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PROTOTYPE PARKING SENSOR ON A SHIP AT THE DOCK USING SENSOR BASED ON ARDUINO UNO R3

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Abstract— *The main issue that needs to be addressed in this research is to enhance the safety and efficiency of the vessel berthing process by reducing the risk of collisions with the dock. With the advancement of technology in the maritime industry, there is still a reliance on various parties such as tugboats, ship crew, and dock authorities to ensure safe vessel berthing. Therefore, it is necessary to design a modern technology-based parking sensor system to provide assistance in the vessel berthing process. By using a parking sensor system based on the Arduino Uno R3 and ultrasonic sensors JSN-SR04T and AJ-SR04M, this research aims to address the risk of collisions with the dock, which can result in serious damage to the vessel, dock, and the surrounding environment. This parking sensor system is designed to reduce this risk by providing early warnings to the users. Furthermore, the research aims to reduce dependence on human factors and minimize human errors. Lastly, the research also aims to improve the efficiency of the vessel berthing process. By designing and implementing this prototype, the research aims to provide a technological solution to address the above-mentioned issues, enhance safety, and optimize the vessel berthing process around Motor Vessel BIN NO.2 EKS. SANYO MARU NO.8.*

Keywords: *dock, parking sensor, prototype. ship, ultrasonic.*

Intisari— *Permasalahan utama yang perlu diatasi dalam penelitian ini adalah meningkatkan keselamatan dan efisiensi proses berlabuh kapal dengan mengurangi risiko tabrakan dengan dermaga. Seiring dengan perkembangan teknologi di dunia pelayaran, masih ada ketergantungan pada berbagai pihak, seperti tugboat, awak kapal, dan otoritas dermaga, untuk memastikan berlabuh kapal yang aman. Oleh karena itu, perlu dirancang sebuah sistem sensor parkir berbasis teknologi modern untuk memberikan bantuan dalam proses berlabuh kapal. Dengan menggunakan sistem sensor parkir yang didasarkan pada Arduino Uno R3 dan sensor ultrasonik JSN-SR04T serta AJ-SR04M, penelitian ini bertujuan untuk mengatasi resiko tabrakan dengan dermaga dapat menyebabkan kerusakan serius pada kapal, dermaga, dan lingkungan sekitarnya. Sistem sensor parkir ini dirancang untuk mengurangi risiko ini dengan memberikan peringatan dini kepada pengguna,selanjutnya penelitian ini bertujuan mengurangi ketergantungan pada faktor manusia dan meminimalkan kesalahan manusia dan yang terakhir penelitian ini juga bertujuan untuk meningkatkan efisiensi proses berlabuh kapal. Dengan merancang dan mengimplementasikan prototipe ini, penelitian ini bertujuan untuk memberikan solusi teknologi yang dapat mengatasi permasalahan-permasalahan di atas, meningkatkan keselamatan, dan mengoptimalkan proses berlabuh kapal di sekitar Motor Vessel BIN NO.2 EKS. SANYO MARU NO.8.*

Kata Kunci: *dermaga, sensor parkir, prototipe. kapal, ultrasonik.*

INTRODUCTION

Informasi Teknologi will improve user comfort and lessen system instability by developing technology (Sun, Pernando, & Saragih, 2021). Error doesn't just occur in systems; it frequently occurs when people operate things manually. Due to this, manual operation will automatically worsen and move to equipment (Setiawan & Purnamasari, 2019). IT technology is evolving rapidly and generating stronger innovations (Frima Yudha & Sani, 2019). In this case, artificial intelligence can replace various objects, suggesting greater

automation in many aspects of our lives (Guo & Zhang, 2019).

Built on the concept of a microcomputer, a microcontroller is a little piece of technology used to operate a wide range of automation systems and electrical equipment (Dawolo et al., 2021). Microcontrollers are frequently employed to manage particular activities in a variety of applications, including autos, medical equipment, and household electronics (Snyder et al., 2021). Microcontroller functions as an electronic brain that regulates and controls a variety of tasks and functions required by such devices and systems (Nguyen, 2020). With their increasing capabilities, microcontrollers can improve performance, efficiency, and automation in various industries and in everyday life (Michael & Gustina, 2019).

