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# Implementation Color Filtering and Harris Corner Method on Pattern Recognition System for Underwater Objects

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**ABSTRACT**

Color recognition and angle detection of underwater objects can be done with the help of underwater robots (ROV) with image processing applications. The processing of the object's image is recognizing various shapes and colors of objects in the water. In this research, the color filtering and Harris corner method will be designed, studied, tested and implemented. The color filtering method is used to recognize object color patterns, while the Harris Corner method is used to detect angles of underwater objects. Then classify images to get data on environmental pattern recognition. The color patterns tested include red, green, yellow and blue. the results obtained are all color patterns can be recognized well. while the shape of the object being tested includes cubes, triangles, rectangles, pentagons, and hexagons. the results of testing some of the shapes can be detected with a good angle and others still have errors. This is because testing the form of objects is done in various positions, such as from the front, right, left, up and below.

**Keywords**: Underwater Robotic, Color Filtering and Harris Corner

## I. INTRODUCTION

Robots can be used for exploration in an unknown environment, especially in dangerous ones. It is common to employ an advanced robot for such tasks. However, the robot is susceptible for solving task in such environment because a failure of the robot means the failure of the entire mission [1]. Underwater robot vision allows underwater robots to be controlled and operated automatically. Especially, underwater tracking and visual image technology that is very valuable for underwater robots can move towards its destination and grab objects. The underwater environment is very different from the air environment, where natural lighting is strongly influenced by refraction, abortion and scattering when in the water [2]. for this problem one of the proposed techniques is underwater robotic visual tracking (RUTS) based on real time KCF. RUAS is used for underwater image restoration. Meanwhile, we attempt to compare RPG descriptors with HOG descriptors in tracking accuracy and computing speed. Through experiments on our underwater system in real marine environment, results demonstrate the satisfactory efficiency of RUTS with high computing speed and good enough tracking accuracy [2].

Generally, under its control system the underwater robot is divided into two types namely Autonomous Underwater Vehicles (AUV) and Remoted Operated Vehicles (ROV). AUV is an underwater vehicle capable of moving in water automatically without direct human control. While the ROV is an underwater vehicle whose motion is directly controlled by humans via a remote controller from above the water level. In the scenario, AUV will cross a well-known and safe tracking. If the environment is unknown and diverse, then AUV through the previous tracking may be one, or only, a safe tracking to and from a particular site. In these examples, it is very important to maintain security and security, then follow the previous steps. While the ROV is still operated even though the tracking taken is unknown. The contribution of this work is the successful implementation of each underwater vehicle, which the system relies on improvements made to image registration techniques. This system uses sonar as the main imaging sensor [3].

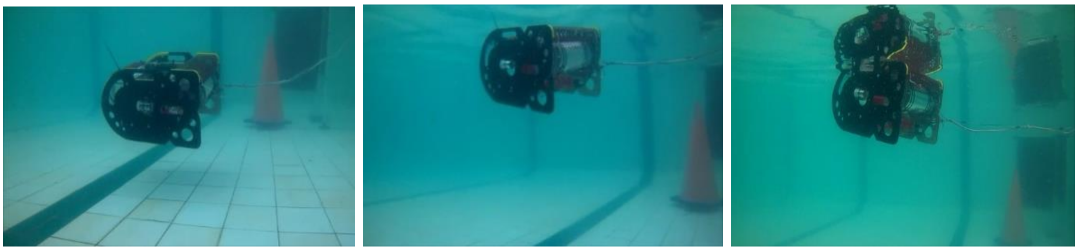

Figure 1. Remoted Operated Vehicles (ROV) in underwater

The camera can be used as a visual device in water. The camera will take and process the image. This process can be used to observe and search for underwater objects. Underwater objects can be recognized using a hybrid of color filtering and angle detection methods. Angle detection is the basis for many image processing procedures including pattern recognition and motion detection [4]. Angle detection is a method of finding the angle of an object in an image. These angles can be calculated and identified to find underwater objects. Many features or features of an image can be used as a representation of an image. This feature can be in the form of edges, angles, colors, lines, and many others. In this paper using the Harris algorithm angle detection method to detect angles contained in an image.

