DESIGN AND DEVELOPMENT OF AN AUTONOMOUS WATER SURFACE CLEANER ROBOT

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***Abstract*— This paper describes the design of an autonomous water surface cleaner robot cleaning rubbish floating on the water surface. Water is a vital important source of life. It is a well-known fact that life originated with water, and water cleanliness is a critical part of life on Earth. Because of the nature of the cleaning work, we developed the vehicle structure to provide high stability, good manoeuvrability, and the ability to readily gather all trash flowing in between. In addition, millions of tonnes of plastics and other floating garbage are poured into the water every day as a result of carelessness in the usage and management of water bodies. The majority of the time, water bodies are cleaned manually using human labour, which takes a long time and costs a lot of money. To overcome this, the proposed effort in this article attempts to build and create an Arduino-Mega controlled surface water trash cleanup autonomous boat. The simulation findings demonstrate that the proposed work would be a low-cost and more convenient alternative for surface water rubbish collection and water cleanliness maintenance. The waste collection and removal capabilities of the robot prototype were demonstrated during testing. The robot's maximum trash load is up to 10 kg.**

Keywords*— An Autonomous Water Surface Robot, Cleaning rubbish floating on the water surface and using an Arduino Mega to controlled the robot.

I. INTRODUCTION

In developing countries, the accumulation of floating waste on city canals or ponds, such as plastic scraps, foam scraps, or tree leaves, can clog water drainage and cause pollution. As a result, cleaning the water's surface is an important routine activity.

This research aims to develop robotics technology that can operate in water areas as an alternative solution to the problem of waste in water areas. The proposed applied research is expected to provide an alternative solution for disaster prevention, especially floods. In the form of an eco-robot, robotics technology was created with the primary goal of collecting waste. This approach entails analysing the robotic cleaning system, designing the robot, developing the robot, deploying the robot to clean waste in small water areas, and assessing the robot's effectiveness in cleaning garbage for a larger area. This article focuses on the robot's design and creation.

This work presents a method for identifying and locating waste floating on calm water surface by using a low cost laser system before the cleaning robot starts navigation. An ultrasonic sensor is utilized as a waste detector heading into water surface for floating waste. When the waste detector is mounted on the robot floating on water surface, force causes 360 degree rotations.

II. LITERATURE REVIEW

This Section describes previous works on the water surface cleaner robot based on various technologies developed by other researchers throughout the world.

Vidhya Sagar N explained the model for River Surface Monitoring and Cleaning Robot using sensors, a controller, a Wi-Fi module and a transmission system. Through features such as real-time remoteness surveillance, warning notification, software validation and other quality monitoring measures, the problems and challenges with the existing solution can be addressed. The warning about maintenance or emptying the bin makes maintaining even easier[1] .Bhavna Mahendra Moon designed a Remote Controlled River Cleaning Machine using a black box housing the RF recipient. The project work can be done to integrate the system and the cloud in IoT and Android apps [2]. Soumya has developed a Pond Cleaning Robot using Arduino UNO, L2930 Motor Driver, DC Motor and Bluetooth Module. The robot can be used with the android phone in all four directions. The robot direction is an indicator that uses LED robot system indicators[3]. Zhang Zhi Yuan [4]developed a Floating Garbage Disposal Vessel using battery, solar panel and conveyor belt. This design is primarily the construction of the rescue and transmission unit, mainly for the design of the conveyor belt. Hossen Mobarak[5] developed a Design and Construction of a Radio Controlled Floating Waste Collector Robot using Arduino UNO, motor driver, Li-po, battery, conveyor belt. This system is time-saving, mobile, affordable, power-consuming and easy to use to use anywhere. This system is available.

III. RESEARCH METHODOLOGY

This paper explains the system "An autonomous water surface cleaning robot" in order to explain the concerns raised in the previous section. The suggested system architecture includes sensors to record characteristics such as obstacle detection and distance from the boat, as well as trash detection. The boat is controlled with a wide range of extension arms make it easy to collect floating rubbish in the water based on the sensor detection. Figure 1 demonstrates a block diagram of the proposed system. The system design concept is discussed, which comprises the integration of sensors on a water boat.

