450


Mean shape of leaf pointsets
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.25
-0.2
-0.15
-0.1
-0.05
0
0.05
0.1
0.15
0.2
0.25

Eigenvalues calculation

```
[D, W] = eigenCalc(newPS);
figure
plot(D);
title("Plot of sorted eigenvalues");
```

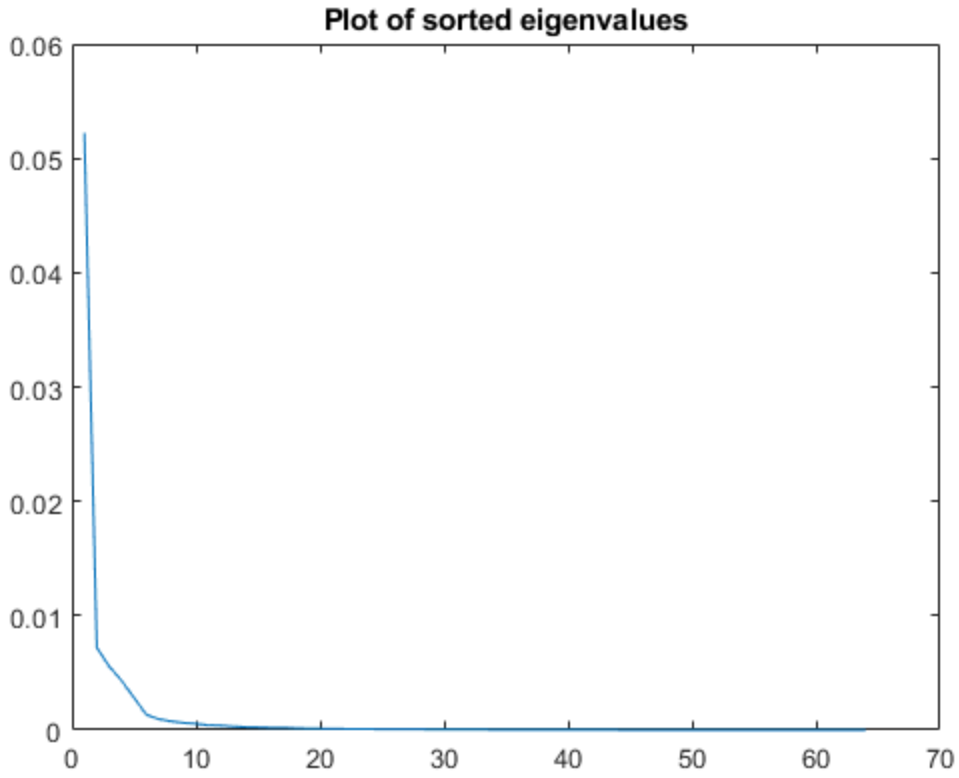


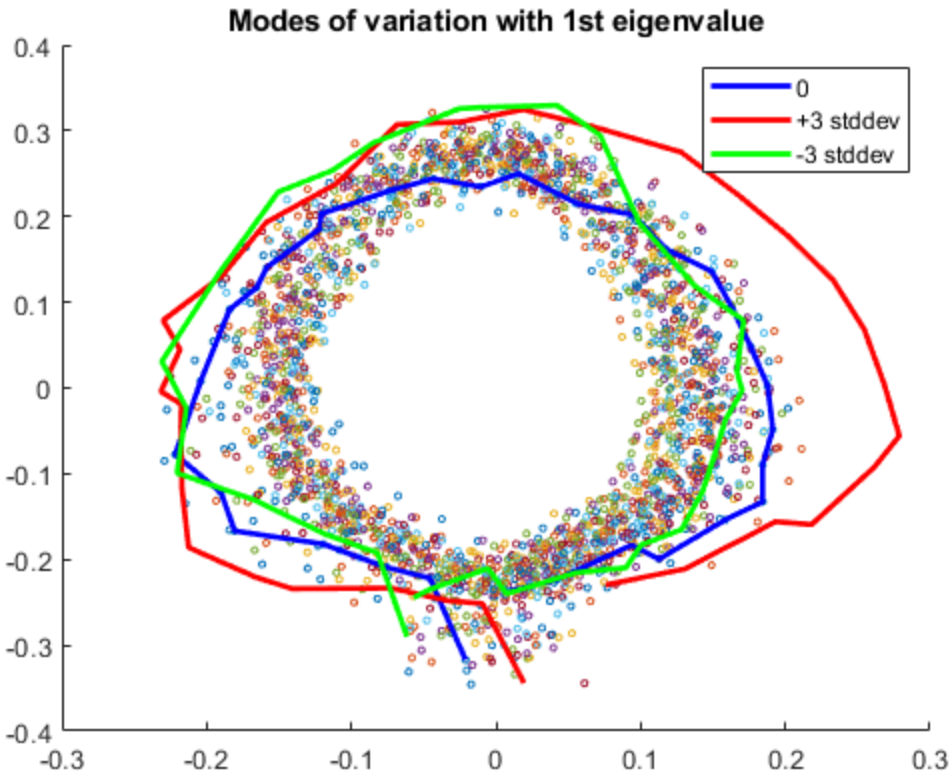


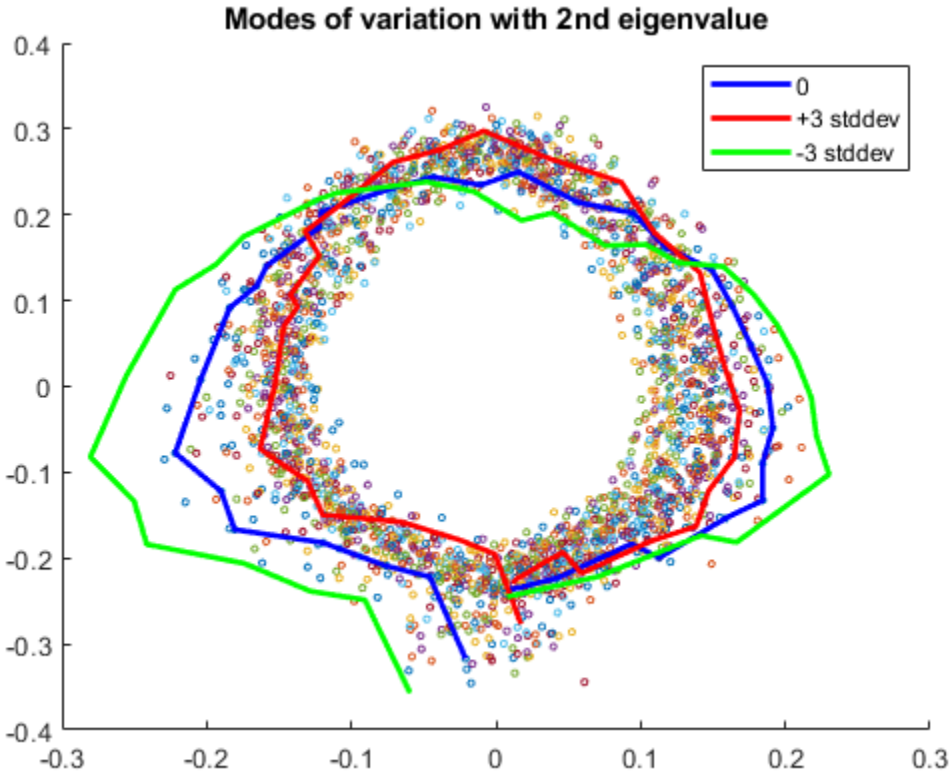
Top 3 modes of varations

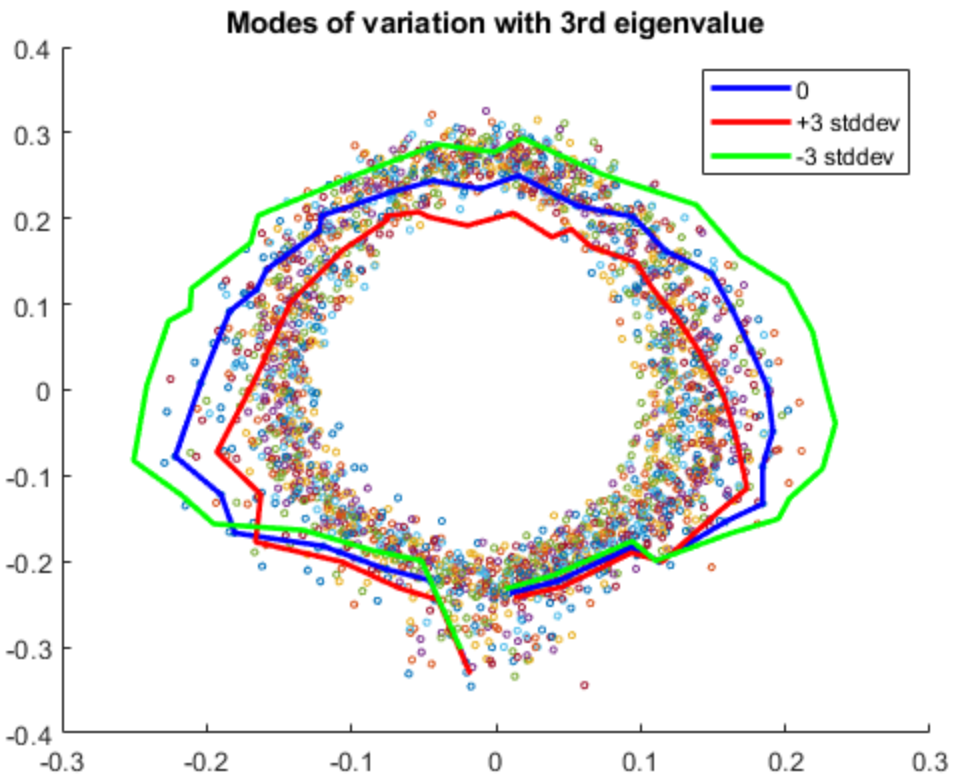
```
% 1st eigenvalue
ms1 = ms + 3 * sqrt(D(1)) * reshape(W(:, 1), [2, m]);
ms2 = ms - 3 * sqrt(D(1)) * reshape(W(:, 1), [2, m]);
figure
hold on
for i = 1:n
    scatter(newPS(1, :, i), newPS(2, :, i), 6);
end
p1 = plot(ms(1, :), ms(2, :), 'Color', 'blue', 'LineWidth', 2);
p2 = plot(ms1(1, :), ms1(2, :), 'Color', 'red', 'LineWidth', 2);
p3 = plot(ms2(1, :), ms2(2, :), 'Color', 'green', 'LineWidth', 2);
title("Modes of variation with 1st eigenvalue");
legend([p1, p2, p3], "0", "+3 stddev", "-3 stddev");
hold off

% 2nd eigenvalue
ms1 = ms + 3 * sqrt(D(2)) * reshape(W(:, 2), [2, m]);
ms2 = ms - 3 * sqrt(D(2)) * reshape(W(:, 2), [2, m]);
figure
hold on
for i = 1:n
    scatter(newPS(1, :, i), newPS(2, :, i), 6);
