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# Design and Development of Internet of Things Based Autonomous Boat for Aquatic Weed Inhibition and Water Quality Assessment

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**Abstract:** Lakes and ponds are the major sources of water that are commonly found in every village and religious place in many countries. Lakes account for about 0.3 % of the 2.5 % of surface water. In recent years, lakes are slowly vanishing due to weed growth and lake sediments. Clearing the sediments and muddy lakes costs a heavy price and this is recurrent that needs regular maintenance. Also, garbage deposition on lake water is a major concern which results in water contamination. Many lakes and ponds have become non-usable water sources due to weed growth and pollution. Causes of pollution depend on various factors such as garbage deposition, unnoticed animal and/or human bodies, hazardous chemicals, etc. Mud deposits may be recurrent if not maintained regularly. Various methods are employed so far to solve these issues. However, the traditional manual approach is inefficient and labor-intensive. In the proposed work, an automated system is designed to maintain the cleanliness of the water. This is an initiative wherein the boat can make its own decision while maneuvering and even when it encounters an obstacle and can return to the charging point to recharge by itself when its battery is low while making sure of very low or minimal weed growth. This is designed to inhibit the growth of weeds on surface water and to assess the quality of water by measuring pH and turbidity levels regularly. Hence, such a system will definitely help mankind and animals.

**Keywords:** Unmanned water vehicle, Surface water, aquatic plant, growth prohibition, quality inspection.

## 1. INTRODUCTION

Surface water bodies such as lakes, ponds and rivers are major sources of water for the survival of living beings [1]. Over the centuries, lakes and ponds have been treated as sources of drinking water and also, contribute to preserving groundwater. Knowing the importance of surface water bodies, they were preserved and managed by our older generation. However, the increase in population and urbanization has witnessed the extinction and pollution of surface water bodies. India had abundant water sources but we are gradually moving towards water scarcity. Hence, preserving and maintaining surface water bodies is a major challenge faced by the country. Lakes account for about 0.3% of the 2.5% of surface water. In India lakes and ponds are commonly found in every village and religious place. In recent years, lakes and ponds are vanishing due to the growth of weeds and sediments. Clearing the sediments and muddy lakes costs a heavy price and this is recurrent that needs regular maintenance. Also, nowadays garbage deposition that contaminates water is a major concern. Many lakes and ponds have become non-usable water sources due to weed growth and pollution. Causes of pollution depend on various factors such as garbage deposition, unnoticed animal and/or human bodies, hazardous chemicals, etc. Extreme climate changes, floods and drought may also greatly affect the quality of water [2].

### A. Related Work

The government has initiated various methods to solve these issues by investing huge capital in several projects. However, the traditional manual approach is inefficient and labour-intensive. In addition to this, several researchers proposed their idea for maintaining the cleanliness of the water. Remote-controlled water surface cleaning boat that focuses on deploying a solution to remove settled floating waste on the water's surface by collecting the trash with the help of a conveyer belt [3]. An RF module controls the boat's movement by employing less workforce. The major issues highlighted by the team are Compact design and reliable power supply. Also, the ship is entirely manually controlled with the help of a remote for future work; the authors suggested using solar energy to address power-related issues. [4] developed a manually controlled RF robot to collect waste that floats on water bodies. The authors also incorporated a pH sensor that automatically determines the quality of water. The main issue highlighted is that the designed system is complex and not cost-effective. Saran [5] came up with an IoT-based prototype for monitoring water health using a combination of different sensors and also a system for cleaning the

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surface of the water. But the main disadvantage of the system is it is Bluetooth controlled, which makes the system unusable in the case of large lakes or ponds. Also, the whole system relies on batteries.

