IMAGE BASED OBJECT TRACKING TARGET ON SHIP ROBOT FOR OIL WASTE CLEANER

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ABSTRACT

The existing oil waste water contains oil, solids, water and heavy metals. This oil waste is a contaminant material that can cause negative impacts to the aquatic environment as well as the existing living creatures around it so that it requires a careful and fast handling to clean. The research resulted in the tracking system on the image-based-ship robot by using the method of *histogram* and *fuzzy logic controller* that can detect the image of waste water well. The result of the testing of the ship robot done on the pool indicated that it took about ± 196.92 seconds for the robot to detect the image of oil waste objects. The oil waste suctioning process took a maximum of 60 seconds for once.

Keywords: image, histogram, fuzzy logic controller, ship robot, oil waste

1. INTRODUCTION

The petroleum industry has the potential as a source of impacts on water, soil and air pollution either directly or indirectly. Oil pollution is an oil waste formed from the process of collecting and depositing oil contaminants. It contains oil, solids, water, and heavy metals. It is a contaminant material that can cause negative impact to the environment which must be addressed immediately.

Sea cleaning from the oil waste is a mandatory process. Although there are many methods of marine cleansing right now, the fact that most of the oil spill situation ends with the worse conditions simply because of ineffective recovery methods. It may be due to the oil properties in reacting to the different cleaning systems. So that is why the best cleaning method according to the oil properties is required [1]. Currently there have already been several existing methods for the purification of the aquatic environment. Mostly are limited to micro purification, chlorination and oxygenation of aquatic life. Most of the methods used to remove the macroscopic waste are manual or manually operated machines/devices [2].

The study is focused on the sensors capable of sensing, processing, and transmitting information about oil spills (locations and thickness) and it uses two new detection methods based on spectral differences in absorbance and the electrical conductivity properties of oil and water. The results of these experiments confirmed the effectiveness of the proposed method under the different lighting, salinity, temperature, and sea conditions [3].

Some researchers and oil companies are trying to take some precautionary measures for oil spill problems by using robotics technology [4] [5]. Some Robotics researches implementing the images in identifying the targets and as a guide have been done [6] [7] [8]. The histogram method has been applied in image data processing in water and robotics [9] [10]. The Fuzzy Logic Controller method has been applied in the control of robotic motion based on image data [11] [12].

The purpose of this research is to produce an image-based ship robot tracking system using histogram and fuzzy logic methods in performing its duty to detect the oil waste in the water and to process the oil waste suction.

2. LITERATURE

2.1 Histogram

Important information about the contents of a digital image can be determined by creating an image histogram. An image histogram is a graph depicting the deployment of *pixel* intensity values of a particular image or part in an image. The frequency of relative emergence of the intensity of the image is known from a histogram. Many things

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about brightness and contrast of an image are also shown by histogram. Therefore, histogram is a valuable tool in the job of image processing both qualitatively and quantitatively [13].

Mathematically, the image histogram can be calculated by the formula according to equation (1).

$$h_i = \frac{n_i}{n} \quad (1)$$

n_i is the number of *pixels* that have the degree of gray *L*, *n* is the total number of *pixels* in the image, and *i* is 0, 1, ..., 255. Especially for the color image, the histogram is made for each RGB channel (Red, Green, Blue).

The image histogram provides a lot of important information as follows:

1. The h_i value represents the *probability of pixels*, *P (i)*, with the degree of gray *i*. The sum of all h_i values equals to 1, or

$$\sum_{i=0}^{L-1} h_i = 1 \quad (2)$$

The opportunity of a *pixel* having a gray degree smaller or equal to a certain degree of gray is the number of h_i for $0 \le i \le j$, or