Whereas, to detect underwater object patterns can use the color filtering method of HSV on underwater robotic (ROV). Color filtering will recognize various shapes and colors of objects in the water. Color filtering aims to improve image quality so that it is easily interpreted by human computers. The input is the image and the output is also the image, but with better quality than the input image. For example, the image is less sharp, blurred, contains noise (eg white spots), so it needs


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processing to improve the image because it will be difficult to interpret because the information conveyed is reduced.

This research will propose a hybrid method between color filtering and *Harris* angle detection. Both of these methods will be tested to identify underwater objects in the ROV underwater robotic type. These objects can be of a certain shape or color, and the results can be used as an ROV navigation system to search for and recognize underwater objects. Color filtering is used to identify certain colors, while the angle detection method to recognize the shape of a particular object. Hopefully, the combination of these two methods can produce and become one of the better development of the vision computer method

## II. OVERVIEW

### 2.1 HSV COLOR SPACE

Several methods can be used to process and detect object patterns such as feature detection or based on color. Fixed color features based on geometric transformations (scaling, translation, and rotation) of an image. Colors in digital systems represent various color models. Image processing hardware, in general, applies RGB color models with consideration of the ease of displaying technical colors. Other color models focus on the perception of the human eye on color, such as HSV. This color model represents colors as three components, Hue (H), Saturation (S) and Value (V) [5][6]. The HSV color space defines color in terms of Hue, Saturation and Value. HSV channels are described as follows, Hue: Describes a pure colour (e.g. pure yellow, orange or red). Saturation: Describes how much a pure colour is diluted with white light.Value: Refers to brightness of the colour [7]. Figure 3 is a yellow detection image from RGB to HSV to binary conversion.

Hue states the actual type of color, such as red, violet, yellow and, while the spectrum is where the color variations vary. Hue states the color spectrum angle from 0 to 360 degrees. Hue is associated with the wavelength of the light found in the dominant color received by the sight of the human eye. Saturation states purity level of a color, indicates how much white is given. Saturation of a color is purity measure of the color. Hue is still red but saturation value is reduced. Saturation is a measure of the white light amount mixed with the hue. Component Saturation (S) represents the purity of a color, with value between 0 until 255 and indicates the value of greyish color that 0 indicates gray and 1 indicates pure primary color.

Value is an attribute states amount of light received by an eyes regardless of the color. Value also called intensity, which is a measure of color brightness or amount of light coming from a color. Value measure from 0 to 255. Color with 0 value appear as dark as possible, and color with 255 value appear as bright as possible. Because HSV color is a color model derived from RGB color, we have to do color conversion from RGB to HSV in order to get the HSV color. See in Figure 2 below to know about HSV color model.

In order to be processed into HSV color model, RGB image must be converted to HSV color model. HSV color model is a nonlinear transformation of RGB color model. Calculation of RGB to HSV conversion can use equation (1) and (2) below [7].

$$r = \frac{R}{(R+G+B)}, g = \frac{G}{(R+G+B)}, b = \frac{B}{(R+G+B)} \quad ...(1)$$

$$r = \frac{R}{(R+G+B)}, g = \frac{G}{(R+G+B)}, b = \frac{B}{(R+G+B)}$$

$$V = \max(r, g, b)$$

$$S = \begin{cases} 0, & V = 0 \\ 1 - \frac{\min(r,g,b)}{V}, & V > 0 \end{cases}$$

$$H = \begin{cases} 0, & S = 0 \\ \frac{60*(g-b)}{S*V}, & V = r \\ 60 * \left[2 + \frac{b-r}{S*V}\right], & V = g \\ 60 * \left[4 + \frac{r-g}{S*V}\right], & V = b \end{cases}$$

$$H = H + 360 \quad H < 0 \quad ...(2)$$

Thresholding technique provides an efficient way, both in terms of simplicity of implementation and data processing. The time needed for the image segmentation process also becomes shorter. Automatic image selection from the optimal threshold value remains a challenge in image segmentation [8]. Thresholding is the process of converting gray-level images into binary or black-and-white images so that it can be known which areas include objects and backgrounds from the image clearly. Thresholding results are usually used further for object recognition and feature extraction processes.

$$T = T\,[x, y, p(x, y), f(x, y)] \quad ...(3)$$

T is thresholding value,
x, y are coorninate point of thresholding value,
p(x, y), f(x,y) are pixel point of grayscale.


