CS682: Homework #4

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Part 1

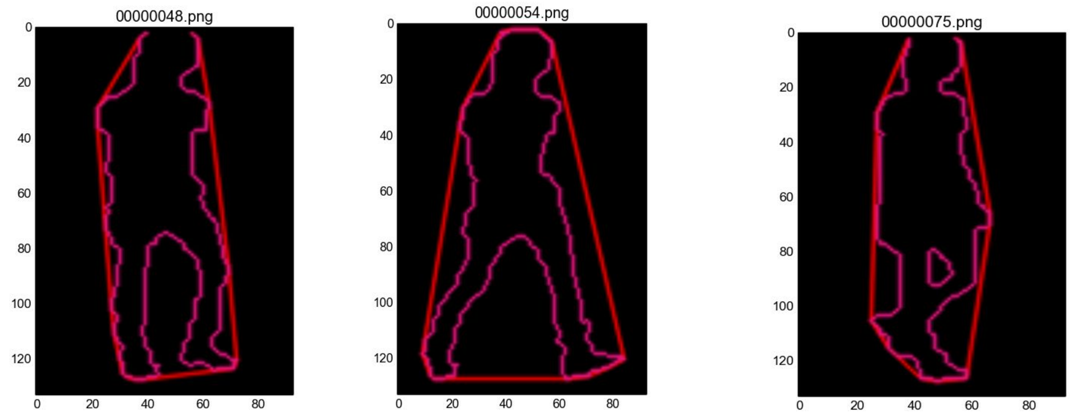

Fig. 1 Contours and Convex Hull

Fig.1 shows contours and convex hulls on 3 images.
The red outer line represents the convex hull and the pink lines represent the contours.

To find contours, I used the RETR_CCOMP mode because I wanted to get the hierarchy of each contour. The approximation method used is CHAIN_APPROX_SIMPLE. The hierarchy helped draw the last image with a hole in between the large outer contour.

Convex hulls were found in the clockwise direction. I used *drawContours* to visualize the above results.

In Fig. 2 below, the faint blue lines represent the polygonal approximation of the contours. The value of epsilon in *approxPolyDP* is 3. To visualize clean, continuous lines, I set the closed parameter to True.

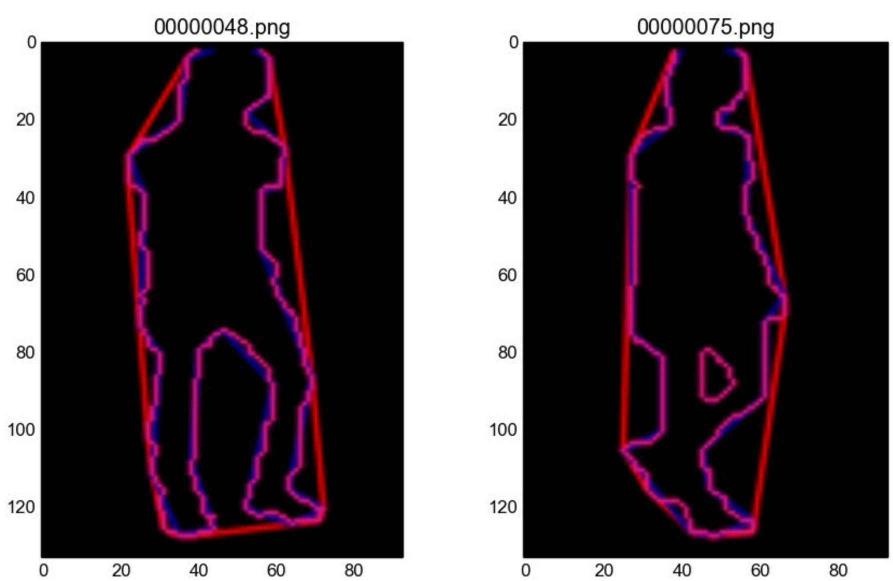

Fig 2. Polygonal Approximation (blue lines)

In Fig. 3 below, the yellow points represent convexity defects. More accurately, they represent the farthest point on the contour from its convex hull.

