Robot for Under Water Monitoring

C. Gnana Kousalya, G. Rohini, T. Sasilatha

Abstract: Unmanned underwater vehicle is the branch of robotics which comes under the autonomous underwater vehicle. These robots have the wide applications like research, collection of the samples and observation of underwater bodies. The proposed work involves underwater robot for measuring the parameters of water and surveillances for inspecting underwater structure. The contamination of the water bodies can be found out by using the light density method. The evaporation level of water bodies can be studied through temperature measurements and also the acidic and alkaline nature of the water can be seen through pH measurement. To move easily through any standard inspection doors, the robot is designed with the length of 240 mm, breadth 94.68mm and height of 130mm by considering the mass to length calculation method based on floating theory. In addition, this robot is fitted with air tubes of dimension 81.5mm which is a standard size for 5kg robot. This work makes use of Arduino UNO commands to control the motors, light density measurement and water sample collection and communication through Bluetooth communication between the user and the float which floats on the surface of water. The customized mobile application makes the robot user friendly and easily controllable. In this work, an underwater 4K ultra HD camera is fitted to the hardware. This camera is used to record the underwater view. The recorded sequences of images stored in micro SD card are used to analyze surrounding objects in the target area. All the elements connected to the Arduino are controlled by the user. The robot is designed for monitoring the under water.

Keywords: Unmanned Underwater Vehicles, Remotely Operated Vehicles.

I. INTRODUCTION

Recently, the scope of underwater robot has got increasing demand application such as environmental monitoring, pollution control, ecosystem study, submerge structures, testing measurements etc. The UUV (Unmanned Underwater Vehicles) sometimes known as underwater drones are the vehicles that are able to operate underwater without a human occupant. These vehicles may be divided into two categories ROV (Remotely Operated Vehicles) which are controlled by the human operators and AOV which are autonomous.

The information in ROV which is controlled by user is transferred to the receiver present in the float by using the Bluetooth module. This information is processed by the processor and it is provided to the robot. According to the user guidance, the motor runs by the transfer of high and low signals. ROV are highly maneuverable and are operated either by the crew or by the single person.

By using ultrasonic sensors collision avoidance is done which is helpful in avoiding the obstacles. The water parameters which vary very often like temperature, pressure and the pH are measured and are displayed in the mobile app by using the Bluetooth module. These parameters are considered for analyzing the ocean particles and water bodies. This robot is designed in such a way that it is used to monitor these parameters. The water contains different minerals and dirt contents in the water. These parameters are used for the pollution monitoring and for the global monitoring. They are analyzed by analyzing the water samples collected from the bodies. This robot is designed in such a way to collect the water sample to do this process.

Nir, Jak& Mon proposed a floating waste scooper robot on water surface [1]. In this work, the authors designed a robot that replaces human force for floating waste scooping and investigate performance of the designed waste scoopers installed on the Floating Waste Scooper Robot.

Ted and Wir proposed saving water with water level detection in a smart home bathtub using ultrasonic sensor and fuzzy logic [2]. This study proposes the development of saving water tool by using automatic device which open and close the water-tab to reduce water wastage. When the bath tub is full of water, smart home will decide to close the water-tap automatically. This study uses ultrasonic sensor to detect water level. Fuzzy logic approach was used to analyze the water level indication to make the water stops in the right time.

Fet et al. proposed a miniature water surface jumping robot [3]. In this work, the author addresses this problem by using carbon fiber strip to store energy, two wings to flap the water surface, a hollow body to initially support the robot, and an intermittent gear train to charge and release energy. Ken et al. proposed development of water surface mobile robot inspired by water striders in [4].This work describes a water surface mobile robot utilizing surface tension forces. Recent biological studies on water striders revealed how they stay afloat and move on the surface of water.

Bel and Jou [5] proposed development of a novel robotic dolphin and its application to water quality monitoring. This work presents the mechatronic design and hydrodynamic analysis of a novel bio inspired robotic dolphin used for mobile water quality monitoring. A 3-D dynamic model based on the Lagrange method is employed to predict the propulsive performance, followed by simulations of continuous diving and surfacing motions.