Modern technology can replace the work we do every day. Artificial intelligence is increasingly able to automate more human tasks, enabling increased productivity and efficiency, but also raising questions about its impact on the labour market and human resources. With technological progress continuing, it is vital to continue to observe and manage the social and economic effects of this automation (Peeters, 2019). Technology in ports and ships accelerates and protects maritime transport(Mashuda, Acik, n.d.). When cutting-edge navigation technology is integrated on board, tracking and navigation become safer and more accurate (Zaher et al., 2021). Integration of advanced navigation technology on board enables more accurate tracking and navigation as well as improved safety of navigation (Singal & Rindengan, 2021). When a ship approaches a port at low speeds, the maneuvering of a ship can be difficult(Alam & Ermin, 2019). To ensure that the ship can rely safely and efficiently, there are several stages of the manoeuvre process that must be followed (Arun Francis et al., 2019).

First of all, the ship needs to change direction towards the port. This is done by adjusting the steering wheel and using the propulsion of the engine wisely (Hendrawan, 2019). A good understanding of direction and wind is crucial at this stage. Once the direction of the ship is set, the next step is to reduce the speed. This can be achieved by reducing the engine power or using a braking system if available (Yogie Junan et al., 2018). The engine can be turned off or have its power drastically decreased when the ship gets closer to the port and the capture procedure gets underway. As a result, the ship can dock securely (Sun, Pernando, & Safari, 2021a; Yonky Pernando, 2022). The safety and efficiency of the procedure depend on the crew, navigational aids, and maneuvering system working together in unison and maintaining correct ship position throughout (Murthy et al., 2021).

When the ship is landing, it is important for the pilot and master of the ship to have a deep understanding of the conditions around them. The ship's manoeuvres must be adjusted to factors such as weather, ship speed, distance, and angle with high accuracy. Control of ship speed is key in preventing collisions that may cause damage to the ship's armor and other ship infrastructure. Captains must ensure that the ship moves at a safe speed and in accordance with the conditions in the port or landing area. Besides, an in-depth understanding of weather conditions such as winds, currents, and waves is essential. The ship's captain and pilot must be able to respond to changes in the weather quickly and perform the necessary manoeuvres to maintain the safety of the ship and port facilities.

In a landing situation, good communication between the pilot and the crew and with the port authorities is essential to ensure the safety of the ship and the efficiency of operations on land. Safety and collision avoidance should be a top priority in the maneuver of a ship during the landing process (Perkovič et al., 2020a).

Source: (PT SAL, 2024)

Figure 1. Documentation of P.T. Shipping Sea Asih Lines

In Figure 1, there is a type of bulk cargo ship found at PT. Sea Asih Lines. Bulk cargo carriers fall into the category of cargo ships used to transport bulk goods such as cement, coal, metal ores, grains, and the like. In bulk cargo carriers, there are separate cargo holds or compartments (Sariyati et al., 2019). Skipping the ship is still done with the help of the tugboat, because for maneuvering large ships will be complicated and difficult procedures. Many accidents occur when ships land due to environmental factors surrounding the ship and the port environment that can not be accurately identified by the pilot. Accidents at ports can have a significant adverse impact on the company's or shipowner's finances, injury to workers, and also risk to port operations (Kim et al., 2021). One of the processes of modern technology such as IoT can help and exploit such technology to be effective in the process of placing ships in ports or landing (slow or we can say parking) on shipping processes.

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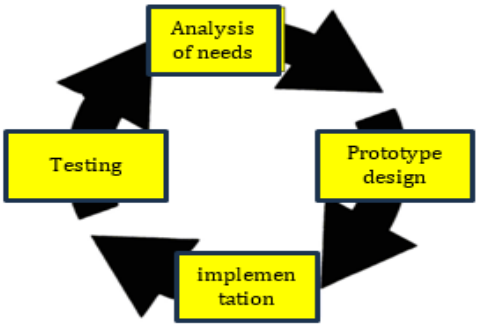
In the process, you may find some weaknesses and discomforts in the system that is currently in use. As a ship's captain or captain, especially large ships will find it difficult to park their ships in narrow areas and may also be caused by a shortage of crew (Kamolov & Park, 2019).

