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Navigation Lamp Detection to Avoid Collision for Unmanned Surface Vehicle (USV)

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ABSTRACT

Unmanned Surface Vehicle (USV) or unmanned ship has become a major focus in the development of shipping technology to improve the efficiency and safety of navigation on the water. This research carried out the design and creation of an unmanned ship system equipped with an ESP32 camera to detect the navigation lights of other ships and avoid potential collisions. In this system, the initial response of the ESP32CAM camera reads the color of the lights approaching the unmanned ship with less than 100 cm. ESP32CAM reads and identifies colors through image processing. When ESP32CAM detects green and red-light colors, the ESP32CAM microcontroller commands the buzzer to sound. The color detection system works with this command, if ESP32CAM detects red then the ESP32CAM microcontroller will send a signal to the servo motor to move left, while ESP32CAM detects green the ESP32CAM microcontroller will send a signal to the servo motor to move right. The servo motor functions as a ship rudder drive of a USV or unmanned ship. The Navigation lamp system test using ESP32CAM camera to prevent ship collisions is carried out with a predetermined scenario, independent light color testing, and whole system testing. The results of the research are : Color detection is successful. The camera can recognize the color of the light and the unmanned ship is able to take appropriate action to avoid collisions based on the color light signal and the navigation lamp system. The ESP32CAM camera can identify the optimum light at 100cm.

Keywords: *ESP32CAM, unmanned ship, navigation light, servo motor, rudder, prevention of ship collision*

INTRODUCTION

In general, every ship has navigation tools to avoid collisions between one ship and another. Ship collision is an emergency caused by the collision between two ships, a ship with a dock, or a ship with a floating object, that can endanger human life, property and the environment [1]. Therefore, a good navigation system is needed on every ship. Navigation technology that must be on board when sailing, namely navigation lights, magnetic compasses, and other navigation equipment such as GMDSS, echo, 2018. equipment such as GMDSS, echo sounder, gps, radar, engine telegraph, internal telephone and loudspeaker.

All ships sailing on the ocean, according to the regulations of the classification society, must be equipped with navigation lights. Classification society

must be equipped with navigation lights as part of a navigation system that complies with the as part of the navigation system in accordance with the requirements that have been (COLREGS) Classification Societies or the International Regulations for Preventing Collision at Sea, as also established by the IMO organization. Established by the IMO (International Maritime Organization) organization. As explained above, the function of ship navigation lights is one of the ship's safety tools, because it can help prevent accidents at sea. Prevent accidents at sea. Ship navigation lights are not used for lighting but are used as a symbol or position of the ship and some important objects on the ship. Some important objects on the ship. These navigation lights must be installed in a predetermined position according to P2TL regulations. These navigation lights must be installed when the vessel is sailing at night, in dark, foggy, rainy or limited visibility weather. Darkness, fog, rain, or when visibility is limited.

There are various kinds of navigation lights, both in color and function, namely hull lights (side light), stern light (stern light), anchor light (anchor light), dangerous cargo light, not under command light, crossing signal light, and immigration light, as stated in the COLREGS and P2TL Regulations Number PM 11 of 2023 concerning navigation lights rules 20 to 30.

Autonomous technology that can be implemented on the water surface or can be called an unmanned ship. Conventional unmanned vessels usually use one of two means of navigation, namely between visual readings or coordinate points. In order to work more accurately and precisely to achieve a goal, a system is needed that functions to determine the coordinate point of a place and is equipped with image processing features in order to avoid objects that block the ship's speed when heading towards the coordinate point. when heading to the coordinate point.

This research aims to identify navigation lights as specially in the night situation, this research uses an EPS 32 CAM camera for detecting the color of the lights connected to the ESP32CAM microcontroller to identify the color of the lights according to the camera reading which is connected to a servo motor as an automatic ship driving rudder. rudder to drive the ship automatically.

a. Problem Formulation

1) How to design a navigation lamp detection system to avoid ship collisions?
2) How can the navigation lamp detection system using ESP32CAM be used to prevent collisions on unmanned ships?

b. Problem Limitation

The problem limitations of this research are as follows:

1) The detection distance of the system is limited by the maximum optimal distance of ESP32CAM.
2) This system only detects some colors according to the capabilities of the ESP32CAM which is an analog of a navigation lamp.

