OBSTACLE DETECTION FOR MARINE AUTONOMOUS VEHICLE (OD-MAV)

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INTRODUCTION

Maritime accidents have been imposing various risks to individuals and societies in terms of human and property loss, and environmental consequences. The most frequent problem which they face is the collision whether it is vessel to vessel or vessel hit any hard substance. Marine radars are the best collision avoidance system ever developed for the recreational boater. Radar is a vital navigation component for safety at sea and near the shore. Captains need to be able to manoeuvre their ships within feet in the worst of conditions and to be able to navigate "blind", when there is no visibility at night or due to bad weather.

In our project we are trying to equip the vessel with an ultrasonic radar system to trace the obstacle (rock or vessels) and there by minimise the possibility of a collision by precisely finding the obstacle position using a Microcontroller integrated with a servo motor. The information from the Microprocessor is then fed to a led display near to the captain or the sailor thereby he/she can make appropriate decisions. Main advantage is that it is of low cost and so even fishermen can afford it.

In section 2, we will be dealing with the background of this project. We will study about the problems that led us to execute this device. We will analyze the statistics of various maritime accidents over the years. We will also look into the pollution caused by these accidents and its effects on the environment.

In section 3, we go into the technical aspect of this project. We will study the various processes required to achieve our goal. We will also study the microprocessors used in this project and the block and circuit diagrams.

In section 4, we will analyze our results from our implemented prototype. We have calculated the distance and angle of an object to pinpoint its location.

ENVIRONMENTAL CAUSES

Maritime accidents have been imposing various risks to individuals and societies in terms of human and property loss, and environmental consequences. For probabilistic risk analysis and management, collision detection is the first step. Therefore, it is of great importance to further improve methods to detect possible collision scenarios. By eliminating human errors this problem can be solved greatly.Fig 1. Shows the factors leading to accidents.

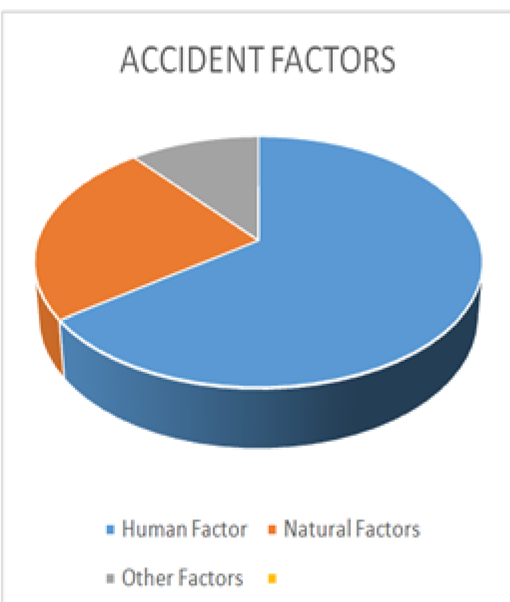

fig 1. Accident factors

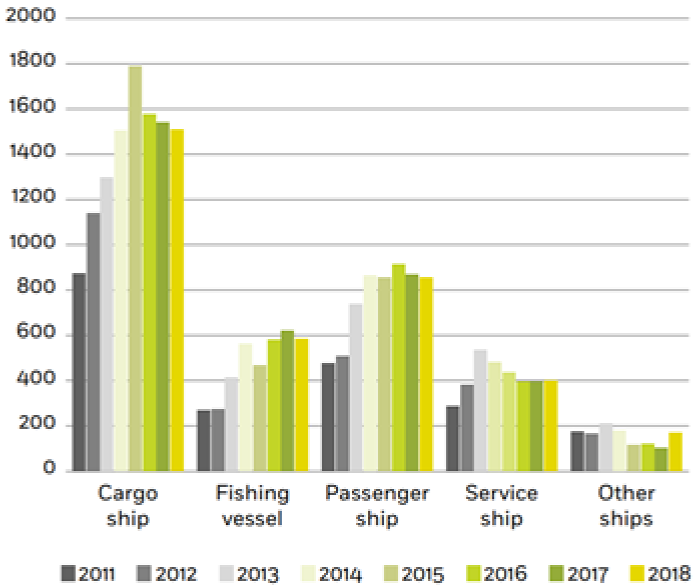

fig 2. Accidents each year

Even with all the advancements of technology in the industry, marine accidents till take place at the sea. Dedicated bodies have been formed to investigate such unfortunate accidents at the sea in order to find the real reasons behind their occurrence. These organizations or units produce reports and case studies based on their investigations and distribute them to the maritime fraternity for education and training purpose, apart from other legal proceedings.

