Prototype of Automatic Control System on Ship

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Abstract. Autopilot control makes a system go to the expected target trajectory. It does not replace the human operator's role but only assists the part of the system control operator. Autopilot control systems contribute to reducing human resources in performing tasks to realize higher reliability, observation, and supervision. Therefore, this study aimed to design an autopilot control system using GPS, compass, and ultrasonic sensors. It used a prototype ship weighing 1.7 kg, with a length, width, and height of 90 cm, 20 cm, 10 cm, respectively. Furthermore, the study tested the prototypes under calm water conditions without extreme external factors. The ATMega 2560 microcontroller was used as an electronic circuit controller-GPS sensor for latitude and longitude coordinates. The results showed that ultrasonic sensors detect objects, while the compass sensor moves the steering gear and rudder to maintain the ship's direction. Therefore, the ship could automatically avoid objects and navigate the target trajectory.

Keywords: Autopilot, Control System, Microcontroller, GPS, Compass

1 Introduction

Autopilot controls a system towards the target trajectory without replacing the role of human operators [1]. However, the system reduces human resources by performing tasks with higher reliability, observation, and supervision. Its purpose is to control the rudder's movement, ensuring that the ship's direction is maintained according to the target trajectory. This is because ships are always influenced by environmental disturbances caused by wind, tides, waves, and ocean currents at

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sea.

The control system is studied extensively for unmanned ship, such as [2], which used five proximity sensors as obstacle detectors, a compass sensor as a primary direction detector, and two main DC motors. These two motors run by a microcontroller acting as the system's brain, making the boat work automatically. Another study on a ship's autopilot control system developed an unmanned ship design using a microcontroller and GPS control system [3] [4] [5].

In this research, the autopilot control system on the ship, controlled by a microcontroller circuit that utilizes tools from navigation such as GPS sensors, compass, and ultrasonic used as input data media. Data in location points, latitude, longitude, direction, proximity sensor to detect objects. A microcontroller is used for a chip as a controller of the electronic circuit process through the driver and dc motor to control the movement of the rudder and ship propeller so it can sail to the destination track automatically.

2 Research Methodology

Several methods are combined and used to adjust the ship's trajectory automatically. For instance, Sliding Mode Control Algorithm was used by [6], while fuzzy logic, artificial neural network, GSM, and compass were adopted by [7], [8], [5] and [9] [10], respectively.

In this study, the control system has three main parts, including inputs composed of GPS data, a compass, and ultrasonic sensors. The microcontroller as a chip is the general process of the control system, and the output manages the motor controller, DC motor, servo, and rudder. The combination of ultrasonic and compass sensors used for Heading Measurement could reduce the error value in the results [11]. Similarly, the combination of GPS and compass is more effective than other navigation systems [12].

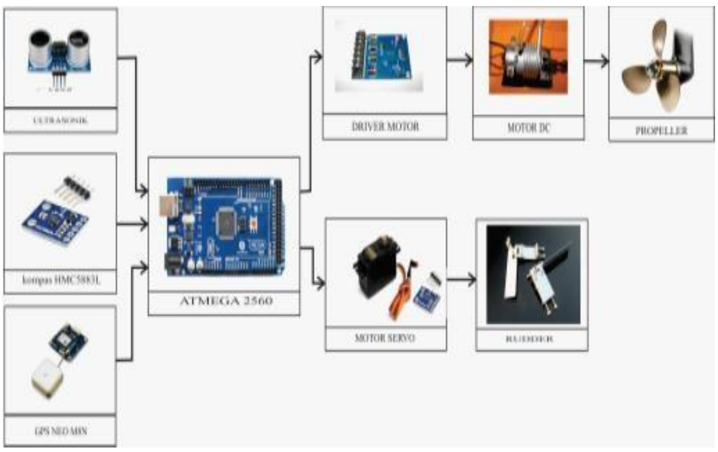

Fig. 1. Control System Design.

Figure 1. is an installation of hardware from a control system with a data input part in the form of a GPS sensor, compass, and ultrasonic. AtMega 2560 use as a microcontroller that processes or controls the entire system. The output of the control system helps the performance of the autopilot control system on the ship. The main advantage of the AtMega 2560 is that it allows the robotic hand to use for different purposes. Also, other communication protocols that would enable writing various programs are another advantage [13].

The hardware installation shown in **Figure 1.** will form the basis for manufacturing autopilot control systems on ships. The structure uses original images of each electronic component used on a hardware system to look like an actual device. The workings of the control system device on the ship begin with turning on the microcontroller system, GPS module, compass, ultrasonic, and motor driver. To run the control system, first, determine the coordinates of the location of the departure and target of the ship by storing latitude coordinates, and the longitude of the vessel will be ready to be operated will be able to Sail on the target track automatically. On testing the autopilot operation, the ship control system departs from the departure point and the target ship destination stored on the AtMega 2560 microcontroller program.