end
```

```
p1 = plot(ms(1, :), ms(2, :), 'Color', 'blue', 'LineWidth', 2);
p2 = plot(ms1(1, :), ms1(2, :), 'Color', 'red', 'LineWidth', 2);
p3 = plot(ms2(1, :), ms2(2, :), 'Color', 'green', 'LineWidth', 2);
title("Modes of variation with 2nd eigenvalue");
legend([p1, p2, p3], "0", "+3 stddev", "-3 stddev");
hold off

% 3rd eigenvalue
ms1 = ms + 3 * sqrt(D(3)) * reshape(W(:, 3), [2, m]);
ms2 = ms - 3 * sqrt(D(3)) * reshape(W(:, 3), [2, m]);
figure
hold on
for i = 1:n
    scatter(newPS(1, :, i), newPS(2, :, i), 6);
end
p1 = plot(ms(1, :), ms(2, :), 'Color', 'blue', 'LineWidth', 2);
p2 = plot(ms1(1, :), ms1(2, :), 'Color', 'red', 'LineWidth', 2);
p3 = plot(ms2(1, :), ms2(2, :), 'Color', 'green', 'LineWidth', 2);
title("Modes of variation with 3rd eigenvalue");
legend([p1, p2, p3], "0", "+3 stddev", "-3 stddev");
hold off
```




Modes of variation with 1st eigenvalue
0
+3 stddev
-3 stddev
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
0.3

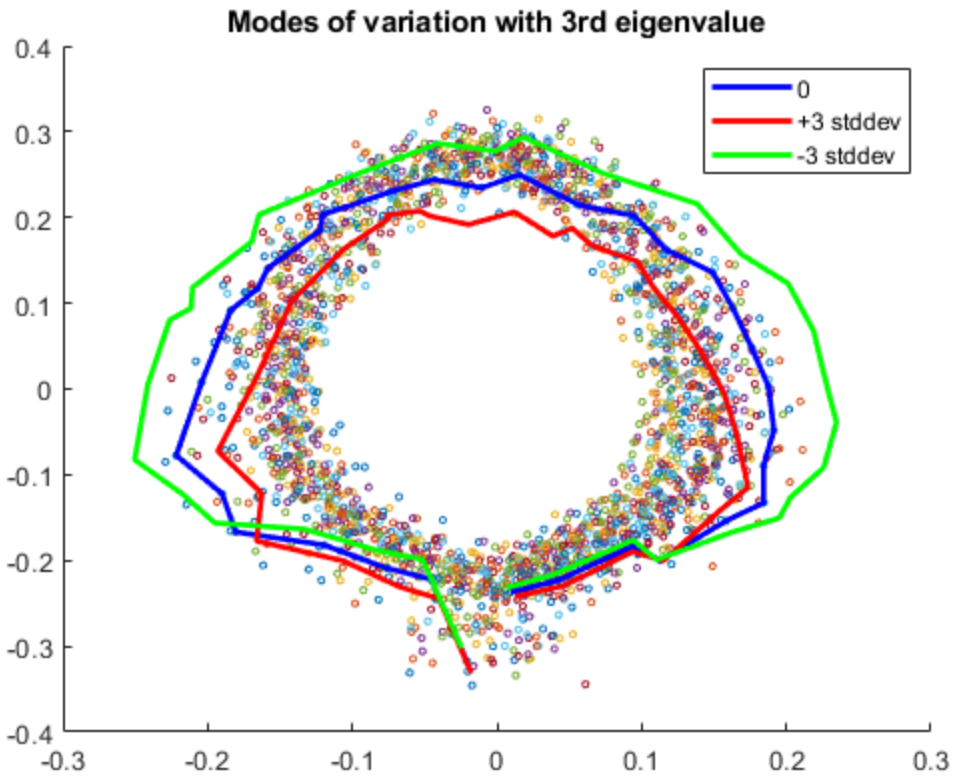

Modes of variation with 2nd eigenvalue
0
+3 stddev
-3 stddev
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
0.3