LITERATURE REVIEW

Some of the theoretical foundations that support this Research are as follows:

a. ESP32CAM

ESP32CAM is a low-cost ESP32 development microcontroller equipped with an on-board camera and is small. Because it is equipped with Wi-Fi and Bluetooth, it is ideal for IoT applications, smart home devices and others [4] The specifications of the ESP32CAM microcontroller in Figure 1 used are:

- Microprocessor: 32-bit LX6 CPU
- Power Supply Range: 5V
- IO Port: 8 - RAM: 520 KB
- Wi-Fi: 802.11 b/g/n/

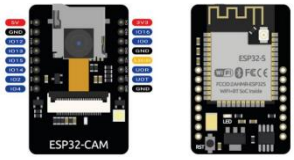

Figure 1 ESP-32 CAM

b. Motor Driver

Motor Driver is an electronic component used to control the direction of rotation of a DC motor. One L298 can be used to control two DC motors. In addition to being used to control the direction of rotation of the DC motor, this L298 can also be used as a bipolar Stepper motor driver. The L298 driver IC could drive a DC motor up to a current of 2A and a maximum voltage of 40 volts DC for one channel. Enable pins A and B are for controlling the motor speed, input pins 1 to 4 are used to control the direction of rotation. The output pin on IC L298 13 is connected to the DC motor which was previously through a diode arranged in an H-bridge. Motor speed regulation uses PWM (pulse width modulation) technique which is input from the microcontroller through the Enable pin. PWM for rotational speed that varies the high-level [1] Figure 2 of the device is an example of a Motor Driver capable of issuing voltage output for DC motor and stepper motor of 50 Volts.

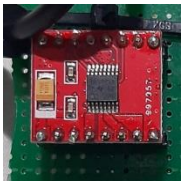

Figure 2 Motor driver

b. Servo Motor

Servo motors are electrical devices used in smart industrial machines that function to push or rotate objects with control with high precision in terms of angular position, acceleration and speed, an ability that ordinary motors do not have [10]. This device will be installed in the ruder section of the ship.

c. Rudder

In principle, the ship's steering motor is greatly influenced by the design, propulsion system and steering system. A number of these elements directly affect the hydrodynamic forces and moments acting on the rudder leaf. Another thing that can also affect is due to the condition of the rudder leaf that is too large, so that there is a mismatch between the rudder drive engine and the rudder when the ship is deflected [2].

d. Unmanned Ship

Unmanned ships are ships that can move automatically, which can be said to be autopilot [7]. Autopilot is the most developed open source-based module for autopilot modules. Both autopilots for aircraft (Arduplane), Multicopter (Arducopter) and also land vehicles (Ardurover). This module uses the Arduino microcontroller which is very popular in the field of instrumentation.

e. Breadboard

Breadboard is a component that helps design a simple electronic circuit. This board also functions so that it can work on electronic circuits without having to be soldered [8]. Where the top hole is a negative line and below is positive, it is called vertical for the entry of electricity or current. While what makes up the horizontal is to place each pin of the Arduino which will be connected to other components.

f. DC Motor

According to [10] the definition of a DC motor is a direct current motor with a stator that uses a permanent magnet. direct current motor with a stator that uses permanent magnets. A magnetic field is defined as an area or region where if an electrically is in or moving in that area then the object will get a magnetic force. the object will get a magnetic force. The existence of a magnetic field around the electric current was proven by Hans Christian Oersted through the Experiment. The force that one magnet exerts on another can be described as the interaction between one magnet and the magnetic field of the other.

g. P2TL (Regulation of Prevention of Collision at Sea)

In Regulation No. PM 11 of 2023, P2TL stands for the Regulation on Prevention of Collisions at Sea which is the form of P2TL (Regulation on Prevention of Collisions at Sea) Implementation to Prevent the Occurrence of Ship Accidents at Sea in the Context of Supporting the State Economy, applied internationally to all ships on the free sea (high seas) in all waters.

(high seas) in all waters that are interconnected and navigable by ships. by ships. P2TL is a collection of rules that have been set by the world shipping body, namely the IMO, which regulates the flow of Merchant Marine and to prevent ship collisions at sea. Collision is an emergency caused by the collision of a ship with a pier. collision of a ship with a pier, or a ship with other floating objects that can endanger human life. an emergency caused by the collision of a ship with a pier, or a ship with other floating objects that can endanger human life, property and property.

METHOD

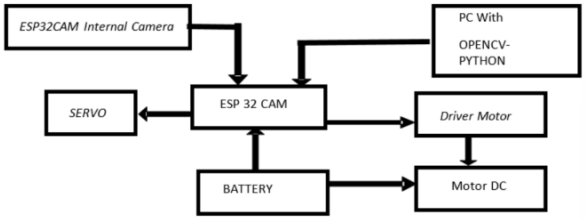

Figure 3. Diagram Block System

Figure 3 above shows the operating system in this research. OPENCV-PYTHON is software intended for real-time digital image processing. ESP32CAM is a microcontroller that processes signals and light sensors and regulates the output to give commands to the Servo Motor and DC Motor. ESP32CAM Internal Camera as a light capture lamp to be sent to the ESP32CAM. Motor Driver is to control the speed and direction of rotation of the DC motor. Servo Motor is a DC motor whose rotational motion can be adjusted according to the programmed, functioning as a rudder angle regulator. Battery as a power supply for DC Motor and ESP32CAM.