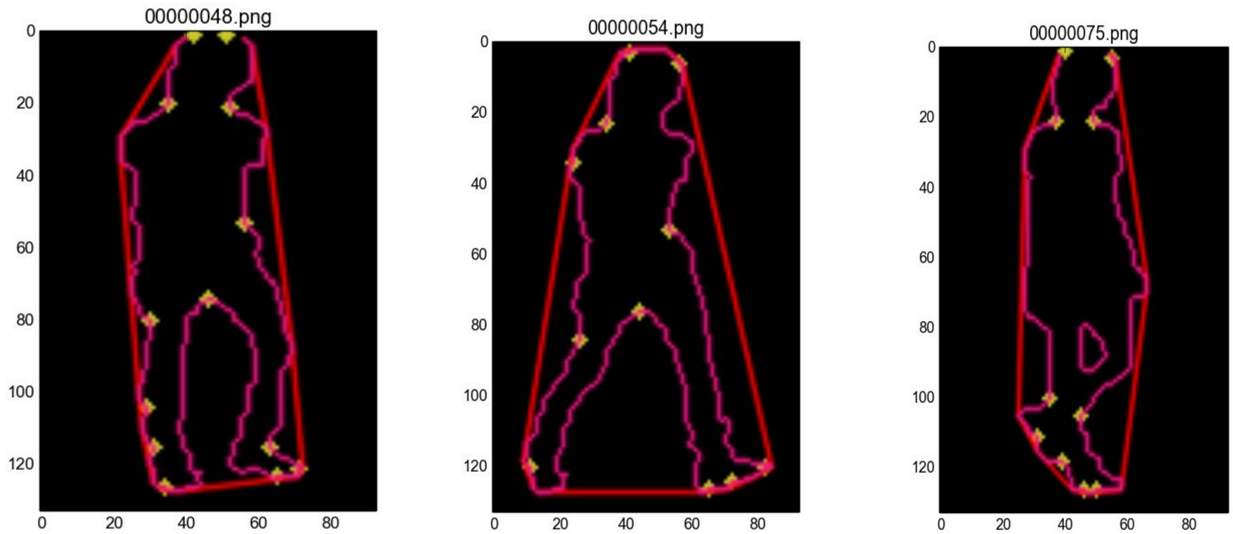

Fig. 3. Convexity Defects (yellow points)

After finding the moments for the contours and convex hulls, I plotted the centroids calculated for each of them onto the same images. In Fig. 4 below, the white circle represents the centroid for the image, the blue circle represents the hull centroid. The green outline is the contour whereas the red outline is the convex hull.