The control system on the ship will run after pressing the push bottom button on the control. The ship will sail on the target track at latitude and longitude points to find the stop destination; in setting the engine, the program reduces speed after walking the remaining way. For example, 6 meters will slow down if the remaining distance is only 4 meters. The ship's engine will die automatically before the length of 2 meters for the vessel to arrive at the destination coordinates. The aim is to avoid collision control systems when the ship reaches the target's destination. Then the autopilot ship control system can also avoid objects in front of it on the ship's track. Finally, the vessel's steering wheel will take the ship off track and move the steering wheel to the right or left dan back to the target track to arrive at the coordinates of the ship's destination.

3 Result and Discussion

The staged testing was advanced to the overall device testing process using the results and discussion. First, this study tested the Power Supply, where the circuit supplying the ATMega 2560 microcontroller voltage must be stable with sufficient current to ensure no voltage drop when the system is operating. The power supply for this device comes from a single battery with a voltage of 7.2 VDC. The output voltage on this battery is to supply the ATMega 2560 , while DC motor produces 7.2 volts. Second, the Compass Sensor GY-273 HMC5883L was tested by assessing changes in direction data generated by the compass module. Compass sensor testing activates the analogue board ATMega 2560 Vcc, GND, SCL, and SDA pins, where the Vcc output pin is 5 volts. The sensor is connected to the Vcc and GND pins on the Mega 2560 as a positive and negative voltage source. The SCL and SDA output pins send data and compass sensor information simultaneously.

Third, the NEO-6M GPS Sensor was tested using a microcontroller circuit and serial monitor because the GPS is only a chip module. Testing this system is successful when it displays data readings of south latitude and east longitude according to the GPS location. The ATMega 2560 Vcc and GND, as well as TX1 and TX2 board pins are activated by pushing the system. The GPS sensor's 3.3V Vcc and GND output pins are connected to the Vcc and GND pins on the ATMega 2560 as positive and negative voltage sources. In this case, the output pins of TX1 and TX2 are used to transmit GPS sensor information. Fourth, testing was performed on the Ultrasonic Sensor system that connects the ATMega 2560 and ultrasonic pins. The Ultrasonic Sensor system activates the ATMega 2560 Vcc, GND 13, and ar12 pins. Moreover, the 5-volts Vcc and GND output pins are connected to the Vcc and GND pins on the ATMega 2560 for ultrasonic sensor activation. TRIG and ECHO output pins detect and generate ultrasonic sensor signals. Fifth, the study tested Servo and Steering system devices using the active ATMega 2560. The Servo motor has three wires, including voltage, GND, and signal to transmit data. This system activates the board pins on the ATMega 2560 Vcc, GND, and pin 8. Similarly, the Servo's 5-volts Vcc and GND output pins are connected to the Vcc and GND pins on the AtMega 2560 for servo activation. They are also connected to pin 11 to provide command instructions used to move the ship's rudder.

This test is to do step by step and relates to one another. If the first stage is not successful, the test will be delay until the first stage of testing is complete. The software and hardware must be prepared and carried out in stages so that everything goes smoothly and any defects can be analyzed and resolved. The overall test is a test that combines the full software and hardware system. Comprehensive system testing by determining the target trajectory of the ship's destination; latitude and longitude coordinates are at use for the departure and destination data of the ship control system.

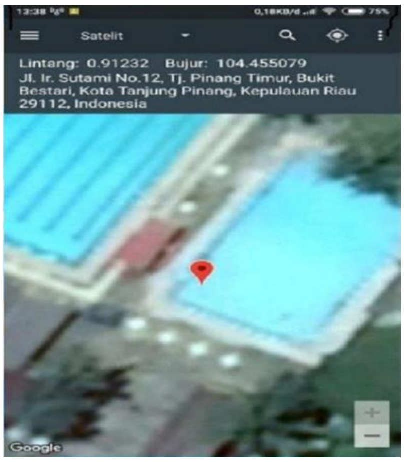

Fig 2. Starting Point (A)

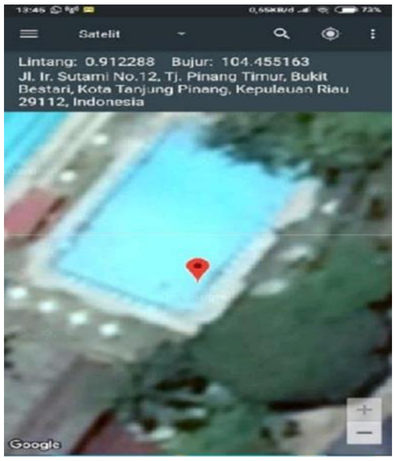

Fig 3. End Point (B)

Then the navigation test is carried out to see if the system can do to navigate. First, the system test by providing the coordinates of the target ship's trajectory location, 10 meters from the ship's departure point (coordinates of point A to B). Next, the vessel will be observing whether it can get to the destination coordinates. Finally, the test's success parameters are established by the ship's control system in reaching the coordinates on the target trajectory or not.