A prototype is a design or can be defined as a product design. Prototyping is a process in the development of an approximation of a product. A prototype is usually used to test an idea against a product quickly. Based on the background exposure above, then in this study the topic that the researchers will discuss is the implementation of ultrasonic sensors on the prototype ship using the Arduino Uno R3 microcontroller. Stand by giving notifications or information to the user. The way this parking system sensor works is by detecting objects in front of the sensor and if the object is detected, then the system will notify the user/customer. The one where the object is considered closest when the distance is ≤ 10 cm, and 20 cm is in the near status and ≥ 31 cm in the safe status. Distance calculation can be compared on a scale of 1:100 with a real ship on landing. Thus, it is hoped that with the presence of a parking sensor on this ship can help users in the dock. In this research, the approach used is a combination of UML design and flowcharts to understand how users will interact with the prototype. The prototype model is chosen as the primary development method with the aim of simplifying the design and implementation process of this ship sensor prototype, making the results more effective and efficient.

MATERIALS AND METHODS

Technological development has brought many benefits to mankind, one of the processes of technological development is that it can help the process of placing ships in ports or landing (slow or we can say parking) on the shipping process. In this study, the author designed a prototype of a parking sensor on a ship that supports the ship to land with the help of an ultrasonic sensor (Kamolov & Park, 2019).



Source: (Research Results, 2024)

Figure 2. Model Prototype

Prototyping, an interactive device development module that creates prototypes that meet anticipated demands, is the approach employed in this study (Perkovič et al., 2020b). Prototyping is a method of system development to generate a more detailed picture of system specifications (Musdar & Arfandy, 2020). Here's an explanation of the phase of the prototyping methodology:

a. Need analysis is the process of analyzing input and output data to determine what requirements to be met in order to build a system. During the analysis phase, the researchers will examine requirements such as the components required, the specs of the prototype ship, and the sensors and microcontrollers to be employed (Ridani et al., 2021; Sly & Boelman, 2021). On the prototype with a length of 80 cm, the researchers just used 4 ultrasonic sensors to detect objects on the left and right sides of the ship 30 cm away from the sensor, on the right and left sides respectively there was 1 JSN-SR04T ultrasonic sensor on the front and 1 AJ- SR04M ultrasonic Sensor on the rear, using the Arduino Uno R3 microcontroller, and 4 red LEDs as an indicator that there are objects detected, 4 green LEDs to indicate that no objects are detected and a buzzer for voice notification if there is an object detected. On the propulsion system use a 12V DC motor and a Servo motor to adjust the direction of the ship.
b. Prototype design: Using the findings of earlier research, this stage will concentrate on the collection of components and design the sensor on a ship prototype (Martinsen et al., 2020). After obtaining the necessary instruments and supplies, the researchers will go on to the device's design stage. Researchers build ship prototypes, assemble parts, and program sensors at this point.
c. Implementation: The design of the prototype's component parts leads to the presentation procedure. As of right now, the prototype is planned ahead of time and will execute exposure using the system that has been coded to enable the sensor to operate as intended (Cao et al., 2020; Fitzpatrick et al., 2020).
d. Testing to ensure that every component of the prototype has been put to the test and that the results fit the specifications (Sun, Pernando, & Safari, 2021b). Researchers will use the sensor test results to gather data, and if any inaccuracies or weaknesses are found, they will make the required modifications (Guida et al., 2020; Hanfei et al., 2020).

Source: (Research Results, 2024)

Figure 3. Photo of Captain Evendi Dewa

In Figure 3, the researcher is engaging in a conversation with the ship's captain to conduct an interview regarding the ship sensor prototype. The prototype was made of HPL material and coated with fiber glass. Then the researchers designed the layout of components such as the ultrasonic sensor, the Arduino Uno R3, and other support systems.

