CS 7690, Advanced Image Processing
Project4 Active Shape Models
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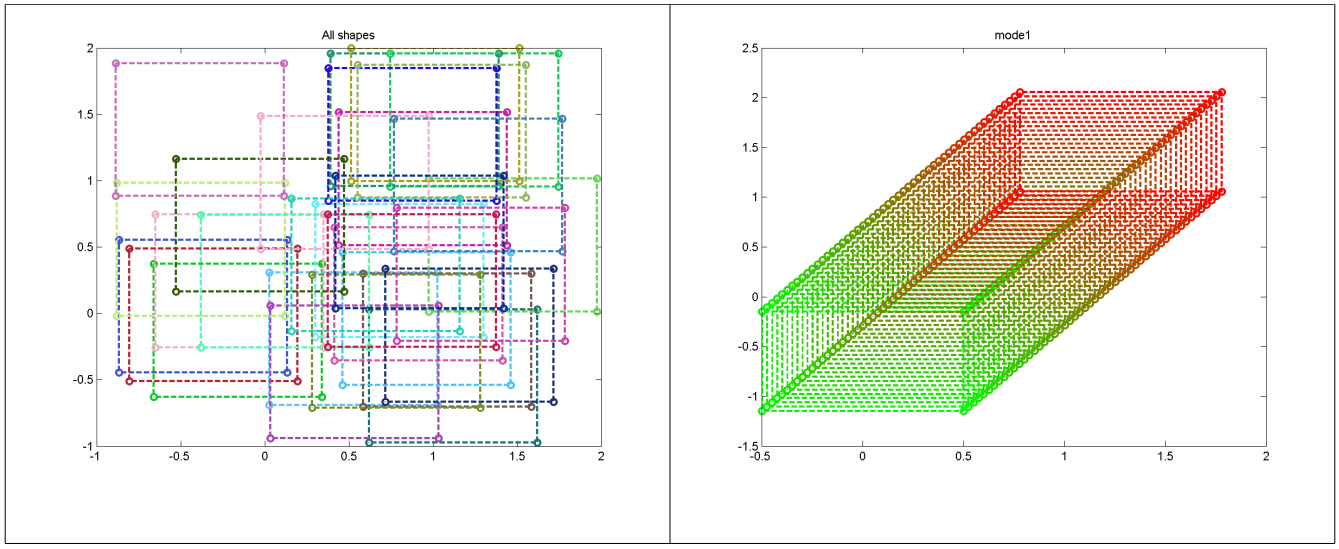
The implementation of the ASM modeling and the major modes of deformation

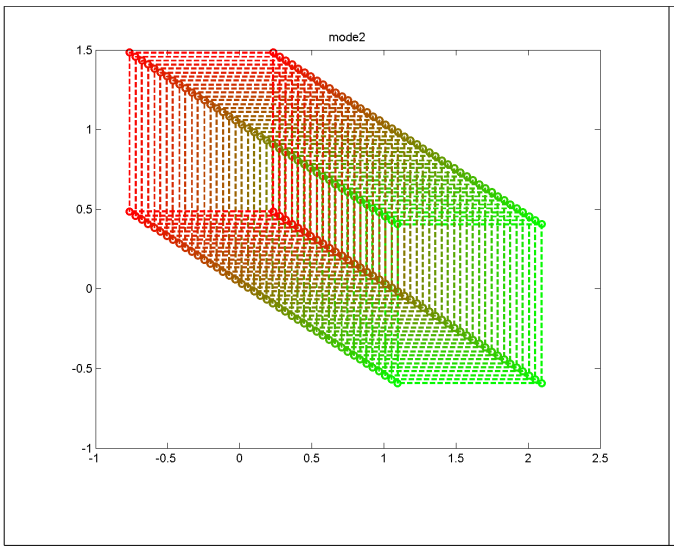
ASM modeling:
Compute the mean of the shapes.
Subtract the mean from each shape.
Compute the covariance matrix.
Do the eigen decomposition of the covariance matrix, get the eigenvalues and eigenvectors.

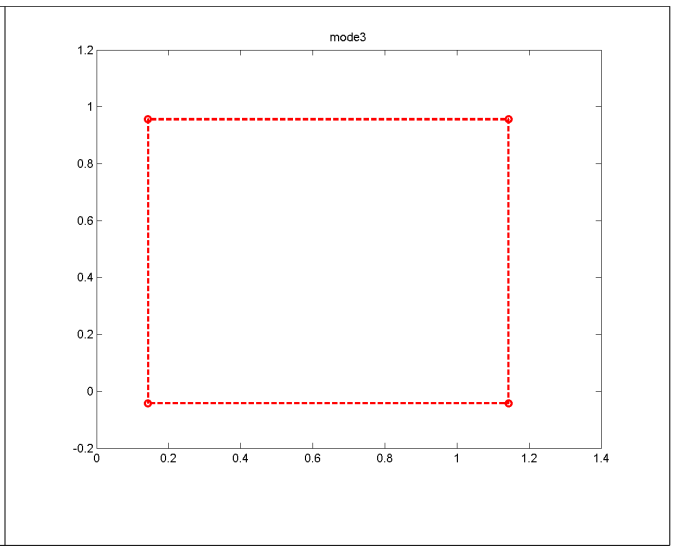
Major modes of deformation
Sort the eigenvectors based on the eigenvalues.
Select the first N modes (eigenvectors).
Compute the corresponding standard deviation for each mode.
Synthesize a bunch of shapes deviating from the mean along each new shape modes.
Display the synthesized shapes.

Application

Randdom translations:

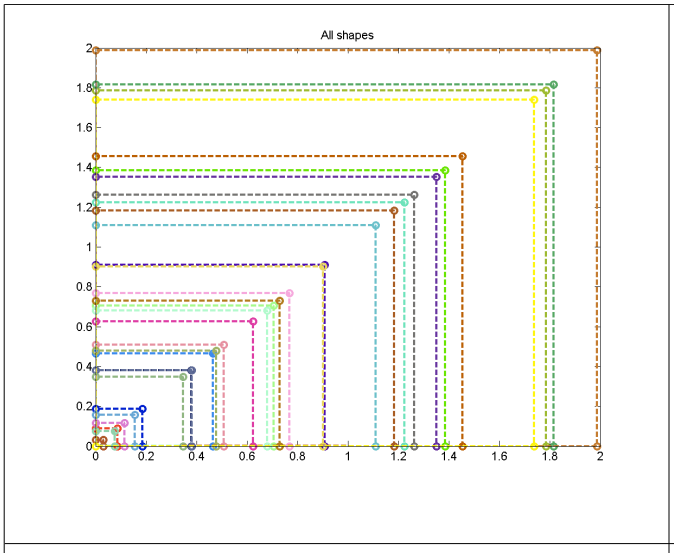


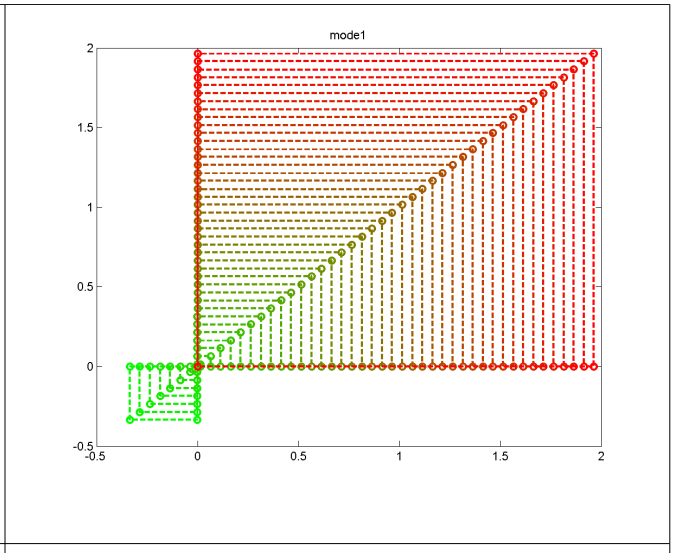


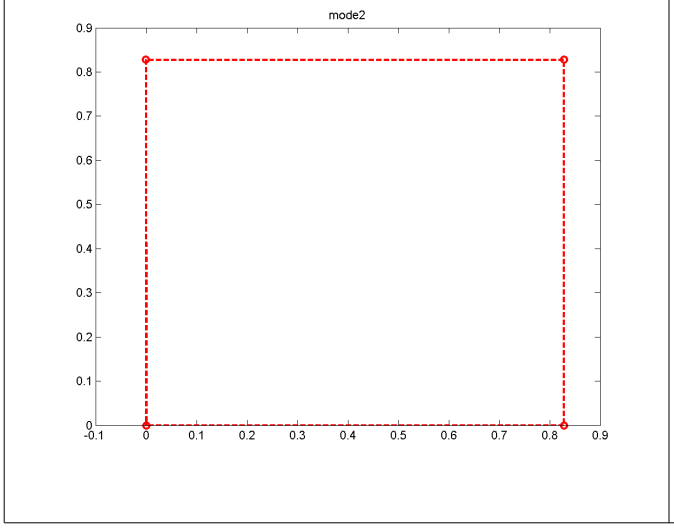


Evals = [1.6363 1.2097 0.0000 0.0000 -0.0000 -0.0000 -0.0000 -0.0000]

Random Scale:

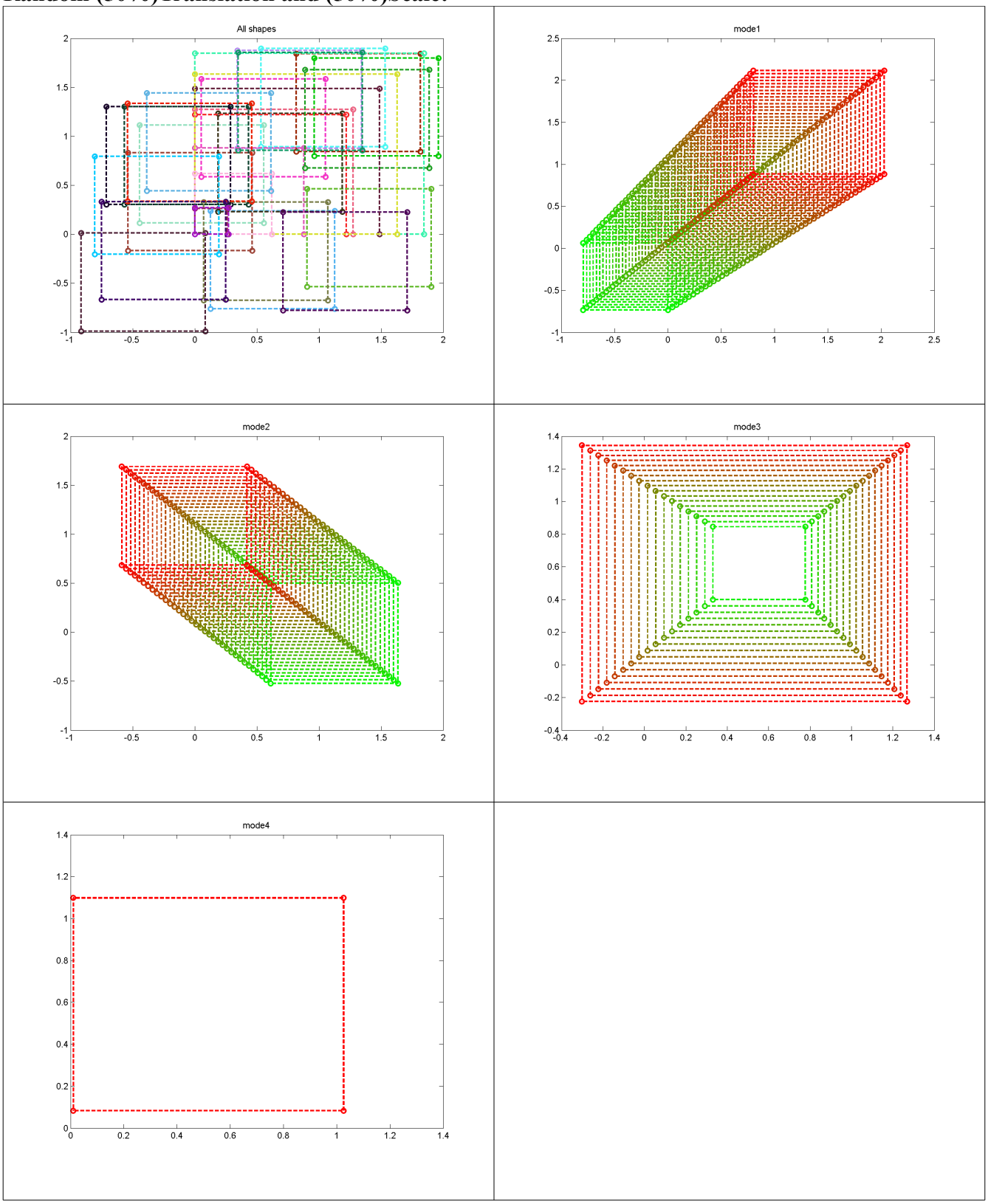






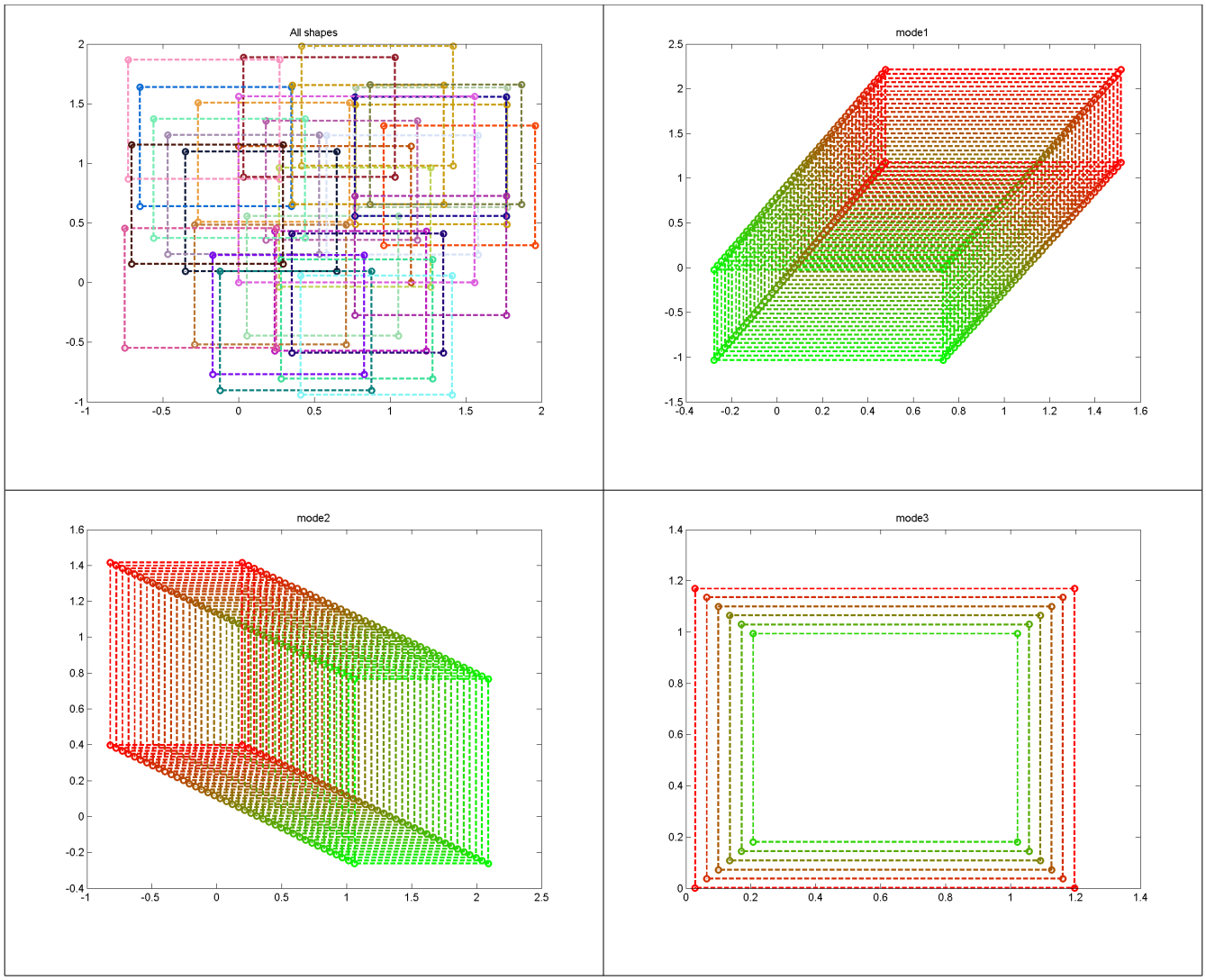
Evals = [1.2280 0.0000 0.0000 0.0000 0 0 0 -0.0000]

Random (50%)Translation and (50%)Scale:



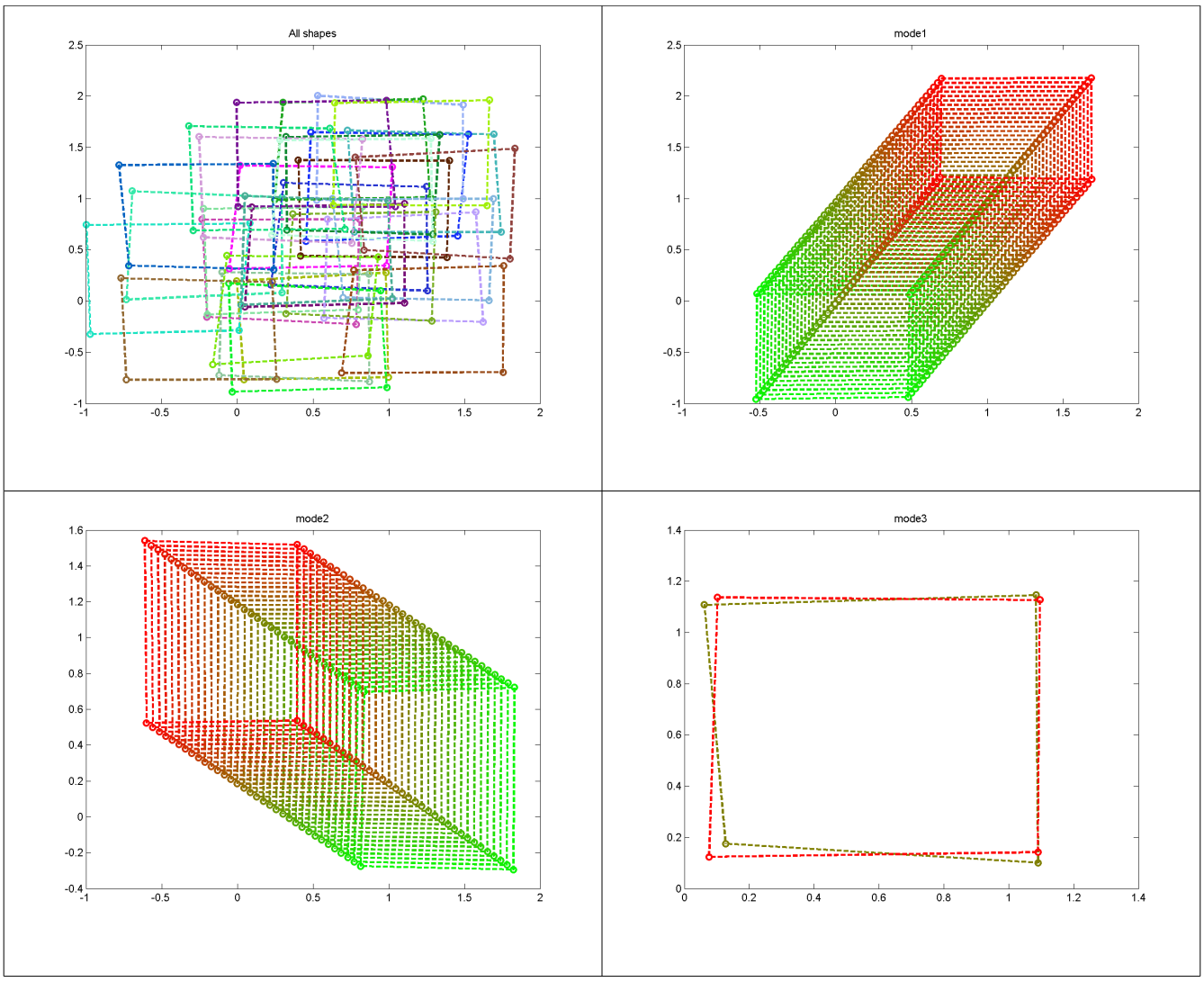
Evals = [1.7245 0.7282 0.1646 0.0000 0.0000 0.0000 -0.0000 -0.0000]