[6] came up with the concept of a river-cleaning machine that can be used to collect garbage from the river. The main idea behind the system is to overcome the non-availability of a skilled workforce. Also, the drawback of the system is a requirement of a manual workforce, where a worker needs to continuously pedal the boat. [7] developed the idea of a mechanical river harvesting and trash cleaning machine which can be used to collect the trash and cut the weed inside the water up to 6 feet underwater. The disadvantage of the system is the requirement of a diesel engine, the requirement of a manual workforce and also the overall cost of the system is on the higher side. [8] designed a prototype concept of an underwater cleaning robot that uses a new concept of a flexible crawling mechanism. The design is based on a minimalistic approach to achieve a compromise between maximum performance and reasonable complexity and cost of the system. [9] designed a robot that replaces human force for floating waste scooping and investigated the performance by installing a floating waste scooper robot. The robot design, mechanism, waste scoopers, and control are presented. Further, the robot has been tested on a calm water surface such as a pond. The inland lake monitoring system developed in 2015 [10] is capable of assessing water quality. This system can be fixed to a boat or can be placed on the surface of the water. However, placing the system in the required region is manual. This system assesses the water quality but lacks garbage collection and weed control. Several aquatic weed control products are available in the global market such as Rakezilla, Aqua Thruster, WeedShear, Lake Groomer, etc.[11]. However, these products need manual operation, many are bulky and most important is that the products are not of Indian origin. A few works proposed earlier are available in the open literature, which has discussed the development of special-purpose robots [12][13][14][15][16]. However, are limited to one function only. Maintenance of surface water is a tedious task because weed growth is a recurrent process and removal of weeds every year is a tedious task. The growth of weeds and algae may contaminate water bodies [17]. Hence there is a need for a feasible solution to maintain water bodies.

The Internet of Things (IoT) sphere integrated with autonomous aquatic vehicles has garnered interest in water quality assessment and aquatic weed inhibition. Notable in this realm is the development of a real-time water quality monitoring system employing a remotely controlled boat alongside an initiative utilizing a fleet of autonomous boats for aquatic weed management. Both ventures, underpinned by an Arduino-Uno setup, leverage IoT technology for continuous water monitoring based on parameters like pH, electric conductivity, temperature, and turbidity. Additionally, the autonomous boats excel in subsurface hydro acoustic imaging, machine learning for automated weed identification, and herbicide deployment for targeted vegetation control, showcasing the potential of autonomous robotics in environmental remediation tasks[18].

Broadening the scope of autonomous monitoring, a venture into developing an Autonomous Underwater Vehicle (AUV) based system for water quality monitoring has been delineated. This invention underscores the essence of advancing autonomous vehicles to ensure the advantageous utilization of water resources, thus paving the way for innovative solutions in monitoring water quality autonomously[19].Furthermore, an exhaustive review encompassing IoT-based aquaculture has been articulated, providing insights into recent research trajectories, environment settings, research methodologies, and common water quality parameters. This review underscores the breadth of solutions IoT applications offer in monitoring water quality in aquaculture environments, thus extending the narrative of IoT applications beyond surface water monitoring[20]. Additionally, the narrative of autonomous aquatic vehicles is further enriched by the advent of Opa, an open-source autonomous 3D-printed boat capable of navigating open waters while transmitting real-time telemetry over WiFi. Though in its nascent stage, this project lays down a promising blueprint for future endeavours in autonomous water navigation and monitoring technologies[21]. The continuum of innovations elucidated above underscores a compelling narrative of the technological evolution in IoT-based autonomous aquatic vehicles for water quality assessment and aquatic weed inhibition. This trajectory of advancements resonates well with the thematic core of the present work, thereby highlighting the symbiotic relationship between IoT technology and autonomous vehicles in addressing aquatic environmental challenges.

