IoT Based Underwater Robot for Water Quality Monitoring

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Abstract. With the rising population in India, an increase in requirement of fresh water for agricultural, industrial and other purposes is being witnessed. As such fresh water management has become the need of the hour. In this model automated evaluation of water quality such as its pH value, turbidity and temperature is done. For underwater communication, ESP32 is being used because of its built-in Wi-Fi and low power consumption. Machine to Machine communication (i.e., devices communicating with each other and accordingly processing the data efficiently), pH sensor and turbidity meter have been integrated in developing this IoT based project. Adding to this, machine understanding algorithm using K Means has been used in analyzing the water quality based on predefined standards. This project has been developed as a small prototype consisting of low-cost embedded devices such as ESP32, Arduino Uno.

1. Introduction.

The traditional method of water quality monitoring still depends upon collection of water sample, testing it in the labs and then planning for water treatment if and as required. But in modern times the IOT based models are used. These models are very different from the stereotype models, perhaps it is a totally revolutionized way of managing fresh water. As clean water is an essential part of life, therefore monitoring and cleaning of water is inevitable and doing so by using this robot reduces manpower requirement, operational time and related errors. Nowadays water sample collection, its analysis and planning for suitable solutions is done in real time. The real time monitoring system use special IP address for accessing the sensor data stored on the cloud [7]. Further the artificial intelligence system using deep learning techniques is used to detect the water contaminants and predict whether it is usable or not [8]. Many underwater monitoring robots are available but this model is based on simple architecture and uncomplicated design. This model is very much useful in continuously monitoring water bodies like lakes, rivers, ponds, canals etc. It is easy to assemble and operate. In this project, the machine is operated mechanically using electronic components and IoT platform. This robot can be deployed with ease, operated by personnel even without any technical expertise.

1.1. The objectives of underwater robot are:

1. To do real time analysis of water quality.
2. To eradicate human errors and get more accurate readings.
3. To carry out water quality analysis at remote locations.
4. To eradicate accidents that used to take place earlier when the data was collected manually.
5. To make the process more efficient and cost effective.

2. Research methodology.

2.1. Problems in existing systems:
2.1.1. The traditional method used for testing the quality of water is very expensive and time consuming.
2.1.2. No proper system for regular updates of monitored quality of water.
2.1.3. Existing underwater vehicles are not durable, very slow and have very little power backup.
2.1.4. Many times, the readings are inaccurate.

2.2. Market Survey:
On market survey it has been found that several types of water quality monitoring robots were available which help in reduction of manpower but the cost of these machines was very high due to which all these machines were not practical to use.

2.3. Problem Identification:
In literature survey, the problems identified were that in many local and large water bodies, water monitoring done by previous robots were only for a short span and a very few parameters were taken into account. The second major problem was that in these places, the monitoring of water took too much time and man power because the area to be monitored was very large.

2.4. Innovative features in project:
A few features that make this project innovative and revolutionary are:
2.4.1. This underwater robot is very compact as compared to other machines available in the market.
2.4.2. This model offers maximum durability and minimal maintenance requirement.
2.4.3. It has multi-section chassis which helps it to go underwater easily without any instability.
2.4.4. DC and stepper motor have been installed to move vehicle under water smoothly.
2.4.5. An automated syringe is used for water infusion inside the robot to help it go underwater.
2.4.6. Wi-Fi or Internet connectivity is used to control vehicle and facilitate live video streaming [2].

2.5. Development:
The machine consists of several components including Arduino Atmega (328), ESP-32, camera (OV2640), pH sensor, turbidity sensor, stepper motor, DC motor, driver IC’s (ULN2003), DC to DC converter (LM2596), temperature sensor, max 232 and a battery. These parts are fitted on the interconnected chassis. The mechanical design of this robot contains fixed and flexible links to move the robot in 360 degree [1].

2.6. Testing:
Each and every component of the robot was tested separately and it was ensured that every component is functioning properly. After testing every part individually, all the parts were integrated together and then the working of the model was checked. After examining it has been concluded that the monitoring performance of the robot is satisfactory and it can remain underwater for long durations without any problem of water seepage.

3. System Hardware Infrastructure:
The water quality monitoring system shown in fig1 uses sensors to measure parameters such as pH value, temperature, Electric Conductivity. Microcontroller processes the data received from different sensors. The processed data is communicated to the central server using Wi-Fi data communication module.
3.1. **Arduino UNO:**
The Arduino Uno 328 is a microcontroller board consisting of the ATmega328. Arduino Uno consists of 14 digital input-output pins (6 used as PWM outputs), 1 UART (hardware serial port), 6 analog inputs, a 16 MHz oscillator, a power jack, a reset button, a USB connection and ICSP header [9].

3.2. **ESP32 CAM module:**
The ESP32-CAM consists of a compact dimensions camera module which can work independently. ESP32-CAM is generally used in all types of inter connected IoT applications. ESP32 is ideal for industrial use, wireless controlling, smart home devices, location system applications, client server communication, wireless signals, QR identification and other IoT applications. For IoT applications ESP32 is appropriate. ESP32 shown in Fig 3 is dual in-line packed. ESP32 can be plugged straight into circuit for fast in line production. ESP32 provides a rapid connection which is reliable and is suitable to
use in different IoT circuit work stations. Some specifications of ESP32 are: Low power, dual core 32bit CPU to support application processors which ranges to 240MHz, small size 802.11b+g+n Wi-Fi system on chip (SoC), external 4MB Pseudo static RAM, in-built 520 KB Static RAM. ESP 32 also supports various interfaces like Universal Synchronous Asynchronous Receiver Transmitter (USART) for serial peripheral interface, I2C, ADC and PWM. ESP32 supports TransFlash card and uploads images using Wi-Fi [2].