Maritime accident investigation reports and case studies are often used as valuable resources for educating maritime professionals regarding various reasons that lead to fatal accidents at the sea. Fig 2. Explains the reported accidents over the years 2011-2018. Learning from others mistakes to enhance personal and ship safety is extremely essential

Annual Overview of Marine Casualties and Incidents 2020

The Annual Overview of Marine Casualties and Incidents consists of a high-level analysis of marine casualties or incidents accidents reported on 10 July 2020 by the EU Member States in the European electronic database (EMCIP) established by the Directive 2009/18/E

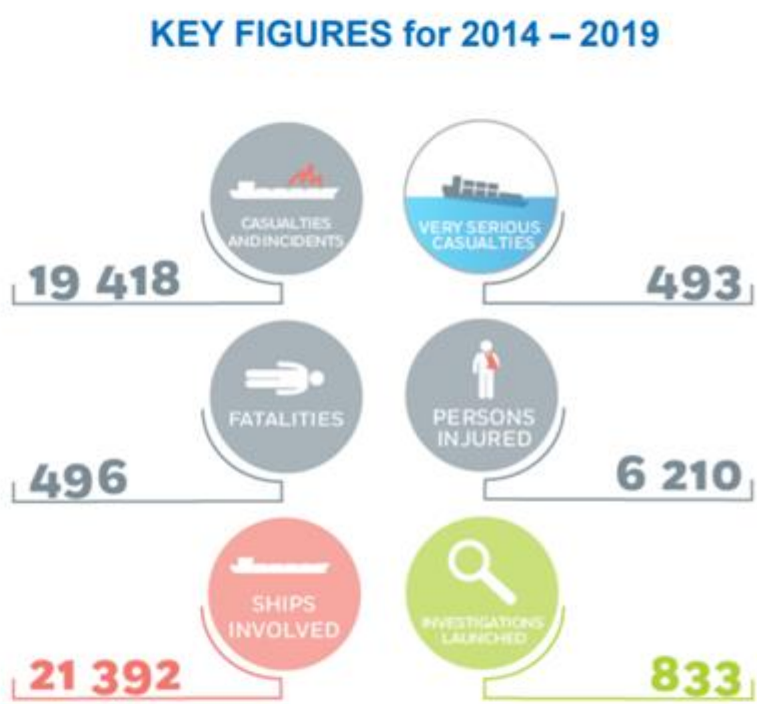

fig 3. Casualities in 2020

ANNUAL OVERVIEW OF MARINE CASUALTIES AND INCIDENTS 2020 EXECUTIVE SUMMARY

The year 2019 appeared to have been a positive year considering the improvement or stabilisation of some indicators, such as the number of ships lost, fatalities and injuries. A number of 3062 occurrences was reported in 2019. A reduction of 200 casualties in comparison with the year 2018 was recorded. The total number of occurrences stored in the EMCIP database has grown to 19500 over 2014-2019. This represents an average of 3236 marine casualties or incidents per year over the period.

A total of 106 very serious casualties reported in 2018, which corresponded to an increase of 68% in comparison with 2017, while the total number decreased back to 63 in 2019. A similar evolution regarding the number of ships lost was noted: after a peak in 2018, a decrease in 2019 was recorded, with 21 ships lost.

During the 2014-2019 period, 320 accidents resulted in a total of 496 lives lost. After a continuous important decrease from 2015 to 2017, a limited increase was recorded for the years 2018 and 2019. 88.3% of the victims were crew members. Fatalities mainly occurred during collisions. When the event is limited to persons, falls were the main cause for losses of life. The main event resulting in fatalities was collisions when it related to a ship and falls when it related to persons.

In 2019, 1382 cargo ships were involved in marine casualties or incidents that resulted in 19 fatalities.

With a total of 91, fishing vessels remain the category of ships with the highest number of ships lost over the 2014-2019 period. In 2019 the number of occurrences involving fishing vessels slightly increased; however, the number of ships lost reduced to 14 (in comparison with 16 in 2018) and the number of injuries stabilised at 220.