In the proposed work, an automated system is designed to inhibit the growth of weeds and to assess the quality of water by measuring pH and turbidity levels. The proposed system aims at developing an autonomous boat which can take care of multiple functions such as inhibition of weed growth and assessment of the quality of water. This provides a sustainable solution to the existing issues that can save human efforts. Contributions of the proposed work are as follows:

- Design and development of autonomous boat to maintain surface water.
- Present a mathematical model for the direction of an autonomous boat.
- Present an algorithm for controlling boat movement.
- Present algorithms for obstacle detection and battery

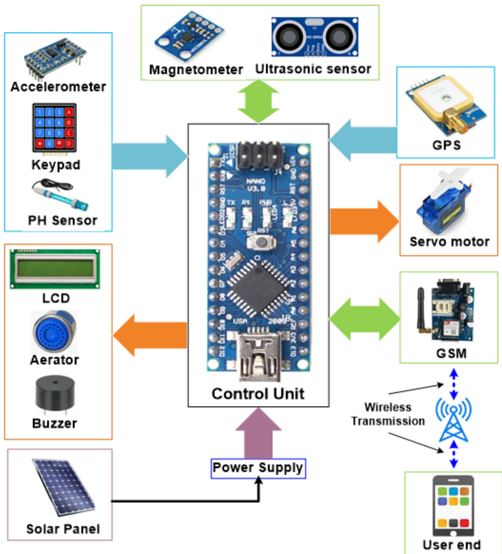


Figure 1. Functional diagram

level indication.

- Design of secure casing of controlling circuitry in the boat.
- Develop an automated water quality assessment system.
- Propose a remote assessment mechanism for the proper functioning of the boat.

## 2. Methodology

The present work aims to design and develop an autonomous boat for controlling weed growth and monitoring the quality of water. This includes building an autonomous boat that can perform the aforementioned functions. Several components and tools are used to incorporate these functions. Specifications of the components used are listed in Table I. Also, suitable algorithms are developed to drive the boat automatically and perform the necessary functions.

The functional diagram of the proposed system is shown in Fig. 1. It is a well-known fact that a continuous movement of water can control aquatic weed growth. Hence, we propose an autonomous boat that moves regularly on the water's surface. This requires a smooth operation of the boat. Hence, a controller takes care of all the necessary functions. To perform multiple operations, the boat requires a continuous power supply. Hence, the battery levels of rechargeable batteries are monitored continuously using battery level indicators. Also, it is required to monitor the location of the boat on the water surface for smooth operation. This is achieved by Global Positioning System (GPS).

The autonomous boat construction measuring 60cmx50cm in dimension, focuses on providing buoyancy and protection against water damage through floating and waterproof plywood materials. The boat is equipped with four motors and specialized wheels, ensuring efficient propulsion and controlled navigation in various water bodies. Ultrasonic sensors add an extra layer of safety by detecting obstacles and allowing the boat to maneuver accordingly. A solar panel harnesses renewable energy to power the boat, supplemented by a battery backup system for continuous operation even in unfavorable conditions. However, the distinguishing feature of this design is the incorporation of an aerator module, which significantly contributes to maintaining water cleanliness. By promoting air circulation within the boat, the module prevents stagnation and maintains optimal oxygen levels for the aquatic ecosystem. This mitigates the growth of harmful bacteria or algae, creating a healthier environment for aquatic life. The boat's autonomous operation relies on a random path algorithm for independent navigation and a GPS for accurate positioning and efficient data collection. Moreover, the boat is equipped with specialized sensors to measure water quality parameters such as temperature, pH levels, dissolved oxygen, and turbidity. The collected data undergoes analysis to assess overall water quality and identify potential issues or contamination. The buzzer, Global System for Mobile communication (GSM) and mobile phone are used for alerting and remote monitoring purposes. In the proposed system, a secure box module is provided to protect the components placed inside the boat that can be opened using the passcode. The keypad is used for entering the passcode. This comprehensive water quality monitoring and maintenance approach demonstrates the boat's effectiveness in contributing to environmental preservation and conservation efforts.

### A. Boat Movement Control

The boat moves regularly on the water's surface and hence it requires a continuous power supply. It is not practical to monitor the battery level manually. In the proposed work, the boat heads to the charging station whenever the battery level is low. This is achieved by updating the location of the boat. The current GPS location is saved if the battery level goes below the set value (if the battery goes below 20 %). The boat is rotated such that it faces north using a magnetometer. Further, the boat is rotated towards the charging point or starting point using trigonometric formulae. The nearest distance between the boat and the charging point is calculated using the distance formula and the boat is directed towards the charging point as shown in Fig.2.

