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Applied Physics 186

Activity 4 — Measuring Area from Images

Synthetic (100 X 100) images of a circle, a rectangle, and a triangle as shown in Fig. 1 were generated in Python. The areas were pre-determined. The circle generated has radius 40 pixels and thus, it shall have a theoretical area of 5024 square pixels, the rectangle which is 20 pixels long and wide shall cover 1600 square pixels, and the theoretical area for the synthetic triangle is set to be 1800 square pixels. Edge-detection algorithm was employed to the image array and the result is shown in Fig 2.

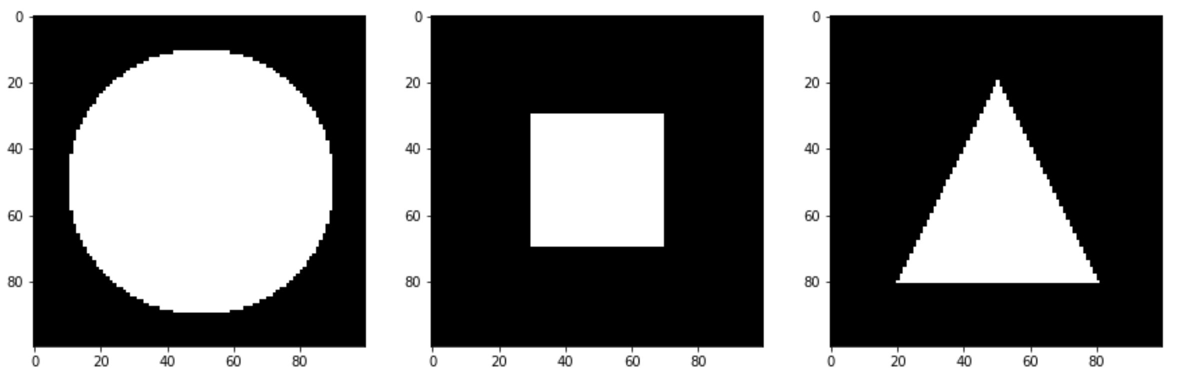

Figure 1. Synthetic images of geometric shapes.

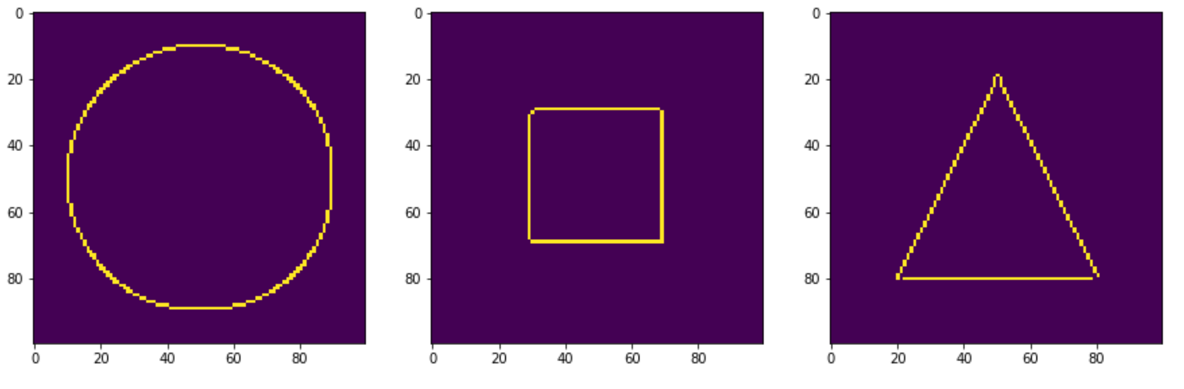

Figure 2. Edge-detected using Canny package from Open-CV.

At start, I don't know how these edge-detected points were arranged on my coordinates list. One way to check is to measure its polar angle with respect to the centroid point. To employ this, I used **numpy.arctan2**. Shown in Fig. 3 is the calculated polar angle vs their index on the coordinate of the edge points of my synthetic circle. Evidently, edge-detected points adjacent to each other on the plot weren't listed adjacent to each other on my coordinate list. I sorted the polar angles in an increasing manner as shown in Fig. 3 and saved the indices. The coordinate list was then sorted with respect to increasing polar angles using the saved indices.

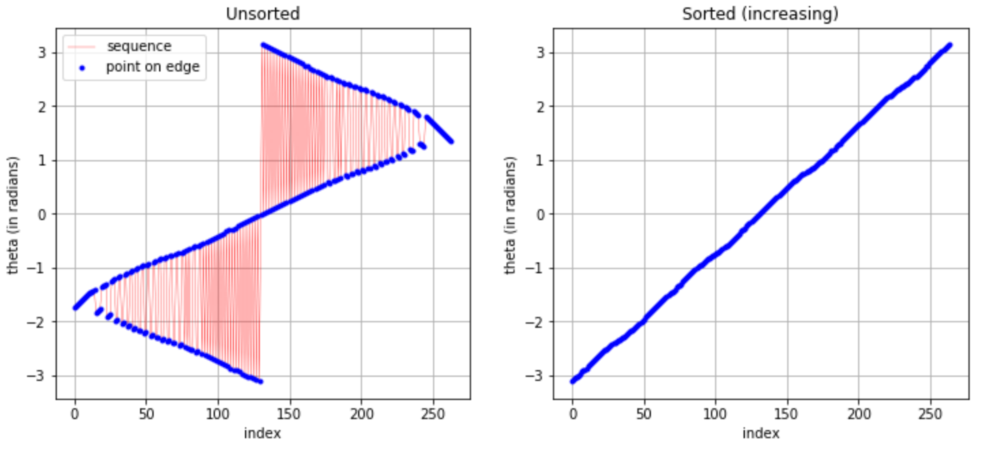

Figure 3. (Left) The coordinate list returned by my edge detection algorithm is classified to be unsorted since the polar angle calculated isn't arranged sequentially. Red lines show how adjacent indices have fluctuating polar angle counterpart. (Right) The coordinate list now has their indices arranged in an increasing polar angle.