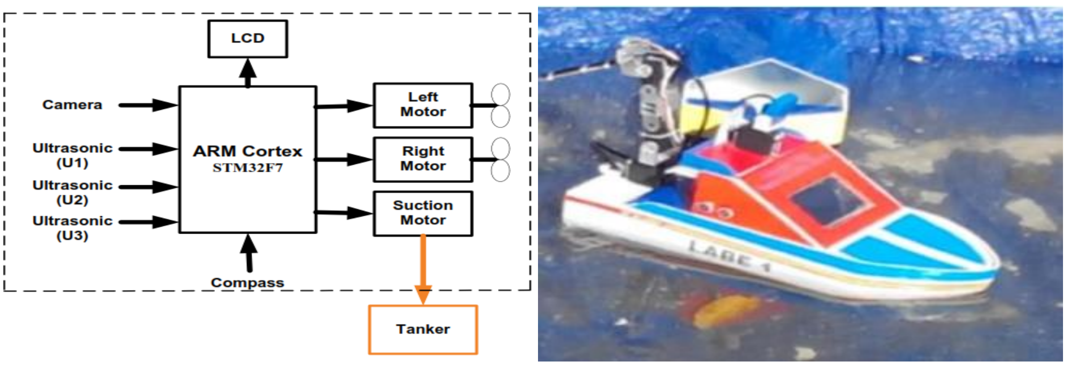
$$P(i \le j) = \sum_{i=0}^{j} h_i, 0 \le j \le L-1 \quad (3)$$

2. The peak of the histogram shows the prominent *pixel* intensity. The width of the peak shows the contrast ranges of the image. Images that have too bright contrast (over exposed) or too dark (under exposed) have a narrow histogram. The histogram is seen using only half of the gray degree area. A good image has a histogram that fills the gray-level region in full with a uniform distribution of each *pixel* intensity value.

3. RESEARCH METHODOLOGY

3.1 Robot Design

This research has done the design of robot in the form of a ship equipped with a camera to detect an image object in the form of waste oil, 3 pieces of ultrasonic sensor to detect the distance of the obstacle, a digital compass useful to determine the direction/position of the robot, 2 pieces of DC motor to drive the *propellers* mounted on the right and left sides of the robot's rear body to make the movement or maneuver in the water. LCD is used to display the *output* data of the ship robot. While ARM Cortex M7 serves as a processor that works to implement the *hardware* control systems and the decision-making in identifying the presence of waste oil and oil waste suction process. Figure 1 is a robotic design used in this study.



(a) *(b)*

Figure 1. Robot used for experimentation; (a) Hardware overview; (b) Ship robot prototype.

3.2 Control System using Fuzzy Logic Controller (FLC)

The motion decisions for this ship robot are based on the stage of the Fuzzy Logic Controller shown in Figure 2. The purpose of the Fuzzy Logic Controller is to allow the robot to represent the motion toward the target, that is, the displacement of the image and its speed of the target object. FLC design is for controlling of the robot steering commands. The controller output is responsible for steering the ship robot in such a way that the target of an oil waste image object appears simultaneously in the center of the image.

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The camera has a fixed focal length and the same target size through the experimentation. The target area in the image is used as an indicator of the distance between the ship robot and the target. This rule is based on heuristic knowledge about the behavior and limitations of the experimental platform. When this rule is applied, it generates the fuzzy output variable responsible for the robot steering command. Sensory information available for steering commands is the target position on the image. Horizontal motion components are only selected because the robots and targets are both assumed to move in calm waters and the camera orientation relative to the waters is fixed.

The fuzzification process has its input in the form of image data with the 4 membership functions: Low (L), Medium (M), High (H) and Very High (VH). While the fuzzy output of DC motor velocity has its membership functions: Idle (I), Slow (S), Medium (MD), Fast (F) and the activation of suction motor has its membership functions: Idle (ID), and Action (ACT). Figure 3 is membership function design for fuzzy input whereas figure 4 is a membership function fuzzy output.

Rule Evaluation is the process of determining rules or making conclusions based on the membership functions of 1 input and 2 output. The fuzzy rules applied in this study are described in Table 1 as the rule evaluation for this system.