Random (90%)Translation and (10%)Scale:



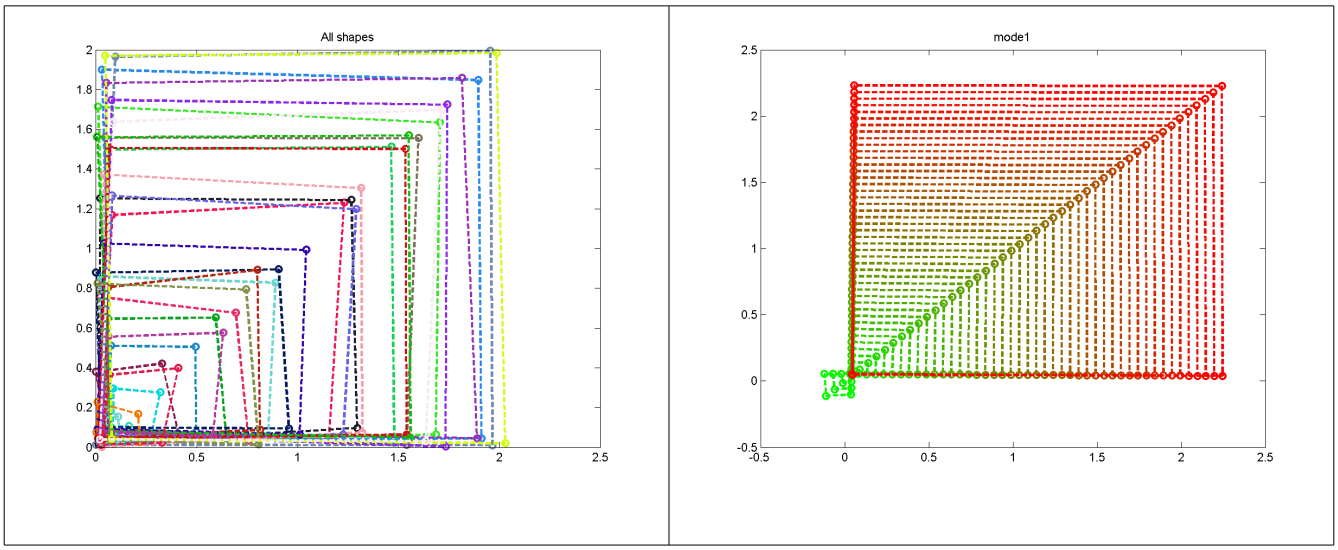
Evals = 1.3884 1.0390 0.0216 0.0000 0.0000 0.0000 0.0000 -0.0000

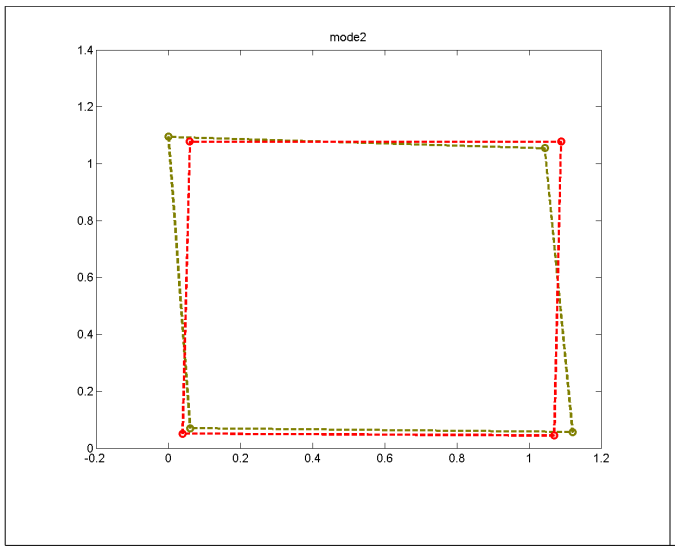
Random translation with noise:

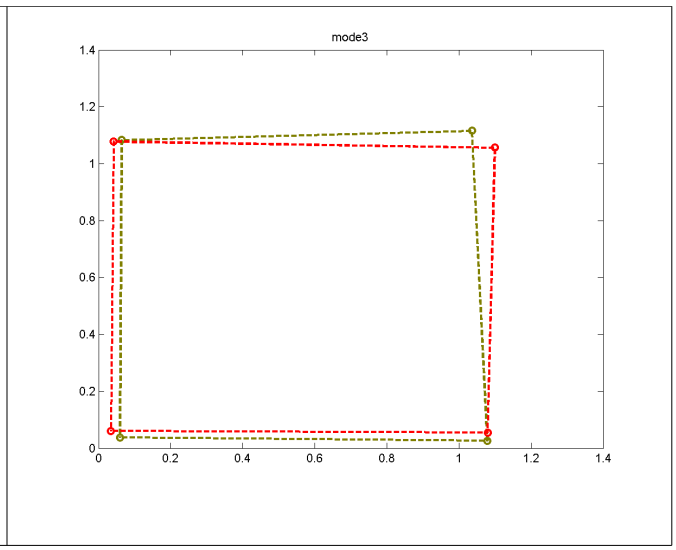


Evals =[1.5275 0.7192 0.0015 0.0012 0.0007 0.0007 0.0005 0.0003]

Random scale with noise:

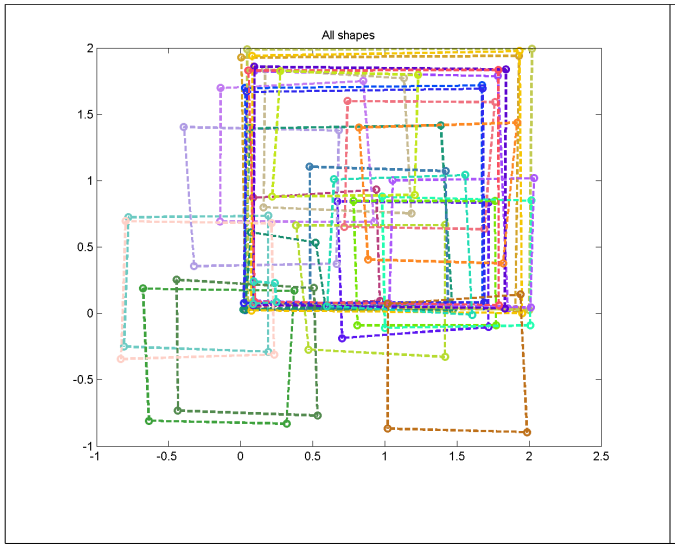


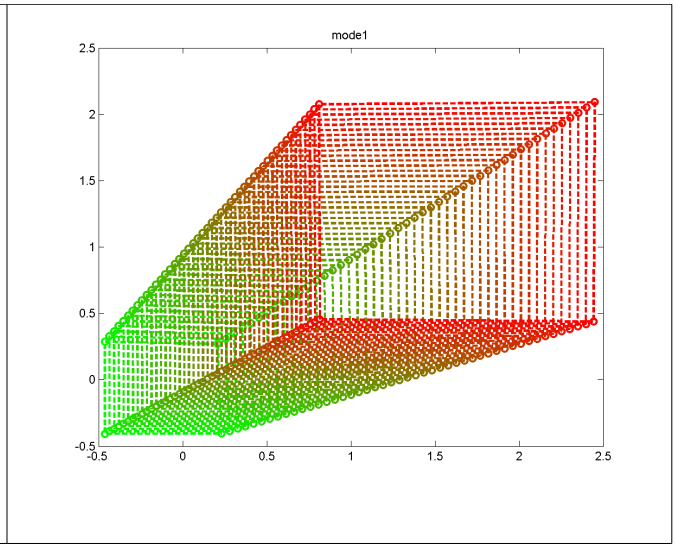


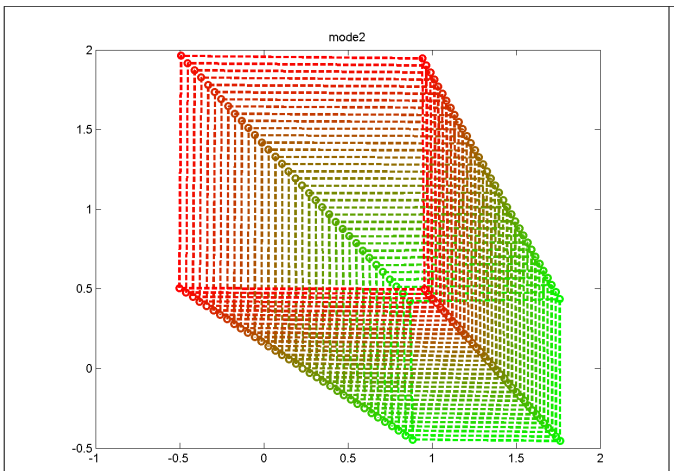


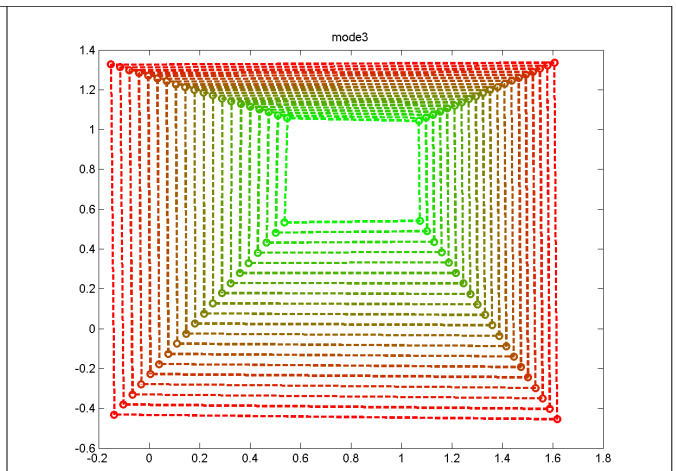
Evals = [1.4174 0.0017 0.0013 0.0009 0.0007 0.0005 0.0003 0.0002]