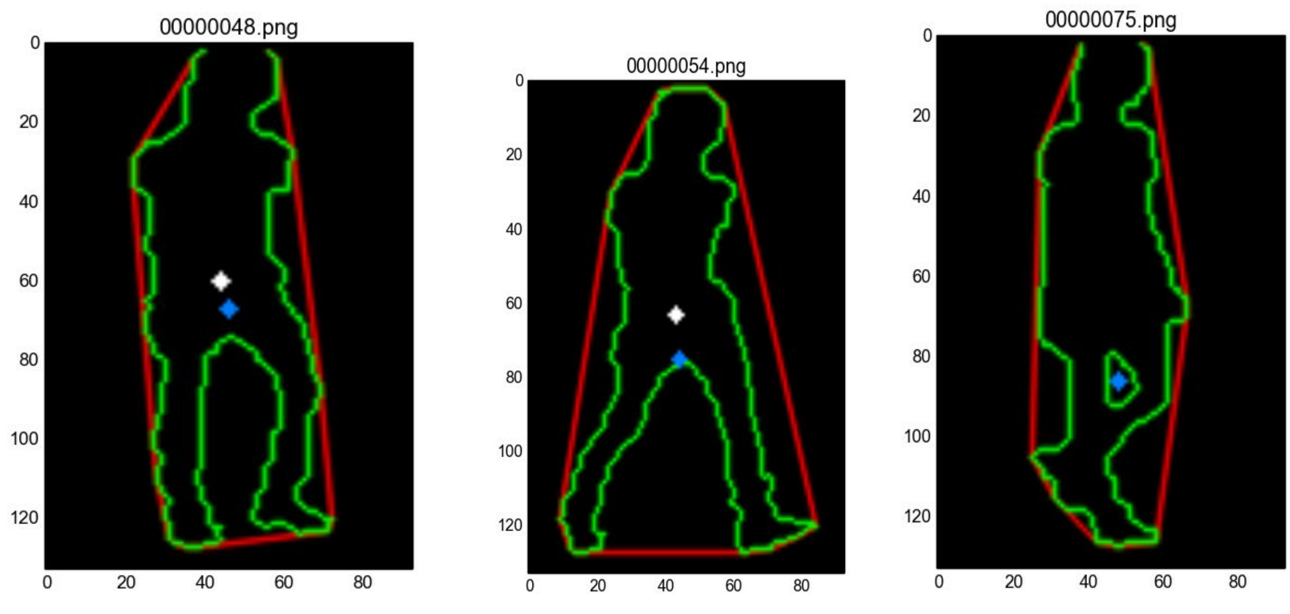

Fig. 4 Centroids - white represents image centroid, blue circle represents hull centroid

Part 2

The table with all the feature calculations is in an Excel sheet here.

Metrics are calculated for all contours and hulls where there may be more than one present.
In the case of frames where there is a hole within the external contour, the contours are numbered as 0, 1 and 2 (where present). 0 is the 1st contour in all images.

https://docs.google.com/spreadsheets/d/1-ChPtSMBGaOnm17xaKJeHnVfpVnJ8yWFVjABB8YRq5I/edit?usp=sharing

Part 3

I calculated the curvature at each point in an image by first plotting the contours and then using a set of 3 points relative to each point on the contour to estimate the curve κ at that point.

Then, I used a scatter plot with markings that color code the curvature depending on how low or high it is. In each of the images in Fig. 5 below - red or pinkish hues suggest high curvature whereas bluish colors suggest low curvature at a point.

Fig. 5 Curvature at each point in the contours

Part 4

Distance Transform: I used the OpenCV implementation to calculate distance transforms for all the frames.
The two main parameters were distanceType which I set to DIST_L2 for Euclidean distance and maskSize was set to DIST_MASK_3.

The resulting images are shown in Fig. 6 below.

Fig. 6 Distance Transform - Euclidean Distance

Part 5

Chamfer Matching

Part 6

a. Is there periodicity and how it shows in results (parts 2 & 5)?

Yes, there is periodicity in the gait. When we look at results from Part 2, we see that the perimeter of the external contour varies in cycles ranging from the first frame to the last. Every few frames, the perimeter stays in a particular range and then drops suddenly, then rises again. This indicates a certain type of swing in the movement of the subject. This is shown in the plot below. A relation between the area of the hull & frame also appears similar. The sharp dip near frame 133 is because of an error in calculation of the features (all were calculated as 0).

Fig. 7 Perimeter of the contours plotted by frame

b. Two most distinct phases of gait correspond to the widest and the narrowest profiles. Can you detect them from features displayed in 2.

The first phase is the stance phase in the beginning from frames 00000048.png through 00000084.png - in these frames, the contour area is highest and the profile is widest after which it thins and the contour area gradually reduces to the thinnest profile when the subject is walking straight. The narrowest profile is from frames 00000092.png to 00000173.png.

This is shown in Fig. 8 below.

Fig. 8 Plot of contour area versus frame.

c. Could you use curvature to detect joints and segment body parts? How?

Yes. Once we plot curvature at each point on the boundary, we can use curvature at that point to segment an area. I think an adaptive region growing algorithm could be used to identify those regions that can be segmented into body parts. If we want to use gait analysis, then it is evident that some body parts show higher swing in the walking process. The curvature is higher at certain points on the knee, arm or foot in certain frames.