After setting the rule base and defining the membership functions of the variable, the next step is to perform the defuzzification process. This stage allows the conversion of the linguistic variables of fuzzy inference into physical variables. Under the Center of Gravity (COG) method, the final result of the fuzzy inference system can be illustrated as follows:

$$COG = \frac{\int_a^b \mu\, A\,(x) x\, dx}{\int_a^b A\,(x) dx} \tag{4}$$

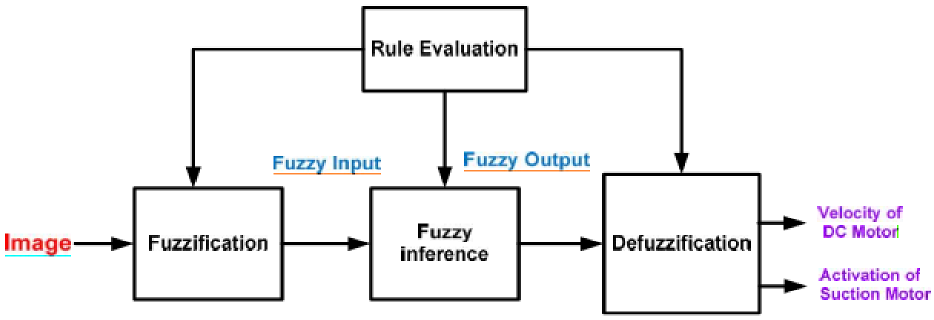


Figure 2. The fuzzy logic control processes.

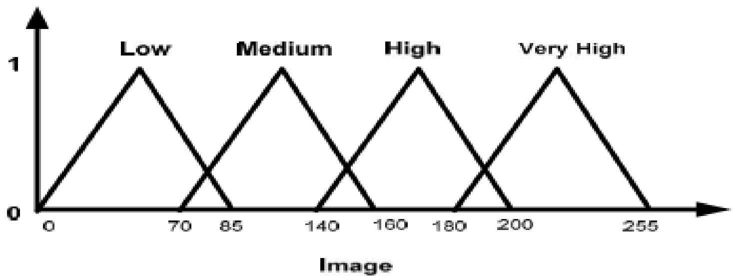


Figure 3. Membership function of input fuzzy.

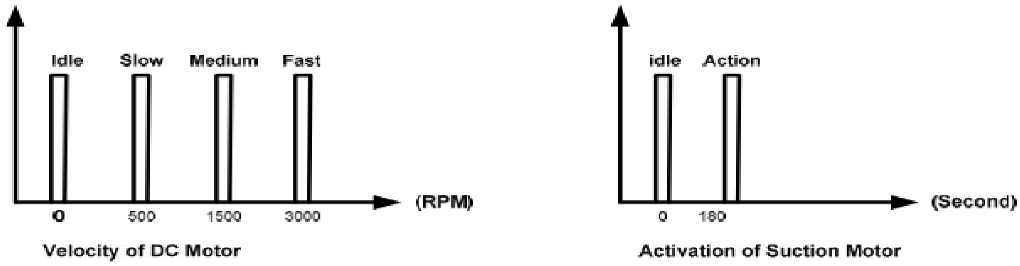


Figure 4. Membership function of output fuzzy; (a) Speed of DC Motor; (b)Activation of suction motor.

Table 1. Rule Evaluation

Input	Output	
Image	Velocity of DC Motor	Activation of Suction Motor
Low	Fast	Idle
Medium	Medium	Idle
High	Slow	Action
Very High	Idle	Action

3.3 Software Design

Globally, the work system for cleaning waste oil in waters on this ship robot is shown in Figure 5. The input from this system is in the form of camera sensor detection results in the form of image data, then gray scale image processing is carried out using the Histogram method. Furthermore, the FLC method was applied to control the performance of the waste oil suction motor. If the image of waste oil is still detected, the suction motor continues to work. If the waste oil image is not detected, the waste oil suction motor stops.