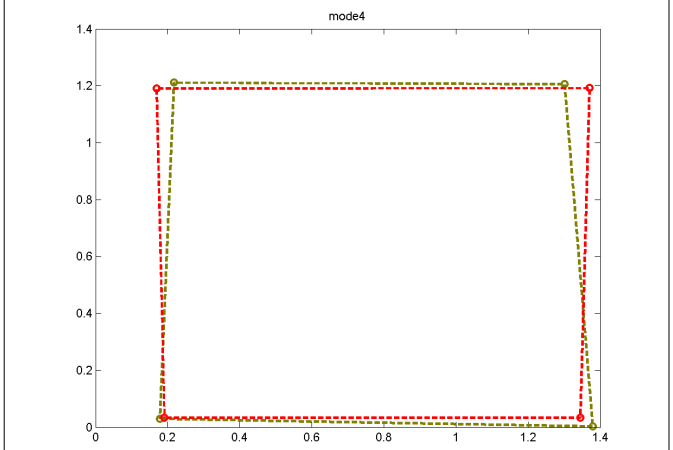
Random translation and scale with noise:





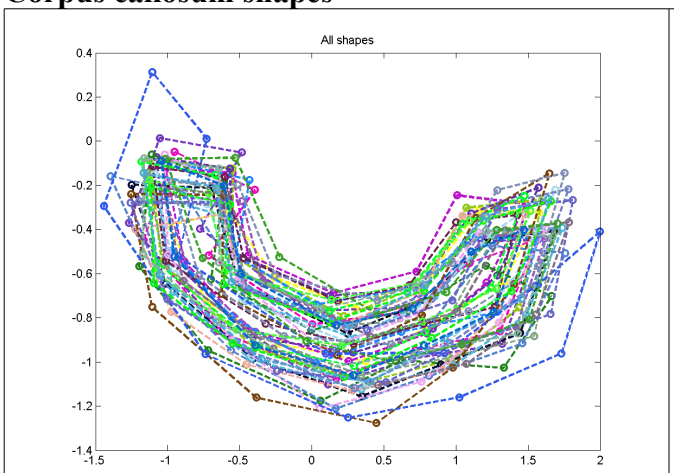


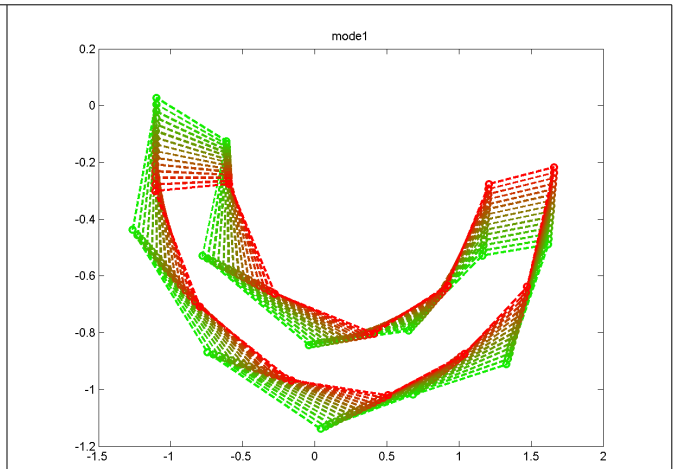


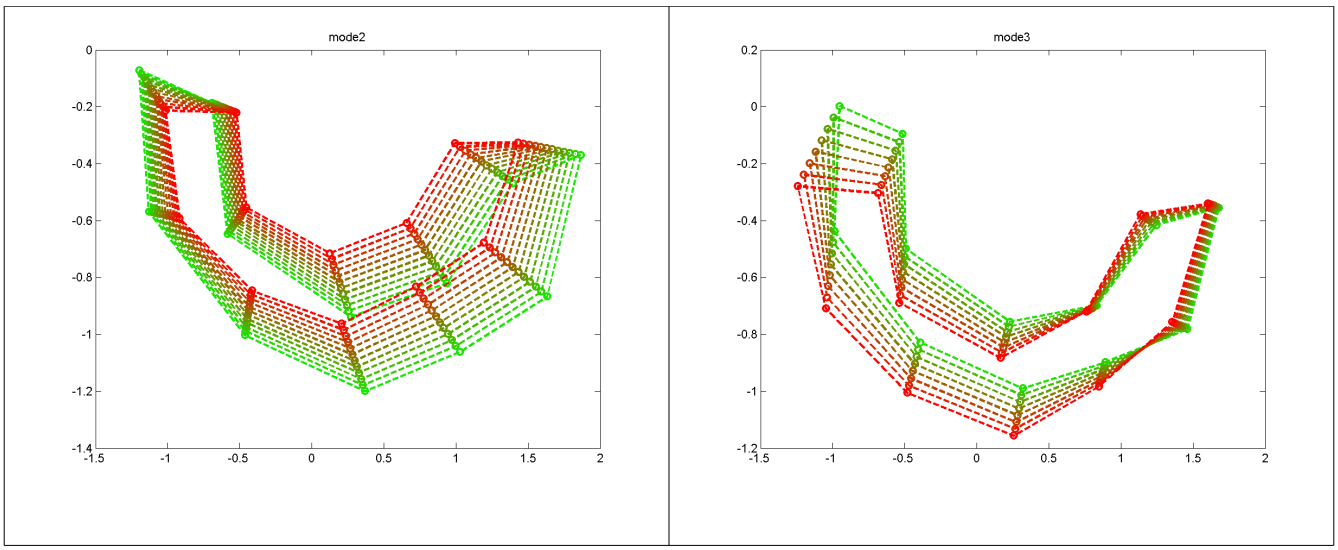


Evals = [1.3684 0.7310 0.2439 0.0012 0.0007 0.0006 0.0005 0.0003]