Once the boat is made to face the geographical north, the current location (B) and the starting point(A) location are noted using the latitude and longitude from GPS which are considered as coordinates (m2; n2) and (m1; n1).

TABLE I. Components and their Specifications

| Name of the Component | Specifications |
|---|---|
| Controller | Arduino ™ Mega 2560R3, Digital I/O Pins: 54; PWMoutputs:15 |
| Solar Panel | 12 V, 40 Watt |
| Accelerometer | 3-axis analog accelerometer IC ADXL335 |
| Aerator | Operating voltage: 12 V, RPM: 106 |
| Servo motor | SG90, Operating voltage: 4.8V, Operating speed: 0.1 s/60° |
| Magnetometer | 3-Axis Digital Compass IC HMC5883L |
| Ultrasonic sensor | HC SR04 |
| GPS Module | NEO-6M, Operating voltage: 2.2 to 6 V |
| GSM Module | GSM Sim900A Module |
| PH Sensor | Operating voltage 3.3V/5V, Range 0-14PH, Resolution ±0.15PH Response time < 1min |
| LCD | 16X2 LCD |

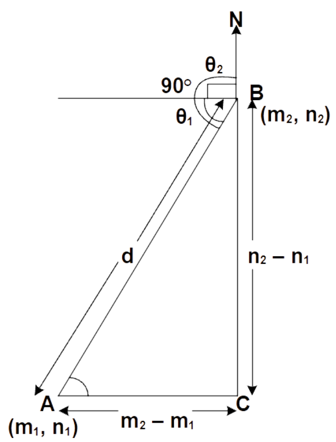


Figure 2. Mathematical Model for Boat Direction

Considering earth as a 3D space model, assuming earth's centre at (0; 0; 0) and with respect to earth's radius (R) the new coordinates are obtained using Eq. (1) to (6).

$$x_1 = R\cos m_1 \cos n_1 \tag{1}$$

$$y_1 = R\cos m_1 \sin n_1 \tag{2}$$

$$z_1 = R\sin m_1 \tag{3}$$

$$x_2 = R\cos m_2 \cos n_2 \tag{4}$$

$$y_2 = R\cos m_2 \sin n_2 \tag{5}$$

$$z_2 = R\sin m_2 \tag{6}$$

Finally, the distance between the two points 'A' and 'B' is determined using Eq, (7)

$$d = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2} \tag{7}$$

Here, d is the hypotenuse of the right-angled triangle ABC as shown in Fig. 2. Hence angle $\theta$ is calculated by using Eq.(8)

$$\theta = \arctan\left(\arctan\frac{(y_2 - y_1)}{(x_2 - x_1)}\right) \text{ radians} \tag{8}$$

$$\theta_2 = \left(\frac{\pi}{2} + \theta_1\right) \text{ radians} \tag{9}$$

From Fig. 2, $\theta = \theta_1$ as they are vertically opposite angles. Hence the total angle $\theta_2$ as given in Eq.(9) is the angle about which the boat is supposed to turn so that it faces the starting point. The boat must move towards the charging point only when the battery level is low. Therefore, there is a need for a battery level indicator. The algorithm used for returning to the charging point is shown in Fig. 3. Initially when the boat is turned ON at the starting point the location of the starting point of the boat is obtained by the GPS module. This is regularly updated. Whenever the battery is low, the boat stops and the current direction of the boat is checked using a magnetometer. Further, the boat is directed to a charging point as explained. If any obstacle is detected on its way to the charging point, the boat is moved away from the obstacle by directing it in a random direction. If the boat fails to move away from the obstacle, then the current location is sent to the authorized person using GSM to retrieve the boat. The pseudocode for the same is given in Algorithm 1 (Fig. 4(a)).