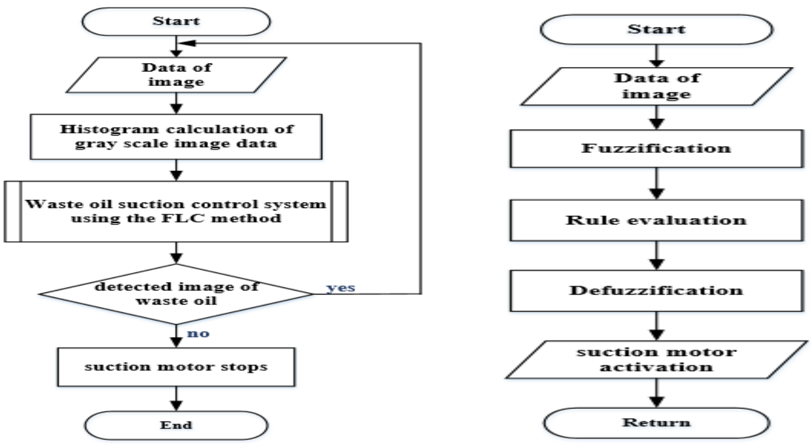


Figure 5. Flowchart of system; (a) Main program; (b) subprogram of FLC.

4. RESULT AND DISCUSSION

4.1 Camera Test Results

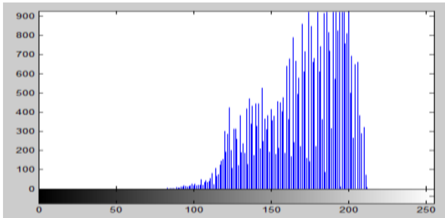
Camera testing is caaried out by running the camera sensor. The expected output is the identity of the image object. Testings were carried out ten times, with some kinds of waste water image object and water condition. The test data obtained are shown in table 2. They are the camera testing data in detecting and identifying the object of this image by using the Histogram method.

Table 2. Data of Camera tests.

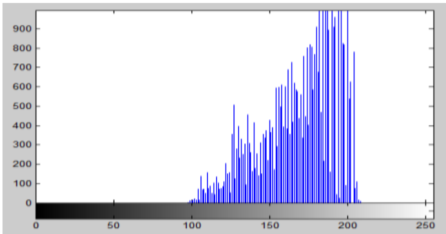
Testing	Type of Image Object	Water Condition	Recognition of Identity Image Object
1	clean water	motionless	successful
2	water mixed with cooking oil	motionless	successful
3	water mixed with diesel fuel	motionless	successful
4	water mixed with oil	motionless	successful
5	water mixed with fuel	motionless	successful

4.2 Histogram Results

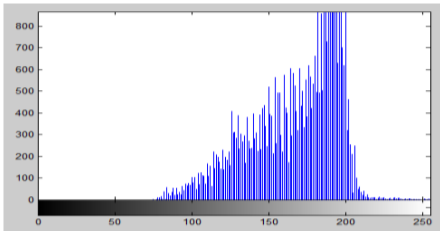
Image data from camera was processed by using the histogram method to get the gray scale for each type of the image object. The value of gray scale that has been generated into a database for the ship robot in the identification of the image of oil waste in the waters. Figure 6 is an image data of clean water and water containing oil waste and image data processing results by using a histogram.

