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UNDERWATER OBJECT SHAPE DETECTION BASED ON TONAL DISTRIBUTION AND EDGE DETECTION USING DIGITAL IMAGE PROCESSING

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ABSTRACT

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Underwater exploration activities always have their own charm, many exotic objects that exist in underwater ecosystems have not been mapped properly due to the lack of related databases of the shapes and names of these underwater objects. Another factor that affects the visibility of objects is related to the quantity of light intensity that enters underwater, also not as much above the surface of the abundant water, especially during the day. This also hinders the process of documenting underwater objects. The main purpose of this study was to obtain the shape of underwater objects for several conditions of light intensity underwater using a low-cost digital image sensor camera. The method used in this research is to combine tonal distributions with object edge detection in digital image processing. The test results show that object detection tests in clear and turbid water can detect objects even though they are using a low-cost and low-resolution camera, but with the help of adequate lighting, it can be done. From that, it can be concluded that the detection of underwater objects is successful.

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1. INTRODUCTION

Underwater exploration activities have their own charm, there are exotic objects in many underwater ecosystems that have not been mapped properly, or for specific research purposes on underwater objects, due to the lack of a database related to the shape and naming of these underwater objects. Another influencing factor is the intensity of the light that enters under the water, which is also not as much as above the surface of the water, which is abundant during the day. This also hinders the process of documenting underwater objects.

A method is needed in this study, which combines tonal distributions; this method was chosen as one way to overcome visual limitations in underwater exploration with object edge detection in digital image processing. In previous research, the underwater environment is very blurry, so filter-based techniques are iterative and adaptive [1]. In the next study stated that in analyzing a shape, a high definition camera is needed, and image processing is used to extract the size of the texture analysis and the various appearance [2], on research [3] stated about the color of the water related to the use of computer vision on the level of health of the water, and also stated in research [4] about the level of turbidity of the water in the type of fresh water in the river with the level of pollution.

In this research, we develop another method that can be used as an alternative in object detection, [5] especially underwater, [6] with the criteria aspects including light intensity, water turbidity, and depth, which in taking pictures of objects, ignores the movement of the axis of motion and the coordinate system of the axes, namely surge, heave, and pitch.

2. RESEARCH METHODS

This study uses an experimental design approach to carry out the research process. The stages of the system are as follows.

