Estimating Object Distances Using Vision On Underwater Robots

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Abstract. Underwater robot technology is one of the robot technologies that is very necessary for carrying out underwater activities. There are still many underwater activities carried out using conventional methods and have high risks. With the presence of underwater robots that are able to move underwater, it is hoped that they can help humans with their tasks. The underwater robot designed is a mini Remotely Operated Vehicle (ROV) with an Arduino driving controller. This robot uses 6 motors to maneuver and is equipped with a camera. So that the camera can also work in the dark, this robot system is equipped with lighting to monitor underwater conditions. Arduino as the main controller is connected to the control joystick via cable so that the robot can be controlled from above the water surface. Apart from controlling movement maneuvers, a watertight mechanical design for the ROV robot is also very important. In testing the robot's movement while in water, the robot is expected to be able to maneuver according to commands and can help with underwater monitoring activities. The focus of this research is how underwater robots can detect and measure the distance of objects in front of them when maneuvering in the water. The object in this research is an orange ball, while the water in which the robot maneuvers is clear, white and clean water without interference from other objects. The process of detecting and measuring the distance of an object is a stage so that the robot can run autonomously later. The way to get the distance of an object is that the frame obtained from the camera's video capture is then converted into an HSV image which is segmented using the color filtering method and the pixel area of the object whose distance is measured can be obtained. The color classification method for segmenting spherical objects on underwater robots produces an average distance estimation error with a measurement range of 20 cm to 300 cm of 5.63% with the color classification method Color Filtering.

Keywords: underwater robot , Vision, Color Filtering.

1 Introduction

Robotics is an important technology in determining the progress of civilization in the world. According to the definition of the Meriam-Webster dictionary, a robot is a machine that looks like a human and performs various complex human actions such as walking or talking, or a piece of equipment that works automatically. Robots are usually programmed to perform tasks repeatedly and have mechanisms guided by automatic control. Meanwhile, robotics is a branch of technology related to the design, construction, operation and application of robots. Robotics is a branch of science that studies robots. This branch of science includes robot machine design, electronics, control, computer programming, artificial intelligence, and so on [2].

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As [2] and friends wrote, there are four basic characteristics that every modern robot must have. These basic characteristics are as follows.

1. Has sensors.
   Sensors are devices that function to measure or feel something in the environment outside the robot, just like the senses in living creatures. With sensors, robots can make decisions based on input from sensors. One example of a sensor is a light sensor to measure and detect the presence of light, a temperature sensor to sense and measure temperature.
2. Has an intelligence system (Control).
   Intelligent systems process input data in the form of conditions or events that are occurring from outside the environment. Next, the intelligence system produces output in the form of decisions or instructions for the robot to carry out a certain action. In general, this system has a working principle like the human brain, which functions to think and decide what actions need to be taken at a certain time.
3. Has mechanical equipment (actuators).
   The function of mechanical equipment is to make robots able to perform certain actions and interact with their environment. Examples include motorized wheels for moving, picking up objects, and so on.
4. Have resources (Power).
   Just as living organisms need food to live, the electrical and mechanical components installed on robots also need a source of energy to move them. The energy source for the robot is a provider of electrical power such as a battery, and includes a transmission control system whose job is to convert electrical power according to the needs of each component.

The development of underwater technology has received little attention from the public. There are still many underwater activities that are carried out by means conventional such as underwater observation, underwater detection and many more [1]. Moreover, underwater activities have been carried out conventionally by humans. Underwater observations have several risks, namely the presence of areas which are difficult for humans to reach, waters affected by toxic waste, limited oxygen, the occurrence of hydrostatic pressure on the diver's body, and the risk of danger which is high due to attacks by wild animals and so on. Hence, robots those who are able to move freely in the water are really needed to help with the task man. One type of underwater robot is an ROV (remotely) robot operated vehicle) [3]. In simple terms, the way an ROV-based robot works is that it is operated using a system that is controlled by the user via a controller device that can make it easier for humans to monitor underwater. The work system that will be built uses an Arduino controller connected to a joystick as input for motor movement. For the exploration process, a camera is used that can be viewed directly (real time) on a computer.

2 Research Methods

In general, there are 2 sub-systems in this study which have their respective tasks and establish communication, one of which is through a serial communication line. The tasks and functions of each sub-system are :

1. The sub-system that is carried out on the host computer (base station) receives input from the joystick controller to be sent to the robot carrying out work according to the command and receives video from a webcam that can be monitored from the host computer [4].

2. The second sub-system is a underwater robot that receives commands from a computer via wifi and controls six actuators to take action according to the command.