Eid et.al [6] proposed online view planning for inspecting unexplored underwater structure. In this work, the author proposes a method to automate the exploration of unknown underwater structures for autonomous underwater vehicles (AUVs). The proposed algorithm iteratively incorporates exteroceptive sensor data and replans the next-best-view in

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order to fully map an underwater structure. Ele et.al [7] proposed survey on traditional research topics in industrial robotics and mobile robotics and then expands on new trends in robotics research that focus more on the interaction between human and robot. Enret. al, proposed autonomous underwater robot in intervention: experimental results of the maris project in 2018[8]. This work presents the developed control framework, the mechatronic integration, and the project's final experimental results on floating underwater intervention.

Geo et.al.[9] proposed underwater data collection using robotic sensor networks . In this work, the author proposes AUV path planning methods that extend algorithms for variants of the Traveling Salesperson Problem (TSP). While executing a path, the AUV can improve performance by communicating with multiple nodes in the network at once.

Pet &Lan [10] proposed underwater vehicle obstacle avoidance and path planning .This paper describes a new framework for segmentation of sonar images, tracking of underwater objects and motion estimation. This framework is applied to the design of an obstacle avoidance and path planning system for underwater vehicles based on a multi-beam forward looking sonar sensor.

II. METHODOLOGY

The proposed work is to design a water proof robot which can move in water according to the user command. This robot is used for monitoring the water parameters and to take images of underwater objects. The water parameters are temperature, pressure, pH of the water are measured and provided to the user .This robot collects the information from the water and provides it to the user. Another aim of this robot is water sample collection .This robot has two parts one is transmitting part and the other is the receiving part .The transmitting part is the user and the receiver part is the float connected with the robot. The added point of this robot is the collision avoidance. The Bluetooth module is used for the transfer of the data to the user and it display. The robot is guided by the user and the command is given by the mobile app. The parameters which are measured by the robot are displayed in the mobile app.

III. SYSTEM DESIGN

A.Block Diagram

The control for the motor and for the sample collector is provided by the user by using the mobile app it transmits the information to the receiver. The receiver receives the information and the processor controls the robot according to the information provided. The user provide the command for the motors to run. The motor controller gets the information form the processor and works accordingly. The bridge in the controller is used for control information in the case of 00 indicates the off condition 11 i.e. high indicates on 10 and 01 indicates the right turn and left turn of the robot and according to which the mortar works. In the same concept the water sample collector also works and used for the collection of the sample. All the commands are provided by the user.