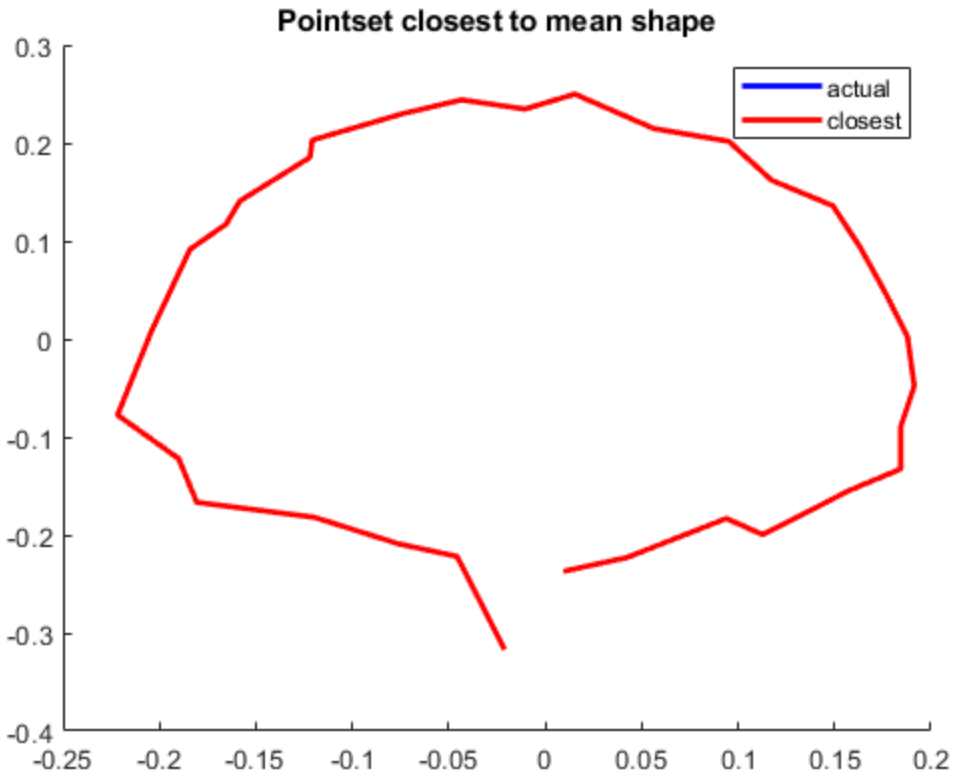


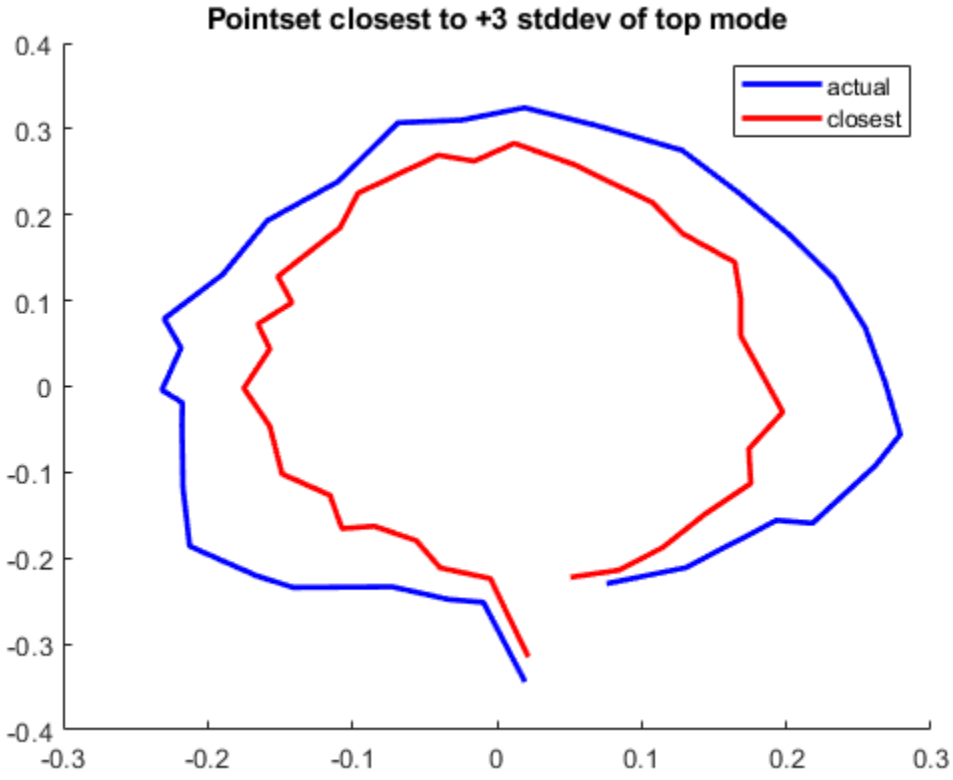
Closest pointsets

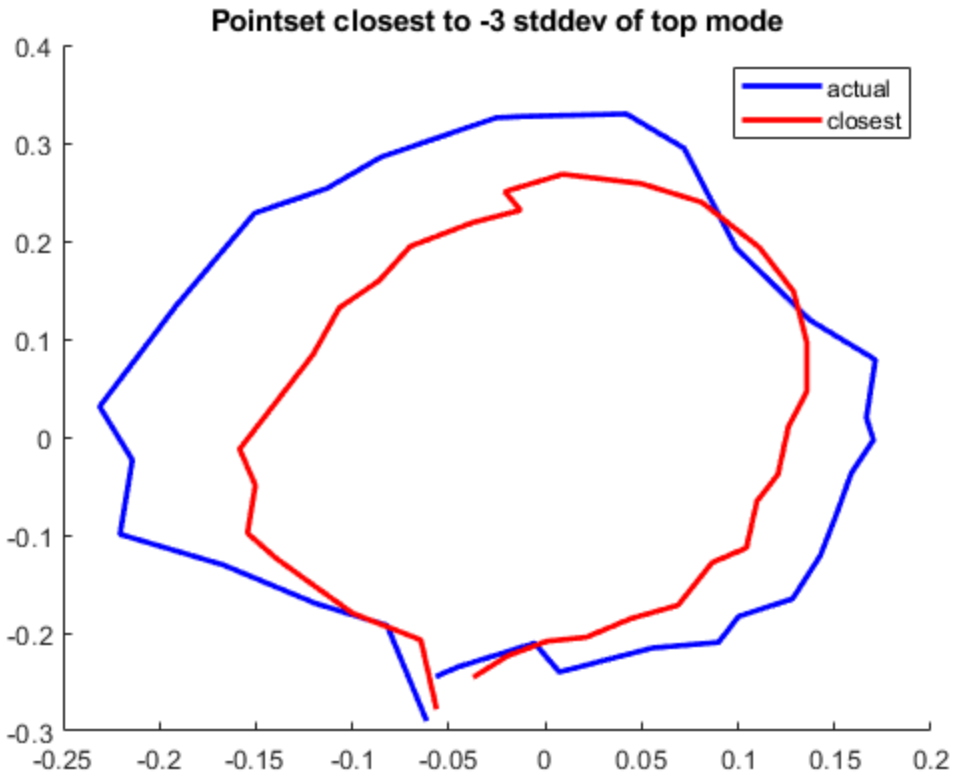
```
ms1 = ms + 3 * sqrt(D(1)) * reshape(W(:, 1), [2, m]);
ms2 = ms - 3 * sqrt(D(1)) * reshape(W(:, 1), [2, m]);

% Closest to mean shape
ps = findMinErrorPS(newPS, ms);
figure
hold on
p1 = plot(ms(1, :), ms(2, :), 'Color', 'blue', 'LineWidth', 2);
p2 = plot(ps(1, :), ps(2, :), 'Color', 'red', 'LineWidth', 2);
title("Pointset closest to mean shape");
legend([p1, p2], "actual", "closest");
hold off

% Closest to +3 stddev
ps = findMinErrorPS(newPS, ms1);
figure
hold on
p1 = plot(ms1(1, :), ms1(2, :), 'Color', 'blue', 'LineWidth', 2);
p2 = plot(ps(1, :), ps(2, :), 'Color', 'red', 'LineWidth', 2);
title("Pointset closest to +3 stddev of top mode");
legend([p1, p2], "actual", "closest");
hold off
```

```
% Closest to -3 stddev
ps = findMinErrorPS(newPS, ms2);
figure
hold on
p1 = plot(ms2(1, :), ms2(2, :), 'Color', 'blue', 'LineWidth', 2);
p2 = plot(ps(1, :), ps(2, :), 'Color', 'red', 'LineWidth', 2);
title("Pointset closest to -3 stddev of top mode");
legend([p1, p2], "actual", "closest");
hold off
```



