ACCURACY ANALYSIS OF DISTANCE MEASUREMENT USING SONAR ULTRASONIC SENSOR HC-SR04 ON SEVERAL TYPES OF MATERIALS

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ABSTRACT

Sonar is a technology that uses the propagation of sound waves to detect the position of an object. Usually, fishermen use sonar to detect fish locations. The problem is that the price of sonar is still expensive, so not all fishermen can afford to use it. One of the devices that can be developed is the HC-SR04 module. HC-SR04 has simple components, and the price is cheap. The use of HC SR04 is still very minimal, so it is necessary to analyze the accuracy of its distance readings on various objects and conditions. The research was conducted using experimental methods in August-September 2023 at the Fishing Exploitation Laboratory, Faculty of Fisheries and Marine Sciences, Brawijaya University. The distance data generated by HC-SR04 is used to measure ceramic, Styrofoam, and fish. Based on the research results, it is known that ceramic and styrofoam objects have a calculated t value = 0 while the one-tail Critical t = 1.65, which means the average distance produced by the tool is the same as the average distance by manual measurement. Meanwhile, in the t-test, the fish samples obtained a value of t stat = 23.24 and t Critical one-tail = 1.65. This shows that the tool will show distance measurement results that differ from manual measurements. Furthermore, the RMSE value of distance measurements on ceramic and Styrofoam objects obtained an average value of 0, which means the measurements are very accurate. Meanwhile, the average RMSE value for fish objects = 37.67, which means that the tool measurements are inaccurate.

Keywords: *Sonar, distance, position.*

1. INTRODUCTION

Sound navigation and ranging (sonar) is a device that utilizes sound waves to detect underwater objects. According to (Akbar *et al.*, 2022), sonar works by producing sound waves. Radiate and receive it back. Furthermore, based on the source of the sound waves, sonar is divided into two, namely active sonar and passive sonar. Active sonar is a sonar that can produce its sound signal to emit. As for passive sonar, its use only receives sound reflections from an object.

Initially, sonar was only used in military activities. The device that utilizes echo was first patented by Lewis Richardson. However, in its development in the 1970s, the United States Navy declassified it to be used by civilians. (Ainslie, 2010).

According to Triarnowo *et al.* (2015), using sonar for now has made many aspects of human life more manageable. Meanwhile, the function of sonar in the fisheries and marine sector is to detect fish, seabed mapping, sea depth detection, and underwater navigation. (Lubis et al. 2019) and (Jaya 2011). Fishermen can improve fishing efficiency by using sonar to detect the fish's position. However, its use is still minimal. Usually, only industrial-scale fishing fleets or fishermen and fish hobbyists who have large capital apply sonar to help determine the position of the target fish. The reason is that sonar technology is still expensive (Widana, 2017).

Efforts to apply sonar with simple construction to make it easier to determine the location of fish need to be made. The trick is to build a sonar distance meter device using the

HC-SR04 module. The modules used are compact in size, easy to assemble, and inexpensive (Nadyawan, 2021). This research was carried out to determine the accuracy of the distance produced by HC-SR04 so that in the future the HC-SR04 module can be used to detect the location of fish in the waters.

2. METHODS

The research uses a comparative descriptive method. Data collection was carried out by conducting laboratory-scale experiments, the research was located at the Fishing Laboratory, Faculty of Fisheries, Brawijaya University. The accuracy test of the tool was carried out by operating the HC-SR04 sonar distance meter directly to measure 3 objects that have different surfaces, as follows: 1) ceramic; 2) sterofoam: and 3) fish has an uneven surface and as an object to be developed detection. The HC-SR04 module used in research and its specification is presented in (Figure 1) and (Table 1). Furthermore, Figure 2 shows how to measure distance

Figure 1. HC-SR04 sonar

Table 1. Specifications of (HC-SR04)

	Specifications
Voltage	5V DC
Current	15 Ma
Frequency	40 kHz
Input Sinyal *Trigger*	10us pulsa *Time to Live* (TTL)
Output Sinyal *Echo*	Sinyal level *Time to Live* (TTL)
Dimensi	45*20*15 mm