Corpus callosum shapes

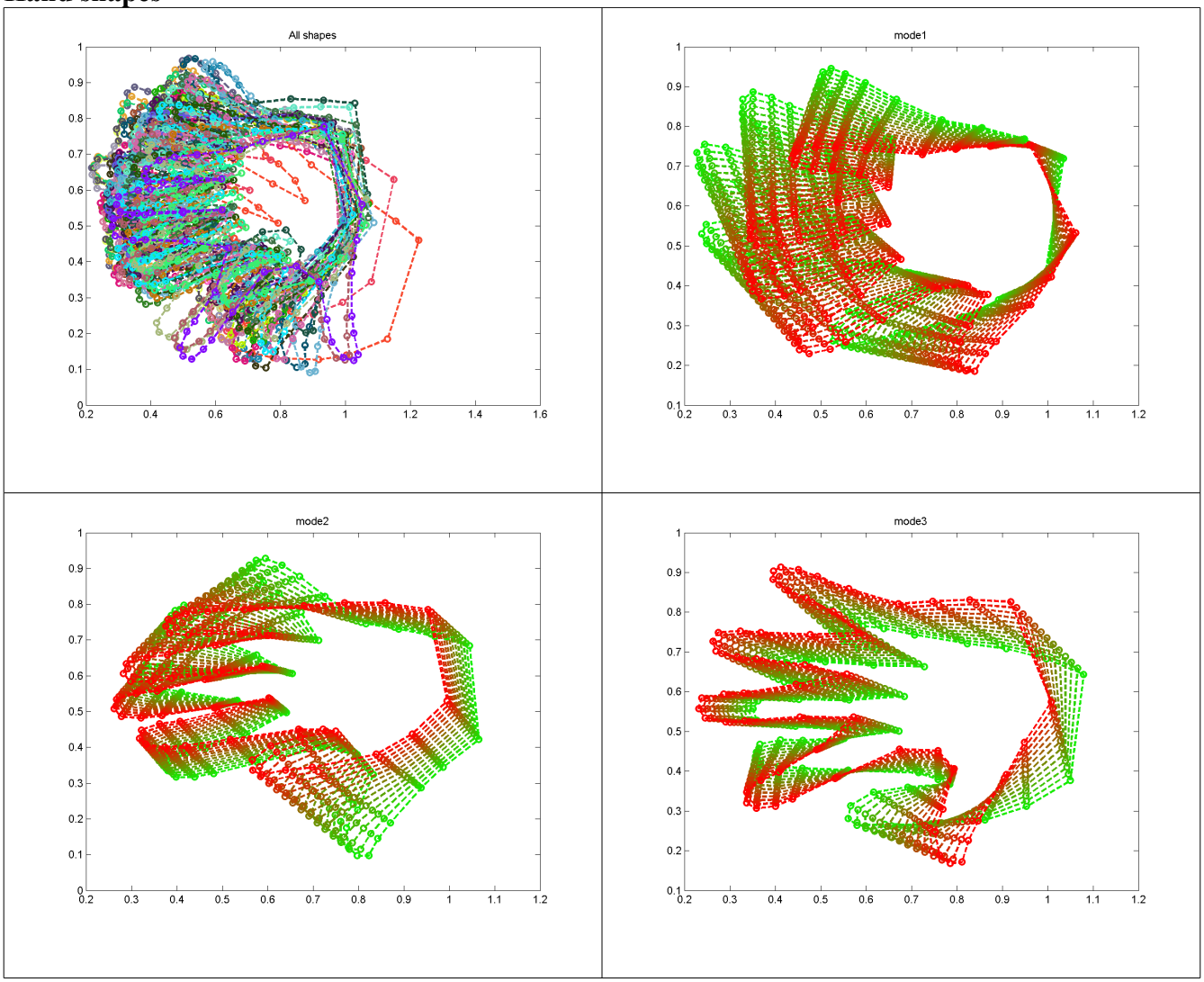


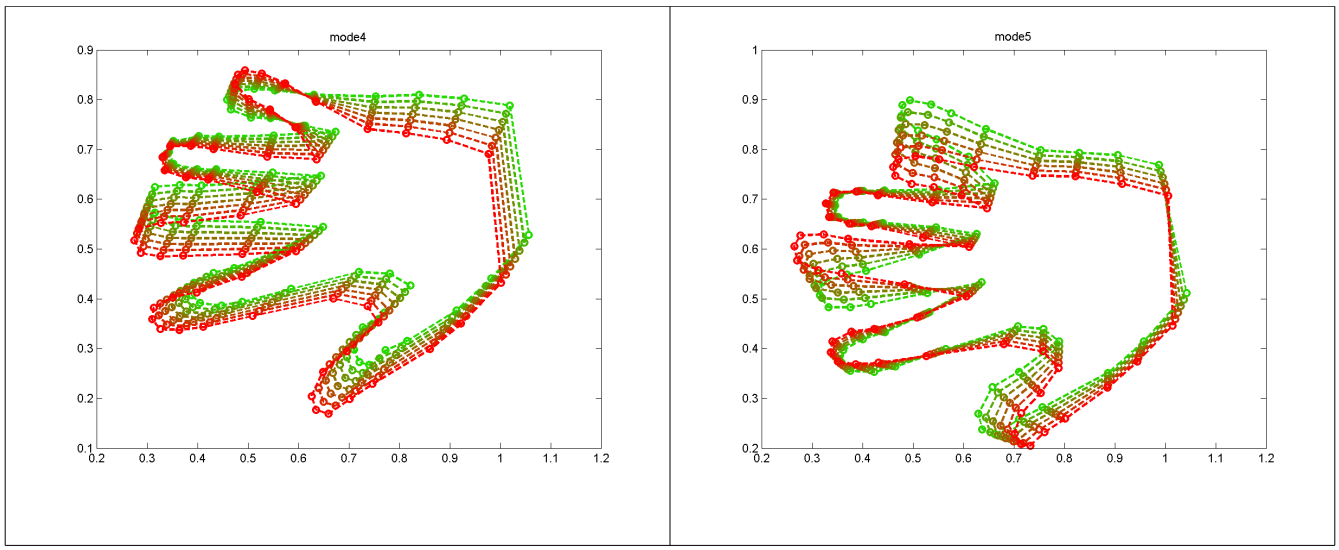




Evals = [0.1348 0.0817 0.0338 0.0247 0.0126 0.0102 0.0067 0.0045 0.0024
0.0015 0.0009 0.0007 0.0006 0.0004 0.0002 0.0002 0.0001 0.0001
0.0001 0.0000 0.0000 0.0000 0.0000 0.0000]

Hand shapes





Evals =

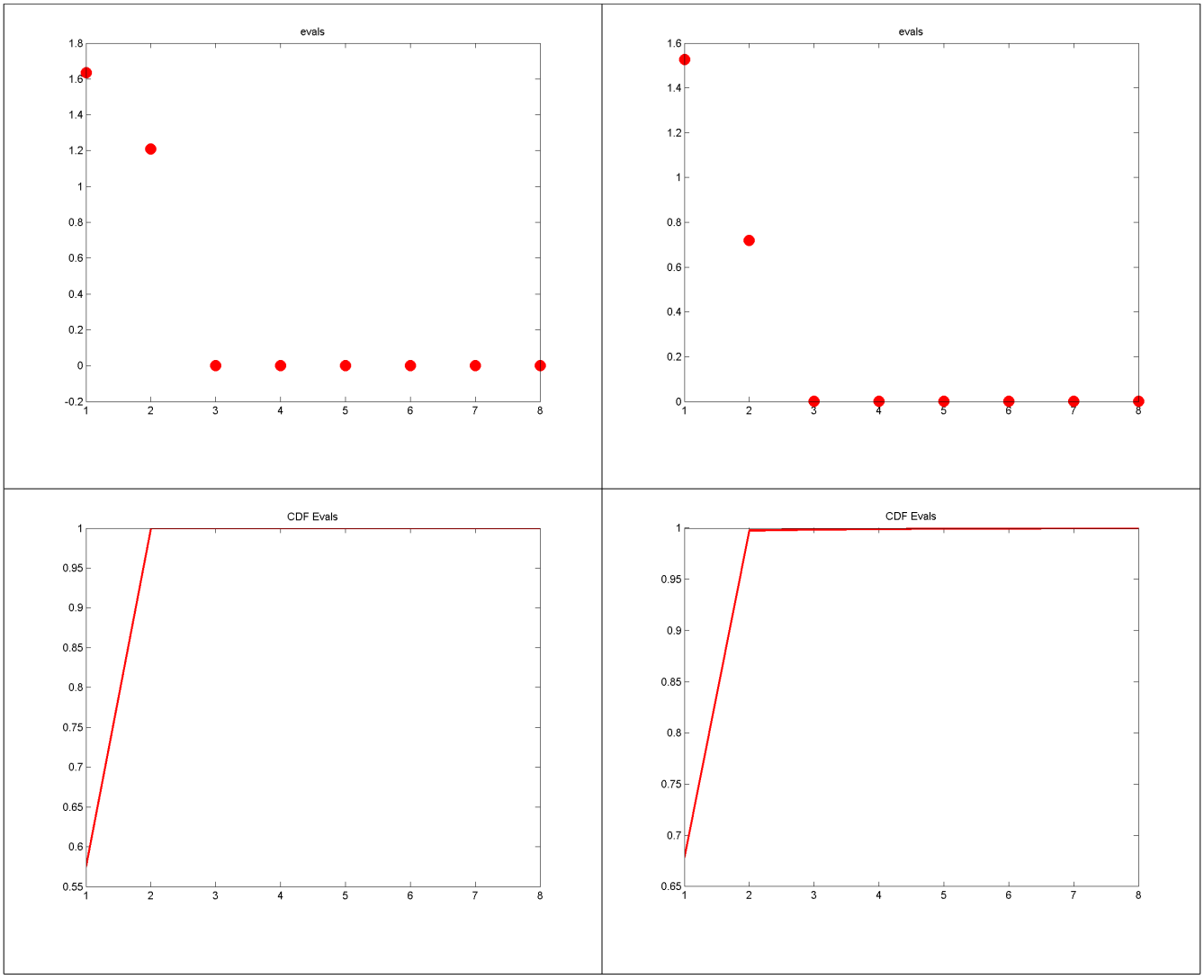
Columns 1 through 9
0.2337 0.1167 0.0948 0.0246 0.0160 0.0074 0.0025 0.0018 0.0017
Columns 10 through 18
0.0011 0.0007 0.0003 0.0002 0.0002 0.0001 0.0001 0.0001 0.0001
Columns 19 through 112
0.0001 0.0000 0.0000 0.0000 …..... 0.0000 0.0000 0.0000 0.0000 0.0000

Plot of the eigenvalues, eventual plot of the cumulative distribution function of the eigenvalues

Random translations

Evals = [1.6363 1.2097 0.0000 0.0000 -0.0000 -0.0000 -0.0000 -0.0000]
Evals_noise = [1.5275 0.7192 0.0015 0.0012 0.0007 0.0007 0.0005 0.0003]

Without Noise	With Noise

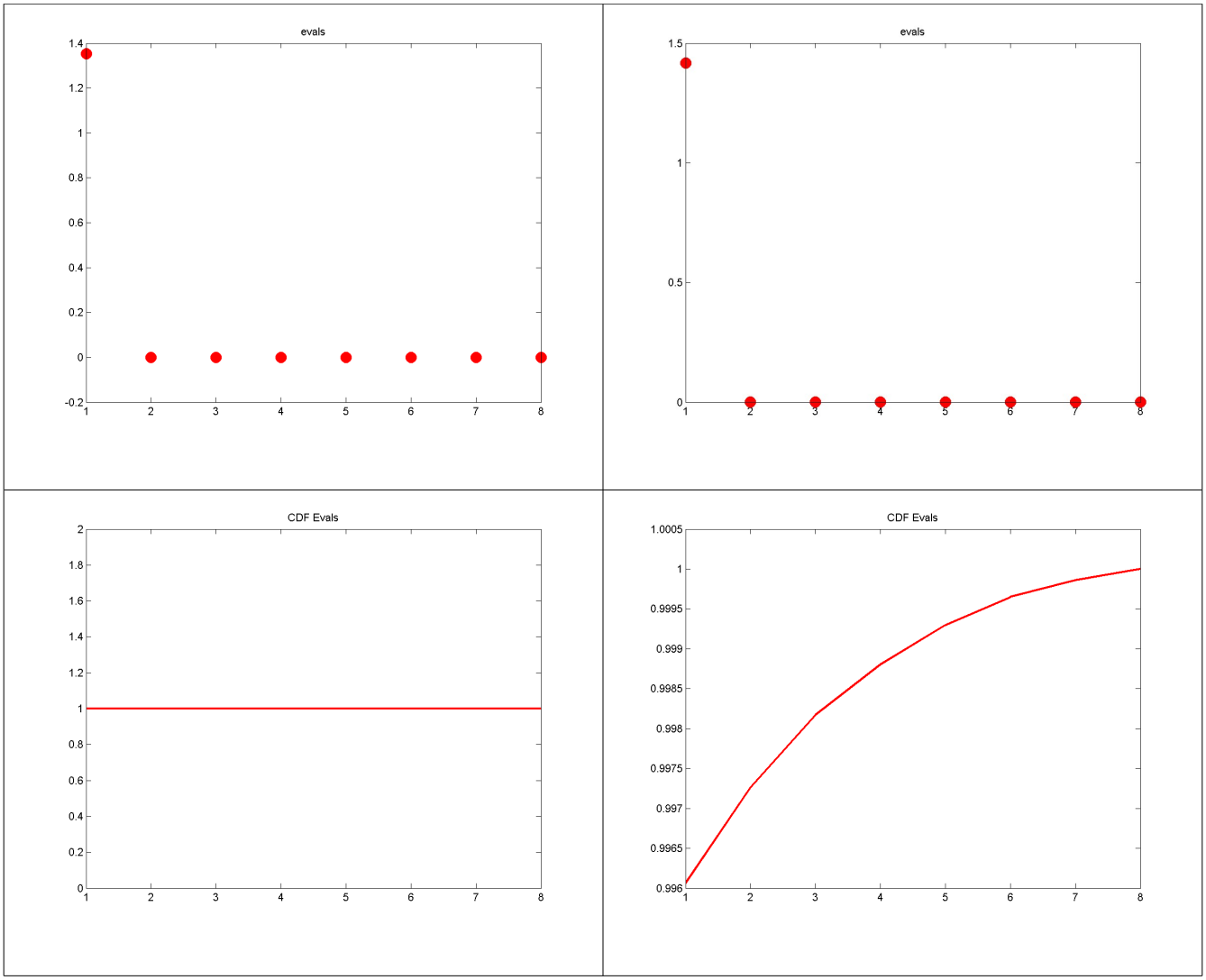


Random scale

Evals = [1.2280 0.0000 0.0000 0.0000 0 0 0 -0.0000]