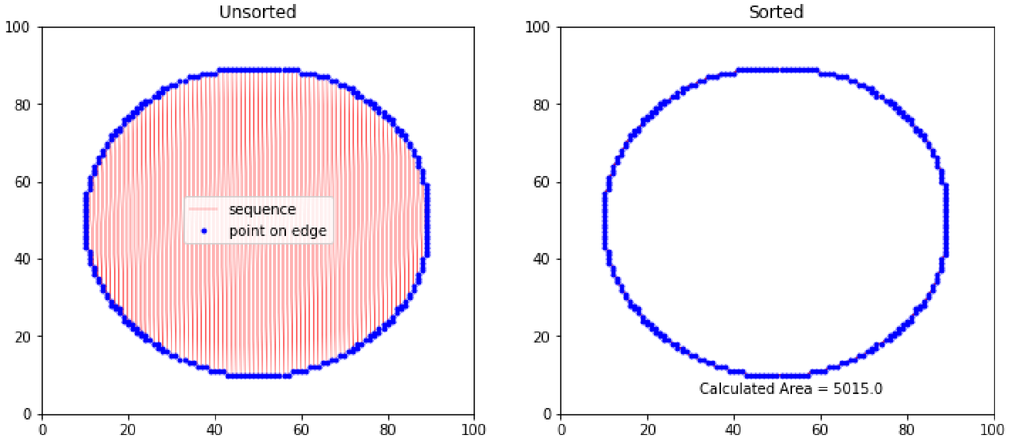

Figure 4 (Left) Red lines represent the order at which the initially edge-detected points were listed, hence the plot shows that it is unsorted. (Right) Now, the red lines obey the desired sequence as it traverses along the perimeter.

The sorting step of the coordinate list is essential in order to calculate the area using Green's Theorem in Eq. (1) where x and y are boundary coordinates of the sequentially arranged coordinate list [1]. Shown in Table 1 is the results summary.

$$A = \frac{1}{2}\sum_{i=1}^{N_b}\left[x_i y_{i+1} - y_i x_{i+1}\right] \quad (1)$$

Table 1. Implementation of Green's Theorem to calculate the area of a closed surface turned our to have a high accuracy with respect to the analytical area.

Shape	Analytical Area	Calculated Area	% Error
Circle	5024	5015	0.1791
Square	1600	1611.5	0.7188
Triangle	1800	1848.5	2.69

Application

It was shown previously that the method works well (at a high accuracy) for shapes which are regular and symmetric. The challenge is to apply the same technique is calculating the area from an irregular and asymmetric shape. As shown in Fig. 5, I chose an island from my home region. Using Google Maps, I traced the edges of the island (where white sand meets the sea). According to the application, the closed contour that I draw enclosed a space of 73,402.46 sq. meters.

Figure 5. The area of interest chosen was Mantigue Island, part of the Camiguin Island province in Northern Mindanao.

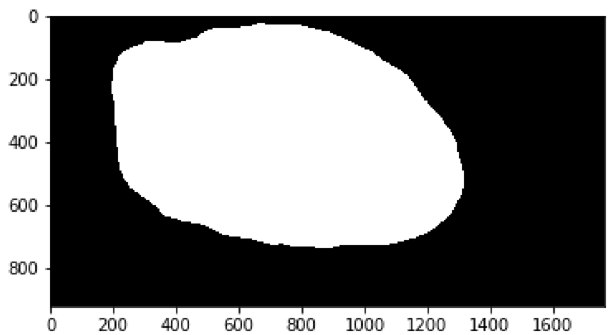

Figure 6. Using GIMP, I traced the edges and filled the area of interest with white pixels and turned the rest to black pixels.

After generating a synthetic image for the island shape, the same methodology was employed. First it was edge detected, then the coordinate list was sorted according to increasing polar angles. The area of interest covered around 631786 square pixels of the screenshot image. The next challenge is to convert these pixel area to units such as square meters. Luckily, a scale on the bottom portion of the screenshot was present and the 20 meter scale is actually covering 59 pixels of the image. From this relation, a square pixel is therefore equivalent to 0.115 square meters.

The actual area from the calculation using the pixel-to-meter relation and the shape area in pixels using Green's theorem is 72,201.83 sq. meters, 1.64% error from the value returned by Google Maps. Using image processing, I was able to calculate for areas of symmetric and asymmetric irregular shapes with high accuracy.

Self Evaltuation: 10

I'm quite satisfied with the results, especially on the application. It has always been my dream to go back to Camiguin and explore this island sanctuary. Though there was a moment when I was stuck and the sorting doesn't work because I manually implemented np.arctan(y/x), which has a possible range of -90° to 90° only. Thanks to my lab instructor Jayson for recommending me to use np.arctan2(y,x), a more appropriate implementation which covers the ranges -180° to 180°. It really took me a while to figure out what's wrong, so lesson learned, know your basics. Here's another photo of Mantigue Island for us to all appreciate <3

http://zionspeak.net/wp-content/uploads/2018/07/mantigue-island-camiguin.jpg

REFERENCE:
[1] Soriano, M. Measuring Area from Images. (2019)