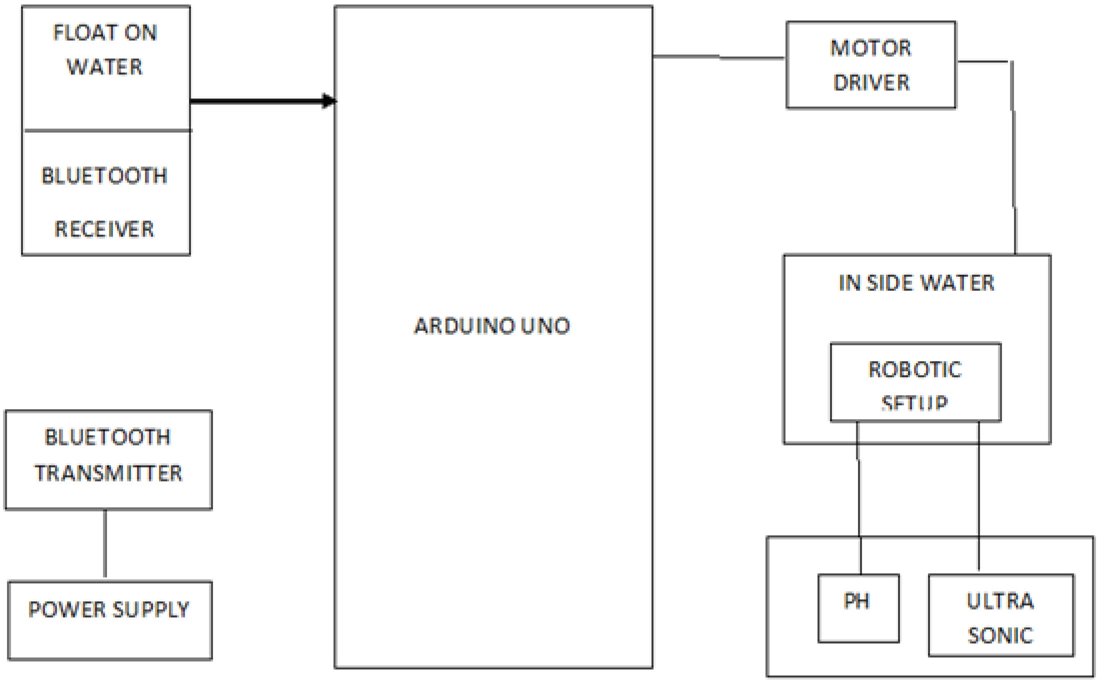

Fig. 3.1 Block diagram

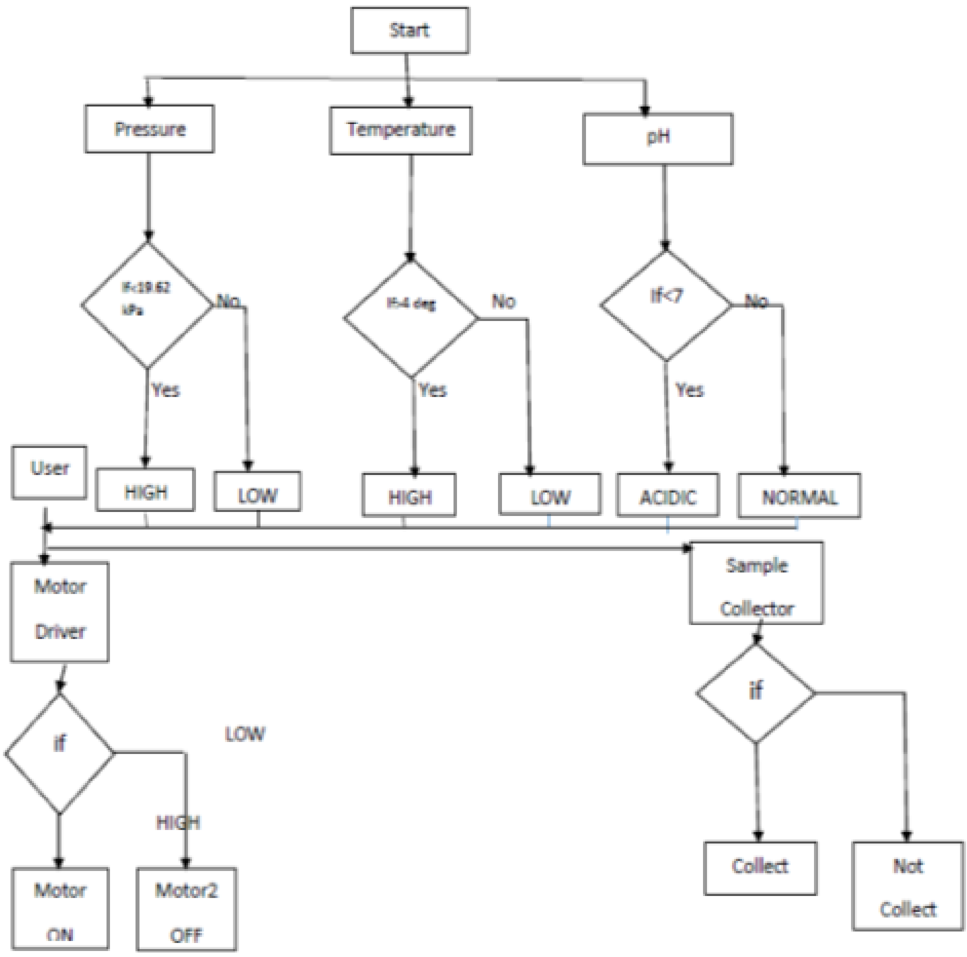

Fig. 3.2 Program flow diagram

B. Design Procedure

For designing the different parameters have to be taken in the consideration like stability, insulation, speed and size. The robot must be designed with reduced size for the easy movement and efficiency. This robot is designed by the material called acrylics which gives the robot stability and good body structure.. This design is provided with the space for the air bag tube and for placing the sensors. Another issue in designing the underwater robot is the insulation since the robot moves in the underwater the robot is affected by the pressure and stability. Insulation of the components is another problem. The motor is insulated with the plastic material in such a way that the water does not enter into the motor and provides proper insulation.

Front Design Procedure

This length of the robot is designed to be 240mm since the air tube dimension is 81.50mm which is a standard size. The above said procedures are followed for drawing the design. First, a rectangle of length 240x94.68mm is drawn. And then the place for air tube is given with the size of 91.50mm diameter which is a standard size. By considering the stability the intermediate shaft of length 94.68mm is made. This provides strength to the robot. Then the places for screw of standard size 2mm is made.