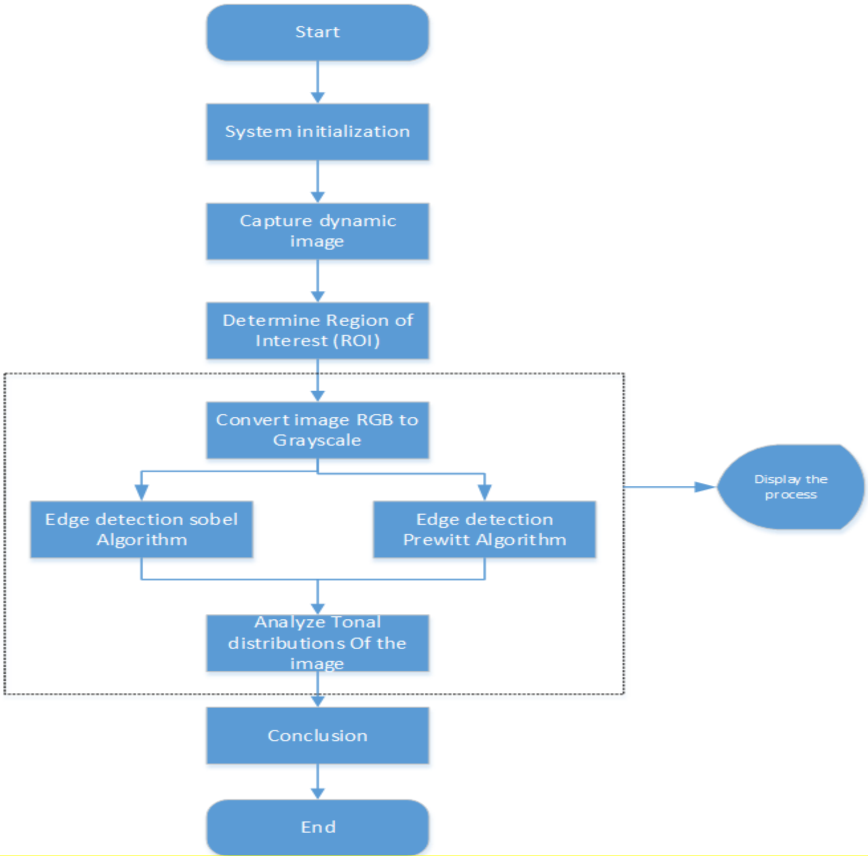


Figure 1. Experimental Design of the System

Figure 1 shows the research methodology used to detect objects, starting with system initialization, then taking digital image sampling, followed by determining the area to be processed (ROI). This area is made into 1 layer on grayscale[7], to be analysed for pixel values, then edge detection. Using the Sobel and Prewitt algorithms, to analyse the clearest shape of the object, after that using tonal distribution the values that appear most frequently are taken, to determine the shape of the object in the area in the image.

2.1 Detection System

In this study, an experimental design approach was used in carrying out the research process. The stages of the system are as follows. It is a process for recognition and communication of each hardware and software component, which is used for image processing, for hardware starting from the camera, image processing center, to the viewer or image processing display, while the software starts with image capture algorithms by I/O cameras, data processing centers, application of algorithms related to ROI (Region of Interest) [8] determination, the region of interest can determine by

$$\sum_{X=-\infty}^{+\infty} \cdot \sum_{y=-\infty}^{+\infty} I(r-x, c-y)\, M(x, y) \quad (1)$$

where on the 2D image using coordinates *x* and *y*, while convolution mask *M(r, c),* and the image origin *I(r, c)*; this conversion from dynamic RGB to grayscale images, edge detection, to the process of capturing processing results, that image. Capture dynamic image: This is the process of capturing images by a camera device in the form of moving images or video, where in this process, the composition consists of the captured lighting intensity, the number of sensor capabilities in pixels, and also the fps (frames per second) of the camera device. In determining the detection area, using the following equation [9].

$$\varepsilon_{lnt} = \int \alpha(S) \| f_s(S)^2 \| + \beta(s) \| f_{ss}(S) \|^2 \, ds \quad (2)$$

where, s is arc-length along the curve $f(s) = (x(s);\ y(s))$, $f(s) = (x(s);\ y(s))$ and $\alpha(s)$ and $\beta(s)$ are first and second-order continuity weighting functions analogous.

2.1.1. Convert Image RGB to Grayscale Color Space

This method is the process of converting RGB images to grayscale, to facilitate the search for color composition, into a single layer. And is used to find the histogram value of the degree of grayness of a pixel that often appears to be a decision-making parameter[10].

*Grayscale Intensity (I) = 0.2989 * Red (R) + 0.5870 * Green (G) + 0.1140 * Blue (B)* (3)

This formula uses the weights 0.2989, 0.5870, and 0.1140 to represent the human eye's sensitivity to different colors. The weights are chosen to approximate the perceived luminance of each color channel.

2.2 Object Detection with Edge Detection Operator

Object detection used to find out the shape of objects, based on edges, using the edge detection algorithm [11] from Prewitt is particularly effective at detecting edges by highlighting areas of rapid intensity change. The Prewitt operator [12]also uses two 3x3 convolution kernel dan Sobel, on the Sobel operator [13]is a common gradient-based edge detection operator[14] in image processing[15] to calculate the gradient of an image at each pixel. This purpose for clarifying the shape of objects when conditions are less light.

In the Sobel operator, there is a weighting of the pixels, namely the derivatives of the vertical *gy* and horizontal *gx* derivatives, as follows [16].