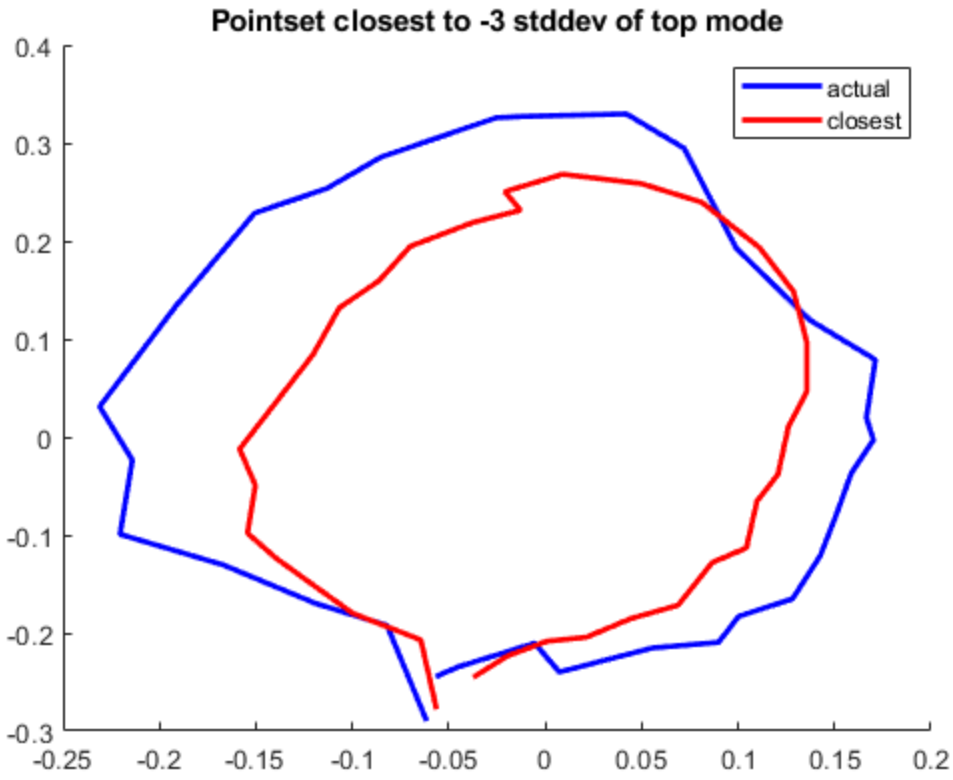

Pointset closest to mean shape
actual
closest
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.25
-0.2
-0.15
-0.1
-0.05
0
0.05
0.1
0.15
0.2

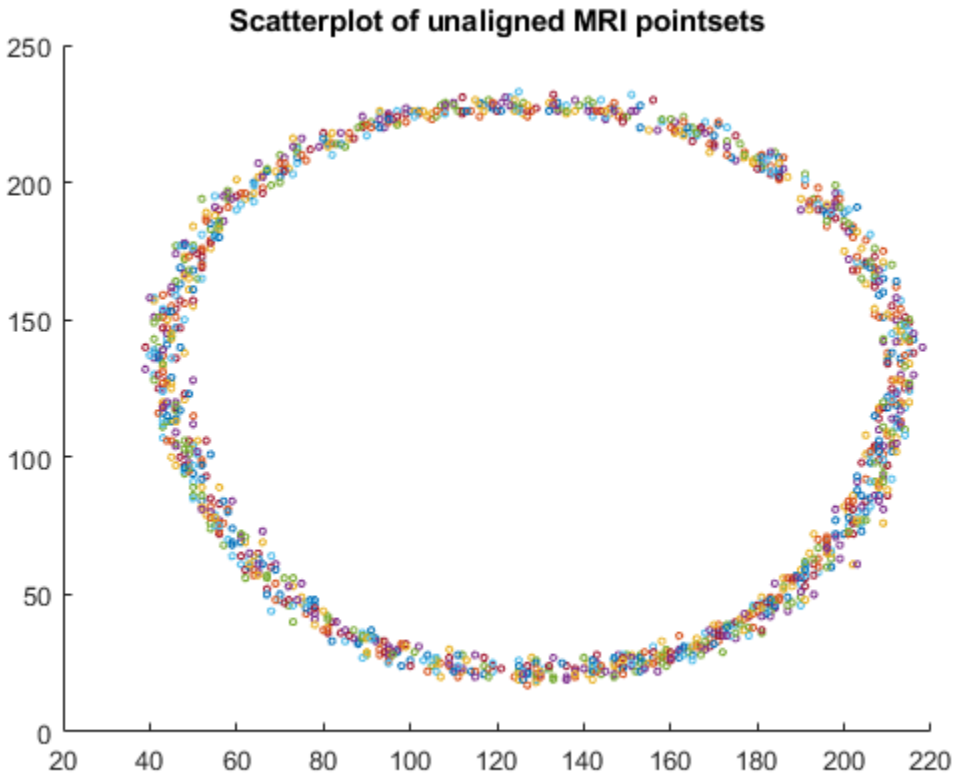

Pointset closest to +3 stddev of top mode
actual
closest
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
0.3



Reading MRI data

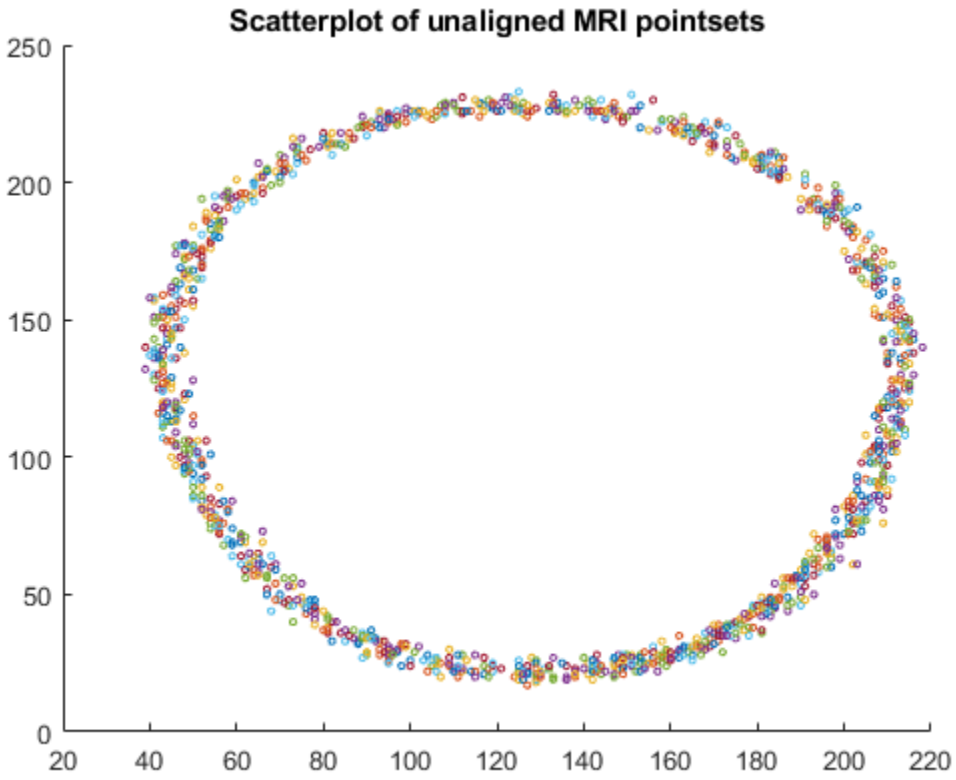
```
filePath = "../data/brain/data/mri_image_";
%tracingBoundaries(".png", 40, 32, filePath);
data = load("../data/brain.mat");
imgs = data.shapes;

[dims, m, n] = size(imgs);

% plotting all the hands
figure
hold on
for i = 1:n
    scatter(imgs(1, :, i), imgs(2, :, i), 6);
end
title("Scatterplot of unaligned MRI pointsets");
hold off
```