Source: (Research Results, 2024)

Figure 4. Ship Prototype

Research involving devices such as sensors, microcontrollers, batteries, and other components is an attempt to develop technological solutions that can be used to collect data, and control a device. The ultrasonic sensor used requires programming through the Arduino Uno microcontroller. These sensors will be tested first for measurement accuracy. The ultrasonic sensor used requires programming through the Arduino Uno microcontroller. These sensors will be tested first for measurement accuracy

RESULTS AND DISCUSSION

Planning

In this planning section, the researcher will explain in detail the steps that will be taken to carry out this research. Careful planning will be a strong foundation in ensuring the smoothness and success of the entire research process.

Hardware Requirements

The hardware needed in designing the prototype parking sensor on this ship is modules as well as components. As for the required details as follows:

Table 1. Hardware Requirements

Prototype components	Module
Battery 12V	Arduino Uno R3
Remote Control	Ultrasonic sensor JSN-SR04T or equivalent
Jumper Cable	Buzzer
Shaft, Propeller and Rudder	LED
DC motor and Servo motor	Breadboard
ESC and Receiver	Arduino Uno R3
Solder and lead	
Fiber Glass	
High Pressure Laminate (HPL)	
Impraboard	

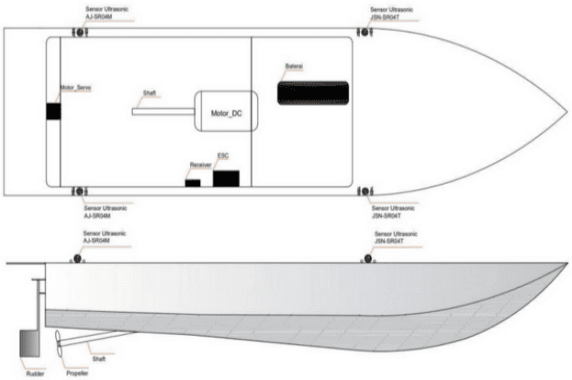
Source: (Research Results, 2024)

Software Requirements

The software used in the design of this parking sensor is to use Arduino software via PC (Personal Computer) that will be uploaded into the uno arduino module. So that the Arduino module in receives input from the ultrasonic sensor when detecting objects in accordance with the set distance and Arduin will process and send output signals through LEDs and Buzzer with beep notifications (voices) according to the distance.

Hardware

Planning Network



Source: (Research Results, 2024)

Figure 5. The prototype design is visible on top and side.

Figure 5 is a series of prototype ship designs to be made. The prototype is 80 cm long, 21 cm wide, and 13 cm tall. On this set there are 4 sensors with LEDs located 4 points (2 areas right, 2 areas left), 1 unit motor dc in the center, 1 unit servo motor in the middle rear, 1 set ESC and receiver in the right, and 1 unit 12V battery in the center of the ship.

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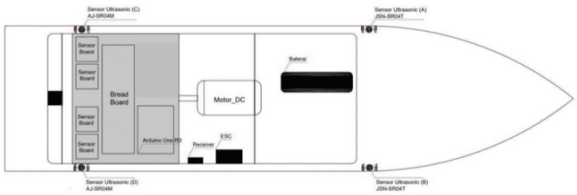
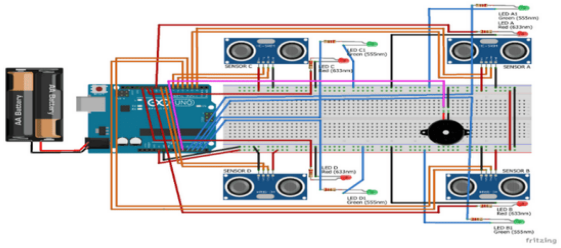


Source: (Research Results, 2024)
Figure 6. The prototype design looks up with a second layer

Further on Figure 6 there is an additional layer above the shaft area of the ship intended for the place of the control device. There's one Arduino Uno unit, four Sensor Board units of each sensor, one Breadboard unit used for connecting components, one Buzzer unit for beep notifications, and the cables.

Fritzing

Figure 7 shows a range of sensors using fritzing. There are four ultrasonic sensors connected to the Arduino Uno, with LED and Buzzer outputs. With a 12V power supply from the battery to the arduino uno.