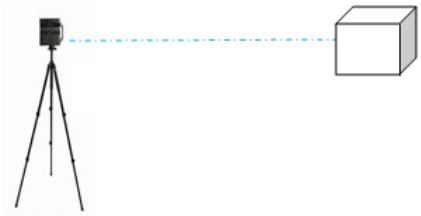

Figure 2. Data collection

The data from the distance measurement results will be tabulated and analyzed both descriptively and statistically. The statistical test was carried out with a paired t-test according to (Montolalu & Langi, 2018), as equation follows:

$$t_{\square} = \frac{\bar{D}}{\frac{SD}{\sqrt{n}}}$$

$$SD = \sqrt{var}$$

$$SD = \sqrt{\frac{\sum d^2 - \frac{[(\Sigma d)^2]}{n}}{n-1}}$$

which:
t = t value calculated
SD = Standard deviation from the difference between paired observations
$\bar{D}$ = average measurement difference of 1 and 2
d = differences between paired data
n = total observations

Furthermore, Root Mean Square Error (RMSE) accuracy test is a method used to measure the level of error between the actual value and the predicted value in a model. The steps in calculating RMSE are: calculating the difference between the actual value and the predicted value, and the prediction value, square each difference, adding up all the squares of the difference, divide the number of squares of the difference by the number of observations and take the square root of the result of the division. In the results of the accuracy test, if the smaller (closer to 0) the RMSE value, the more accurate the prediction results are (Budiman, 2016)

$$RMSE = \sqrt{\frac{\sum(Actual - Prediction)^2}{n}}$$

which:
n = number of data

3. RESULTS AND DISCUSSION

Based on laboratory scale testing, it can be seen that the measuring distance of the HC-SR04 sonar distance meter on the three materials is different. The HC-SR04 sonar module can measure the distance between ceramics and styrofoam well. Meanwhile, when measuring the distance of a fish's body, the HC-SR04 module's capabilities decrease.

The HC-SR04 module can measure the distance between ceramics and styrofoam up to 430 cm. As for fish objects, this module can only detect fish as far as 135 cm. Furthermore, statistical analysis shows that the t stat value for ceramics and Styrofoam = 0 or < t Critical one-tail, namely 1.65. (Table 2) This proves that the received H0 or average distance reading from the HC-SR04 module is the same as the average distance from the measurements manually. Meanwhile, the t stat value of the fish object = 23.24> from t Critical one-tail: 1.65, so it can be concluded that the average fish distance reading between manual measurements is different from the HC-SR04 module measurement (Table 3).

Table 2. t-test for ceramics and styrofoam

	Manual measurement	HC-SR04 measurement
Mean	217.5	217.5
Variance	15442.16	15442.16
Observations	430	430
Pooled Variance	15442.16	
Hypothesized Mean Difference	0	
df	858	
t Stat	0	
P(T<=t) one-tail	0.5	
t Critical one-tail	1.646632	

Table 3. t-test for fish

	Manual measurement	HC-SR04 measurement
Mean	200.2907	28.66279
Variance	19825.96	3629.618
Observations	430	430
Pooled Variance	11727.79	
Hypothesized Mean Difference	0	
df	858	
t Stat	23.23801	
P(T<=t) one-tail	0	
t Critical one-tail	1.646632	

Based on the RMSE test results for ceramics and Styrofoam, an RMSE test value was obtained of 0. This RMSE test value shows no difference between the actual distance and the distance value produced by the sonar distance meter (HC-SR04). Furthermore, the fish object shows a value of 37.67, or there is a difference with the manual measurement value. This difference shows that the sonar distance measuring device (HC-SR04) has an inaccurate accuracy level for detecting the fish's distance.

Styrofoam and ceramic objects can be detected at a good distance by the HC-SR04 sonar module because they have a flat surface even though the density is different. Meanwhile, fish objects that have a bulging, uneven and scaly surface will cause refraction when subjected to reflected sound waves. The results of this research are in accordance with research by (Susilo *et al.*, 2015; Prayetno and Ulinnuha 2020; Risandes *et al.*, 2024) and (sRohana et al. 2022) which states that the rougher the surface will reflect less sonar reflections.

4. CONCLUSION

The conclusion that can be obtained from the research is that the sonar distance meter is very good for measuring the distance of objects that have a flat surface, RMSE=0. As for measuring objects that have a surface such as, fish. The distance detection accuracy of the HC-SR04 module is significantly reduced RMSE=37.67.

5. ACKNOWLEDGEMENT

This research was funded by a Novice Brawijaya University Researcher Grant in 2023 contract number 611.41/UN10.C200/2023. The

author thanks the head of the Fishing Exploitation Laboratory of the Faculty of Fisheries and Marine Sciences, University Brawijaya, who supported and facilitated the course of research.

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