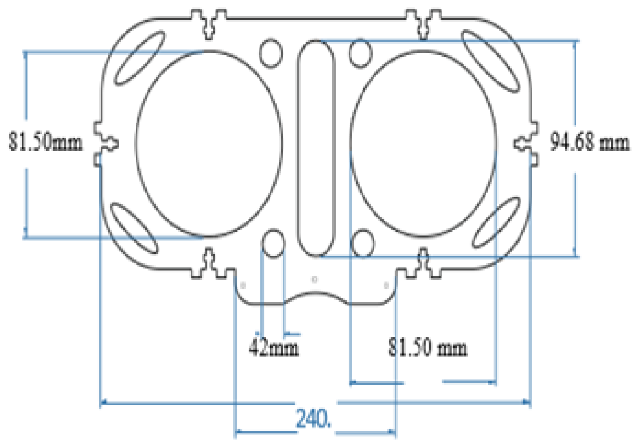

Fig. 3.3 Front design

Motor Setup

This robot is designed with the three motors for the motion. Two motors for the front and back movement and the other is for the stability. The speed of the motor reduces inside the water hence high speed motor is to be used the motion of the water in the water bodies i.e. the currents reduces the motor speed hence this robot is powered up with the 300 rpm motor for attaining the optimum speed. Unlike the traditional robots the motor is directly connected to the fans instead of

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going to the propellers and gear systems this provides high speed. These robots are controlled by the user. For stability considerations the motor is placed in the bottom of the robot where it operates in this motion for the stability of the robot.

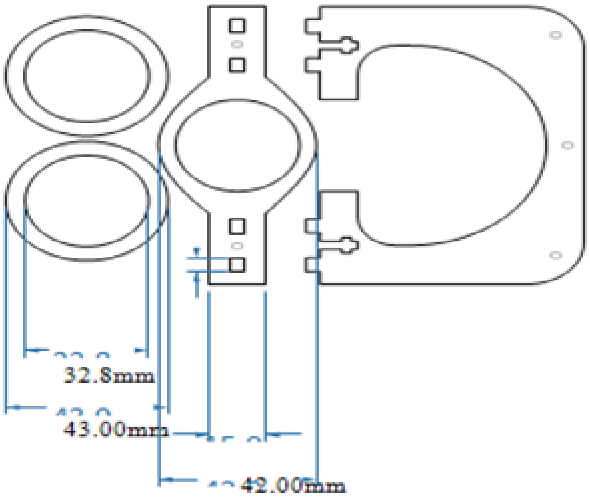

Fig. 3.4 Motorholder design

The motor used in this design is 300rpm motor which is of standard size 32.80mm in diameter. Hence the holder is designed in the size of 32.8mm. This design is made by drawing the circle shape from the tool bar with the dimension 43mm. These two holders are used for the forward and backward movement motors.