A. Hardware requirements

The hardware of the system is based on the Arduino Mega 2560 platform. One Arduino Mega 2560 board is used for operating the boat's wheels and receiving sensor information, while the other is utilised to control the robot. The following section goes through the hardware requirements.

i. MICROCONTROLLER (Arduino MEGA 2560):

The Atmega2560-based Arduino Mega 2560[6] is a microcontroller board. When compared to comparable boards on the market, it has more memory space and I/O pins. The inclusion of 54 digital I/O pins and 16 analogue pins on the PCB distinguishes this device from others. PWM is utilised on 15 of the 54 digital I/O. (pulse width modulation). On the board, a crystal oscillator with a frequency of 16MHz is installed.

This board includes a USB cable connection for connecting to and transferring code from a computer to the board. A DC power jack is connected to the board and is used to power it. Some Arduino boards lack this feature, such as the Arduino Pro Mini, which lacks a DC power connection. The ICSP header is a fantastic addition to the Arduino Mega, which is used for programming the Arduino and uploading code from a computer.

The controller utilised on the Arduino Mega 2560 platform is an ATmega328. The controller receives input from the sensors and operates the robot as needed.

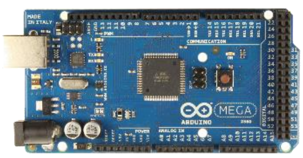

Figure 1: Arduino Mega 2560

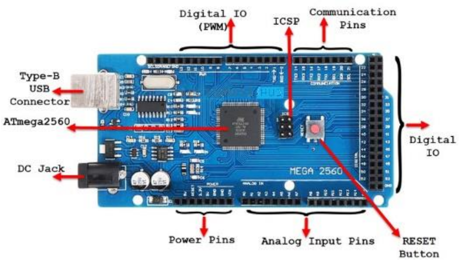

Figure 2: Arduino Mega Pinout

ii. ULTRASONIC SENSOR:

An ultrasonic sensor[7] is a gadget that uses sound waves to determine the distance to an item. It estimates distance by emitting a sound wave at a certain frequency and then listening for the sound wave to return. The distance between the sonar sensor and the item can be calculated by recording the duration between the sound wave being generated and the sound wave reflecting back.

Thus in our project, the distance measuring sensor is used to detect the obstacle and its distance from the water boat.

Figure 3: Ultrasonic sensor

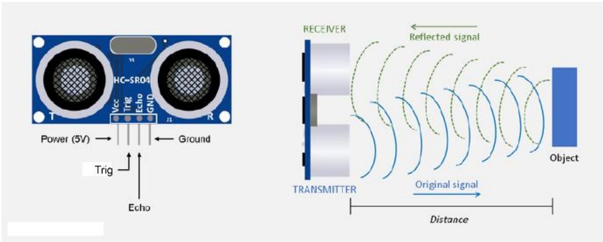

Figure 4: Ultrasonic sensor module function

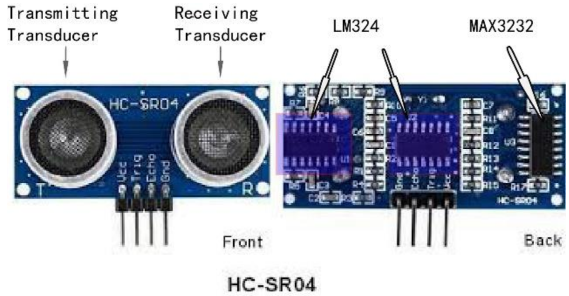

Figure 5: Ultrasonic sensor specifications

iii. SERVO MOTOR:

The SG90 is a 9 gramme servo motor that can rotate from 0 to 180 degrees (approximately) in 0.3 seconds (0.1s/60 degrees) [8]. The SG90 is frequently employed in low-cost applications involving motorised vehicles and robotic arms. Because it is affordable and simple to use, the SG90 is an excellent tool for education and prototyping. The SG90 is also compatible with Arduino software, which will be used in this lesson to rotate the servo to see how the gear reduction from the small DC motor gear to the bigger and slower gear utilised in motor applications works.