-1	-2	-1
0	0	0
1	2	1

-1	0	1
-2	0	2
-1	0	1

Figure 2. Sobel mask

In Figure 2, it combines these kernels with the image, which involves dragging them across each image pixel and calculating the weighted sum of the pixel values in the kernel. The resulting gradient approximation for horizontal gx and vertical gy changes is used to find the magnitude and direction of the image edges.

$$gx = (z3 + 2z6 + z9) - (z1 + 2z4 + z7) \tag{4}$$

$$gy = (z7 + 2z8 + z9) - (z1 + 2z2 + z3) \tag{5}$$

In the Prewitt operator, there is a weighting of the pixels, namely the derivatives of the vertical gy and horizontal gx derivatives, where this operator does not have '2' and '-2', which is like in Sobel, the following is the equation of the Prewitt operator [16].

$$gx = (z3 + z6 + z9) - (z1 + z4 + z7) \tag{6}$$

$$gy = (z7 + z8 + z9) - (z1 + z2 + z3) \tag{7}$$

2.3 Image Analys in Tonal Distribution

Analyze image is an image analysis process based on shape and value, according to the desired set point for a particular purpose. Based on the input from the camera for RGB, grayscale, Prewitt, and Sobel edge detection methods. Conclusion is a conclusion drawn based on data analysis, which has been obtained, then to be followed up. The end process is turns off the system and ends the image detection process. In the analysis of tonal distribution, the following equation is used [9].

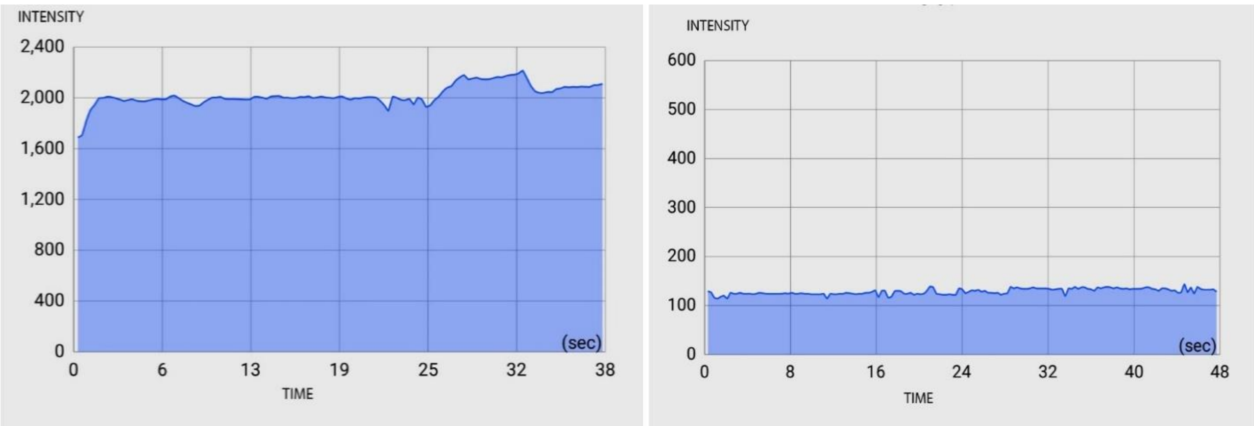
$$I(x,y) = H'_H(x,y) + H_L(x,y) \tag{8}$$

where, $H'_H(x,y)$ is the base layer of contrast image reduced by scaling to the desired log-luminance range[17], and $H_L(x,y)$is the log luminance of image, which can then be exponentiated to produce the tone-mapped (compressed) [18] luminance image. This process is equivalent to dividing each luminance value by (a monotonic mapping of) [19] the average log-luminance value in a region around that pixel [20].

In our analysis, we represent the tone distribution in the form of a histogram of the distribution of grayscale values to the number of pixels in the digital image of the object.

3. RESULTS AND DISCUSSION

The testing process was carried out in two categories, namely, with clear water and turbid water levels, where during the test light intensity was also measured with lux units, the camera used was a low-cost camera type, with a built-in LED light capable of providing intensity up to 250 lux. The following is the measurement of light intensity.