Evals_noise = [1.4174 0.0017 0.0013 0.0009 0.0007 0.0005 0.0003 0.0002]

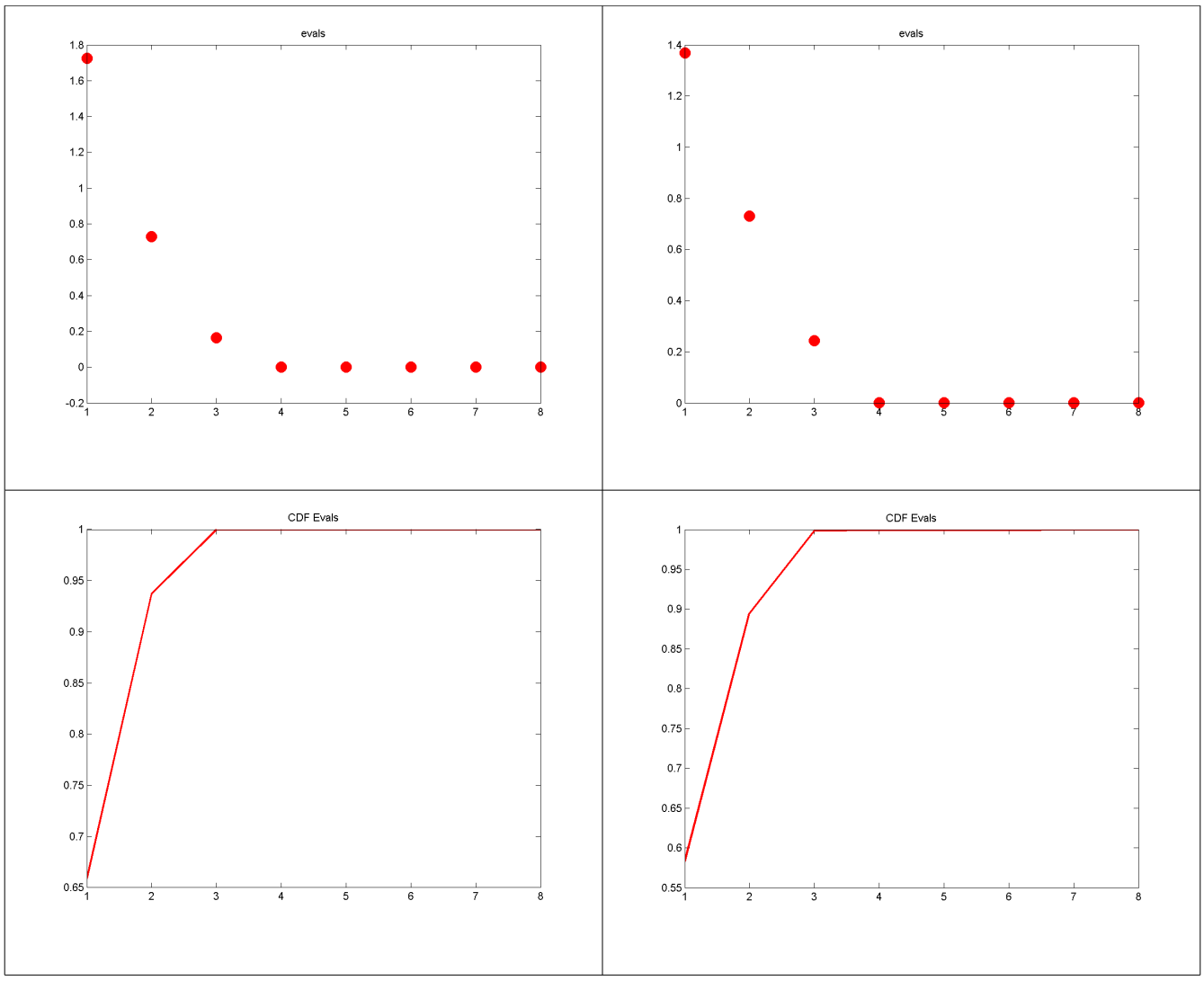
Without Noise	With Noise



Random translations and scale

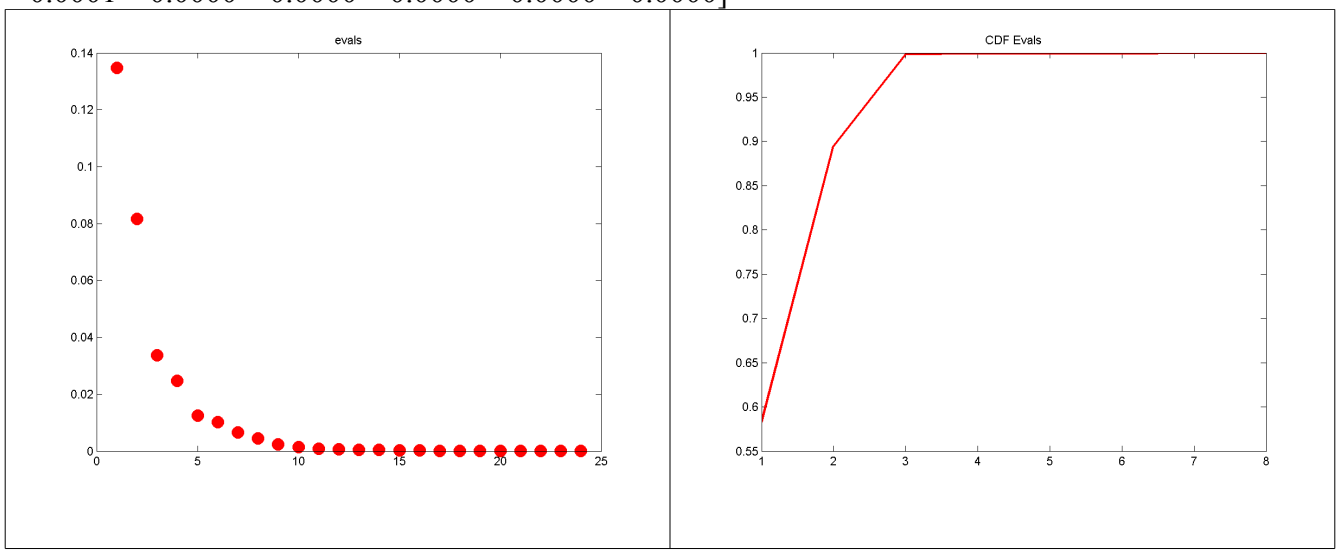
Evals = [1.7245 0.7282 0.1646 0.0000 0.0000 0.0000 -0.0000 -0.0000]
Evals_noise = [1.3684 0.7310 0.2439 0.0012 0.0007 0.0006 0.0005 0.0003]

Without Noise	With Noise



Corpus callosum shapes

Evals = [0.1348 0.0817 0.0338 0.0247 0.0126 0.0102 0.0067 0.0045 0.0024
0.0015 0.0009 0.0007 0.0006 0.0004 0.0002 0.0002 0.0001 0.0001
0.0001 0.0000 0.0000 0.0000 0.0000 0.0000]



Hand shapes
Evals =

Columns 1 through 9

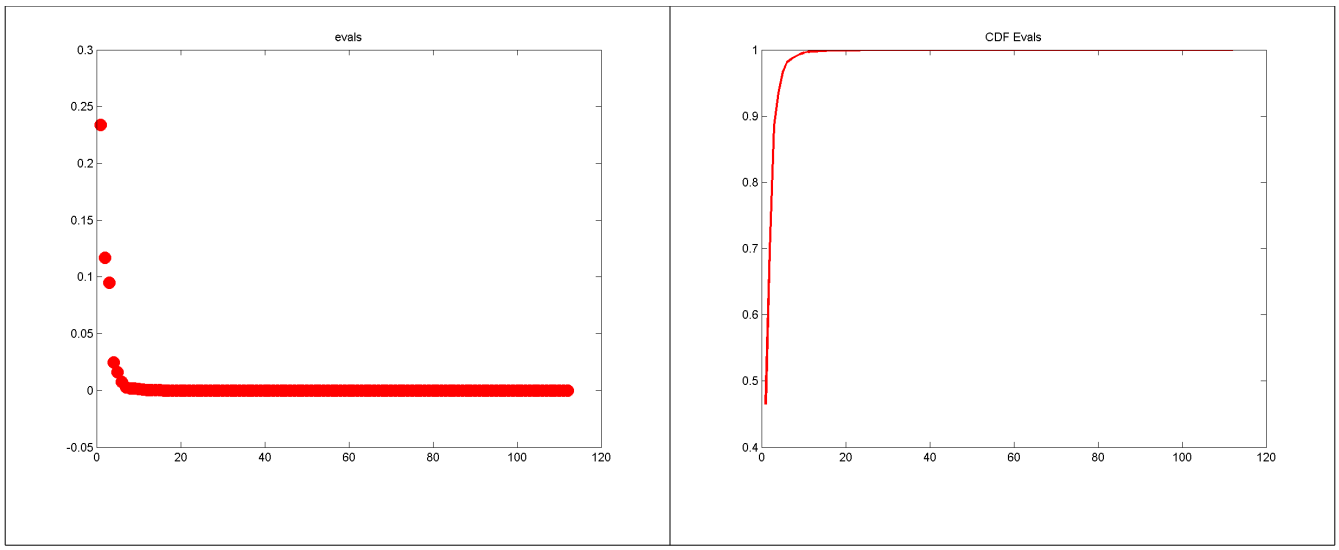
0.2337 0.1167 0.0948 0.0246 0.0160 0.0074 0.0025 0.0018 0.0017

Columns 10 through 18

0.0011 0.0007 0.0003 0.0002 0.0002 0.0001 0.0001 0.0001 0.0001

Columns 19 through 112

0.0001 0.0000 0.0000 0.0000 …..... 0.0000 0.0000 0.0000 0.0000 0.0000



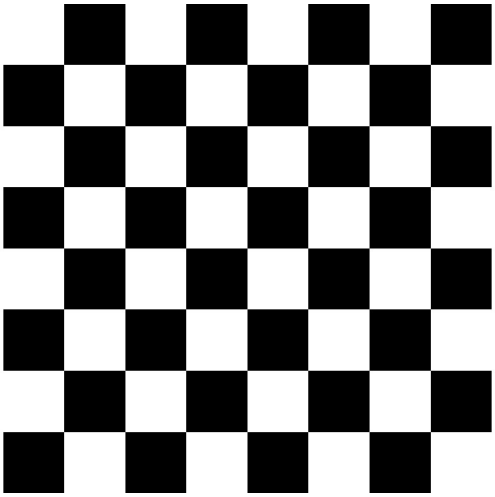
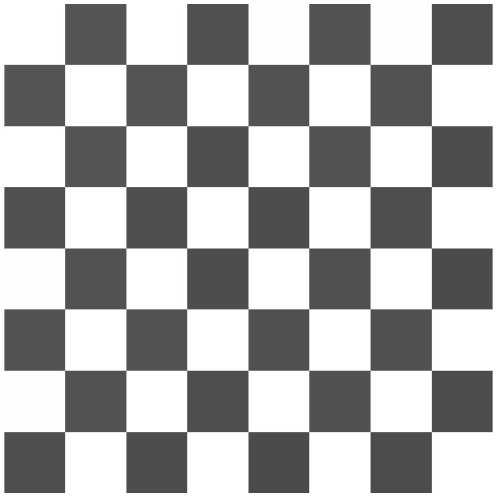
Discussion:
First, the number of the non-zero eigenvalues are not dependent on how complex the data is. In the case of just translation or scale, the first two or one eigenvalue is non-zero, but after we add some noises, the number of non-zero eigenvalues are increased. In addition, the value of the original eigenvalues are changed. Usually, they are decreased.