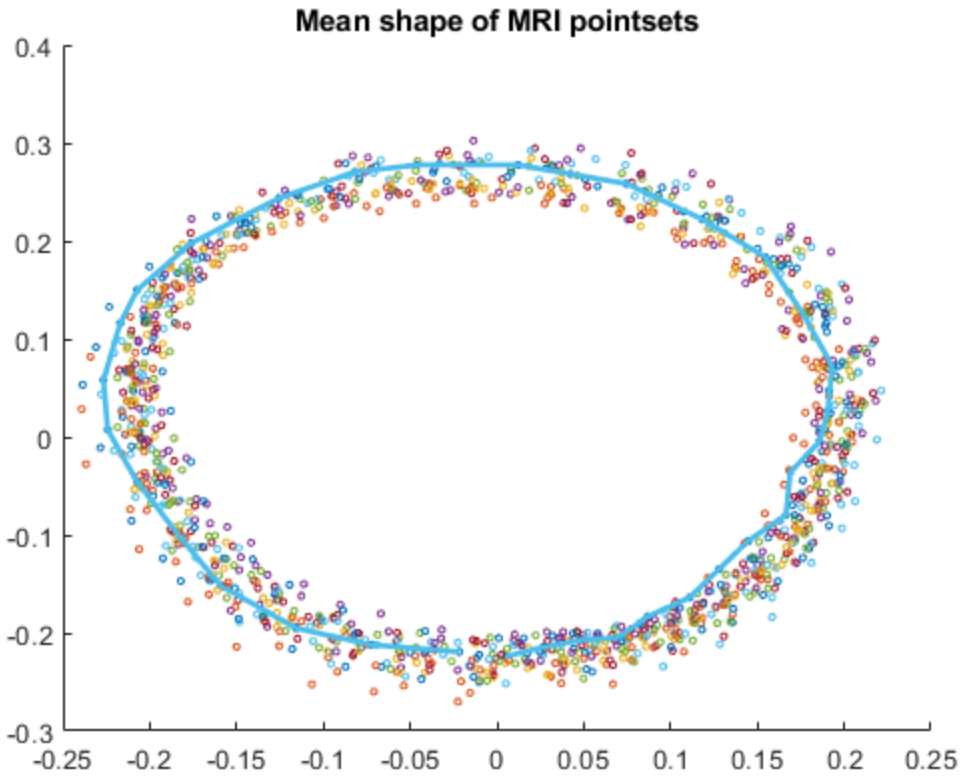

Pointset closest to -3 stddev of top mode
actual
closest
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.25
-0.2
-0.15
-0.1
-0.05
0
0.05
0.1
0.15
0.2


Scatterplot of unaligned MRI pointsets
250
200
150
100
50
0
20
40
60
80
100
120
140
160
180
200
220

Mean shape of MRI data

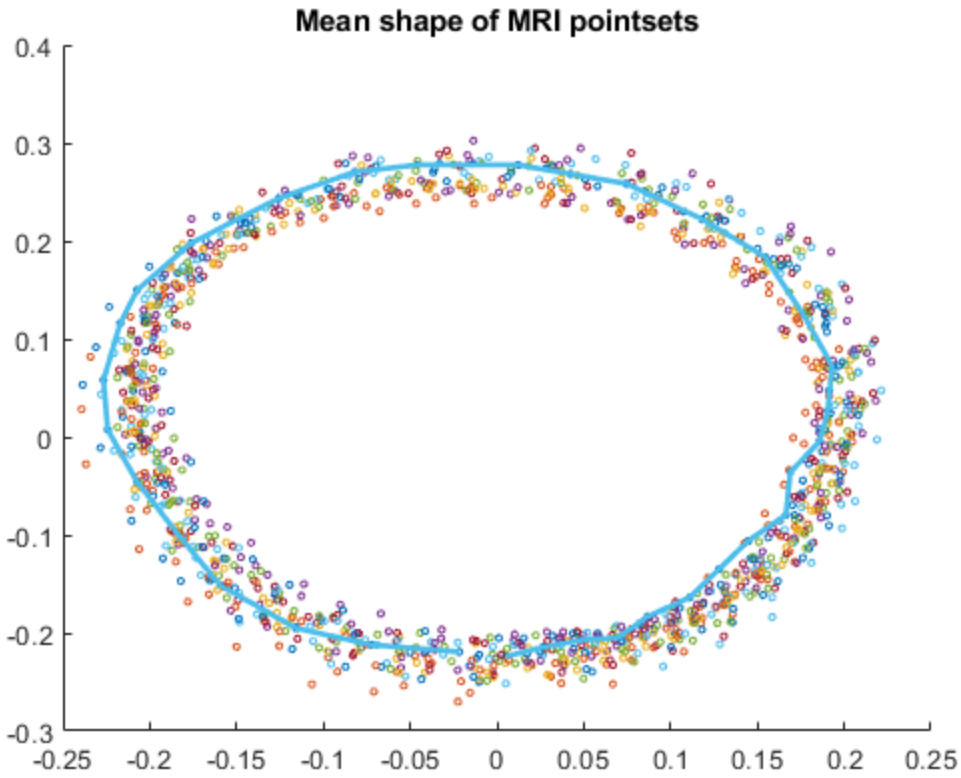
```
[ms, newPS] = meanShape(imgs);
figure
hold on
for i = 1:n
    scatter(newPS(1, :, i), newPS(2, :, i), 6);
end
plot(ms(1, :), ms(2, :), 'LineWidth', 2);
title("Mean shape of MRI pointsets");
hold off
```