(a) (b)

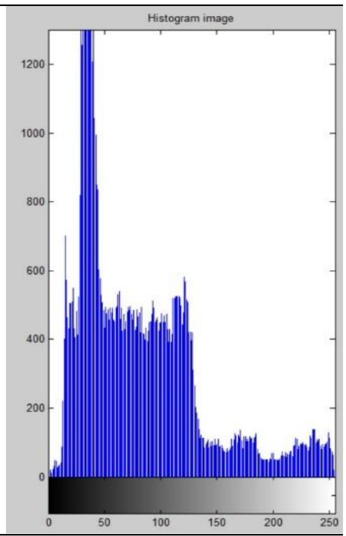
Figure 3. The Measurement of Light Intensity
(a) The Intensity of Light on the Surface of the Water, (b) The Intensity of Light on the Surface of the Water

Figure 3 (a) shows the average light intensity in lux units, where the measurement is carried out in daytime conditions, with indirect sunlight, for the time in seconds taken above the water surface, while in **Figure 3** (b) measurements are carried out, in daytime conditions in water with a depth of 30 cm.

3.1 Underwater Object Detection 1

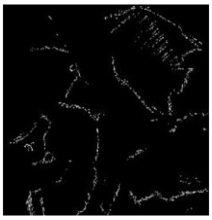
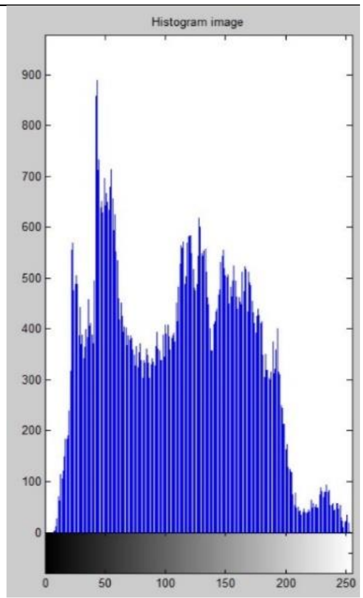
The underwater test was carried out several times with different object conditions, namely with multiple objects and a single object in clear water, and a second test with multiple objects and a single object in turbid conditioned water, to test how effectively the camera and detection system work under those conditions. The camera used is a low-cost type with VGA video recording capability of 649 x 480 pixels, there is an internal light source with a power of 125 lux. Digital image processing using MATLAB, conditioned water depth 25 cm.

Table 1. Testing on Clear Water, Single Detection Object

Origin image	Grayscale image	Sobel Edge-detection	Prewitt Edge-detection	Histogram grayscale image
				

In testing **Table 1**, it was found that objects in clear water can be detected well, both visually and in image processing, with grayscale image histograms obtaining the highest values in the range of 30 to 50, with pixel frequency values above 1200 output pixels.

Table 2. Testing on Clear Water, Multi-Object Detection

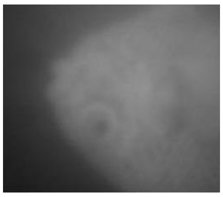
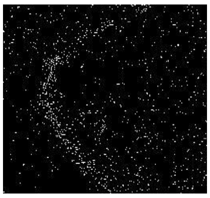
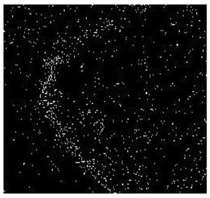
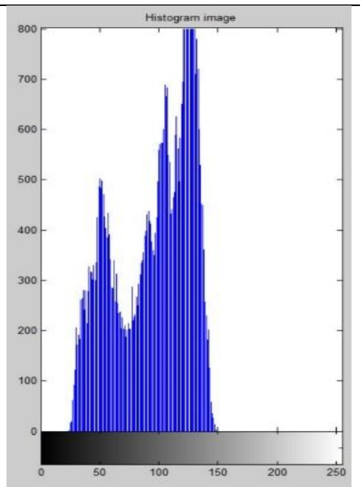
Origin image	Grayscale image	Sobel Edge-detection	Prewitt Edge-detection	Histogram grayscale image
				

In testing **Table 2**, it was found that multiple objects in clear water can be detected well, both in image processing and visualization, with grayscale image histograms obtaining the highest values in the range of 40 to 50, with pixel frequency values above 900 output pixels and for the degree range a grayscale between 100 and 170 has a pixel frequency between 500 and 600 output pixels.