For our project accordingly, to receive a control signal indicating a desired output position of the servo shaft and operate its DC motor until the shaft turns to that position.

Figure 6: Servo motor SG90

iv. BRUSHLESS DC MOTOR:

The brushless DC motor's permanent magnet rotor is powered by the magnetic force of the stator's winding circuit. While a brush and commutator are used for current switching in a brush DC motor, a sensor and an electronic circuit are used in a brushless DC motor [9]. The advancement of semiconductor and peripheral device technology has enabled the development of this motor. This motor combines the advantages of DC motors (current and voltage are proportional to torque and rotating speed, respectively).

We used DC motors with wheels are used to propel the water boat as per the commands given.

Figure 7: Brushless DC motor

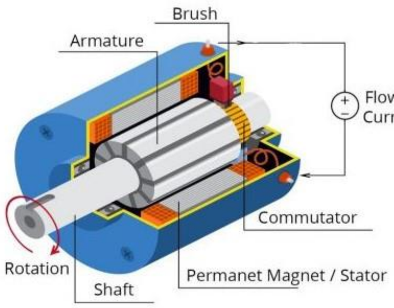

Figure 8:Brushed DC motor internal construction

v. MOTOR DRIVER L298N MODULE:

The L298N is a 15-lead Multiwatt and PowerSO20 integrated monolithic circuit. It is a high voltage, high current dual full-bridge driver that accepts conventional TTL logic levels and drives inductive loads like as relays, solenoids, DC and stepping motors [10].

The module can power DC motors with voltages ranging from 5 to 35V and peak currents of up to 2A. To control both speed and spinning direction of one DC motor with Arduino Mega 2560.

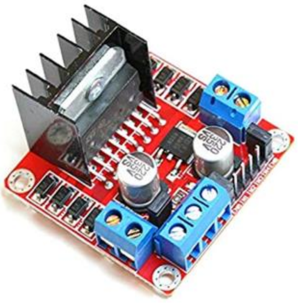

Figure 9: MOTOR DRIVER L298N MODULE

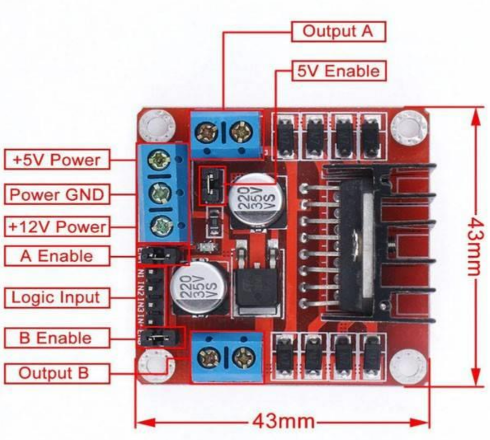

Figure 10: Motor Driver L298N Pinout Configuration

vi. NEO-6M GPS MODULE:

The NEO-6M GPS chip's data pins are separated into "0.1" pitch headers. This includes the pins required for UART communication with a microcontroller. The module can operate at baud rates ranging from 4800bps to 230400bps, with a default baud rate of 9600 [11]. The NEO-6M chip's operational voltage ranges from 2.7 to 3.6V.

To provides a strong satellite search capability. With the power and signal indicators, we can monitor the status of the module.

Figure 11: NEO-6M GPS MODULE

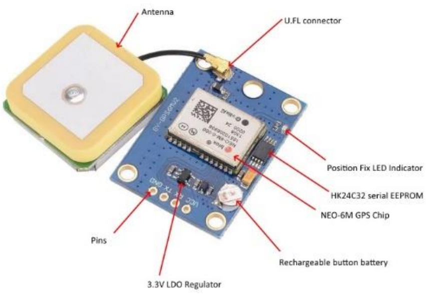

Figure 12:Neo-6M GPS Pinout

vii. LITHIUM POLYMER BATTERY (LIPO):

A lithium-polymer (LiPo, LIP, or Li-Poly) battery is a form of rechargeable battery with a soft polymer case that holds the lithium-ion battery inside a soft exterior "pouch." It could also refer to a lithium-ion battery with a gelled polymer as the electrolyte. However, the phrase is most usually used to describe a sort of lithium-ion battery in a pouch style [12].

