CS 736 : Assignment — Shape Analysis

Instructor : Suyash P. Awate

Maximum Points: 130
(Solutions: 117 Points + 13 Points for using the correct submission format.)

Please read, carefully, the submission instructions. Points shall be deducted if the instructions are not followed.

1. (30 points) Shape Analysis on Simulated Ellipse Shapes.

   Get the dataset of images, shared along with the assignment, showing solid-ellipse objects.

   There are a total of 150 images.

   Construct a pointset of 16 points per image, by placing points on boundary of the ellipse. For the whole dataset, this should give you a matrix of size 150x16x2: the last 2 for the 2D coordinates of each point.

   Hint: Points can be placed in clockwise or counterclockwise manner. Also you should follow some intuitions like quadrants for placing points so that they are placed in similar regions of ellipse across images.

   Taking the generated pointset as the input, implement an algorithm (covered in class lectures) for computing the shape mean and the modes of shape variation.

   Implement the following functionality as part of the shape-analysis algorithm:

   (a) (3 points) Code to capture pointsets modeling the shape of each object.
   (b) (3 points) Code to align two pointsets of equal cardinality via similarity transformations.
   (c) (3 points) Code to find the optimal shape mean, within every iteration.
   (d) (3 points) Code to find all the modes of shape variation.

   Report the following:

   (a) (3 points) Show a plot of the initial pointsets, as given in the dataset. Randomize the color for each pointset, to show all 2D pointsets in one graph. For ease of visualization, draw connecting line segments between the points to depict a piecewise-linear (poly-line) approximation of the object shape, as done in Figure 1.
   (b) (3 points) Show a plot of computed shape mean (poly-line visualization), together with all the aligned pointsets.
   (c) (3 points) Show a plot of the variances (eigenvalues; sorted) along each mode of shape variation.

(d) (6 points) Show a plot of the computed shape mean (poly-line visualization), all aligned pointsets, as well as two other pointsets (poly-line visualizations) depicting the principal (top) mode of shape variation around the mean ($\pm$ 3 standard deviations around the mean). Do this for top three modes of variation.

(e) (3 points) Pick the image in the dataset that has the pointset whose shape is closest to the shape mean, and show that image along with the pointset superimposed (poly-line visualization).

Pick the image in the dataset that has the pointset whose shape is closest to the shape that is $+3$ standard deviations away from mean along the top mode of variation, and show that image along with the pointset superimposed (poly-line visualization).

Pick the image in the dataset that has the pointset whose shape is closest to the shape that is -3 standard deviations away from mean along the top mode of variation, and show that image along with the pointset superimposed (poly-line visualization).

2. (27 points) Shape Analysis on Human Hand Shapes.

Get the pointsets for human hand-outline shapes, shared alongwith the assignment.

Repeat all the analysis in the first question, except the pointset-capture part.

3. (30 points) Shape Analysis on Leaf Shapes.

Get the dataset of images, shared alongwith the assignment, showing leaves.

There are a total of 75 images.

Construct a pointset of 32 points per image, by placing points on the boundary of the leaf. Refer Figure 1 as an example. This should give you a matrix of size 75x32x2.

Repeat all the analysis in the first question.

4. (30 points) Shape Analysis on MRI images of the Human Head.

Get the dataset of MRI images, shared alongwith the assignment, indicating skull shapes.

There are a total of 40 images.

Construct a pointset of 32 points per image, by placing points along the skull. Refer Figure 2 as an example. This should give you a matrix of size 40x32x2.

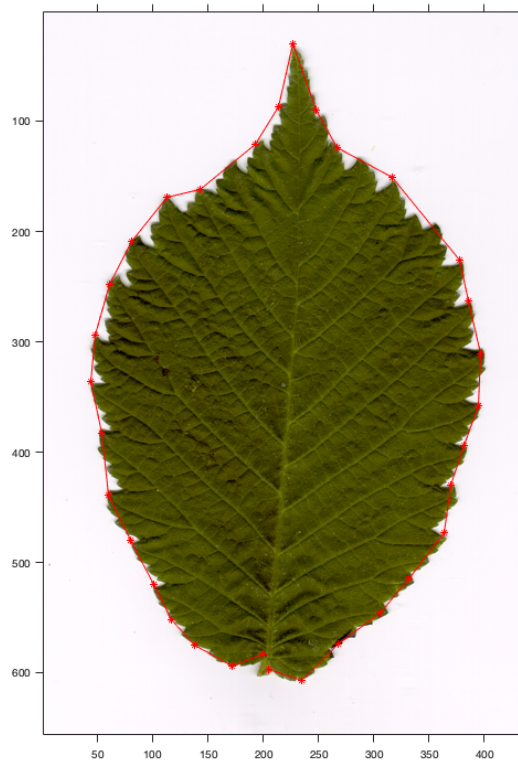Repeat all the analysis in the first question.

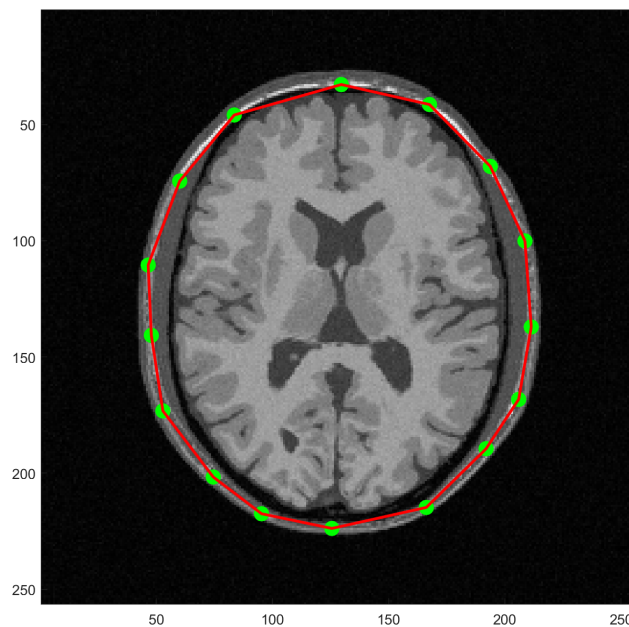Figure 1: Leaf image superimposed with a poly-line visualization of the shape modeled by the pointset.

Figure 2: Head MRI image superimposed with a poly-line visualization of the shape modeled by the pointset.