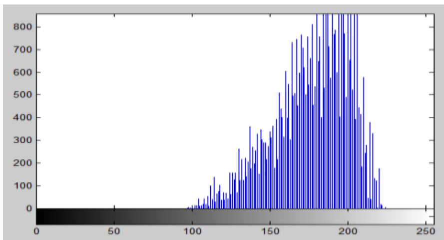
(a) (b)

(c) (d)

(e) (f)

(g) (h)

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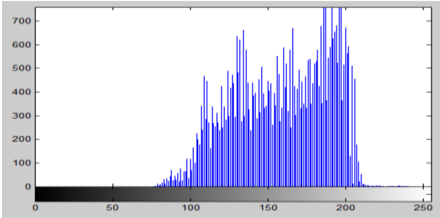
(i)



(j)

Figure 6. Data of clean water and water mixed with oil waste and image data processing results using a histogram; (a) a clean water image; (b) histogram results of clean water image: (c) gasoline mixed water images; (d) the histogram result the image of the water mixed with gasoline; (e) mixed oil water images; (f) the histogram result of the image of water mixed with vegetable oil; (g) the image of oil-mixed water; (h) the histogram result of oil-mixed water image; (i) solar/diesel fuel-mixed water image; (j) the histogram result of the image of solar/diesel fuel-mixed water.

Histogram has many benefits on image processing, such as to determine the parameters of digitization and the selection of threshold limits. The peak of the histogram shows the prominent pixel intensity. The width of the peak shows the contrast ranges of the image. Images that have a lighter or darker contrast have a narrow histogram. The histogram is seen by using only half the gray degree. A good image fills the full gray density with a uniform distribution of each pixel intensity value. Based on Figure 6 it can be explained that the value of gray scale in water mixed with petrol/gasoline has a value of 1092. This value is the highest compared with the other types of image objects.

Table 3. Data on the Results of Waste Suction Testing.

Testing	Time of Waste Suction (seconds)	Volume of Suctioned Waste (liter)
1	10	0.67
2	20	1.34
3	30	2.01
4	40	2.68
5	50	3.35
6	60	4.02

4.3 Integration System Test Results

The testing of the ship robot was performed in the pool measuring 3X3 meter^2. Several experiments were conducted to estimate the time for the ship robot to detect and locate the target image of oil waste and the results tabulated as in table 4.

Table 4. Data of robot tests.

Testing	Time detects an image of oil waste (second)	Distance of robot to oil waste image (meter)
1	187.2	0.10
2	184.2	0.10
3	211.8	0.15
4	197.4	0.11
5	204	0.13

Based on the results of ship robot testing, it could be analyzed that between the distances of the robot to the waste objects affected the duration of the detection of the waste objects. Figure 7 is a graph of ship robot test results.

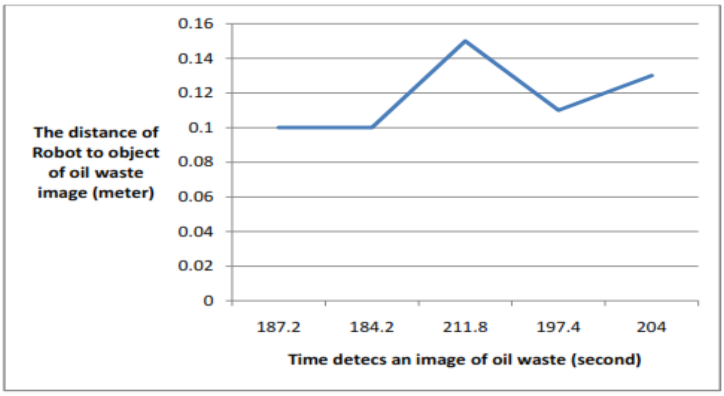


Figure 7. Test results of ship robot.

5. CONCLUSION

The tracking system designed on the robotic boat, equipped with the camera sensors, for oil waste water cleaner in the waters has worked well. The Histogram algorithm used in image data processing greatly influenced the robot's success rate because the histogram output became the database for the ship robot in performing the task of detecting and identifying the oil waste in the waters. The control system of the robotic movement and the activation of the oil waste suction motor using Fuzzy Logic Controller have been applied well. The results of the test in the pool indicated that it required ± 196.92 seconds for the robot to reach the closest distance to the oil waste image object and 60 seconds for the maximum oil waste suction in one process.

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