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Figure 2. Yellow detection, from RGB to HSV to binary conversion

### 2.3. HARRIS ALGORITHM

Harris angle (and edge) detection is one of the most important kernels for processing images, especially for motion detection and object recognition. The procedure is a serial combination of 3×3 filters (derivative and Gaussian), surrounded by the basis of arithmetic and selection operations. This leads to stencil calculations that describe two challenges related to memory access and excessive calculation. Because this kernel might be called intensively on an image processing application, which includes an embedded context. So that implementation to various hardware can be done in the fastest time [4]. Harris corner detection is used because it is able to produce consistent values in images that experience rotation, scaling, lighting variations. Angle detection with the Harris method is based on variations in signal intensity. Large variations in intensity indicate the presence of angles in the image. Submarines or autonomous underwater vehicles are mounted on a camera as the visual senses. Then the camera uses Harris algorithm's angle detection method. This method makes it easy to find underwater objects.

Angle detection methods can be grouped into three categories: the first method is based on the intensity of the gray scale of the image, mainly detecting the angle points by examining changes in the local gray degree value. The second is a method based on the edge feature of the image, which is used to analyze the edge shape features of the image, as the detection of angular points. The third is to use various types of angular parametric models to match images based on the angular model method [9][10]. The windowing function W (x, y) is worth 1 if it is in a window or 0 if outside or using it can also use the Gaussian function. The value in the Intensity Shifted and intensity for the flat/constant part will be of little value, while for the area containing the corner will be of great value. What you want to look for is an area with a large value of E (u, v). For small changes [u, v] we use the bilinear approach:

$$E(u,v) \cong [u,v]\ M \begin{bmatrix} u \\ v \end{bmatrix} \qquad \ldots(4)$$

Where M is a 2x2 matrix calculated from image derivatives (derivative images)

$$M = \sum_{x,y} w(x,y) \begin{bmatrix} I_x^2 & I_x I_y \\ I_x I_y & I_y^2 \end{bmatrix} \quad \ldots(5)$$

The intensity of the window shift changes: eigenvalue analysis

$$E(u,v) \cong [u,v]\, M \begin{bmatrix} u \\ v \end{bmatrix} \quad \ldots(6)$$

$\lambda_1$, $\lambda_2$ are *eigenvalue* of *M*

The expression of the corner response function R is shown in equation (7)

$$R = detM - k(trace\ M)^2 \quad \ldots(7)$$

Where :

$$\det M = \lambda_1 \lambda_2$$
$$traceM = \lambda_1 + \lambda_2$$

In formula (7), R is only related to the characteristic values 1 λ and 2 λ of M, and the k is an empirical constant, which is generally between 0.04 and 0.06. If the pixel is at corner or on the edge, the absolute value of R is relatively large. If the pixel is in the smooth area, then the value of R is relatively small. When the corresponding function value of the target pixel is larger than the given threshold, the pixel is considered as the corner point [9].

## III. SYSTEM IMPLEMENTATION

### 3.1 FRAMEWORK

In this section, the research is focused on design of fire detection system and using cheap device but has good performance. In outline, steps will be done as in Figure 3. In this paper, the data processing mechanism consists of 3 stages, the first is retrieving the original image data before the thresholding process. The second process is color filtering by converting data from RGB to HSV, then the segmentation process, the third performs an angle detection process.

The camera is used to take the object's bottom image in the water, the image data is sent to the computer in each frame of the image. The image resolution used is 320 x 240 pixels, with a length of 320 pixels and a width of 240 pixels. Then, using the RGB2HSV syntax, the image in the RGB space, will be converted into HSV color space (hue, saturation, value). Based on the HSV value that has been obtained, the next step is to detect objects with thresholding techniques. The way it works is to change the color of the HSV image into a binary image, which is 0 and 1 or called


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white and black, after that, a segmentation process is carried out. If the pixel color matches the specific color of the component, the color of the pixel will change to white. If the color does not match the specific color, then the pixel color component is changed to a black background. Figure 4 is a binary image.