In the project description, it says "the number of shapes should be at least twice the number of points to ensure full rank of the covariance matrix". I used 30 rectangles, and each rectangular has 4 points, but the covariance matrix is not full ranked.

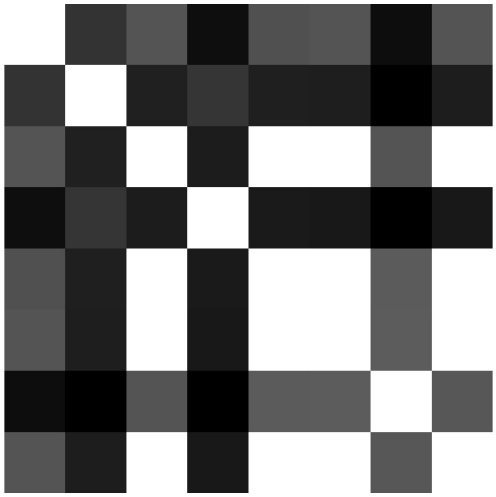
Image of correlation matrix and discussion.

Random translations

Without Noise	With Noise

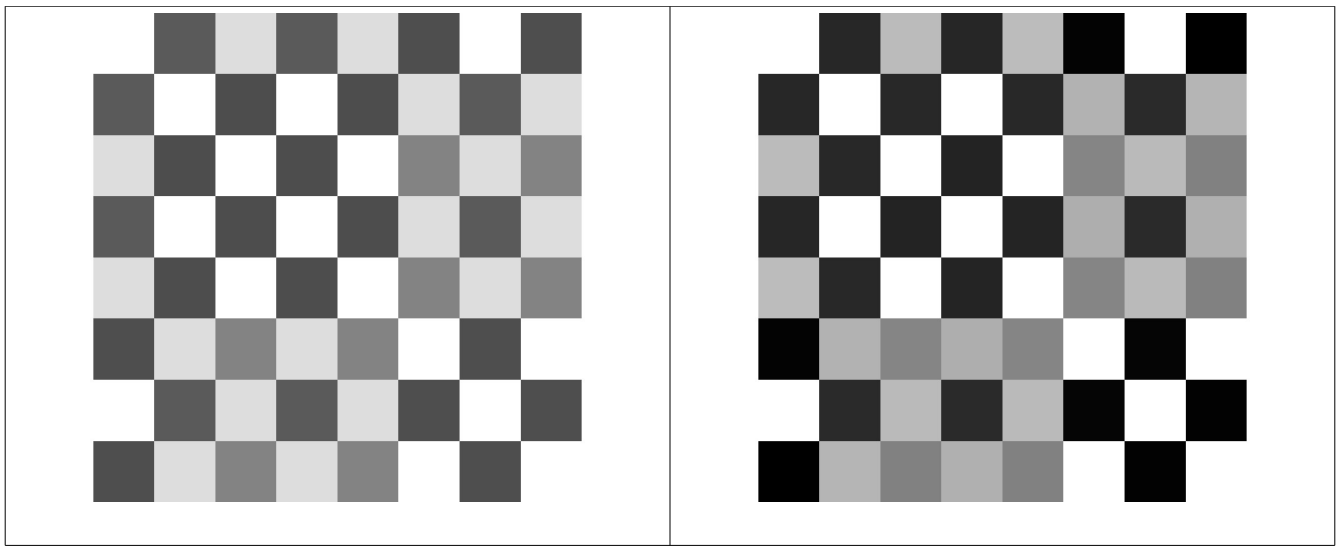
	

Random scale

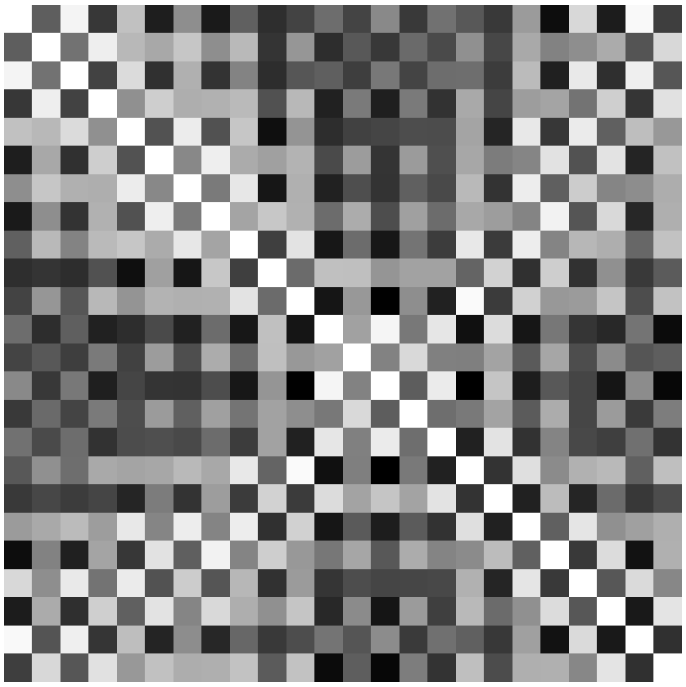
Without Noise	With Noise
No variance in some variable, so failed 	

Random translations and scale

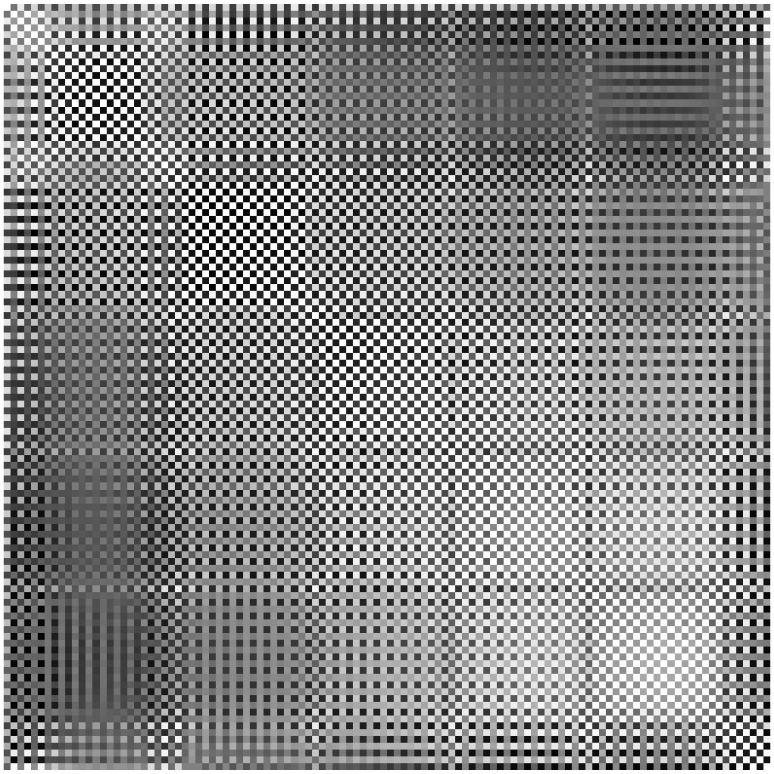
Without Noise	With Noise



Corpus callosum shapes



Hand Shapes



Discussion:

In translation, the x and y are negative correlated, this is probably caused by the translation in the y=-x direction.