### B. Battery Level Indicator

If the battery level goes below the set value (less than 20 %), the current GPS location is saved. The boat is rotated such that it faces north using a magnetometer. The boat is rotated based on the trigonometric formulae such that it faces the charging point. The nearest distance between the boat and the charging point is calculated using the distance formula and the boat is directed towards the charging point and the boat is charged. The algorithm used for battery level indication is shown in Algorithm 2 (Fig. 4(b)).

### C. Obstacle Detection and Random Walker Algorithm

For the smooth operation of the boat, it is necessary that the boat must detect obstacles before deciding the direction.

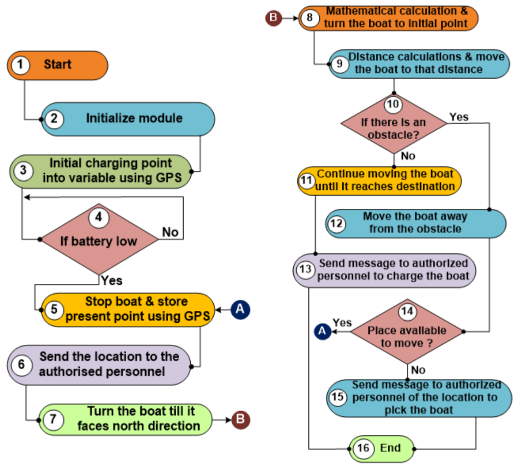


Figure 3. Process flow diagram for returning to a charging point

```
/*Condition if the boat has not reached charging point and there
is an obstacle in front*/
 if((y>10)&&(distance<=80))
 {
  /*Boat turns right after obstacle is detected*/
  analogWrite(E1,255);
  analogWrite(E2,0);
  digitalWrite(I1,HIGH);
  digitalWrite(I2,LOW);
  delay(tude/2);
  distance=UltraSonic();
  distance1=UltraSonic1();
  /*Boat goes alongside the obstacle until there is obstacle*/
  while((distance>80)&&(distance1<=80))
  {
   analogWrite(E1,255);
   analogWrite(E2,255);
   digitalWrite(I1,HIGH);
   digitalWrite(I2,LOW);
   digitalWrite(I3,HIGH);
   digitalWrite(I4,LOW);
   distance=UltraSonic();
   distance1=UltraSonic1();
  }
```
(a)

```
/* Function to monitor the battery level*/
if(v<=11.9) //Checks if the battery is low
 {
  BaRun();
 }
 if(Sensor<=30)  //Condition to check is there sufficient
battery level and obstacle detection in the front
 {
  Obturn();
 }
 analogWrite(E1,255);
 analogWrite(E2,255);
 digitalWrite(I1,HIGH);
 digitalWrite(I2,LOW);
 digitalWrite(I3,HIGH);
 digitalWrite(I4,LOW);
 delay(1000);
 Serial.println("OUT");
}
```
(b)

Figure 4. (a) Algorithm 1 and (b) Algorithm 2

Ultrasonic sensors are used for obstacle detection. Arduino receives signals from the sensors and decides the speed and direction of the motor and hence the boat. If the sensors detect any obstacle, Arduino determines an alternate path by using a GPS module. A random walker algorithm is used for path selection to direct the boat in a particular direction. The boat moves in the specified direction until an obstacle is encountered. The shore is also considered an obstacle and it can detect the obstacle at a range of 1 meter. The random walker algorithm shown in Fig. 5 (a) describes the movement of the boat. The boat is directed towards different directions during the course of its operation. After the initialization of all the modules, an integer at random is selected by the algorithm. Each integer represents a particular direction. Hence when an integer is selected at random by the algorithm the boat starts moving in that particular direction until an obstacle is detected. When an obstacle is detected, the boat rotates180 degree and another integer is selected. Thus, the boat moves in a different direction. Further, the aerator in the boat supplies oxygen which inhibits biochemical reactions that favour the growth of weeds. The motors are run by rechargeable LiPo batteries while the Arduino and the Aerators are powered by solar energy.