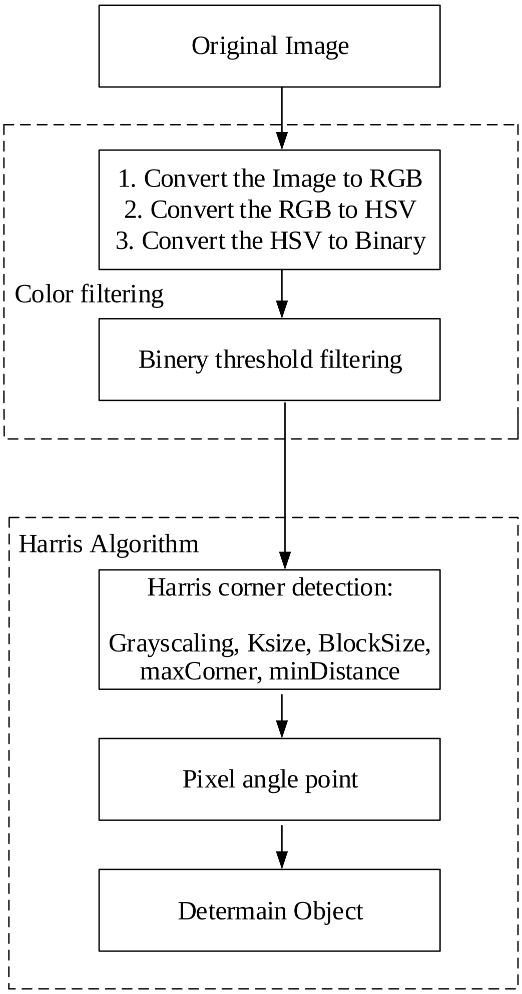


Figure 3. Framework

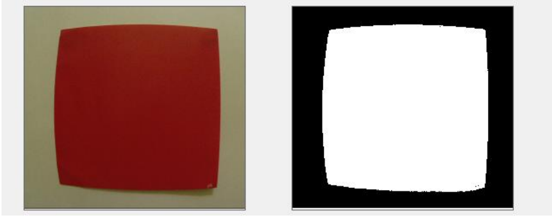

Figure 4. Binary image.

After the color filtering stage, the third step is the angle detection process. Angle detection is the search for the elbow point on the image that forms an angle. At this stage, there are four stages of process parameters to detect angles, the first is image input. In image input, images that have been taken from the camera will be transferred to the microprocessor and then processed in the Python compiler. The second process is block size, the window size considered for angle detection. The third process is ksize, Sobel daerivative derived aperture parameters. The fourth process is K is the free parameter in the Harris equation, k value is an empirical constant with a value of 0.04 - 0.06.

cornerHarris syntax will take the image, the image is converted to grayscale, then calculate the response angle R to find the point with the response of the largest angle R> threshold. After getting the response point of the largest angle R, then only the point taken at the maximum area R. The vertex will be immediately known and marked. To get the desired angle, it can change it via maxCorner and minDistance. maxCorner is the number of maximum angles to return. If there are more angles found, the strongest value of them is displayed. minDistance is the possibility of a minimum Euclidean distance between the angel returned. By adjusting the value, it will get the right angle of the object detected. So the greater the maxCorner the more it gets the angle to be detected. The greater the minDistance will reduce the radius from an angle to get the biggest angle.

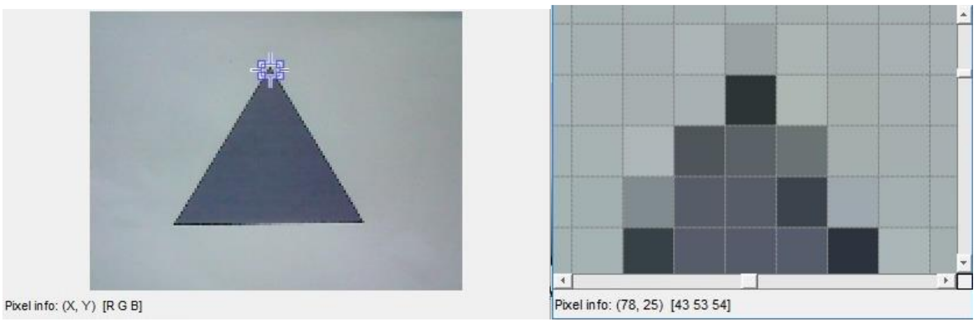


Figure 5. Region Pixel Coordinate Angle

The picture above is the result of program testing and manual testing. The pixel value of the coordinates obtained from program testing and manual testing using Matlab with the same image has a difference of 1-4 pixel region.