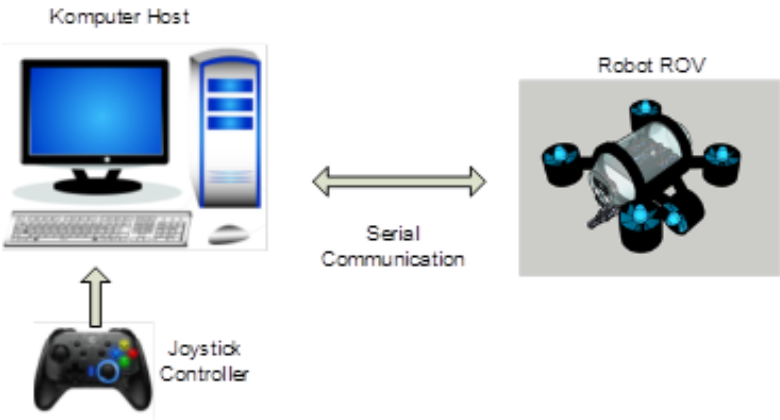

Fig. 1. Architecture of underwater robot communication

The robot is designed to use 2 power supplies, namely, 1 24V 5500mAh lipo battery, as a voltage source for the main drive actuator, 4 Hydrocean P75 motors for vertical maneuvering of the robot, namely for diving and floating, and 1 more 24V lipo battery to supply it. 2 Hydrocean P75 motors for robot maneuvers, namely forward, backward, left and right turns. The power bank is used as a voltage source for the microcontroller. Using 3 separate power supplies with the aim of preventing supply interference between several component parts of the robot (especially the control electronics, microprocessor and specifically the motor actuator). In the object tracking or reading system, the robot uses a Logitech BRIO 4K HDR camera with the addition of a super wide lens to be able to see up to 360o and get a wider range of vision for the robot. The Logitech BRIO 4K HDR camera is placed on the front of the robot so that the robot can see objects in all directions.

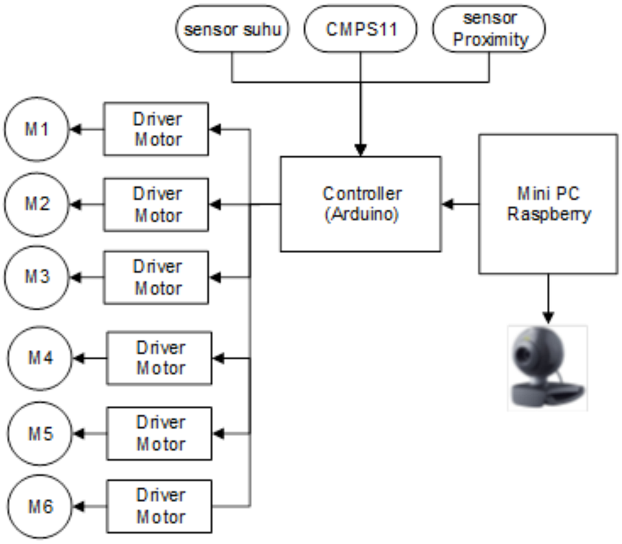

Fig. 2. hardware of underwater robot.

There is also a mechanical and electronic design can be seen in the following picture.

A. Front view of the design

Fig. 3. Front view of the design.

B. View of the design

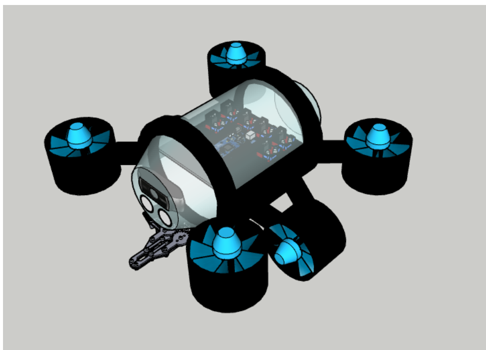

Fig. 5. Top of a View of the design

C. Side view of the design

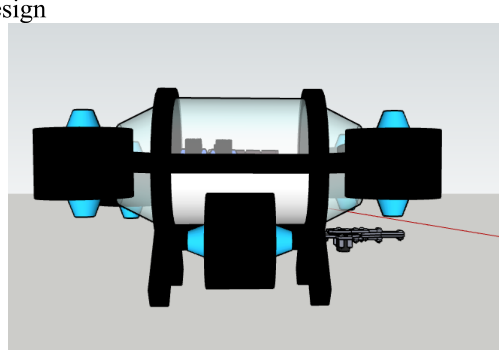

Fig. 6. Side of view of the design

2.1 Mechanical Structure and Materials

Mechanical design of the main propulsion motor The robot is designed to use 6 Hydrocean P75 motors which can rotate back and forth so that the robot can easily move in all directions, there are 4 motors for up and down maneuvers or for diving and floating, and 2 motors for forward maneuvering. back, left and right. The Hydrocean P75 motor is used in the manufacture of this robot because of its simple shape and size but has a high RPM, thus increasing the efficiency of the robot so that it can move freely anywhere. Robot chassis design and component layout In order for the robot body chassis to be strong and sturdy, the materials used for the manufacture of the chassis really need to be considered. The materials used are acrylic and Acetonitrile Butadiene Styrene or ABS. The material parts of the robot body as well as the thickness and weight of the material used [5].