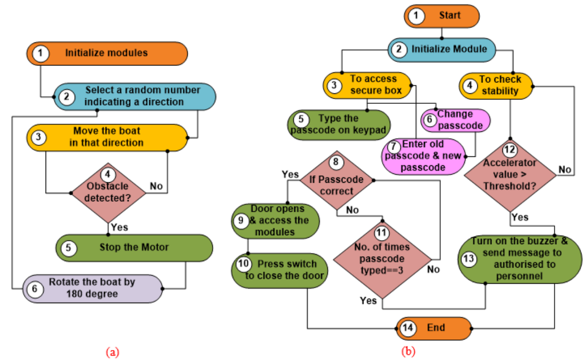


Figure 5. (a)Random walker algorithm and (b)Secure casing algorithm

## D. Secure Casing

In the proposed system, a 'secure box' module is provided to protect the components placed inside the boat. This protects the boat from damage due to anomalies in the environment as well as theft. Only authorized personnel can access the secure casing. When the right passcode is entered, the servo-motor gets activated which in turn opens the lid of the boat giving access to the components placed inside the boat. The authorized user can change the current passcode and update a new passcode to the casing. Additionally, any turbulence experienced by the boat due to a natural anomaly or its theft which will disrupt the set calibrated value is detected by the accelerometer and a signal is generated by the control unit to alert the concerned authority in the control room by activating a buzzer. The flow diagram and pseudocode for the secure casing algorithm are shown in Fig. 5 (b).

It is a pass-code-based lock system. Initially 'Select Choice' is displayed on the LCD. In this case, one among the two choices could be made, choice '1' to change the current passcode of the system, choice '2' to enter the passcode to access the components placed. The secure case door opens only if the passcode matches. If the passcode entered is wrong, two more chances are given to enter the passcode. If a wrong passcode is entered three consecutive times, a buzzer gets activated and also a text message is sent to the authorized person. In addition to this, the secure casing algorithm alerts the authority if any turbulence is experienced by the boat. This is achieved when the boat position obtained by the accelerometer exceeds the threshold value. In case of turbulence buzzer gets activated and also an alerting text message is sent to the authority so that necessary actions can be taken to get the boat back to the shore.

## E. Water Quality Assessment

Water quality is crucial for all living beings. Also, it is essential to use harmless water for agriculture, harvesting