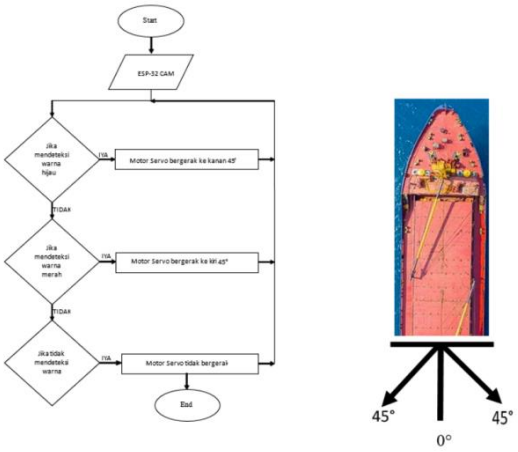

Figure 4. Flowchart System

Figure 4 above shows that this system is divided into several parts such as ESP32CAM, Motor Driver, servo motor, and rudder angle. In general, the system in this study uses ESP32CAM to determine the color where the color value is processed in the ESP32CAM itself, so that with the uploaded program it can command the servo motor and rudder to move according to the program that has been made.

ESP32CAM is placed on the bow of the ship so that it can read the detected light color. The reading value of the light color obtained from the ESP32CAM input is read by the camera on the ESP. Battery as a power supply for all components, when starting click the on/off button, LCD as a copy of the IP Address (Wi-Fi/hotspot), When ESP32CAM detects the light color, ESP32CAM sends a signal to the servo (rudder) and the buzzer will sound when the ESP detects the light color. DC motor as a driver (propeller shaft). Those flows can be illustrated in Figure 5 below.

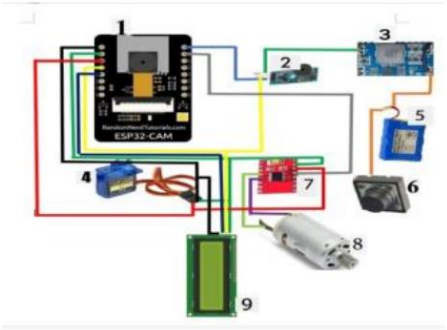

Figure 5. Component Circuit

1. ESP32CAM
2. Buzzer
3. Buck Converter
4. Motor Servo
5. Battery 12VDC
6. On Off Button
7. Driver Motor
8. Motor DC
9. LCD 16x2

RESULT

Data retrieval is done by knowing the ideal distance of ESP32CAM or the maximum distance ESP32CAM can read the color of the green light and the color of the Red light such as navigation lights on ships, then after getting the maximum distance, ESP32CAM will be tested to collect the required data. Record the maximum distance between ESP32CAM and the color of the light, for testing it is done at night so that ESP32CAM detects it maximally.

Navigation lamp detection system design to avoid collisions on unmanned ships using ESP32CAM. ESP32CAM is placed on the bow of the ship so that it can read the light color of other detected ships. The light color reading value obtained comes from the ESP32CAM input. Battery as a power supply for all components, When the start on/off button is pressed, all components on the unmanned ship are on. LCD as a copy of the IP Address (Wi-Fi/hotspot) to copy the Address to image processing. When ESP32CAM detects the color of the light, ESP32CAM sends a signal to the servo (rudder) and the buzzer will sound if ESP32CAM detects green, the servo motor moves to the right. When ESP32CAM detects red, the servo motor moves to the left. DC motor as a driver (propeller shaft). 2. The testing and data collection process is carried out by testing all components. The red LED light is directed directly at the camera. In 3 conditions the distance varies 10cm, 50cm, 100cm and green light with 3 variations of distance 10cm, 50cm, 100cm.

CONCLUSION

Color detection is successful. The camera is able to recognize the color of the light and take appropriate action to avoid collisions based on the color light signal. When the ESP32CAM detects the color of the light, the ESP32CAM sends a signal to the servo (rudder) and the buzzer will sound. If the ESP32CAM detects green, the servo motor moves to the right. When the ESP32CAM detects red, the servo motor moves to the left. The DC motor acts as a driver (propeller shaft). The result of testing the navigation lamp system with the ESP32CAM camera is that the system can function properly. Based on research that has been done, the ESP32CAM camera can identify the optimum light at 100cm.

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