Source: (Research Results, 2024)
Figure 7. Fritzing

Implementasi

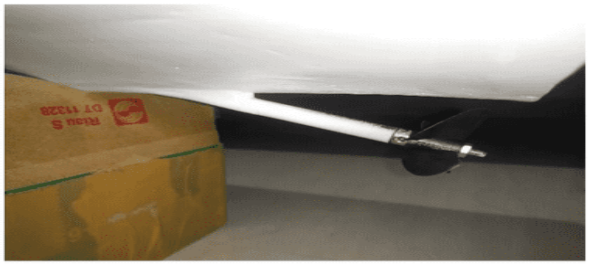
Hull Ship Design

The initial stage of making a ship's prototype hull was to design the shape of a ship using paper. Then the design was cut according to its size and combined into a shape like in Figure 4.10 Hull consists of 80 cm long, 21 cm wide, and 13 cm tall.

Source: (Research Results, 2024)
Figure 8. Hull Ship Design

Installation Shaft already Propeller Ship

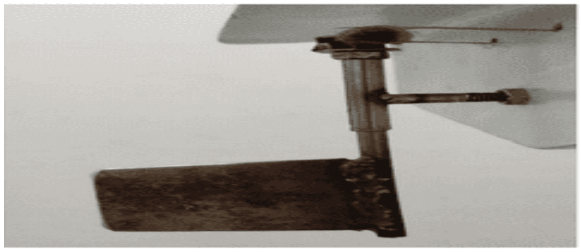
The shaft of the prototype ship is installed after the dampening process is completed, the shaft is removed to the outer surface of the ship about 10 cm, and on the glue is used glue gun. Then on the outside is given a damping and painting is done.



Source: (Research Results, 2024)
Figure 9. Installation Shaft already Propeller Ship

Ship Rudder Installation

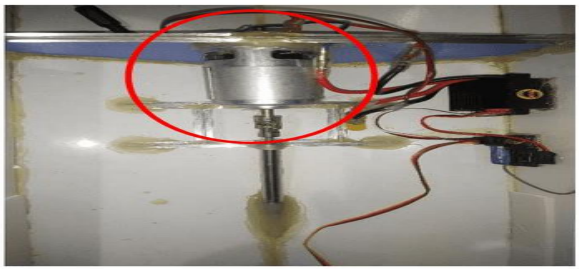
The rods of the prototype ship are made of iron where the rods are placed in the middle position of the ship outside the rear wall.



Source: (Research Results, 2024)
Figure 10. Ship Rudder Installation

Installation of the DC motor

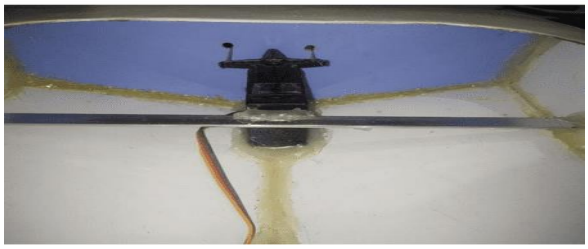
The DC motor is used to move the propellers so that the ship can move. The DC engine is connected to the shaft to proceed to the propeller.



Source: (Research Results, 2024)
Figure 11. Installation of the DC motor

Servo Motor Installation

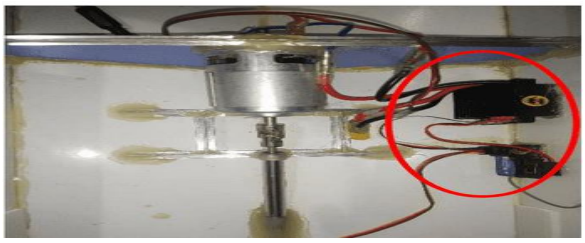
The servo motor is used to move the rudder aimed at directing the direction of the ship.



Source: (Research Results, 2024)
Figure 12. Servo Motor Installation

ESC and Receiver Installation

The ESC and the receiver are mounted on the right side of the ship that is adjacent to the DC motor and the servo motor which will serve to give commands such as the speed and direction of movement of the vessel.