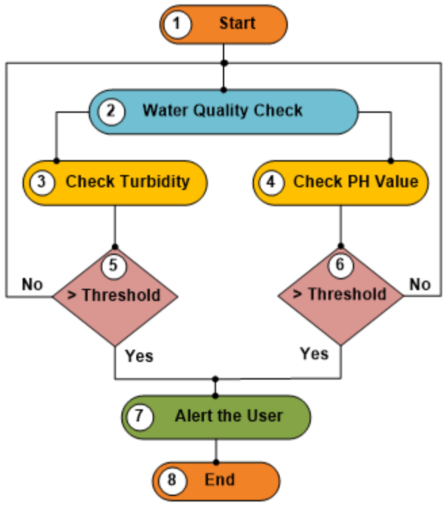


Figure 6. Process of water quality assessment


Figure 7. GPS module displaying the location

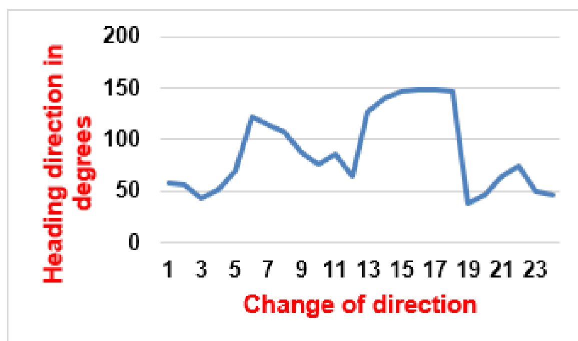


Figure 8. Directions indicated by the magnetometer

and recreation [22]. As per the WHO [23] report water quality is a key measure to prevent diarrhoeal diseases, acute respiratory infections and numerous neglected tropical diseases. Optimal pH levels and turbidity are essential factors in maintaining water quality that in turn helps in maintaining healthy ecosystems. Several sensors such as pH sensors, turbidity sensors, Dissolved Oxygen sensors, ORP sensors, TDS sensors, Blue-green Algae sensors, etc. are available in the market for assessing the quality of water. In this work, a pH sensor and turbidity sensor are used for assessing the quality of water. It is a well-known fact that a pH value of 7 and a turbidity level between 0 and 2 Nephelometric Turbidity Units (NTU) are ideal for drinking purposes. However, a pH value in the range of 6.5 to 8.5 and turbidity value in the range of 0 to 5 NTU are considered safe for drinking as well as other activities such as agriculture and recreation. The flow diagram for the water quality assessment is shown in Fig. 6. Here, if the pH value and turbidity value cross the aforementioned range, an alert message is sent to the authorised user. To test the water quality assessment model, six water samples from different lakes are collected in the Southern region of Karnataka.

## 3. Results and Discussions

The developed autonomous boat inhibits the growth of weeds by creating water waves. Therefore, this boat can be used to maintain the surface water after removing the aquatic weeds and lake sediments. This boat can eliminate the recurrence of aquatic weeds thereby reducing the investment as well as human effort every year. Several modules such as display, GPS, GSM, sensors, etc. are used to incorporate multiple functions. The results of the modules are provided in this section. LCD is used as a display module and it is connected to the Arduino as per the pin description. The GPS module is connected to the Arduino Mega using a MAX232 level converter. The antenna is kept in an open area for the GPS to obtain a better signal. The GPS data (Latitude and Longitude) are displayed on the LCD. Further, calculated distance and direction were also obtained as shown in Fig. 7. Point 'O' in the figure represents starting point or charging point. The remaining points are random locations on the water's surface. The distance between each point and the approximate time taken by the boat to reach the points are listed in Table II. This could be used to determine the location of the boat using Google Maps. This helps in remote monitoring of the boat.

The magnetometer (HMC5883L) is calibrated accordingly with the true north direction and the output obtained from the magnetometer is as shown in Fig. 8. It is evident from the figure that the values get updated based on

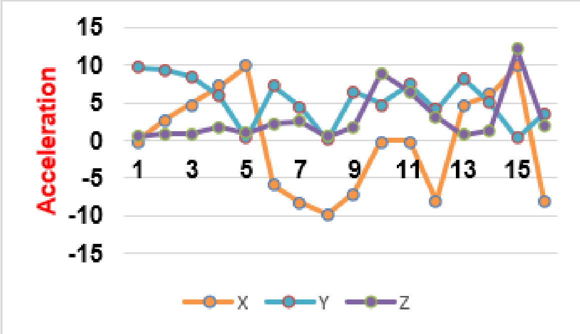


Figure 9. Accelerometer axes values

TABLE II. Details of the boat location

| Direction | Distance (in feet) | Time Taken (in min.) |
|---|---|---|
| $O \rightarrow A$ | 19.28 | 4.0 |
| $A \rightarrow B$ | 13.31 | 3.6 |
| $B \rightarrow C$ | 9.36 | 3.0 |
| $C \rightarrow D$ | 12.94 | 2.8 |
| $D \rightarrow O$ | 18.45 | 3.8 |

the direction indicated by the magnetometer. Thus, the boat turns in the direction calculated by the magnetometer and moves in the path based on the random walker algorithm. Further, the accelerometer is connected as per the pin connections and it is calibrated accordingly with respect to all three axes. Indication of the position with respect to the three axes is verified and the results are shown in Fig. 9.