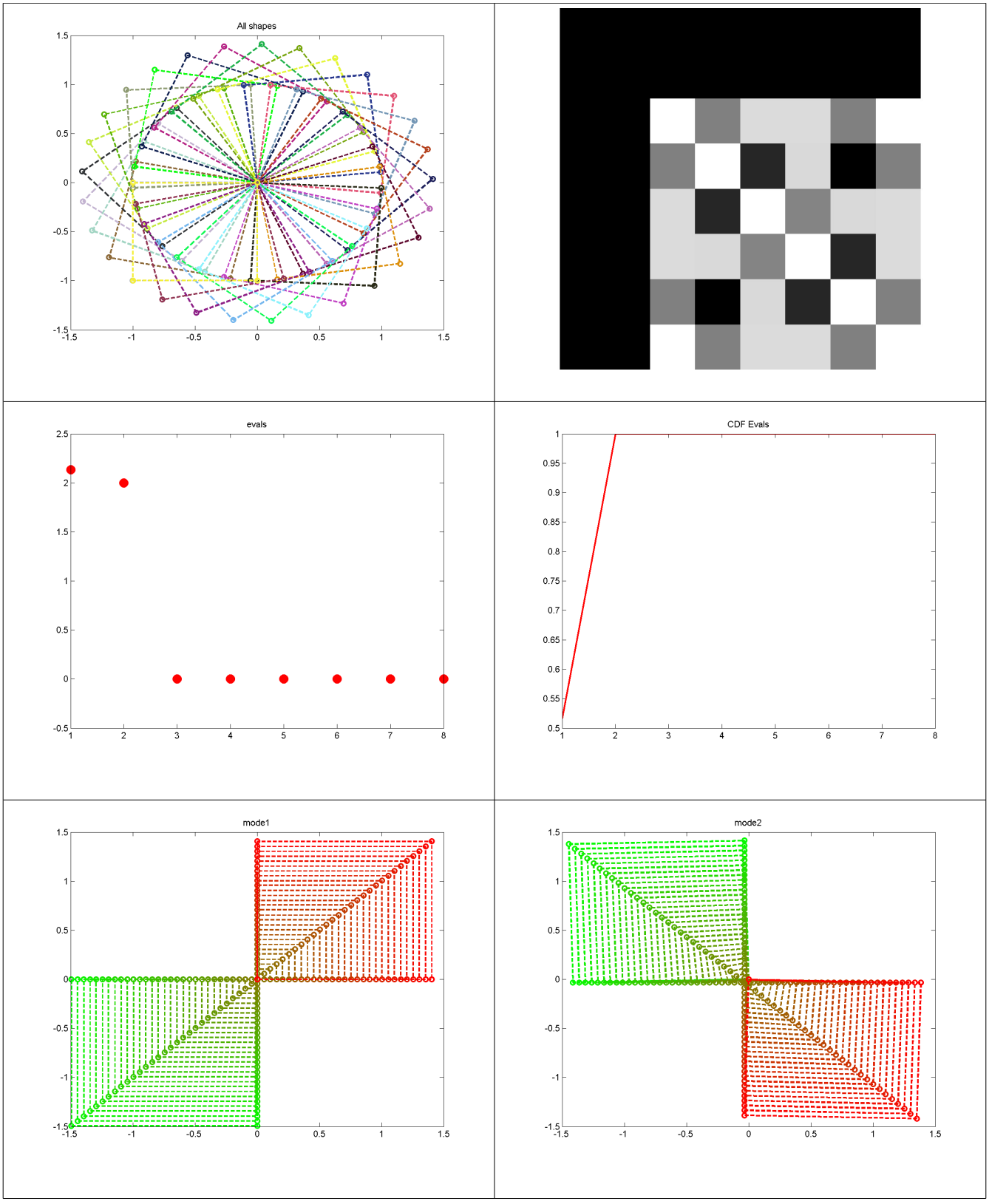
In scale, since the scale of the lower-left corner(0,0) is always 0, so its variance is 0, which means we can't compute its correlation with other variables. So, I may not use (0, 0) as its lower-left corner.

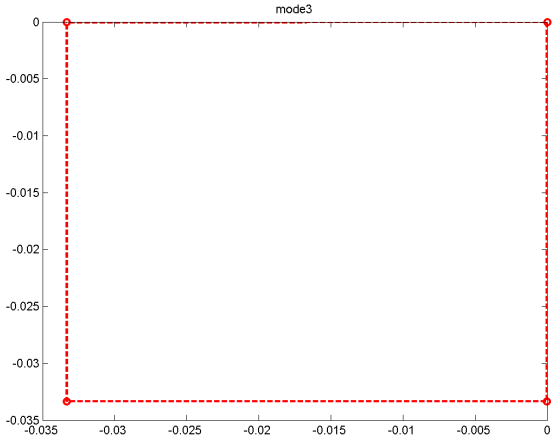
In the corpus callosum, there are two obvious diagonals, the first one means the movement of the points on the corpus callosum are highly correlated with their neighbors. The second one means the movement of the points on the corpus callosum are highly correlated with their symmetric points.

Apply program to a set of rotated shapes. Reconstruct eigenmodes and discuss eigenmodes and eigenvalues.

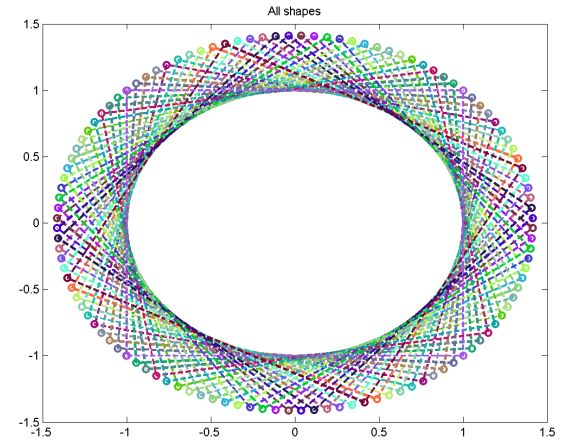
I should two different cases.

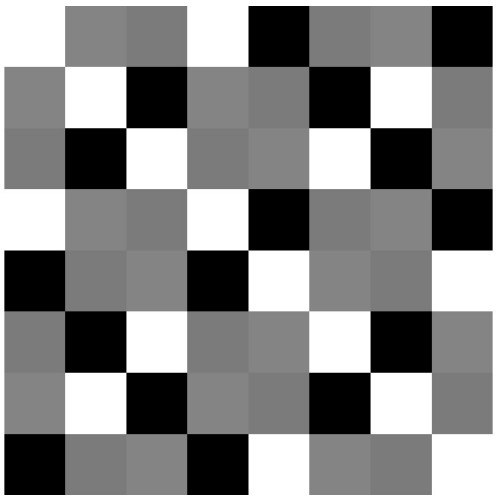
Case1:

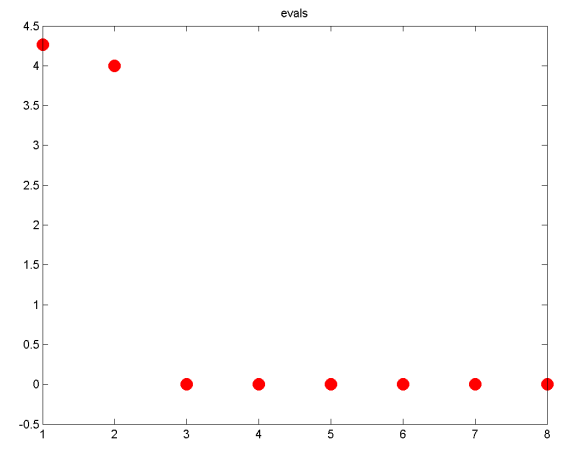

All shapes
evals
CDF Evals
mode1
mode2

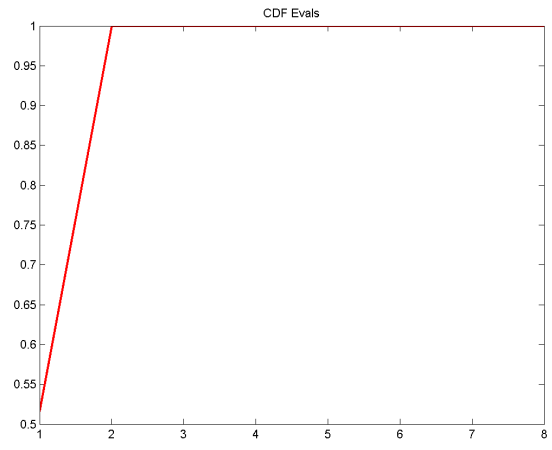

mode3
0
-0.005
-0.01
-0.015
-0.02
-0.025
-0.03
-0.035
-0.035
-0.03
-0.025
-0.02
-0.015
-0.01
-0.005
0

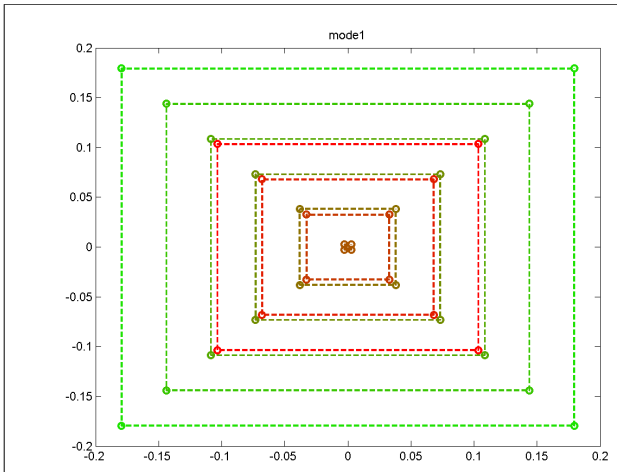
Case2:

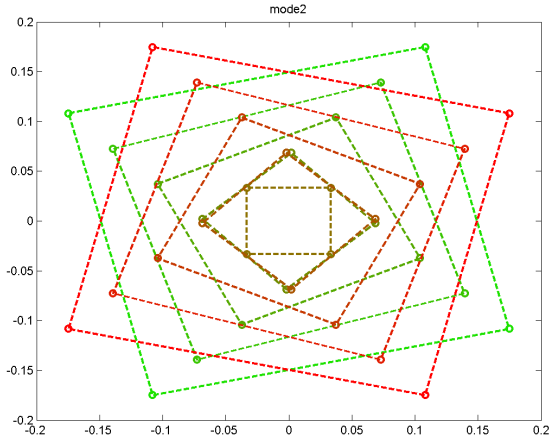

All shapes
1.5
1
0.5
0
-0.5
-1
-1.5
-1.5
-1
-0.5
0
0.5
1
1.5

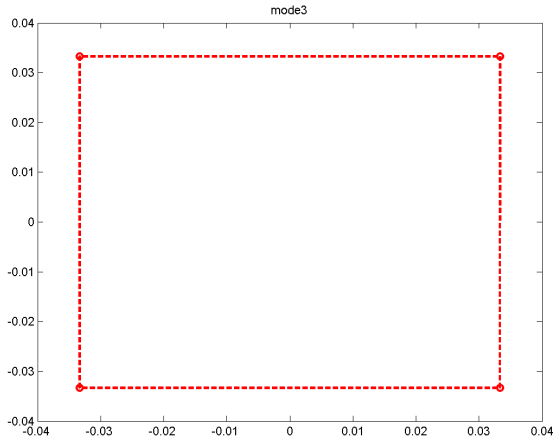



evals
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
1
2
3
4
5
6
7
8


CDF Evals
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5
1
2
3
4
5
6
7
8


mode1
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.2
-0.15
-0.1
-0.05
0
0.05
0.1
0.15
0.2


mode2
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.2
-0.15
-0.1
-0.05
0
0.05
0.1
0.15
0.2


mode3
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.04
-0.03
-0.02
-0.01
0
0.01
0.02
0.03
0.04