This sort of battery is more accurately known as a lithium-ion polymer battery. In portable applications, Li-poly has various advantages over Li-ion: Excellent thermal stability, very safe and benign system during charge and discharge. Lightweight with a high power density. Improved low-temperature performance, reduced voltage depression, and increased capacity delivery. The DC motor will then convert it into electrical force and then deliver it to battery.

Figure 13:Lithium polymer battery (lipo)

B. *Software requirements*

The system is designed around the Arduino IDE. These tools are detailed in the following sections.

i. ARDUINO IDE SOFTWARE:

The Arduino Integrated Development Environment (IDE) is a cross-platform application (for Windows, macOS, and Linux) developed in C and C++ functions. It is used to build and upload programmes to Arduino compatible boards, as well as other vendor development boards with the support of third-party cores.

An open-source integrated development environment (IDE) that enables users to programme compatible boards. The Arduino boards in the proposed work are programmed using the Arduino IDE to read sensor inputs and control the movement of the robot.

Figure 14:Arduino IDE Software

ii. FRITZING SOFTWARE

Fritzing is an open-source initiative that aims to create amateur or hobby CAD software for the design of electronics hardware in order to assist designers and artists who are ready to progress from experimenting with a prototype to developing a more permanent circuit.

Fritzing was distributed under the GPL a long time ago. If necessary, this (the licence being utilised) can be modified. However, it appears to be GPL at the moment. Many people have contributed to the project in the past, and they did so on a GPL software project, i.e. a free software project.

So, we used this software to design our project circuit diangram.

Figure 15:Fritzing Software

C. *Process flow*

This section describes the operation of the proposed water boat with wide range of extension arms. An algorithm has been developed to task the microcontroller to read the inputs from the Arduino Mega 2560 and ultrasonic sensors and based on the sensed information take appropriate action. Once an object is detected by the ultrasonic sensors, the servo motor will move to the object for collect the trash. The Process Flow is given in the Figure 12 depicts the flowchart of water surface cleaner robot assembly operation.