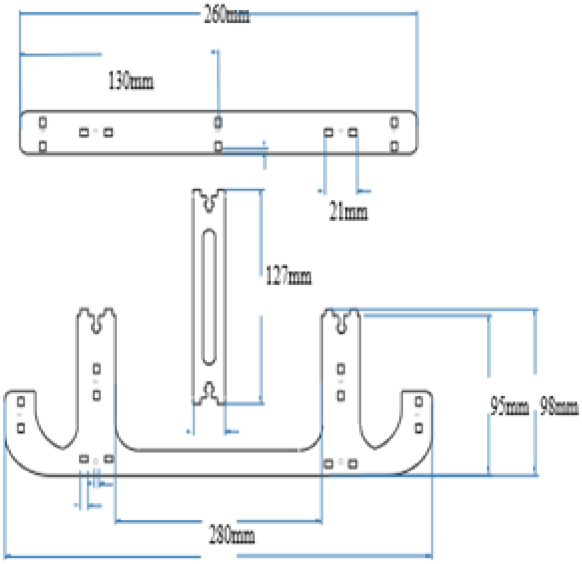

Fig. 3.5 Bottom design

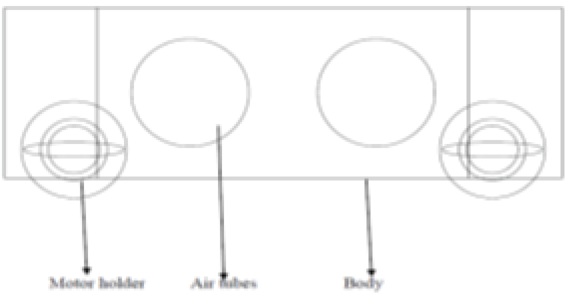

Fig. 3.6 Side view

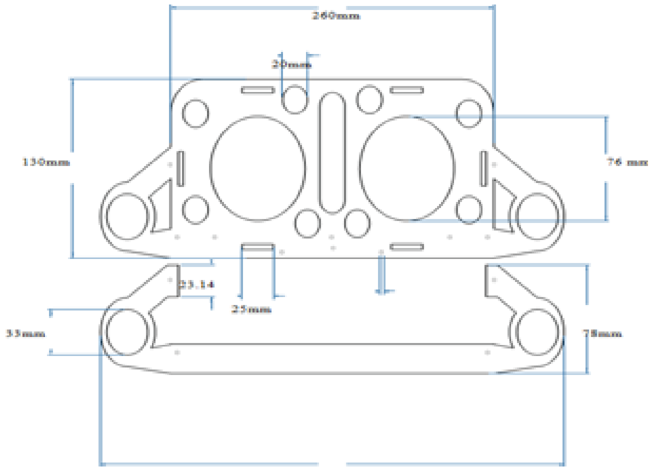

Fig. 3.7 Overall design

In Fig 3.7, it shows the overall design of the robot. It consists of two parts: the robot part and the float part. The robot part consists of the air tubes, motor positioning for forward and backward and for the up down movement. It consists of the solenoid valve for releasing the air from the air tubes which is 33mm of diameter. The float part consists of the transmitter side which is further explained in detail.

C.Float Design

The float is the main part of the robot since the ROV concept is used the robot is to be controlled by the user. The robot has to parts one is the transmitter part and the other is the receiver part. The receiver part in this robot is the float. The float contains the processor placed in it connected with the Bluetooth module. The Bluetooth module receives the information from the user and provides to the processor and also does the process of transmitting the collected information to the user. The float floats on the top of the water where the water sample is collected. The robotic setup which goes inside the water is connected by means of the bus for the transfer of control information's. Since the concept is wireless underwater robot the connections is wireless the Bluetooth concept is implemented. The range of the Bluetooth operating range is of up to 15 feet after which it loses its connection with the user. To improve the range of the other type of communication has to be implemented like RF communication or by increasing the power of the Bluetooth which is done up to the 10 meter after which it is not also possible it has to adopt some other techniques for the communication.