- The main frame uses Acetonitrile Butadiene Styrene or ABS with a weight of ± 1000g.
- The component tube uses acrylic material with a thickness of 5” and a weight of 250g.
- The camera tube uses acrylic material with a thickness of 5” and a weight of 100g.
- Floor component placement using acrylic material with a thickness of 5” and a weight of 100g.

To maneuver (up, down, forward, backward and turn) in the robot control system is to adjust the speed and direction of rotation of the motor which is pivoted with the right and left rotating propellers. The direction and rotational speed of the right and left motors determine the type of robot movement. To determine the direction of movement of the robot while underwater, the processor obtains data from the Logitech BRIO 4K HDR Camera, which is a 360o camera module used by the robot to track objects in water and find a starting point. This system is equipped with a push button that is used as a start button[6].

All data obtained from the sensor will be displayed to the GUI application which is designed using the Application Form. The data displayed is a livestream from the camera, the depth of the robot underwater, compass data and temperature read by the sensors on the robot.

2.2 Distance estimation algorithm with vision

The classification method works in two phases, namely the training phase (also called the learning phase) and the prediction phase. The level of prediction accuracy will depend on the correctness of the training data. In the prediction phase, the frames obtained from the video will take the H, S and V color components and then carry out an object segmentation process based on color using a color filtering algorithm. The image from the segmentation will then be filtered which functions to remove noise from pixel spots to create a better image. Next is to calculate the number of pixels, both the pixel area of the object area and the diameter of the object (take the maximum number on the horizontal line). To obtain an equation for the trendline approach to object distance, the distance of the robot is measured manually, which is then illustrated by the pixel area and diameter based on the distance. After it is plotted, the approximation equation for estimating the distance of the object is searched, assisted by a computer, which is then used to estimate the actual distance of the object.