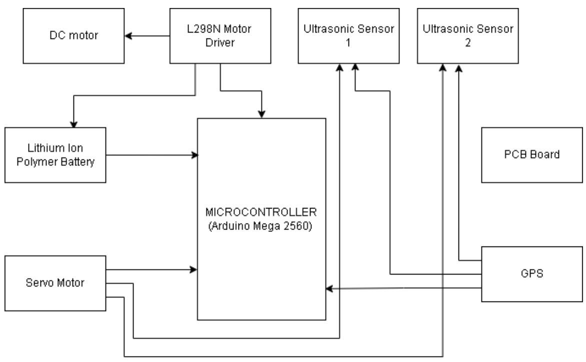

Figure 16:Block Diagram

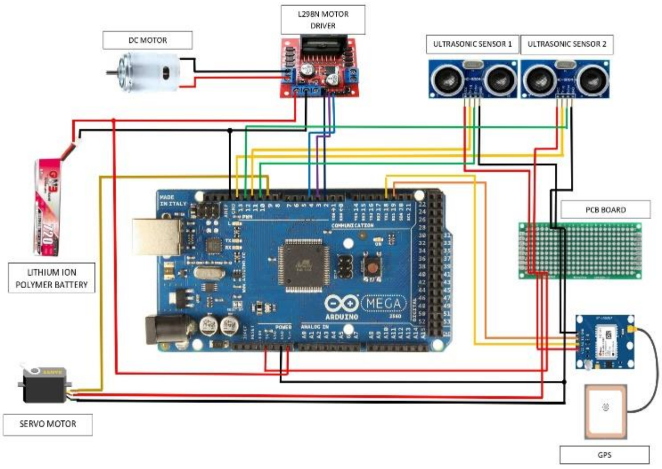

Figure 17:Circuit diagram of Autonomous Water Surface Cleaner Robot

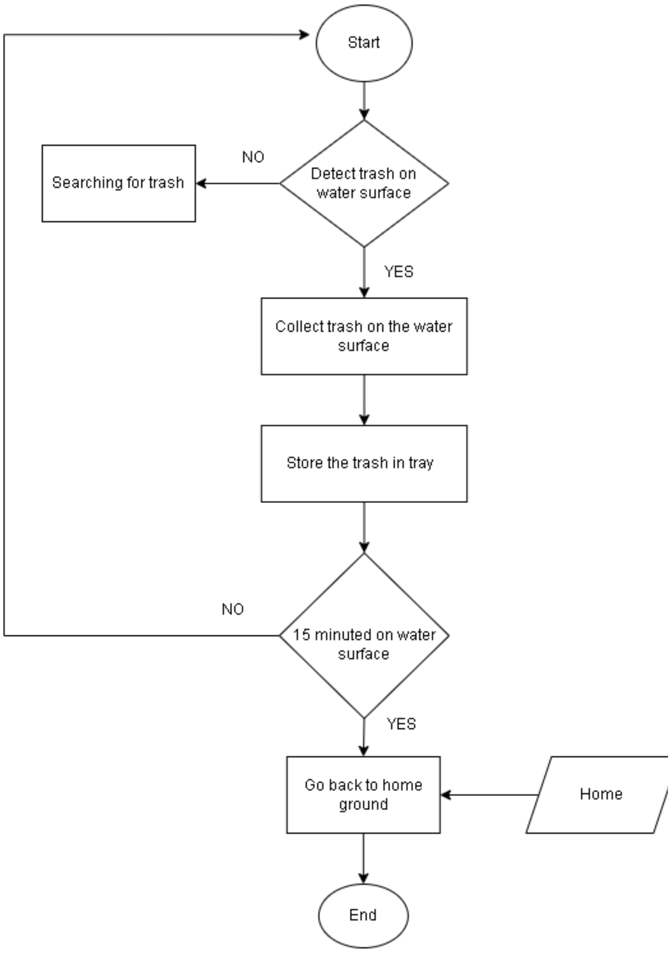

Figure 18:Flow Chart

D. System design

A cost-effective solution, robustness, and durability are the three most important factors to consider while developing a robot. Consider the cleaning function; the robot construction is built to provide great stability, outstanding manoeuvrability, and the ability to effortlessly gather all trash flowing around. A motor with a large range on water has been built for collecting wastes in a section covered with a wide range of extension arms for removal and collection of surface waste. This design allows for simple and effective waste removal while still accommodating enormous amounts of rubbish in a short space.

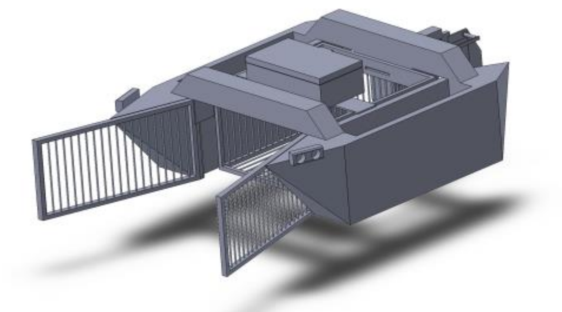

Figure 19:Robot prototype

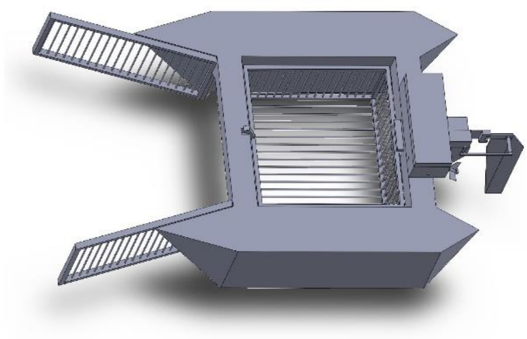

Figure 20:Top view of model

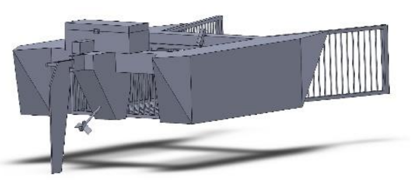

Figure 21:Back view of model

E. Fabrication process

Using the compressed board, we constructed a robot model. Then, using plastic tape, wrap the entire model. First, apply the first layer of fibreglass and wait for it to dry. Continue with the second layer and wait for it to dry. To finish, smooth the fibreglass surface with sand paper. We use waterproof spray to ensure that there are no holes in the model. to make a basket out of an iron net and a metal straw For the final polish, we spray the surface. Then we test the boat's stability in the lake and improve the model.