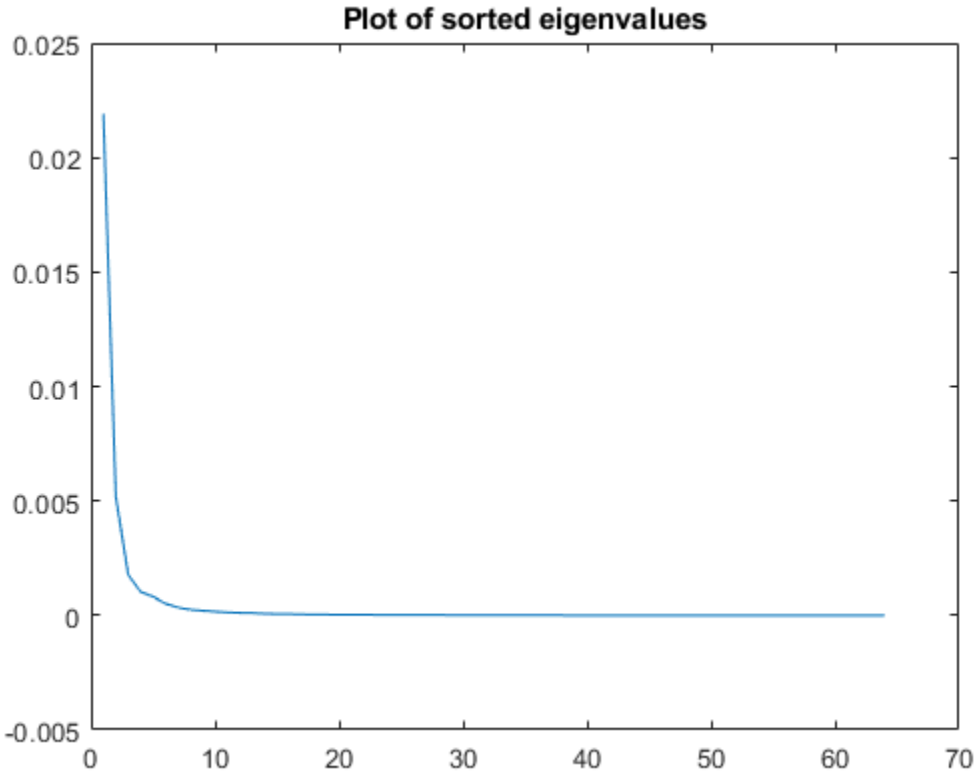




Eigenvalues calculation

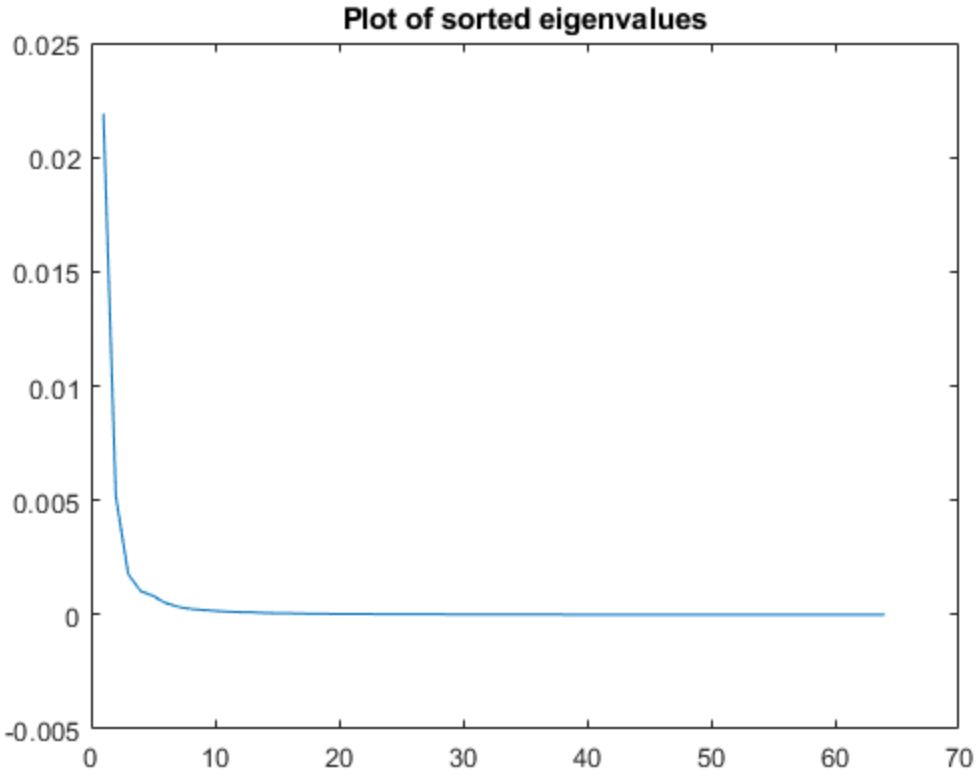
```
[D, W] = eigenCalc(newPS);
figure
plot(D);
title("Plot of sorted eigenvalues");
```

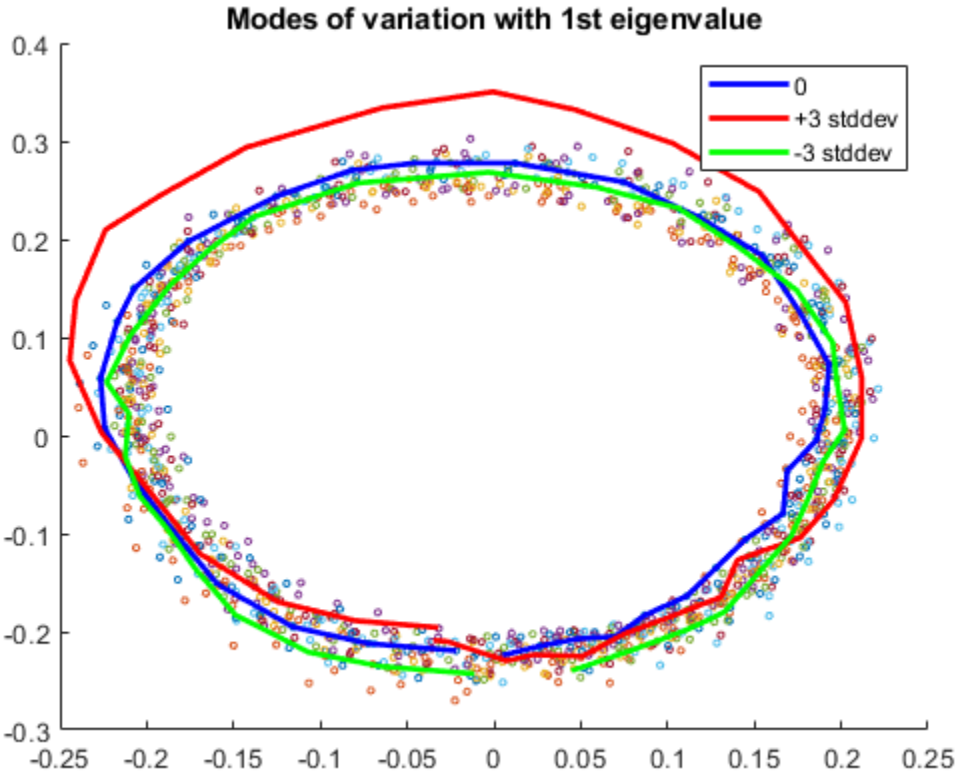

Mean shape of MRI pointsets
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.25
-0.2
-0.15
-0.1
-0.05
0
0.05
0.1
0.15
0.2
0.25

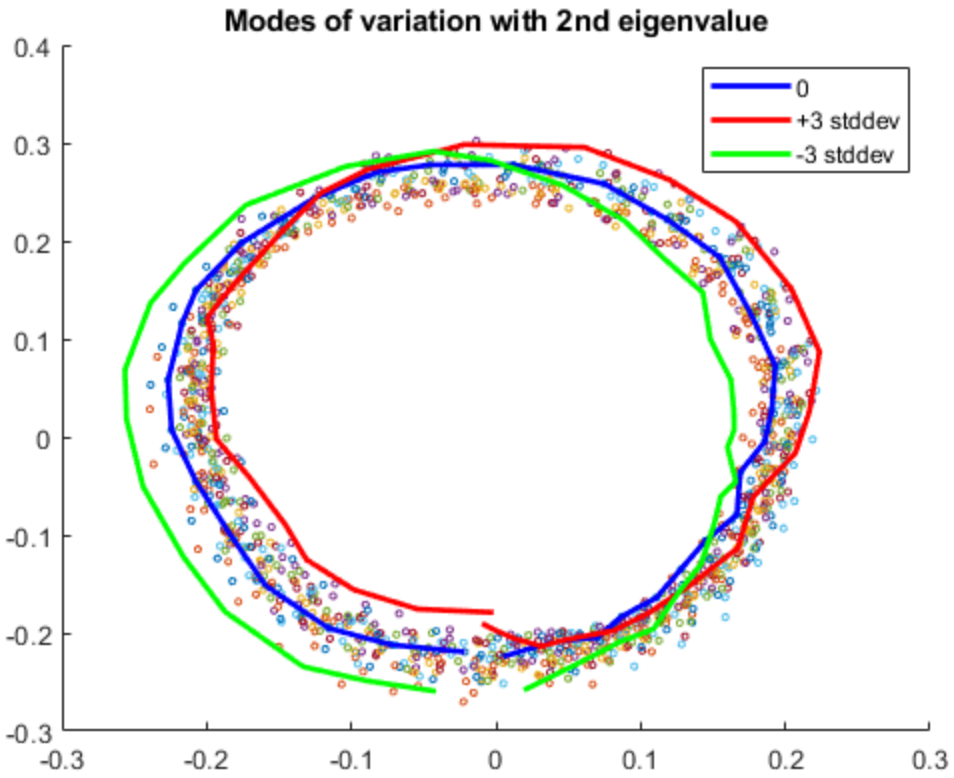

Plot of sorted eigenvalues
0.025
0.02
0.015
0.01
0.005
0
-0.005
0
10
20
30
40
50
60
70