Accident Investigation: Pollutions Resulting from Marine Accidents

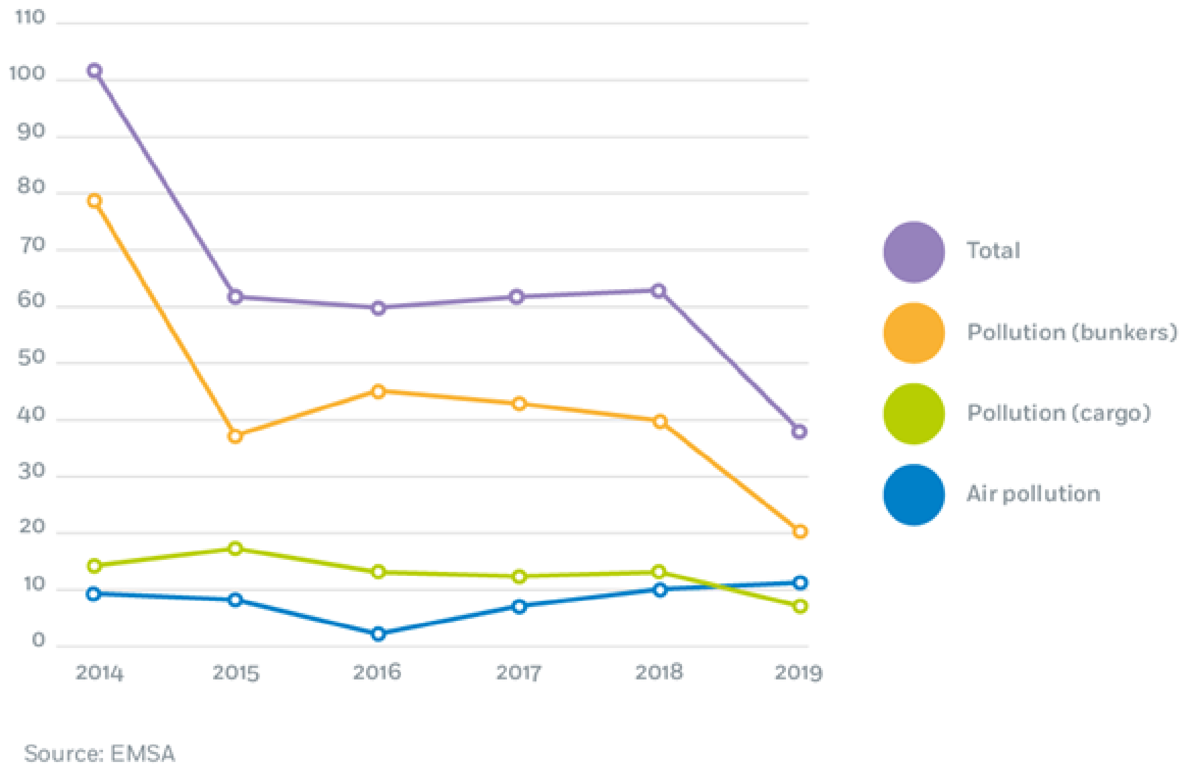

fig 4.pollution due to maritime accidents

From the above report from European Maritime Safety Agency, it is clear that marine accidents is a serious thing and the impact it create is beyond our reach. It is very dangerous for human as well as marine life and the economic loss it cerate is also huge. Fig 4. Shows the graphical data of marine pollution caused due to maritime accidents

There are a number of ways to reduce the risk of collision One such project is the Prepare Ship Project.The focus for the project is on providing better decision support for shipping in order to increase navigation and safety by using technology.

One of the main causes of ship collisions today is lack of awareness of the position of other vessels. By being able to predict future positions for vessels in the vicinity through machine learning and exchange these dynamic predictions with the vessels nearby, smarter decisions can be made.

In addition to reducing the risk of collisions, this project allows for more energy-efficient manoeuvring of the vessels, which contributes to reduced environmental impact.

The project makes use of Galileo and other positioning systems to get accurate positions of how vessels move. It save that data and share that with other sensor signals. So, data concerning issues such as ‘what is the wind currently’ will be collected and will help us learn the hydrodynamic model of the ship.

We then will use machine learning algorithms to assess how the vessel acts in different load conditions. So, once you know how the vessel moves, you're able to make predictions about the vessel’s movements under certain circumstances.

The main challenge was the integration of different technologies together and to devise the overall project objective. When you are dealing with interfaces between different systems, it's a challenge to have a smooth and reliable system. It is mainly software related and the there is no self-correcting mechanism in case of any confusing scenario.

That’s why we come up with our own solution

In our project we use ultrasonic radar technology to provide the user with Real-time data in a much more cheaper way.

Technical

OD-MAV

Obstacle Detection System for Marine Autonomous vehicle (OD-MAV)The system we designed uses an ultrasonic sensor(HC SR04) for obstacle detection and distance calculation. The sensor is mounted on a stepper motor which rotates 360 degree and indicates the obstacle angle. These obtained informations are displayed through a lcd display.