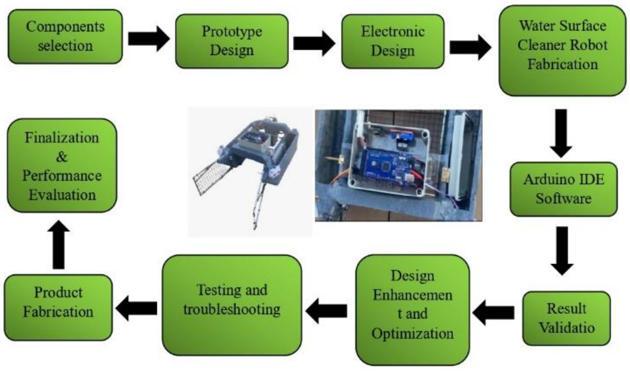

Figure 22: Design and Fabrication of the Boat

Figure 23: Before the boat design

Figure 24: Side view of boat

Figure 25: Top view of boat

Figure 26: Fully design of boat

Figure 27: Electronic components placed on the boat

Figure 28:Robot structure

F. Testing and troubleshooting

The proposed concept is still in the development stage and will incorporate advanced features, the work has been implemented virtually. We determine the point in the process at which the problem first becomes apparent. Examine that step carefully to determine what causes the problem to become apparent. Working backwards through the process and closely observing each stage to determine the root of the problem, begin with the identified stage where the problem becomes obvious.

When the servo does not detect, we make sure to clean or remove any dust, dry out any connectors, and check all cables. We look for a bind in the axis or if the brushes in the DC motor are worn out. Then we check for an incoming power supply using a volt ohm metre. We want to test the servo drive primarily to confirm that the voltage is correct.

When we test the boat on water surface the boat once detect a trash,it will go through the trash and will go straight all the way.unless the sensor sense something like rubbish. The boat will stop moving untill it loss the battery power.
During the coding troubleshooting the boat cannot return back.

Figure 29: Checking the connection of electronic components

Figure 30: Check the boat before placed on water surface

Figure 31: Robot testing on water surface

IV. RESULTS AND DISCUSSION

This project aims to collect surface-level trash in order to create a cleaner water body. Presently, there is a technology known as SEABIN, which was developed in Spain. The SEABIN fulfils the similar function. However, the SEABIN has a few limitations.

i. It stays in one place and does not move.
ii. Working need a power supply.

So, the main objective of this project is to overcome the limitations by applying two ultrasonic sensor mechanisms to detect and collect trash, as well as a servo motor for movement with a wider range of connectivity, thereby reducing human intervention in order to achieve cleaner water bodies. At the moment, the robot is powered by batteries, but the project can be improved by obtaining the necessary electricity from sustainable sources such as solar energy.

Figure 32: Robot detect trash

Figure 33:Robot Collecting Trash

Figure 34: Robot continue moving on water surface

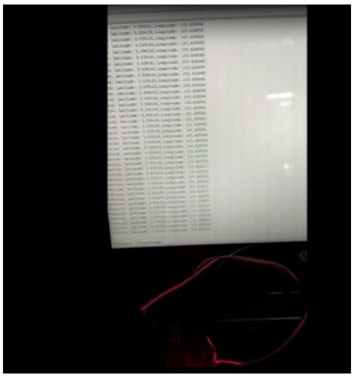

Figure 35: Reading of GPS

V. CONCLUSION

The design and development of an autonomous robot based on Arduino Mega 2560 for surface trash collection in the waterbodies is presented in this paper. To detect and collect rubbish, the suggested work employs two ultrasonic sensor mechanisms. The simulation findings show that the suggested low-cost autonomus water surface cleaner robot will be a reasonable solution for surface water rubbish collection, preserving aquatic life while requiring minimal human effort. The authors' future work will focus on using machine learning and the internet of things (IOT) to make the system totally autonomous.

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