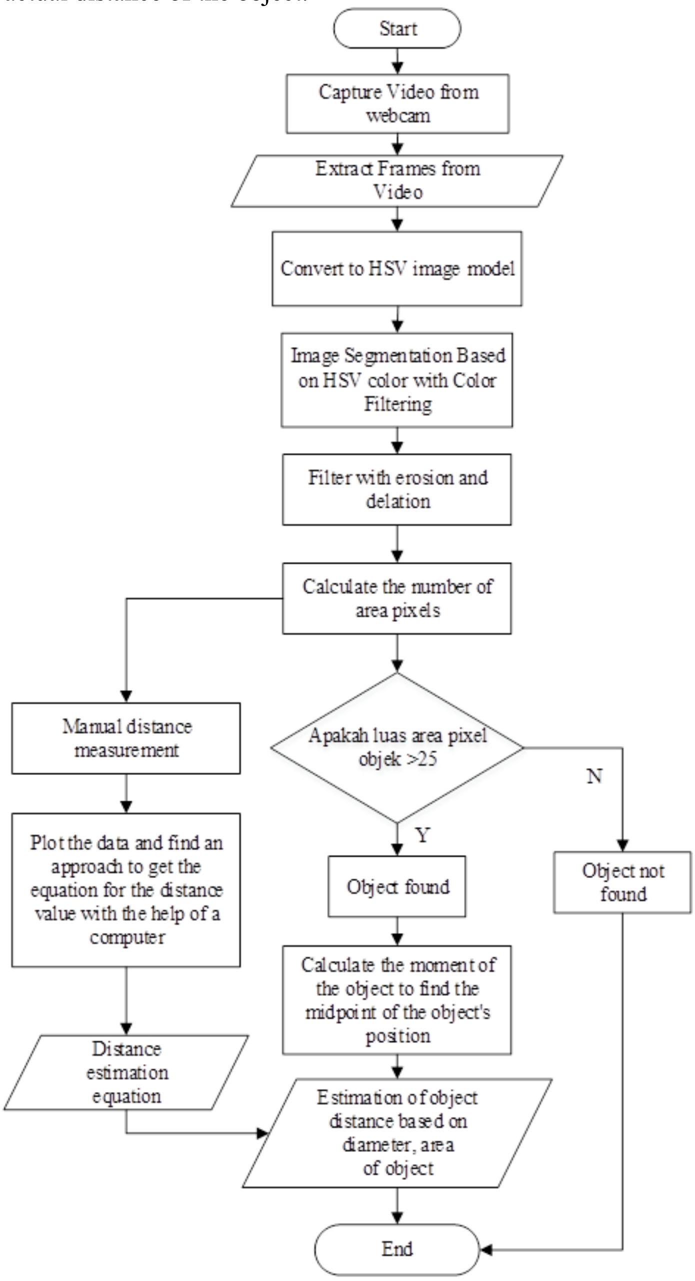

Fig. 7. Distance estimation algorithm with vision

3 Result and Discussion

3.1 Estimating Ball Distance with Color Filtering Segmentation

To convert the pixel area of the ball into distance (cm), the pixel area must first be measured at each distance interval between the robot's and the ball. Table 1 shows the results of measuring the pixel area of the ball at every 20 cm interval with a minimum measurement distance range of 20 cm and a maximum of 300 cm.

Table 1. Test results for ball distance and ball pixel area (color filtering segmentation)

Distance (cm)	Area (pixel)
300	11
280	11
260	12
240	13
220	14
200	14
180	17
160	18
140	22
120	24
100	28
80	35
60	47
40	64
20	87

From Table 1, a relationship curve can be created between distance (cm) and the pixel area of the object (pixel) as shown in Figure 7.

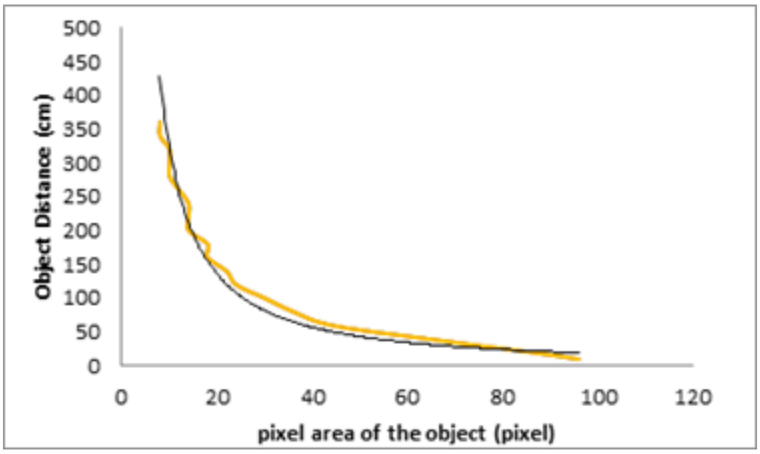

Fig. 8. Relationship between distance and area of objects

In Figure 8, it is shown that the relationship between ball distance (cm) and object area (pixel) obtained from the test results is not linear, but can be used with a power approach.

After the estimation approach is obtained, the distance is then measured based on the area of the object. To get the error percentage, you can find it using the equation.

$$\%error = \frac{Actual\ distance - estimated\ distance}{Actual\ distance} \times 100\%$$

Table 2. Error in estimating object distance (segmentation color filtering)

Actual Distance (cm)	Estimating Distance (cm)	Error (%)
300	277	7,67
280	273	2,50
260	257	1,15
240	220	8,33
220	213	3,18
200	184	8,00
180	169	6,11
160	139	13,13
140	147	5,00
120	126	5,00
100	99	1,00
80	84	5,00
60	62	3,33
40	44	10,00
20	19	5,00
	Average :	5,63

4 Conclusion

From the results of the research conducted, it can be concluded that:

1. The color classification method for segmenting spherical objects on underwater robots produces an average distance estimation error with a measurement range of 20 cm to 300 cm of 5,63% with the color classification method Color Filtering.
2. The segmentation results using the color filtering method are very influential at the calibration stage in determining the range (minimum and maximum values) of HSV.
3. If the calibrated range is too wide, then objects that are not intended will also be detected, whereas if the calibrated range is too small then it may not be detected (an error occurs in image segmentation).

References

[1] Mcandrew , Alasdair. An Introduction to Digital Image Processing with MATLAB, Melbourne: Victoria University Of Technology (2004)

[2] Jatmiko, Wisnu and freinds . 2012. Robotika Teori dan Aplikasi. Perpustakaan Nasional Fakultas Ilmu Komputer UI. Depok, (2012)

[3] Zheng, Chang and Li. A Study of 3D Feature Tracking and Localization Using A Stereo Vision System, IEEE,pp.402-407 (2010)

[4] M. N. A. Wahab, N. Sivadev, and K. Sundaraj. Target Distance Estimation Using Monocular Vision System for Mobile Robot . IEEE Conference on Open System (ICOS2011).(2011)
[5] Team, Buku Pedoman Kontes Robot Indonesia (KRI), Jakarta.(2023)
[6] Putra, Dharma, Pengolahan Citra Digital, Yogyakarta: Penerbit ANDI, (2010)