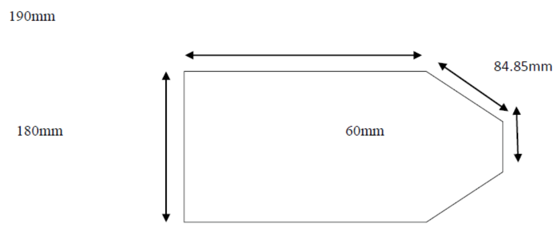

Fig. 3.9 Float design

He float has a dimension of 180x190mm with an extension of 84.85mm and 60mm. the float part consists of the transmitter where the Arduino and the Bluetooth module are placed using a PCB board. The Arduino runs the process and the Bluetooth module is used to transmit the sensor values to the receiver. The float and the robot are connected through a bus where the command is given by the sender through the Bluetooth module and the robot is commanded.

D.Solenoid Valve

The robot uses the submarine concept which uses the air tubes for the up down movement hence the pump is used for pumping the air inside the tubes since the same pressure has to be maintained for the constant height the valves are used they are called solenoid valve. These valves are used to hold the air until and unless the user controls it in this design for the movement.

IV. THEORITICAL CALCULATIONS

A.Gravity Consideration

The Earth is assumed to be in sphere in shape the gravity in terms of height is determined by using the equation

$G=\mu/R2$ ---------------------- (1)

Where r is assumed to be the earth constant.

B.Force

In this work the prototype is assumed to be moving in the fluid which has the density of thousand kilo grams per meter cube from which the external force applied to the vehicle can be calculated

$P=1000$ kg/m3 ------------(2)

The body moves in the water where the weight increases as well as the pressure while increasing the depth hence the force is calculated by

$F=mg$ --------------- (3)

Where m is the mass of the body.

C.Stability

While designing the underwater robot the stability is the main consideration where the robot efficiency depends. The stability of the robot is affected by many parameters like speed, position of the motor, mass of the robot, etc. The main part is the position of the robot this is to be designed or placed as shown in the figure.

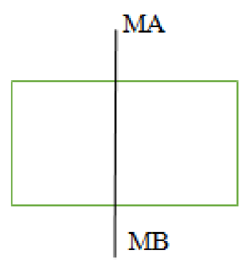

Fig. 3.8a

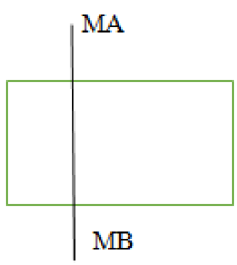

Fig. 3.8b

The robot has to be designed as shown in the Fig 3.8a which provides the better stability of the robot. The Fig 3.8b shows unstable model.

During the movement of robot under the water the weight of the robot keeps on changing hence the force changes in the submarine type robots which is used in this robot hence the equation shown below shows how the force changes

$F=MV+C(V)V$ -----------------(4)

Where f is the added mass and v is the velocity.

The movement is conductive to the vehicle stability this is given by

$Rm=1/2d(B+W)$ ------------------(5)

D is perpendicular between the B and W

When travelling in constant speed the drag force is equal to the friction

$Drag=1/2ps2Acd$ ------------------(6)

Where A is the surface p is the water density which is found out by the above procedures.

D.Pressure

As with air the water pressure is caused with the weight of the medium in this case it is water. Pressure is usually measured in an obsolete or ambient pressure they are relativistic in nature. At the water the pressure due to air is about 14.7 psi. For every 10m depth it increases by 1 atm although it increases linearly the structure must be capable of withstanding a large amount of the pressure than the expected to survive.