## IV. RESULT AND ANALYSSS

### 4.1 COLOR FILTERING

Webcam camera takes pictures of RGB colour image objects with an image resolution of 180 x 90 pixels in real-time. The image obtained is data that will be processed so that it can detect what colour is desired. Software on the underwater object detection system using C # programming language with Microsoft Visual Studio 2015 software. The program to detect this underwater object using image-processing techniques with the camera as the sensor input, which in the software


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there are stages - the process of image processing. The results of testing the image processing software with the detection of any object can be seen in Figure 6 below.

Figure 6. the test result of the software

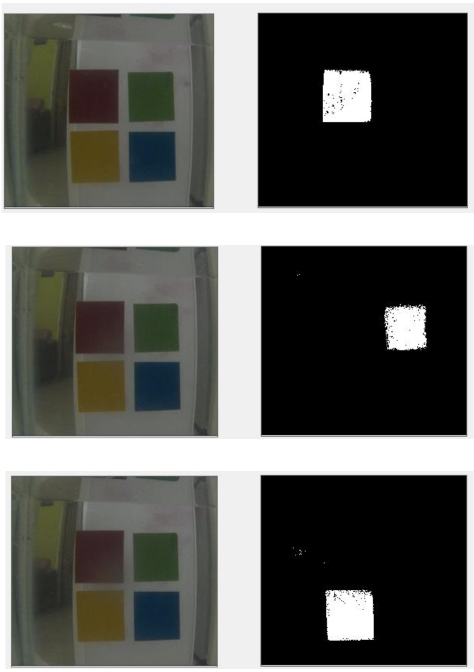


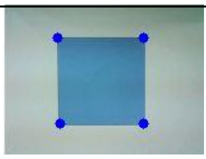
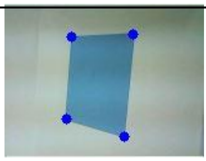
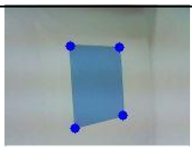
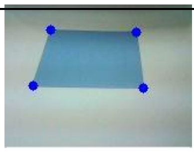
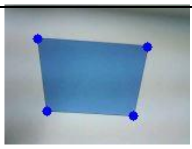
Figure 7. the test result of the red, green, yellom and blue color pattern

In the above test, the test is done 4 times with 4 color variations of objects in water. the object consists of red, green, yellow and blue. the four objects are placed 45 cm from the camera. The result is an object detected as an object in water according to the color of the HSV and binary tests. Based on observations of HSV values for objects in the water, the range of values for Hue: 46 - 99, saturation: 21 - 92 and Value: 5 - 42. Testing the color patterns get good results because the colors of red, green, blue and yellow can be recognized. This value will be used as a threshold for pattern segmentation.

## 4.1 HARRIS CORNER

At this stage, the corners of various flat-build objects will be detected using the Harris corner detection method in the OpenCV library. In the library, there are already corner detection phases, starting from the grayscale stage, the threshold to finding the greatest angle value from an angle. In this test, the number of points on a flat-build object will be searched according to its angle. The flat building object to be tested is a triangle, square, rectangle, pentagon and hexagon shape. The camera is set with 160 x 120-pixel resolution using a webcam camera. The results of the detection of flat building objects can be seen in table 1 below.