The developed model can provide aeration that will prevent aquatic weeds prevention. Also, the pH sensor and turbidity sensor connected to the boat regularly checks the quality of water and thus the boat can assess the quality of water. The obtained pH and turbidity levels for four locations are listed in Table III. The samples are collected from different lakes in the Southern part of Karnataka. It can be observed from the table that the obtained pH and turbidity values are in the safe range. However, the system can be improved by incorporating a few more tests such as acidity level, alkalinity level, chlorides, iron and sulphate levels.

TABLE III. pH and turbidity levels

| Location | pH | Turbidity |
|---|---|---|
| 1 | 6.0 | 0.6 |
| 2 | 6.6 | 1.7 |
| 3 | 7.3 | 0.9 |
| 4 | 6.58 | 1.0 |

In the proposed system, an additional facility for requesting the location of the boat by authorized personnel is provided. When an authorized user requests the location of the boat by sending a particular message to the GSM module, the microcontroller stores the current GPS location and sends the coordinates of the current location in the form of a text message to the authorized mobile phone with the help of the GSM module. These coordinates can be viewed on Google maps. This helps in remote monitoring of the boat.

The constructed autonomous boat underwent rigorous testing to validate its performance, functionality, and adherence to design specifications. The testing phase encompassed various aspects, including the boat's durability, buoyancy, propulsion system, obstacle detection capabilities, and integrated components. To validate the boat's construction, it underwent tests to ensure its durability and resistance to water damage. Immersion tests were conducted to check for any signs of water leakage and verify the boat's buoyancy, ensuring it remained afloat and maintained its structural integrity. The propulsion system, consisting of four motors with attached wheels, was thoroughly tested to assess its performance and efficiency. This involved evaluating the power and control of the motors to ensure smooth and effective movement through the water. The boat's ability to navigate in different directions and at varying speeds was validated to ensure precise maneuverability. The boat's autonomous capabilities were validated through extensive testing of its obstacle detection system, which utilized ultrasonic sensors. The boat was subjected to various scenarios with obstacles at different distances and angles. These tests assessed the accuracy and responsiveness of the sensor system, ensuring that the boat could effectively detect and avoid collisions. The functionality of integrated components such as the solar panel, battery backup system, and charging mechanism was also thoroughly tested. The solar panel was exposed to different light conditions to evaluate its ability to charge the batteries efficiently. The performance of the battery backup system was assessed by simulating scenarios where the solar panel received insufficient sunlight. These tests ensured the boat could operate continuously, even under adverse conditions. Throughout the testing phase, data from the boat's sensors, including those related to water quality parameters, were closely monitored and analyzed. This allowed for the validation of accurate readings and reliable performance, ensuring that the boat could effectively monitor and maintain water quality during operation.

The designed boat is a feasible solution to maintain surface water. Alerting mechanism incorporated will alert the concerned person in case of any anomalies in the environment, theft or increase in the water contamination level. However, this system can be used for maintaining the cleanliness of surface water after the removal of weeds and sediments. The system prevents the recurrence of weed growth by providing aeration.

## 4. Conclusions and Future Work

In the present work, the design and development of a boat proposed that man oeuvres the lake autonomously. This inhibits the growth of aquatic weeds by providing aeration. This performs multiple functions namely inhibition of weed growth and water quality assessment. These functions are controlled by Arduino Mega 2563. The movement of the boat is designed such that it randomly moves over water thereby preventing the algal bloom and it comes back to the charging point when the battery goes low using the current GPS location and mathematical formulation. The developed boat can be used for maintaining the cleanliness of lakes and ponds. Therefore, this boat can be used to maintain the surface water after removing the aquatic weeds and lake sediments. This boat can eliminate the recurrence of aquatic weeds thereby reducing the investment as well as human effort every year. The pH and turbidity sensors assess the water quality and the system alerts concerned personnel in case of contamination. Hence this is a sustainable solution to the existing issues that can save human efforts. Future work would be to develop a low-cost autonomous practically usable system to clean surface water and to incorporate a garbage collection mechanism.

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