MMJ12503 – Computer Programming

Lab module

Function

1. Problem statement

Iris recognition is based on matching patterns in the iris, the donut-shaped coloured part of the eye. Iris recognition is performed with an image collected by an infrared (IR) camera that takes a picture of the eyeball. IR images are in black and white, so the colour information is not part of the image. Iris recognition is one of the most accurate biometrics because of the complex structure in the iris. The iris is one of the few biometrics that does not change as a person age. Most techniques for performing iris recognition first start with a segmentation operation. This operation identifies the iris/pupil boundary and the boundary between the iris and the sclera (or the white of the eye), as shown in Figure 1. For some analysis, a manual segmentation program is used in which a user is presented with an image of an eye on the screen, and the user then clicks on three points on the pupil boundary and three points on the boundary between the iris and the sclera. With three points, the computer can compute the equation of the circle. As an engineer of this research project, you are required to determine the coordinates of the centre of the circle and the radius of the circle that contains the three points with the given three points in a plane.

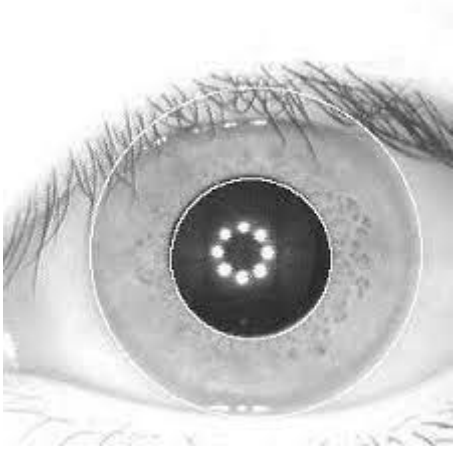

Figure 1 : Image of an eye with iris boundaries identified

2. Input/output Description

Figure 2 shows the inputs to the program are the x, y coordinates of three points. The outputs are the coordinates of the centre and the radius of the circle.

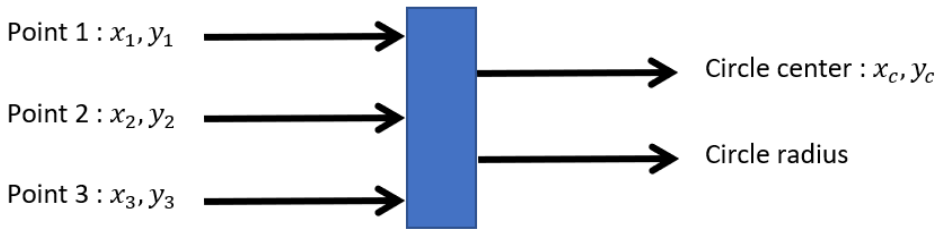

Figure 2 : Input and output of program

3. Hand example

There are a number of techniques for finding the equation of a circle from three points on the circle. The one that is used here is based on finding the equation of a line

through point P_1 and P_2, and the equation of the line through points P_2 and P_3. If these two lines of P_1P_2 and P_2P_3 are not parallel, then the lines perpendicular to these two lines segment go through the midpoints of the line segments, intersect in the center of the circle as shown in Figure 3.

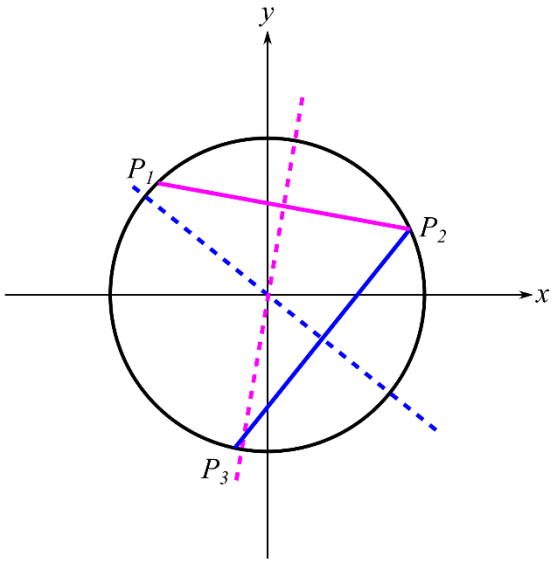

Figure 3 : Relationship between points on a circle and the center

Assuming that the coordinates of P_1, P_2 and P_3 are (x_1, y_1), (x_2, y_2) and (x_3, y_3), respectively. The following relationships are obtained.