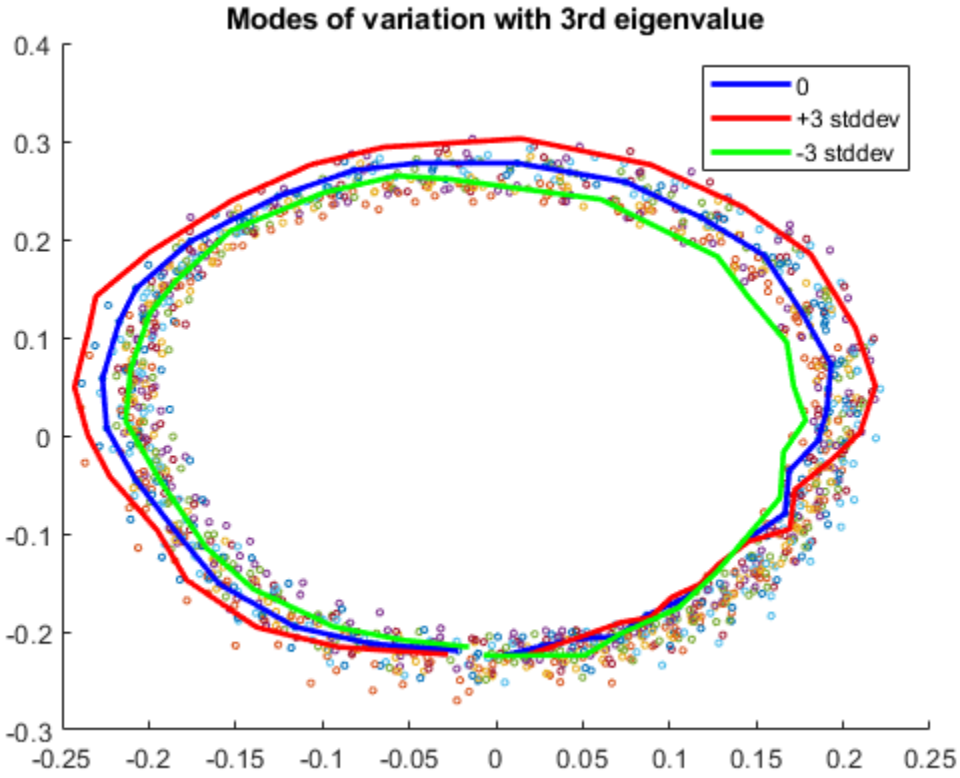
Top 3 modes of varations

```
% 1st eigenvalue
ms1 = ms + 3 * sqrt(D(1)) * reshape(W(:, 1), [2, m]);
ms2 = ms - 3 * sqrt(D(1)) * reshape(W(:, 1), [2, m]);
figure
hold on
for i = 1:n
    scatter(newPS(1, :, i), newPS(2, :, i), 6);
end
p1 = plot(ms(1, :), ms(2, :), 'Color', 'blue', 'LineWidth', 2);
p2 = plot(ms1(1, :), ms1(2, :), 'Color', 'red', 'LineWidth', 2);
p3 = plot(ms2(1, :), ms2(2, :), 'Color', 'green', 'LineWidth', 2);
title("Modes of variation with 1st eigenvalue");
legend([p1, p2, p3], "0", "+3 stddev", "-3 stddev");
hold off

% 2nd eigenvalue
ms1 = ms + 3 * sqrt(D(2)) * reshape(W(:, 2), [2, m]);
ms2 = ms - 3 * sqrt(D(2)) * reshape(W(:, 2), [2, m]);
figure
hold on
for i = 1:n
    scatter(newPS(1, :, i), newPS(2, :, i), 6);
end
p1 = plot(ms(1, :), ms(2, :), 'Color', 'blue', 'LineWidth', 2);
p2 = plot(ms1(1, :), ms1(2, :), 'Color', 'red', 'LineWidth', 2);
p3 = plot(ms2(1, :), ms2(2, :), 'Color', 'green', 'LineWidth', 2);
title("Modes of variation with 2nd eigenvalue");
legend([p1, p2, p3], "0", "+3 stddev", "-3 stddev");
hold off

% 3rd eigenvalue
ms1 = ms + 3 * sqrt(D(3)) * reshape(W(:, 3), [2, m]);
ms2 = ms - 3 * sqrt(D(3)) * reshape(W(:, 3), [2, m]);
figure
hold on
for i = 1:n
    scatter(newPS(1, :, i), newPS(2, :, i), 6);
end
p1 = plot(ms(1, :), ms(2, :), 'Color', 'blue', 'LineWidth', 2);
p2 = plot(ms1(1, :), ms1(2, :), 'Color', 'red', 'LineWidth', 2);
p3 = plot(ms2(1, :), ms2(2, :), 'Color', 'green', 'LineWidth', 2);
title("Modes of variation with 3rd eigenvalue");
legend([p1, p2, p3], "0", "+3 stddev", "-3 stddev");
hold off
```


Plot of sorted eigenvalues
0.025
0.02
0.015
0.01
0.005
0
-0.005
0
10
20
30
40
50
60
70

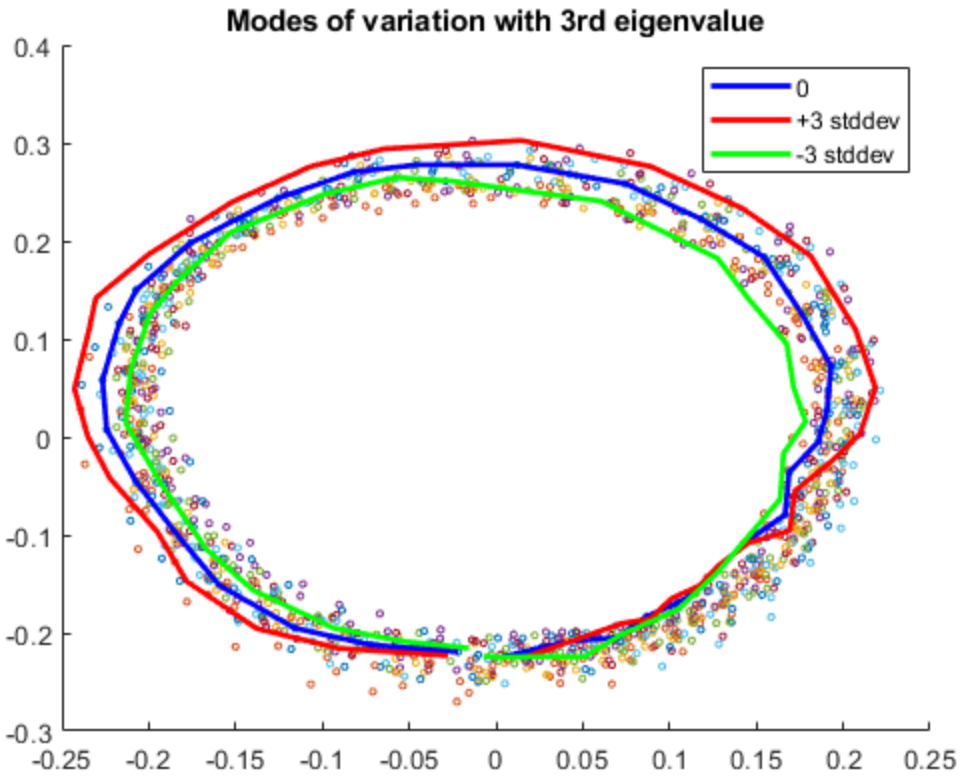

Modes of variation with 1st eigenvalue
0
+3 stddev
-3 stddev
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.25
-0.2
-0.15
-0.1
-0.05
0
0.05
0.1
0.15
0.2
0.25

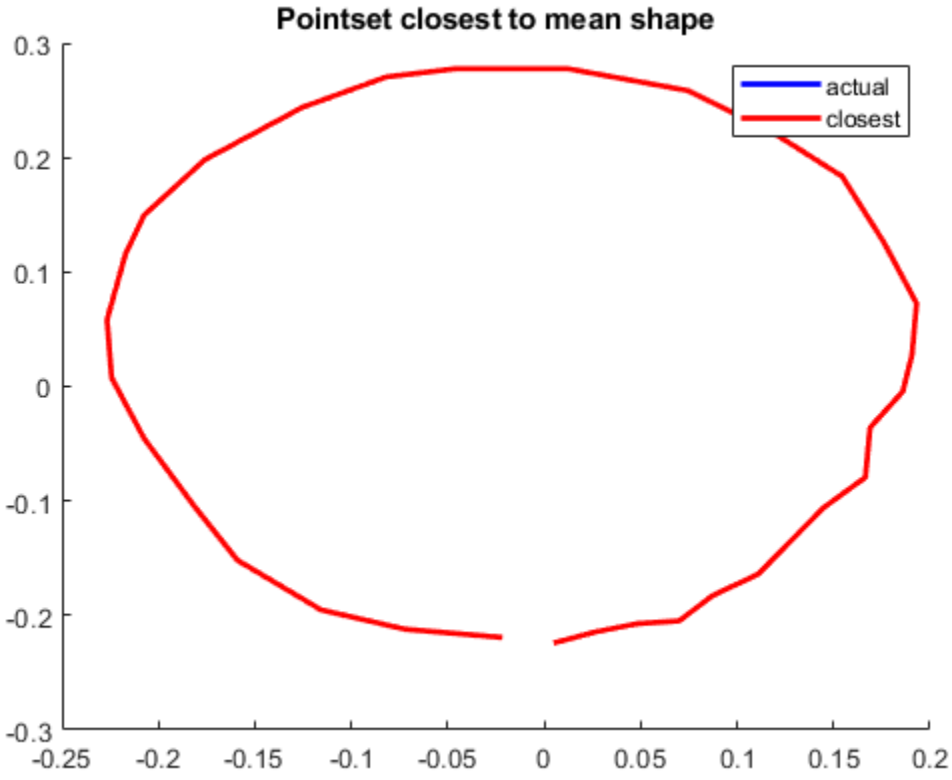

Modes of variation with 2nd eigenvalue
0
+3 stddev
-3 stddev
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.3
-0.2
-0.1
0
0.1
0.2
0.3