BLOCK DIAGRAM

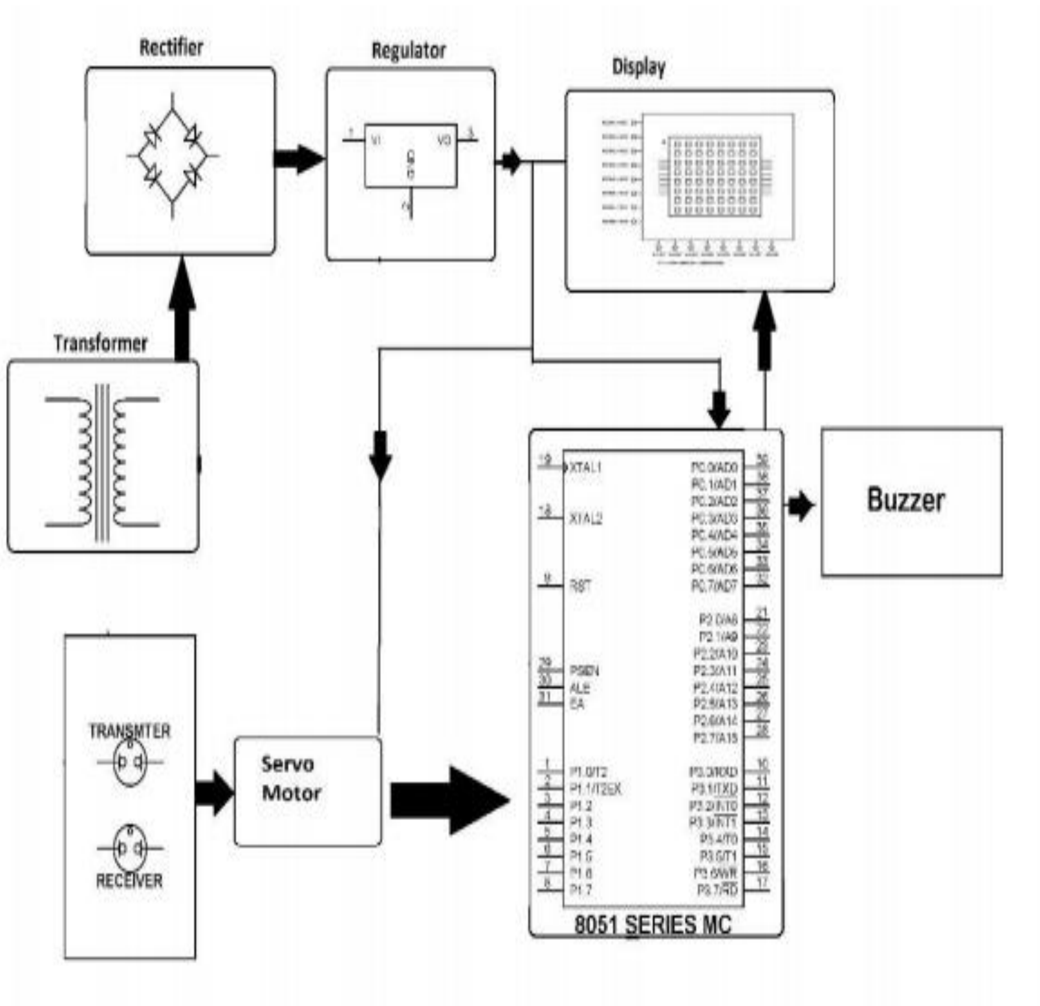

fig 5. Block representation of proposed design

<u>Distance Calculation using ultrasonic sensor</u>

Ultrasonic sensor is used for the diatance measurement purpose and for obstacle detection. The ultrasonic sensor (HC SR04) works on the same principles as a radar system. An ultrasonic sensor can convert electrical energy into acoustic waves and vice versa. The acoustic wave signal is an ultrasonic wave traveling at a frequency above 18kHz. The famous HC SR04 ultrasonic sensor generates ultrasonic waves at 40kHz frequency. 8051 microcontroller is used for communication with an ultrasonic sensor. To begin measuring the distance, the microcontroller sends a trigger signal to the ultrasonic sensor. The duty cycle of this trigger signal is 10µS for the HC-SR04 ultrasonic sensor. When triggered, the ultrasonic sensor generates eight acoustic (ultrasonic) wave bursts and initiates a time counter. As soon as the reflected (echo) signal is received, the timer stops. The output of the ultrasonic sensor is a high pulse with the same duration as the time difference between transmitted ultrasonic bursts and the received echo signal. The microcontroller interprets the time signal into distance using the following functions:

$$Distance\ (cm) = \frac{echo\ pulse\ width\ (uS)}{58}$$

$$Distance\ (inch) = \frac{echo\ pulse\ width\ (uS)}{148}$$

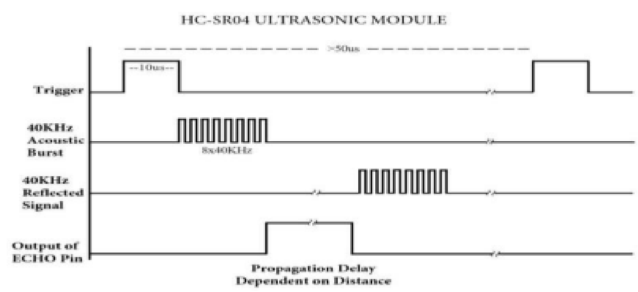

Fig 6. HC SR04 signal propagation

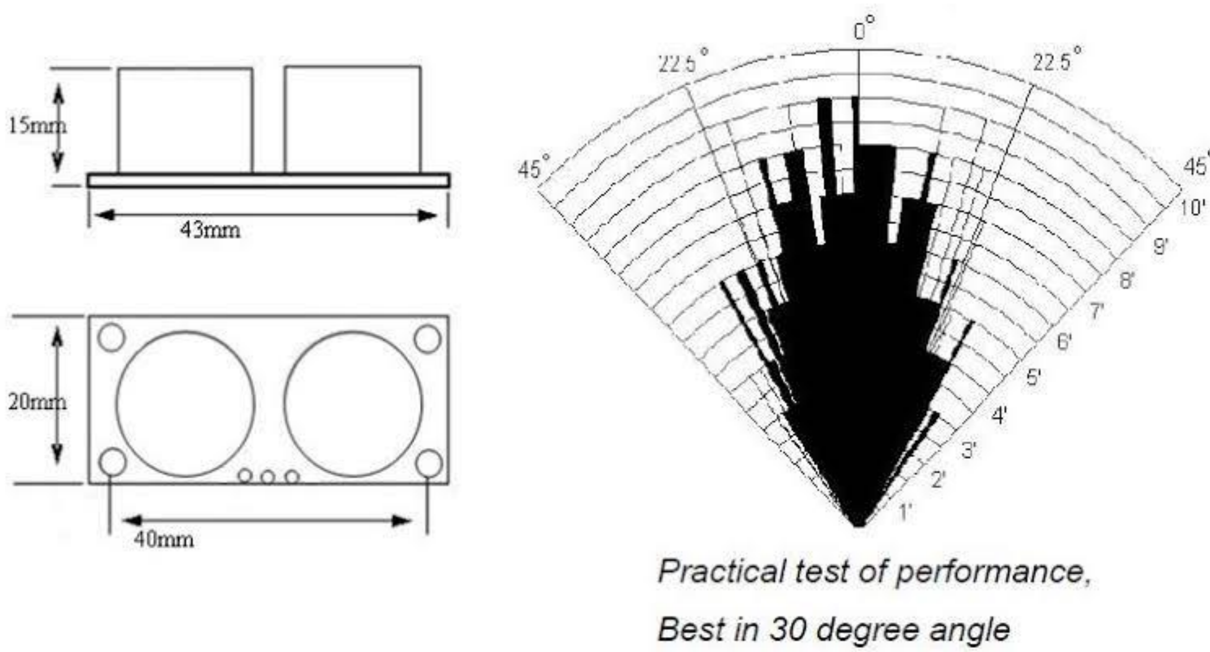

Fig 7.HC SR04 ultrasonic sensor

Theoretically, the distance can be calculated using the TRD (time/rate/distance) measurement formula. Since the calculated distance is the distance travelled from the ultrasonic transducer to the object—and back to the transducer—it is a two-way trip. By dividing this distance by 2, you can determine the actual distance from the transducer to the object. Ultrasonic waves travel at the speed of sound (343 m/s at 20°C). The distance between the object and the sensor is half of the distance travelled by the sound wave.[iv] The following equation calculates the distance to an object placed in front of an ultrasonic sensor:

$$distance = \frac{time\ taken\ x\ speed\ of\ sound}{2}$$

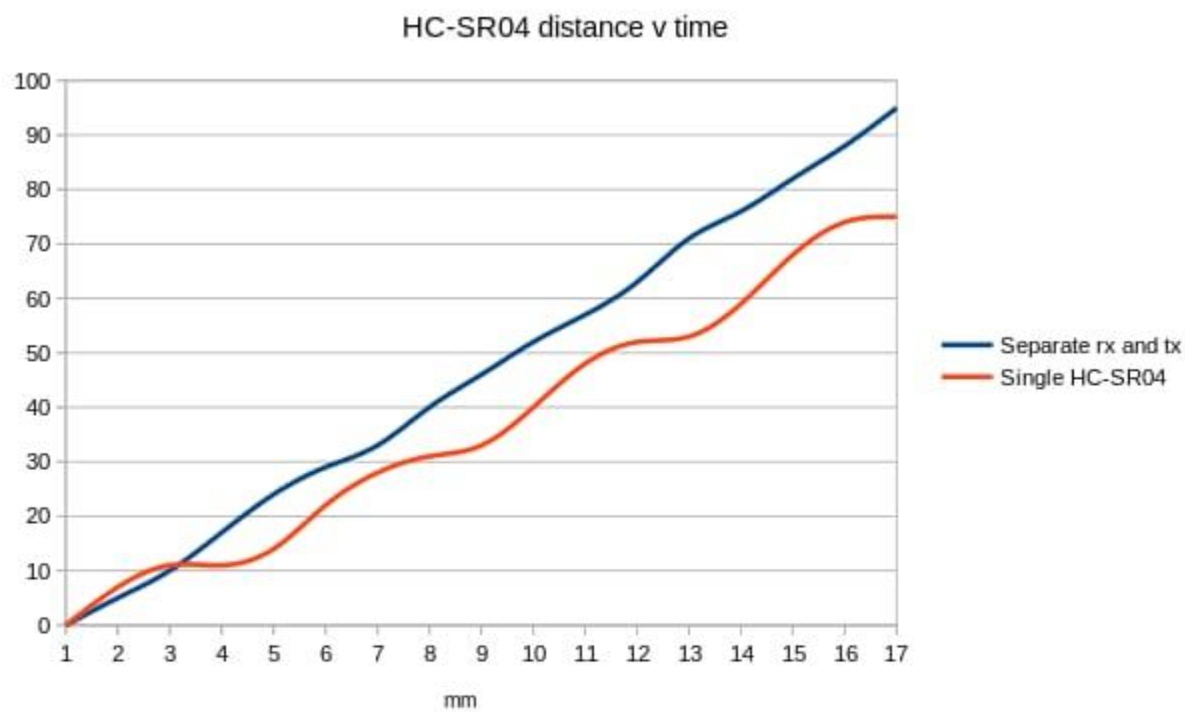

Fig 8. Signal propagation delay with distance

Angle Measurement using stepper motor

In order to measure the angle at which the obstacle is present we use a stepper motor on which the ultrasonic sensor is mounted. The ultrasonic sensor is fixed at origin 0 and is rotated about 360 degree clockwise and anticlockwise simultaneously. In this way a 360 degree angle sweep can be made. When the ultrasonic sensor detects an object a signal is send to microcontroller (for measuring distance) and at the trigger time the microcontroller compute the object angle from the stepper motor pulse width using the formula :