Table 1. Result data from GPS sensor

No	Ship Position	Destination Location Points		Measured Point	
		Latitude	*Longitude*	*Latitude*	*Longitude*
1	Departure	0.912370	104.455085	0.912377	104.455085
	Destination	0.912334	104.455154	0.912314	104.455154
2	Departure	0.912370	104.455085	0.912359	104. 45509
	Destination	0.912334	104.455154	0.912316	104.455146
3	Departure	0.912370	104.455085	0.912356	104.455085
	Destination	0.912334	104.455154	0.912313	104.455154
4	Departure	0.912370	104.455085	0.912364	104.455101
	Destination	0.912334	104.455154	0.912304	104.455169
5	Departure	0.912370	104.455085	0.912354	104.455093
	Destination	0.912334	104.455154	0.912300	104.455177
6	Departure	0.912370	104.455085	0.912362	104.455093
	Destination	0.912334	104.455154	0.912291	104.455169
7	Departure	0.912370	104.455085	0.912350	104.455085
	Destination	0.912334	104.455154	0.912309	104.455177
8	Departure	0.912370	104.455085	0.912344	104.455085
	Destination	0.912334	104.455154	0.912298	104.455169
9	Departure	0.912370	104.455085	0.912345	104.455093
	Destination	0.912334	104.455154	0.912297	104.455162
10	Departure	0.912370	104.455085	0.912357	104.455093
	Destination	0.912334	104.455154	0.912310	104.455154

The test results in **Figures 2 & 3** show that the system's test results can navigate even though the ship's departure and destination coordinates are little changed. So it can conclude that the autopilot system on the vessel can work well. This test is to do until ten times. After that, the ship's autopilot control system device could sail on the target trajectory to find the ship's destination point to stop automatically. For more complete data, please see **Table 1.**

For example, departure orientation at latitude 0.912370 and longitude 104.455085 ships can automatically send to sail on the target trajectory; the vessel will sail to find the destination target point, namely at latitude 0.912334 and longitude 104.455154, to arrive at the ship's target trajectory. Each repetition of the test or the vessel's departure to the ship's destination with the exact latitude and longitude, then the results of reading the coordinate data generated by the GPS sensor always have a slight difference. Because the GPS sensor is only in a chip module, there are minor errors in readings.

Then the last test is to test whether the system can detect obstacles and navigate when given blocks. The system uses the HCSR04 proximity sensor mounted on the front of the ship to recognize a wider area [14]. Testing this system tests how far the system will detect an obstacle in front of the vessel. A block will the place at different distances from the ship in sailing and navigating conditions —distance detection test of parameters determined by checking the serial output of the system. The system can detect distance or work if the ship can avoid obstacles in front of the vessel.

Navigation is carried out as far as 10 meters by being given the right obstacle between the departure point coordinates and the destination point coordinates. The success parameter of this test is that the system can avoid the barriers prepared at location B, which is 1 meter from the coordinate point of A. In addition, the system observes how the avoidance pattern is and the distance the system begins to respond to obstacles.

Table 2. Result data from Ultrasonic sensor

N0	Object Distance (cm)	Avoided Objects	Ship Direction Pattern	Ship Direction Pattern	Distance From Sensor (cm)
1	100	Yes	Left	Right	102
2	150	Yes	Left	Right	155
3	200	Yes	Left	Right	209

From the testing results, the ship's autopilot control system can automatically avoid the suitable object on the trajectory that the boat wants to pass; the ship's servo and steering will control the boat to the right and left. Finally, they will return to the target trajectory to arrive at the ship's destination coordinates. Each reading on the proximity sensor or ultrasonic has a slight error or error in the task. The proximity sensor is only a chip module, so there are several errors or errors in the reading. The following are the sensor readings obtained which are the list in **Table 2.**

4 Conclussions

This study developed a device for the autopilot control system on ship using an ATMega 2560 microcontroller as an electronic component controller chip. The GPS Sensor, compass, and ultrasonic sensor system were used to locate data from latitude and longitude, maintain position and change direction, and avoid obstacles. The results showed that the autopilot control system device could avoid an obstacle from the target track. The device returns to the original target crossing to determine the ship's destination and control the motor rotation speed. Every test of the ship's engine reduces the walking rate when the remaining track distance is 6 meters, and slows when only 4 meters are remaining. The ship's engine stops automatically 2 meters before arriving at the destination to avoid collision in the control system.

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