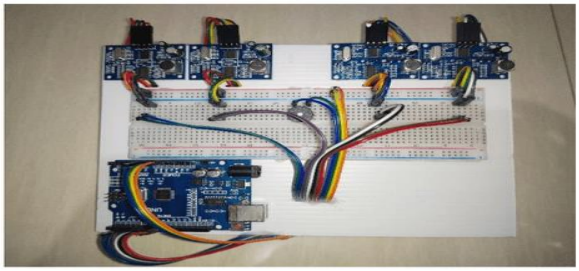


Source: (Research Results, 2024)

Figure 13. ESC and Receiver Installation

Installation of Arduino Uno modules and supporting components

The Arduino Uno module with supporting components such as the breadboard, the buzzer, and the sensor board are mounted on a separate layer. The layer is installed on top of the ship's shaft area. All the sensor cables and LEDs are connected to the arduino module.

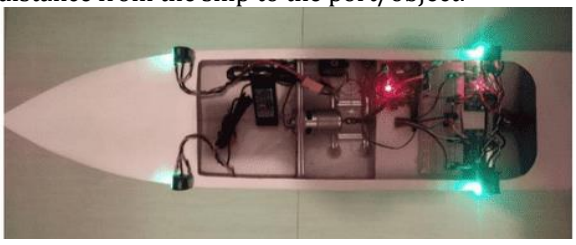


Source: (Research Results, 2024)

Figure 14. Arduino Uno modules and components

Ultrasonic Sensor Installation

Four ultrasonic sensors are mounted on the front left (port side) and the right (starboard side) each one unit, and the rear left and right (right side) one unit each. The sensor is used to detect the distance from the ship to the port/object.

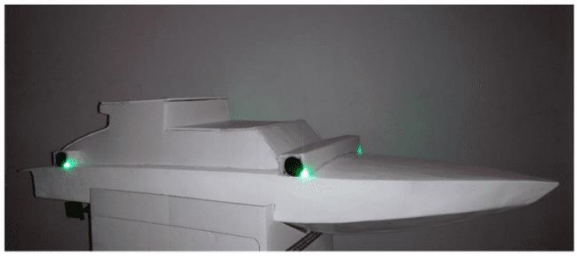


Source: (Research Results, 2024)

Figure 15. After installation of the sensor

Ship Prototype Final Results

In Figure 4.22, the final design of the ship prototype was the final stage of the assembly. The ship's top covering was made of impraboard material so that the ship Prototype would not be too heavy and cost-effective. On The top of the ship is closed so that if tested in the water, the spark does not touch the devices inside the prototype.

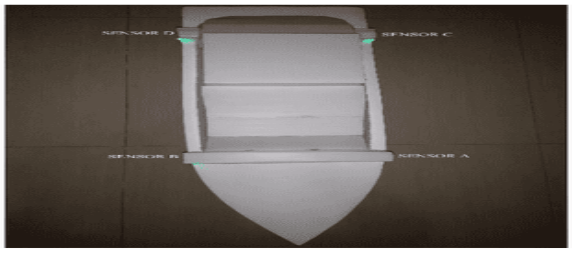


Source: (Research Results, 2024)

Figure 16. Final design of the ship's prototype

Parking system testing on a ship prototype

The testing of the parking system on the ship is simulated in the shape of a prototype ship like in Figure 4.23 which has one sensor on the upper left, one on the top right, one sensor at the bottom left, and one sensor in the bottom right. Where this sensor will detect objects in front of the sensor at a distance of less than 31 cm. The tests were carried out on four different sensor points, which aimed to determine whether the functionality of the designed parking system could work properly or not, or if there were any deficiencies.



Source: (Research Results, 2024)

Figure 17. Insert Sensor

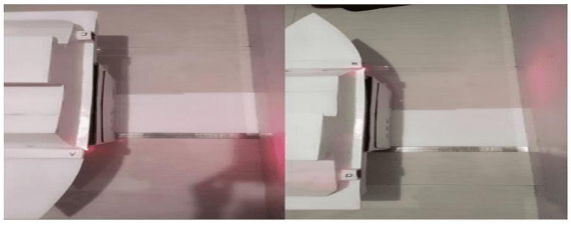
Testing on sensors A, B, C, and D, that if an object is detected less than 31 cm from the sensor distance, then the sensor gives an output signal of notification to the respective LEDs (red) in the form of a noise and a beep sound generated by the buzzer. Then the LED (green) does not light because there is an object detected