Pulse range = maximum pulse width - minimum pulse width

Pulse width per degree = pulse range / 181

*For a specified angle, the pulse width = minimum pulse width + (angle * pulse width per degree)*

MICROCONTROLLER

With this obtained object distance and angle the microcontroller display the data through a 2D led grid. When an obstacle is detected at any angle between 0 and 360 degree, the corresponding led on the grid glows, indicating an obstacle in the path of ship or boat. The software part is the description of 8051 family microcontroller. The 8051 microcontroller is the CISC based Harvard architecture, and it has peripherals like 32 I/O, timers/counters, serial communication and memories. The microcontroller requires a program to perform the operations that require a memory for saving and to read the functions. The 8051 microcontroller consists of RAM and ROM memories to store instructions. Assembly programming language is developed and the compiler “keilu vison” is used to run and compile our code into 8051.

FURTHUR MODIFICATIONS (challenges)

On the practical system we designed, due to the limited availability of 8051 and the continuous firmware error on the USB ISP Programmer we switched it with Arduino uno. The new system uses the same program as the 8051 but different platform. Fig 9. Shows the error in real time distance vs the measured distance using sensor with Arduino.

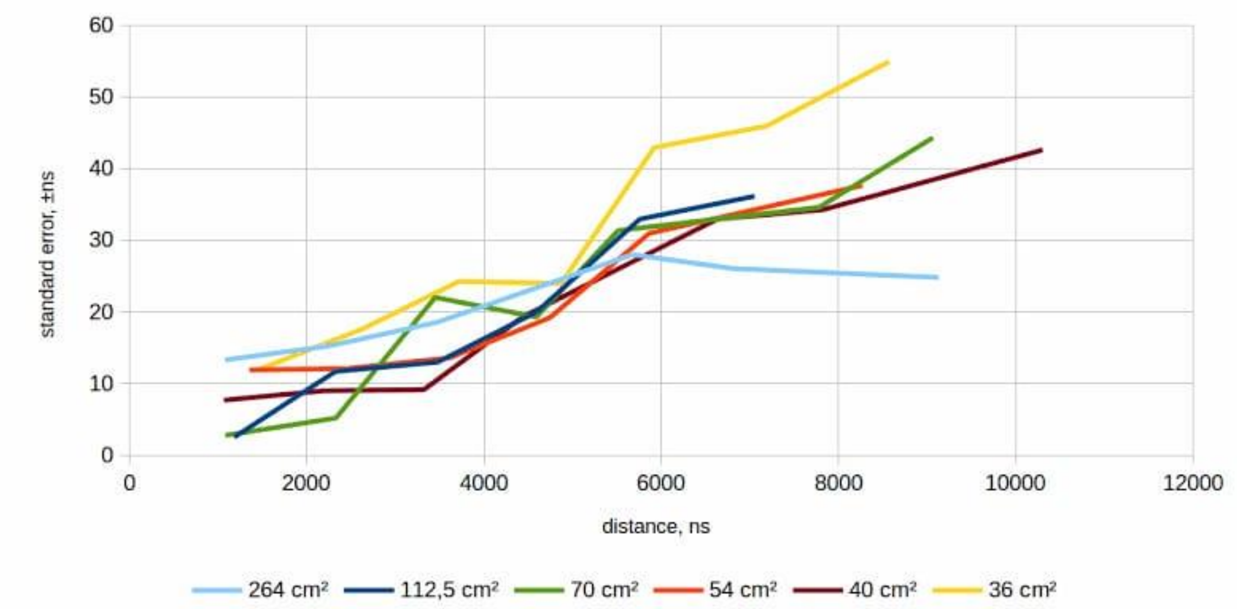

Fig 9. HC SR04 error with Arduino

RESULT

We have tried to physically implement the project(fig 10). Have done some basic distance and angle measurement using an obstacle.

Nb:- In physical model we used arduino uno because of the continues firmware error in programming 8051.