3.2 Underwater Object Detection 2

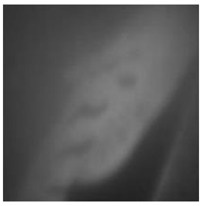
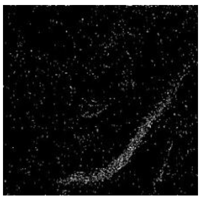
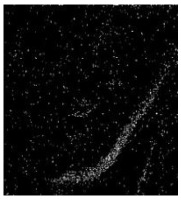
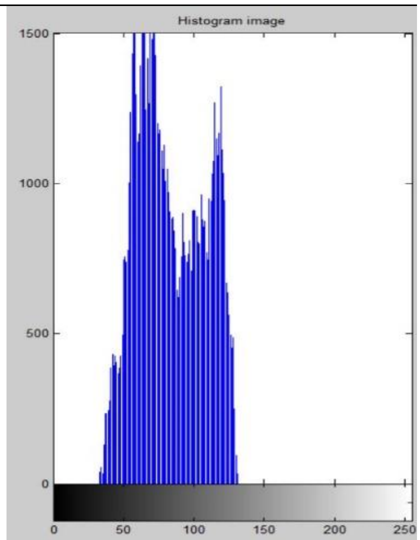
The camera used is a low-cost type with VGA video recording capability of 649 x 480 pixels, there is an internal light source with a power of 250 lux. Digital image processing using MATLAB, conditioned water depth 25 cm, on turbid conditioned water.

Table 3. Testing on Turbid Water, Single Fish Head Detection Object

Origin image	Grayscale image	Sobel Edge-detection	Prewitt Edge-detection	Histogram grayscale image
				

In testing **Table 3**, it was found that objects (fish heads) in turbid water can be detected quite well, both in image processing and visualization, with grayscale image histograms obtaining the highest values in the range of 100 to 150, with pixel frequency values above 800 output pixels The shape of the fish head is still detected using edge detection with little noise, even in murky water, with very limited camera visibility due to murky water.

Table 4. Testing on Turbid Water, Single Object Detection

Origin image	Grayscale image	Sobel Edge-detection	Prewitt Edge-detection	Histogram grayscale image
				

In testing **Table 4**, the detection data shows that objects (fish bodies) in turbid water can be detected quite well, in the experiment, using a lighting intensity of 250 lux, with grayscale image histograms obtaining the highest values in the range of 50 to 60, with pixel frequency values above 1500 output pixels, and between 100 to 130 with a pixel frequency value above 1000, in which the body shape of the fish is still detected using edge detection with noise, even in cloudy water, and very limited camera visibility due to cloudy water. Experiment with the methods segmentation techniques, and edge detection algorithms. Fine-tune parameters based on the specific characteristics of the images.

4. CONCLUSIONS

The results of several testing processes concluded that testing in clear water obtained better object detection with lighting of 125 lux, which, at a depth of 25 cm, was obtained from the lighting on the internal camera, the shape of a fish-shaped object can be easily read, even when using a camera low cost which has a resolution of 640 x 480 pixels, whereas in testing in murky water with the same depth, but with a maximum light intensity of 250 lux, the camera with a resolution of 640 x 480 pixels is quite difficult to detect the shape of the object, where the camera has to get closer to about 5 cm from the object in order to detect the shape of the object. As a whole, the research from this data was declared successful in detecting underwater objects using a low-cost camera.

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