Table 2. Ultrasonic Sensor Test Results

No	SENSOR ULTRASONIK			
	A	B	C	D
1	1	1	1	1
2	1	1	1	1
3	1	1	1	1
4	1	1	1	0
5	1	1	1	1
6	1	1	1	1
7	1	1	1	1
8	1	1	1	1
9	1	1	1	1
10	1	1	1	1

Source: (Research Results, 2024)

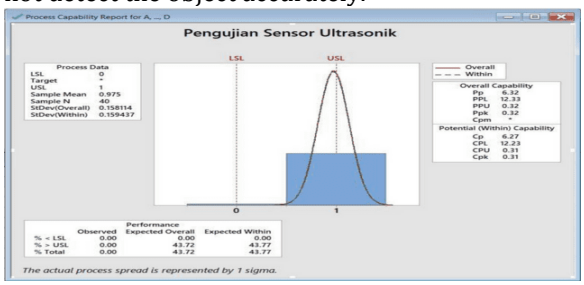
Table 2 is the test results for the distance from the sensor to the object at a distance of 30 cm, in 10x tests carried out against the four ultrasonic sensors on the ship prototype resulted 39x trials successfully detect the object (97.5%), in Table 2, with the criterion of value 1 = sensor successfully detected, while 0 = sensor failed to detect. Any distance that has reached 30 cm the sensor will detect the distance and send the output signal to the Arduino Uno R3.



Source: (Research Results, 2024)

Figure 18. Ultrasonic Sensor Testing

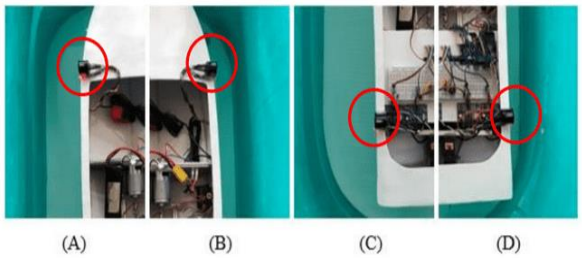
Sensor testing at a distance of 30 cm from the object by performing 40x tests on 4 sensors resulting in a Cp value of 6.27, with the value then it can be stated that the process is very good since almost all the data entered the specification, but the Cpk value still indicates 0.31 which indicates that there are process results not close to the target, because there is 1 data that does not meet or does not detect the object accurately.



Source: (Research Results, 2024)

Figure 19. Minitab Sensor Testing

Figure 19 objects are detected by sensors A, B, C, and D. As described earlier, the LEDs (red) will be flashing and the Buzzer will be beep, while the LED (green) will not be lit. Objects are detected by sensors A, B, C, and D. Like as explained previously, the LED (red) will flash/light up and the Buzzer beeps, while the LED (green) is not lit.



Source: (Research Results, 2024)

Figure 20. Object Detected

On the other hand, if no objects are detected on the sensor, then the LED (green) will light without noise but the LEDs (red) and the buzzer will not light. Under these circumstances proves that the prototype ship's range is in a safe zone. After doing the tests like in the picture above, proving that the sensors can work well. Based on the test results of the parking system and the black box tests, it can be concluded that the parking systems on this prototype ship can run and work well as expected.

CONCLUSION

Ultrasonic sensor designs are positioned on the right and left sides of the ship, each with two sensors in the front and rear. The sensor is designed to detect a port/object while the ship is on board. The ultrasonic sensor takes the voltage from the Arduino and reflects the sound waves from the transmitter to measure the distance of the object that the receiver then receives. After obtaining the distance calculation, the sensor produces a sound output on the LED and a beep sound from the buzzer. The parking sensor works to detect objects such as gates. When the prototype of the ship is landing, the sensor will detect objects up to 30 cm, when the object is detected then the LED (red) will blink and the buzzer will ring. If the object isn't detected, then the led (green) will light up and the Buzzer won't sound. The parking sensor on the ship's prototipe works almost accurately to detect the objects 1 to 30cm away with a success rate of 97.5%.

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