The robot is designed with the consideration of the weight factor. The conversion of the mass in to length is used in this design. That made it so easier. The robot moves in the water which has the varying weight so the design is made with trial and error method considering the weight of the robot. According to the Newtons 2nd law,

$F=Ma$ ------------------(7)

Here F is the force and M is the mass and a is the acceleration. The acceleration is measured in terms of meter per second .Let us consider the Newtons law of gravity

$F=G.(MM/RR)$ ------------------(8)

Where r is the distance between the two objects and G is the gravity which is constant if the mass is in kilo gram and the distance is in meter the unit must be in meter per second. From this the gravity is expressed in terms of mmm/kilogram

In order to convert mass into unit lengths G together with the velocity of light c as which is experimentally determined which is given by

$G=6.6726/10000000000$ ------------------(9)

Then the square c is converted from the equation for the equivalence between energy and mass

$E=mcc$ ------------(10)

$G/C2=6.67268*10-11/2.999*108*2.9979*108$ -(11)

Which gives the conversion factor to be as 7.7424 which is to be multiplied to get in terms of length. Then the result is in the form of length. The length of the robot is designed to be the consideration of maximum five kg to 10 kg so the length is to be given as follows

$7.424*106*5*10-3=371.2$ mm ------------------(12)

So the robot is designed to be with the length of the approximation of 360 which can be seen in the Fig 3.7 where it is seen the length is the same. In the same way the design is made for the others by considering the motor size and the tube weight.

V. RESULTS AND DISCUSSION

When user sends a command through android phone, the transmitter transmits the command to receiver by pre-set program. The receiver receives the command and gives it to arduino. Arduino process the command by pre-set program. Then arduino command to motor driver and the robot starts move. To move forward, horizontally installed motor of both sides have to rotate in clockwise direction. To move backward these motors, have to rotate in anticlockwise. The vertically installed motors will remain stop. To move left, one motor rotate in clockwise and another in anti-clockwise. To move right, one motor rotate in anti-clockwise and another in clockwise. The upper motors will remain stop. To move upward, all upper motor have to rotate in anti-clockwise. To move downward, all upper motor have to rotate in clockwise. The both side motors will remain stop.

A.Design

Fig. 4.1 Float Hardware Design

Fig. 4.2 Overall Hardware Design

B.Algorithm

STEP 1: Specified pin to behave either as an input or an output**.**

STEP 2: Assigning the input pins for specified sensors (pH, temperature, pressure).

STEP 3: Read the value from the specified analog pin.

STEP 4: Read the value from a specified digital pin, either HIGH or LOW.

STEP 5: Transfer the values to Bluetooth module from Arduino.

STEP 6: Display of values in the monitor.

C.Result Analysis

Table. 1 pH Analysis

WATER SAMPLES	READINGS
Normal water	6.4
Mineral water	7.1
Distilled water	6.7
Salt water	7.9

D.Test Results

The normal pH of the water lies between 6.8 to 7.4. The test analysis is done using the robot and different water samples are taken and tested by the pH sensor used in the robot. The table shows the different water sample tests using the pH sensor which lies between the normal readings.

Table. 2 Temperature Analysis

VARIOUS TEMPERATURE	READINGS (in fahrenheit)
Room temperature(33 C)	89
Air conditioner(24 C)	74
Boiled water	198

The above table shows the different sample analysis of temperature using the temperature sensor used in the robot. Various quantity at various temperature are taken and tested using the temperature sensor and the readings are tabulated in the analysis.

VI. CONCLUSION AND FUTURE WORK

The underwater surveillance robot developed has been tested in water pool with a depth of 5m. The robot performed well transmitting the captured video sequence to the user. It also detected the temperature change and updated the change dynamically at the remote computer. Future work to change the shape of mechanical structure into cylindrical for better stability and fast movement to facilitate an experimental drive in the ocean to observe oceanographic environment and take data, images and videos.

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