Table 1. The results of testing the number of angles from various points of view

| No. | Build shape | Name of build | Angle | Angle detection | Note |
|---|---|---|---|---|---|
| 1. |  | cube | Front | 4 | True |
| 2. |  | cube | Right | 4 | True |
| 3. |  | cube | Left | 4 | True |
| 4. |  | Cube | Up | 4 | True |
| 5. |  | cube | down | 4 | True |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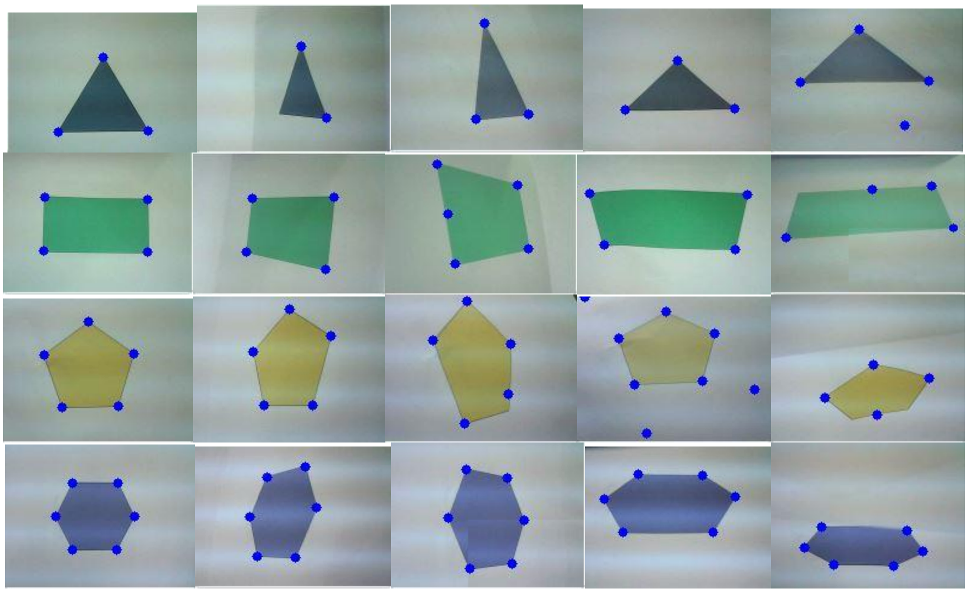
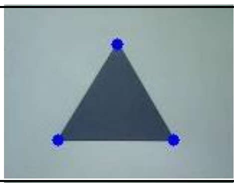
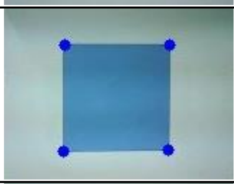
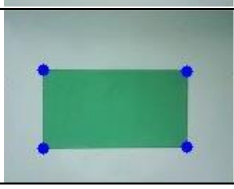


Figure 8. the test result of angle detection

Angle detection will be strongly influenced by light, distance, the angle of view and background of the object detected. To get maximum results, program settings will be adjusted to the condition of the object that will be detected. Testing is also done from a different point of view, it aims to find out whether the program can detect objects properly. The object to be tested from five points of view is from the point of view of the front, right, left, top and bottom. The max distance and minCorner parameter settings are adjusted for the best angle detection.

Table 2. The results of testing the coordinate

| No | Image Coordinate (K) Program | K1 (X,Y) | K2 (X,Y) | K3 (X,Y) | K4 (X,Y) | K5 (X,Y) | K6 (X,Y) |
|---|---|---|---|---|---|---|---|
| 1. |  | 78,27 | 37,93 | 117,93 | - | - | - |
| 2. |  | 41,26 | 115,26 | 41,100 | 114,99 | - | - |
| 3. |  | 27,41 | 127,42 | 27,95 | 127,94 | - | - |

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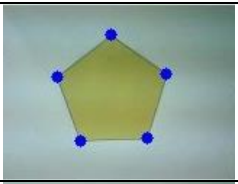
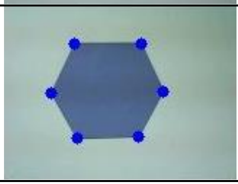
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 4. |  | 74,21 | 37,49 | 112,47 | 53,93 | 99,91 | - |
| 5. |  | 48,26 | 94,26 | 32,60 | 109,59 | 50,91 | 92,90 |

In table 2 above, all test results show positive results, viewed from different perspectives. All angles the cube wake object is detected correctly, both from the front, right, left, top and bottom. Then for the results of testing the entire wake object can be seen in figure 8. Wake up when having 1 detection error, rectangular wake has 2 detection errors, the pentagon has 3 detection errors, and a rectangular wake is detected well.

The coordinates obtained from the results of angle detection, the detection point of the detection point will be the pixel coordinates. Based on the data in table 3, the camera used is at 160 x 120 pixel resolution to capture image images. The pixel can determine the coordinates of the angle with the X and Y axes. So the results of the detection of the coordinate points of X and Y using the program and manually the difference is not very significant and has close results.

## V. CONCLUSION

Based on the results of the tests that have been carried out, object color recognition is in accordance with the expected results. The system recognizes colors well with certain levels of water clarity. The color object can be recognized by setting the desired HSV value, the HSV value in a row Heu: 46 - 99, Saturation: 21 - 92 and Value: 5 - 42. This value is used to display certain colors with the limit of thresholding value for segmentation picture. While angle detection testing also works well, with error rates still within tolerance. Angle detection for the front view position is detected properly. The K values generated for each object form are 78.27 (triangle), 41.26 (cube), 27.41 (quadrilateral), 74.21 (pentagon) and 48.26 (hexagon).

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