Program 2 Report

Ellis Chen

ECPE 124

***Abstract*— This document provides information about the procedure and results of various digital image processing techniques used to detect and classify foreground objects in a given greyscale image.**

I. Image Processing Techniques

1) Double thresholding of greyscale images implemented with the floodfill algorithm using the seedpoint of the highthreshold image to floodfill the lowthreshold image.
2) Erosion and dilation of the double thresholded images to clean up background noise.
3) Connected components using floodfill to define every foreground object with a unique label.
4) Region properties to calculate the moments, central moments, centroids, and area of all labelled foreground objects.
5) PCA uses central moments to calculate the eigen values, major and minor axis, length of axes, direction of axes, and the eccentricity for each labelled foreground object.
6) The Wall following algorithm outlines the perimeter of each labelled foreground object by traversing through each pixel by searching for "on" or "off" neighbour pixels in all for directions.

II. Classification methodology

1) "fruit1.bmp" was the image used to test the above image processing techniques.
2) For the double threshold algorithm, the high threshold value was 190 and the low threshold value was 85.
3) The image was "cleaned up" by apply erosion on the image twice to get rid of the background noise, and then dilated twice to restore the foreground objects.
4) To classify the objects in connected components using floodfill, all the background pixels were labelled as -1 to ensure the algorithm does not detect the background as an object. The algorithm would then search through each pixel and mark each new pixel from a different region with a unique label. The label updates every time by increments of 50.
5) The number of unique labels is used to determine the number of unique region properties. For every label, the region properties algorithm scans the entire image for the corresponding objects and calculates the moments and area first, then the central moments and centroids are calculated after there are no more corresponding pixels with the current label.
6) PCA uses the central moments calculated in region properties and calculates all the values required to construct axes for every foreground object.
7) The wall following algorithm was split into two functions. The main wall following function initializes the direction of the pointer. The pointer is used to identify which direction the algorithm needs to traverse through the image. The second function is called when the pointer is initialized. The second function will update the pointer based on the status of the neighbour pixels "on" or "off". The pixels are marked and the pointer updates every time until there are no more pixels to mark and the perimeter is complete. This process is repeated for every label.
8) The axes are drawn using MATLAB's line function. The major axes are drawn by intersecting two points. One point is calculated already by region properties, centroids, and the other point is calculated using the values from PCA. The same procedure applies to draw the lines for the minor axes.
9) The color of the foreground object is determined by their eccentricity value, if it was greater than 0.5, then it was a banana. Else, then apples are determined by their area being less than 5000 pixels. If the object had more than 5000 pixels for the area, then it was an orange.

III. Results

Fig. 1 Clean image produced by double threshold using high threshold value 190, low threshold value 85, eroding and dilation twice

Fig. 2 Labelled image showing all six objects with different pixel intensities

TABLE I
LABELS OF EACH OBJECT

Label index	Label values
1	50
2	100
3	150
4	200
5	250
6	300

TABLE III
CENTRAL MOMENTS AND CENTROIDS FOR EACH LABEL

	L1	L2	L3	L4	L5	L6
Mu00	5365	3293	6199	6166	5087	3516
Mu11	-4.8e+06	-46754	2.1e+05	85896	-4.6e+06	25458
Mu20	4.9e+06	8.2e+05	2.9e+06	3e+06	6.8e+06	1e+06
Mu02	7.7e+06	9.2e+05	3.2e+0.6	3e+0.6	4.8e+06	9.5e+05
xc	82.52	278.26	168.387	324.6	210	122.69
yc	87.54	66.52	117.95	168.02	238.87	196.15

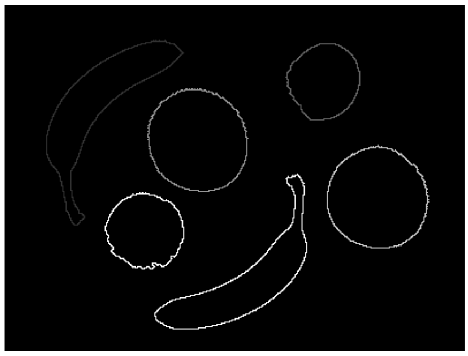

Fig. 3 Image with all the foreground objects outlined with different pixel intensities

TABLE IIIII
AXES INFORMATION FOR EACH LABEL

	L1	L2	L3	L4	L5	L6
eigen1	2.16e+03	284.43	532.78	505.2	2.06e+03	294.09
eigen2	250.34	243.02	457.25	477.31	223.37	267.32
theta	-0.93	-1.19	0.97	0.81	-0.68	0.29
Major length	91.78	33.73	46.16	44.95	90.79	34.3
Minor length	31.64	31.18	42.77	43.69	29.89	32.7
eccentric	0.94	0.38	0.38	0.23	0.94	0.3

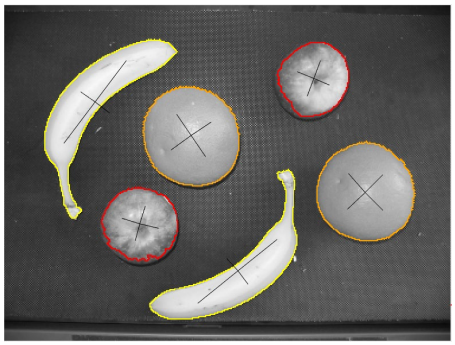

Fig. 4 The final image shows the perimeters colored in accordingly to the classification of the fruit, with the major and minor axes centered on the fruit.

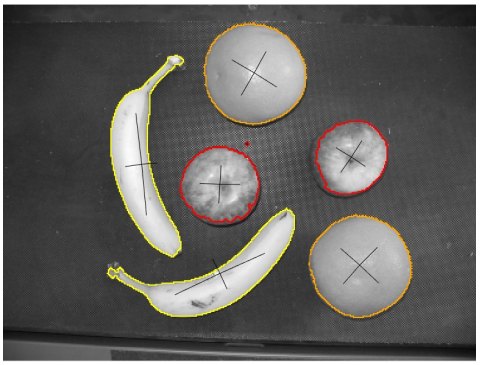

Fig. 5 The final image tested using "fruit2.bmp". The high and low thresholds changed to 200 and 90 respectively.

Overall, the digital image processing techniques applied on "fruit1.bmp" were mostly successful, capturing most of the perimeter of all the foreground objects and classifying them correctly. All the axes are mostly aligned with the center and eccentricity of the objects. The results for "fruit2.bmp" share many similarities as "fruit1.bmp", with only needing to adjust the high and low thresholds.