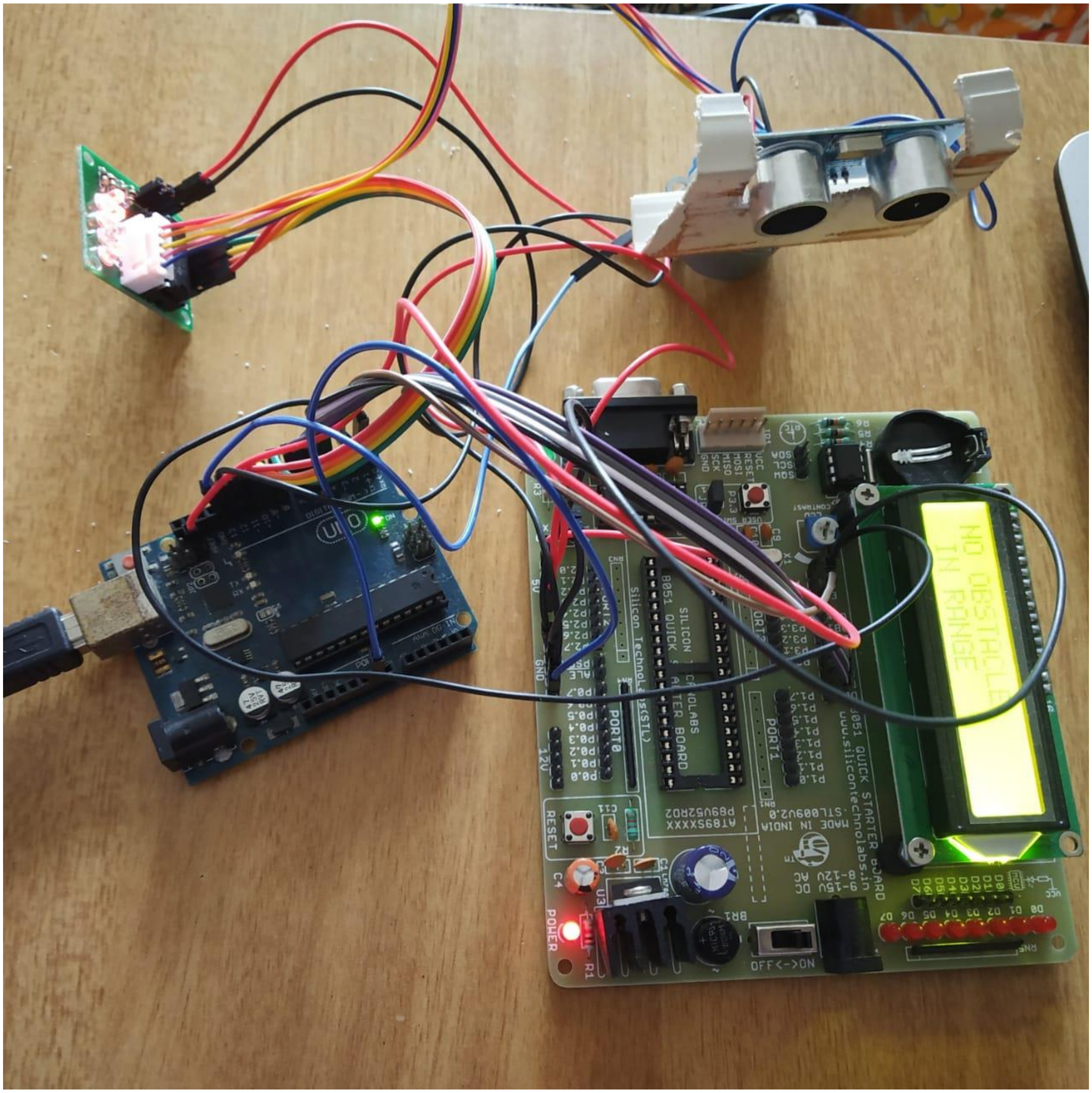

fig 10.Final Project (physical model)

Output

Fig 11. Shows the radar chart with five obstacles placed around the sensor. The chart shows that the five obstacles are correctly identified. The distance calculations were also carried out by our system. The error in distance calculated and real distance is very minute as observed from chart. The testing was done for a range of 20 cm and are carried indoor. The error rate increases by .1 unit as the obstacle distance increases. And as the obstacle distance is very small the error rate is of .01 or less.