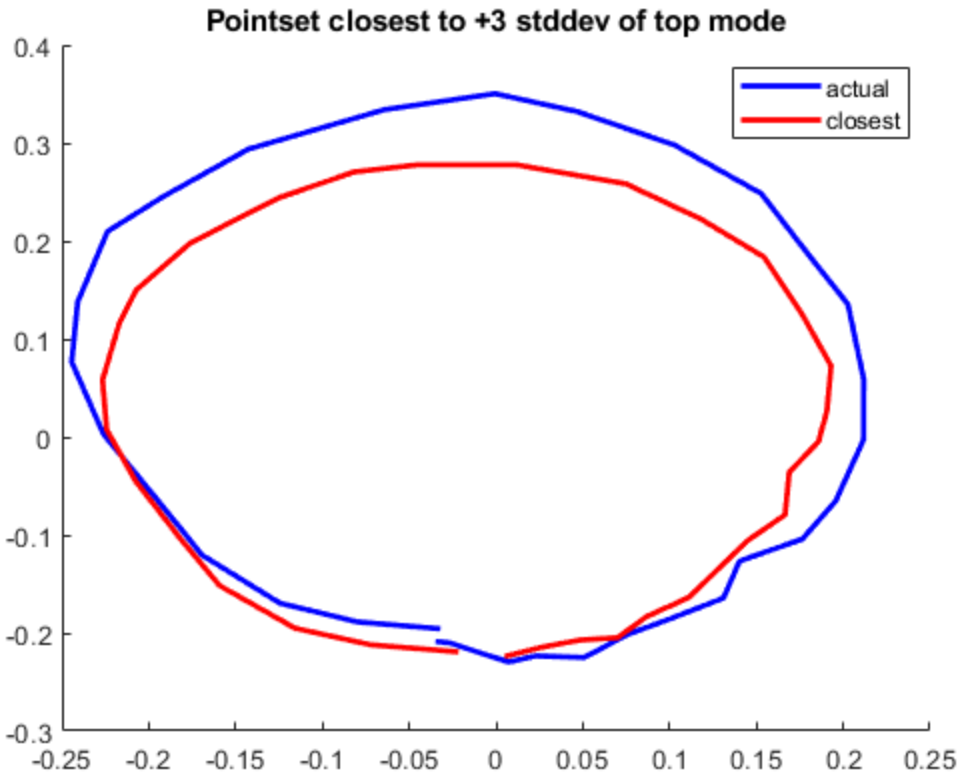

Modes of variation with 3rd eigenvalue
0
+3 stddev
-3 stddev
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.25
-0.2
-0.15
-0.1
-0.05
0
0.05
0.1
0.15
0.2
0.25

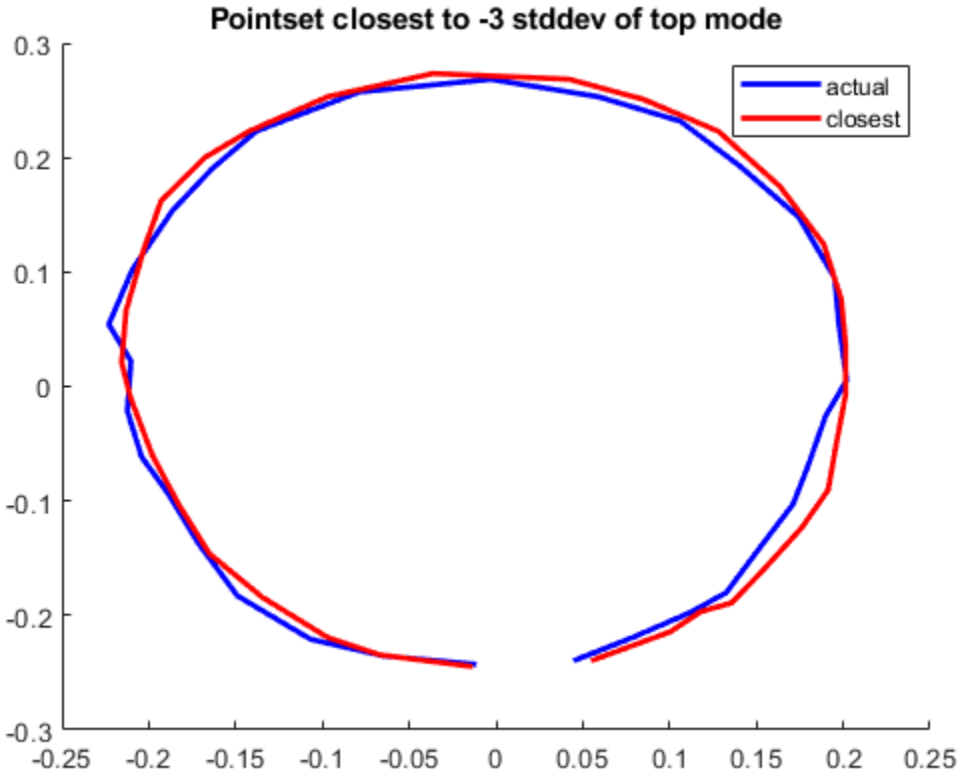
Closest pointsets

```
ms1 = ms + 3 * sqrt(D(1)) * reshape(W(:, 1), [2, m]);
ms2 = ms - 3 * sqrt(D(1)) * reshape(W(:, 1), [2, m]);

% Closest to mean shape
ps = findMinErrorPS(newPS, ms);
figure
hold on
p1 = plot(ms(1, :), ms(2, :), 'Color', 'blue', 'LineWidth', 2);
p2 = plot(ps(1, :), ps(2, :), 'Color', 'red', 'LineWidth', 2);
title("Pointset closest to mean shape");
legend([p1, p2], "actual", "closest");
hold off

% Closest to +3 stddev
ps = findMinErrorPS(newPS, ms1);
figure
hold on
p1 = plot(ms1(1, :), ms1(2, :), 'Color', 'blue', 'LineWidth', 2);
p2 = plot(ps(1, :), ps(2, :), 'Color', 'red', 'LineWidth', 2);
title("Pointset closest to +3 stddev of top mode");
legend([p1, p2], "actual", "closest");
hold off

% Closest to -3 stddev
ps = findMinErrorPS(newPS, ms2);
figure
hold on
p1 = plot(ms2(1, :), ms2(2, :), 'Color', 'blue', 'LineWidth', 2);
p2 = plot(ps(1, :), ps(2, :), 'Color', 'red', 'LineWidth', 2);
title("Pointset closest to -3 stddev of top mode");
legend([p1, p2], "actual", "closest");
hold off
```


Modes of variation with 3rd eigenvalue
0
+3 stddev
-3 stddev
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.25
-0.2
-0.15
-0.1
-0.05
0
0.05
0.1
0.15
0.2
0.25


Pointset closest to mean shape
actual
closest
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.25
-0.2
-0.15
-0.1
-0.05
0
0.05
0.1
0.15
0.2


Pointset closest to +3 stddev of top mode
actual
closest
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.25
-0.2
-0.15
-0.1
-0.05
0
0.05
0.1
0.15
0.2
0.25


Pointset closest to -3 stddev of top mode
actual
closest
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.25
-0.2
-0.15
-0.1
-0.05
0
0.05
0.1
0.15
0.2
0.25

```
toc;
```

```
Elapsed time is 76.551501 seconds.
```

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