- The slope of line P_1P_2

$$m_{12} = \frac{y_2 - y_1}{x_2 - x_1} \tag{1}$$

- The slope of line P_2P_3

$$m_{23} = \frac{y_3 - y_2}{x_3 - x_2} \tag{2}$$

- Equation of line P_1P_2

$$y = m_{12}(x - x_1) + y_1 \tag{3}$$

- Equation of line P_2P_3

$$y = m_{23}(x - x_2) + y_2 \tag{4}$$

- Equation of line perpendicular to line P_1P_2 that bisects the line segment

$$y = -\frac{1}{m_{12}}\left[x - \left(\frac{x_1 + x_2}{2}\right)\right] + \left(\frac{y_1 + y_2}{2}\right) \tag{5}$$

- Equation of line perpendicular to line P_2P_3 that bisects the line segment

$$y = -\frac{1}{m_{23}}\left[x - \left(\frac{x_2 + x_3}{2}\right)\right] + \left(\frac{y_2 + y_3}{2}\right) \tag{6}$$

Solving equations (5) and (6) simultaneously, the coordinate of the center are given as

- Equation for x coordinate of the center of the circle

$$x_c = \frac{m_{12}m_{23}(y_1 - y_3) + m_{23}(x_1 + x_2) - m_{12}(x_2 + x_3)}{2(m_{23} - m_{12})} \tag{7}$$

- Equation for y coordinate of the center of the circle

$$y_c = -\frac{1}{m_{12}}\left(x_c - \frac{x_1 + x_2}{2}\right) + \left(\frac{y_1 + y_2}{2}\right) \tag{8}$$

The equation for radius of the circle can be given as

$$r = \sqrt{(x_1 - x_c)^2 + (y_1 - y_c)^2} \quad (9)$$

Now, assume that three points on a circle are

$$P_1 = (-1, -1)$$
$$P_2 = (1, 1)$$
$$P_3 = (3, -1)$$

Using equations (1) and (2), the slopes for line P_1P_2 and P_2P_3 are

$$m_{12} = 2/2 = 1$$
$$m_{23} = -2/2 = -1$$

Using equations (3) and (4), the equations for the line P_1P_2 and P_2P_3 are

$$y = x$$
$$y = -x + 2$$

Using equations (5) and (6), the equations for the lines perpendicular to line P_1P_2 and P_2P_3 that bisect the line segment are

$$y = -x$$
$$y = x - 2$$

Using equations (7) and (8), the coordinate of the center point of circle is

$$x_c = 1$$
$$y_c = -1$$

Lastly, the radius of circle is calculated using equation (9) as

$$r = 2$$

4. Algorithm development

Decomposition outline of the main program:-

i. Read the coordinates of the three points.
ii. Use a function to determine the *x* coordinate of the center of the circle.
iii. Compute the *y* coordinate of the center of the circle.
iv. Compute the radius of the circle.
v. Print the coordinate of the center of the circle and the radius.

Decomposition outline of the function (assuming the coordinates of the three points are input parameters of the function and the output of the function is the *x* coordinate of the center of the circle):-

i. Compute the equation for two lines connecting the three points.
ii. Compute the equations for the two lines perpendicular to the lines connecting the three points that also bisect the line segments.
iii. Compute the *x* coordinate of the center of the circle.

5. Write a C program

Please convert the decomposition directly into C that has both the main program and the function.