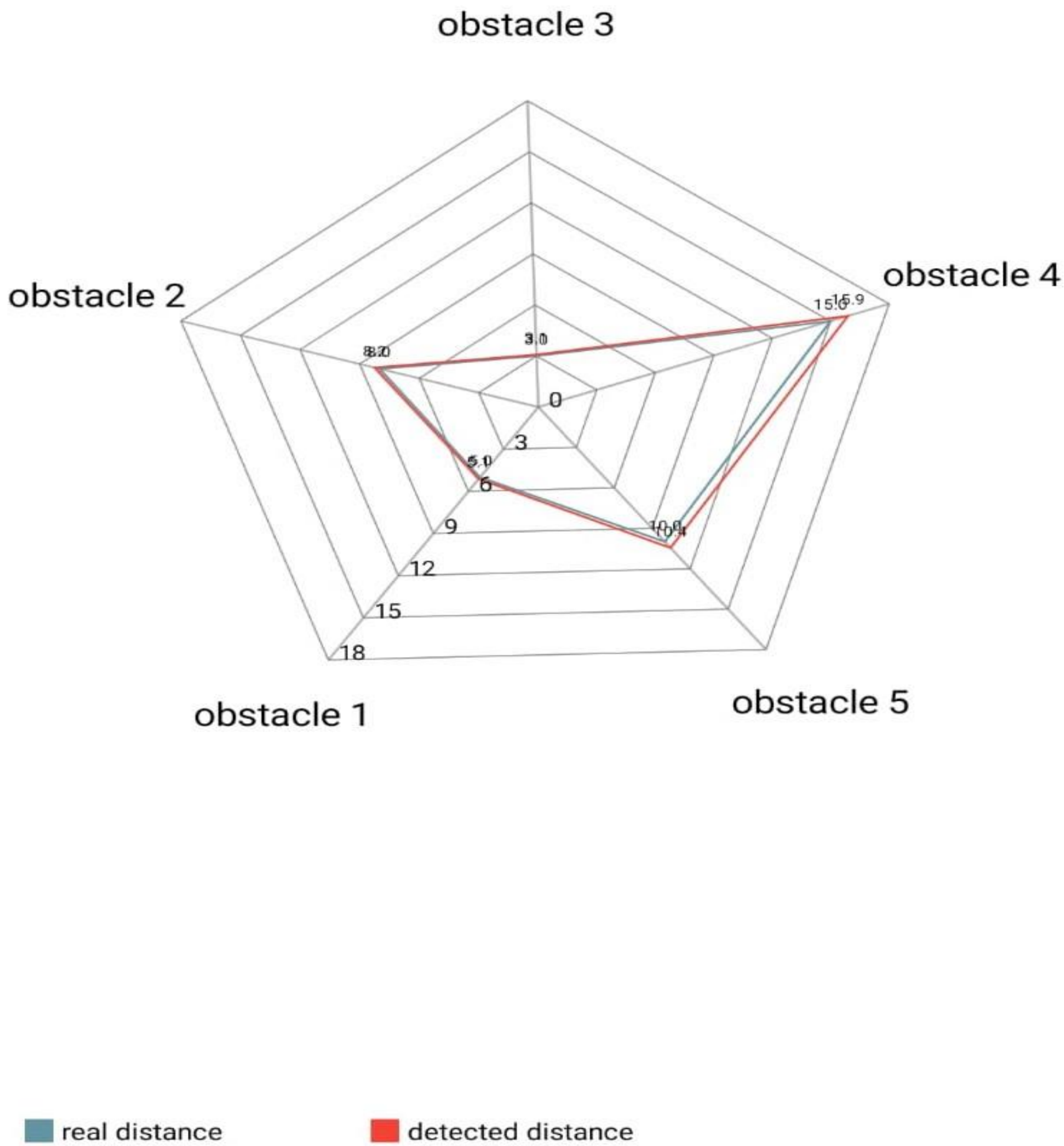

fig 11. Output radar chart

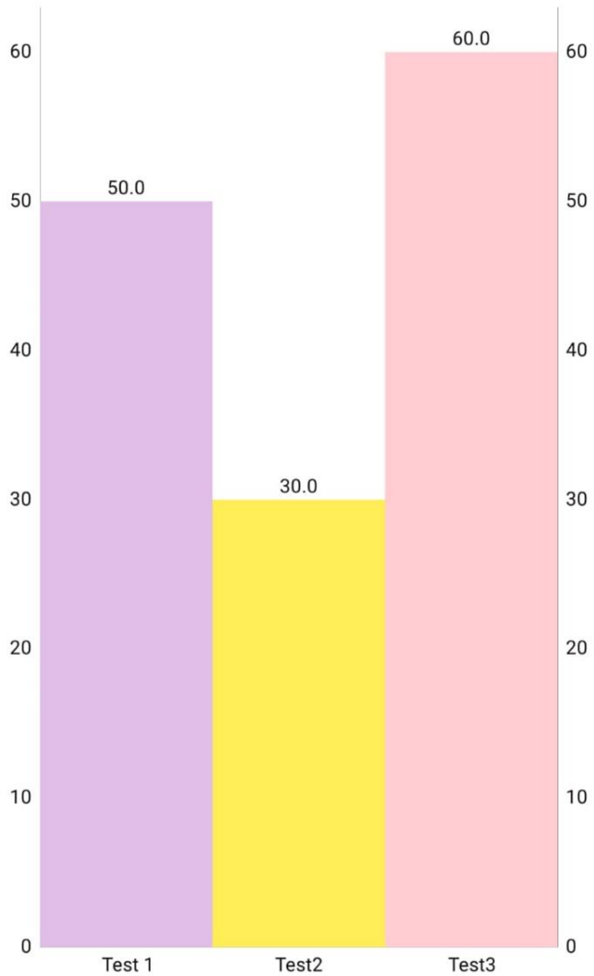

fig 12. Test runs

The test was also carried out a number of times and each time the system was successful in identifying and calculating the distance with less error. Fig 12. Shows the graphical data of the number of tests run on the system.

These graphical data shows that our system is capable of identifying and calculating the obstacle distance with much greater accuracy for the test conducted in this range. The other advantages of ultrasonic sensor along with the method for identifying obstacle lead the system to be used in the future with improved range.

Our future development include the range improvisation, storage facilities, real time data access in coastal and testing in the sea conditions.

CONCLUSION

Once a mariner know what's beyond his sight , he will be confident and be able to make appropriate decisions. This makes the navigation more easy and safe. In our work the mariner or the sailor gets the information about the obstacle on a real time basis with almost accuracy. This will secure his vessel , other vessel in the water and also passengers life. This system can work well in all weather conditions , cost effective and very easy to use and adapt. This system will enhance the sailing experience with safety and makes sailing in tough condition much more easier.