![ESP32 CAM module](image)

**Figure 3: ESP32 CAM module**

3.3. **Sensors**

3.3.1. **Turbidity Sensor:**
Turbidity is a measure of the cloudiness present in water. Turbidity sensors tell about water losing its transparency and can measure turbidity of both the fresh water as well as of sea water. Turbidity prevents the light required by the immersed aquatic vegetation. It is considered as an important factor while estimating water quality [6].

![Turbidity Sensor](image)  

![pH Sensor](image)

**Figure 4: Sensors for measuring turbidity and pH values.**

3.3.2. **pH Sensor:**
The pH of a mixture tells about how much acidic or alkaline the given mixture is. The pH measure is a log measure which ranges from 0 to 14 in which 7 represents neutral. Numbers exceeding 7 represents basic or alkaline mixture and numbers preceding 7 would represent an acidic mixture. The normal range of pH varies between 6 and 8.5. The operating voltage of pH sensor is 5V and it is easy to interface with Arduino [6].

3.4. **Motors**

3.4.1. **Stepper-Motor and ULN-2003 Drivers**
A stepper-motor is a type of device which works on principle of electro-mechanics i.e. stepper-motor combines both electrical and mechanical fundamentals and thus is a device which transforms electrical impulses into distinct mechanical motion. When electrical impulses are applied in a desired progression, the pivot of a stepper-motor revolves in distinct stoop pattern. The stepper- motor revolution and direction is directly coupled to the order and intensity of applied input vibrations. The stepper motor can
be precisely operated in open loop network. In open loop network no feedback data regarding position is required. The speed of the motor pivot revolutions is directly coupled to the frequency of the input vibrations and the length of the revolutions is coupled to the total input vibrations applied. Due to no open loop network there is no need of costly sensing and ocular converters [3].

3.4.2 Water Pump – DC 365
DC 365 is a micro water pump with micro diaphragm shown in Fig 7. The water pump is operated at +5V and the pump flow is about 2-3 liters per minute. The outlet maximum pressure is 1-2.5 Pa. The maximum suction of the pump is 2 meters. The motor length is 32mm, motor diameter is 28mm, the pump length is 36mm and the total length is 69mm. Hence this specification makes this motor suitable for this prototype [3].

3.4.3. DC Gear Motors
A DC motor belongs to a group of rotating electric devices which converts electrical energy (i.e. direct current form) to mechanical energy. The most commonly used DC motors works on the principle of magnetic fields. A electro-mechanical mechanism is present in this motor which helps to vary the current direction inside the motor at regular intervals.

3.5 LM2596 DC to DC Converter:
DC to DC Step down converter (LM2596) power source is a type of step-down voltage regulator. These voltage regulators are of different types and have different fixed voltage outputs i.e. 3.3V, 5V, and 12V. These voltage regulators are efficient and can operate a 3-ampere load with distinguished line and regulation [3].

3.6. Chassis:
In the first step, the voltage is applied to motor which will in turn activate the syringe water infusion process from outside to inside of the robot which will in turn increase the weight of the robot, helping in submerging the robot underwater. This figure 7a is a representation of the movement of chassis to submerge underwater. The chassis will submerge underwater step by step. In the second step, due to water infusion the robot will gain weight and in a balanced manner will submerge underwater and start water quality monitoring using embedded sensors. In the third step, if in case there is a need to bring the robot out from water body, then voltage will be applied to water pump which in turn throw water outside from inside the robot thereby making robot light again. In this manner, robot can be brought back to water surface and this procedure is represented by figure 7b [10, 11].
a. Robotic vehicle underwater  
b. Robotic vehicle on water surface  

Figure 7. Robotic vehicle submerge underwater and out from water

3.7 Flowchart

Figure 8: Flowchart of ESP32 [9]

4. Result and conclusion:

4.1 Result:
The achieved Analytical results of the project following points are to consider.

4.1.1. In order to go underwater in a stable mode, the design of the robot will be having interconnected chassis in a level pattern as well as servo motor operated injection for water infusion.

4.1.2. The design of robot will have different types of motors such as stepper and dc gear motors which helps it to move smoothly horizontally and vertically.

4.1.3. There will be the addition of Wi-Fi camera with 360 degree movement which helps to view surroundings across the robot from remote locations.

4.1.4. In order to make processing speed faster, remote server based on IoT platform will be used [3, 4].
4.2 Experimental result:
The data is based on real time monitoring. The samples were collected on 12th April 2020 between 2 to 5 pm. from Jammu region. The given values are mean value of multiple readings.

| Water Body   | pH Value | Temperature | Turbidity Value |
|--------------|----------|-------------|-----------------|
| Home Water Tank | 7.2      | 28°C        | 3.9 NTU         |
| Tawi River   | 8.1      | 31.2°C      | 42 NTU          |
| Ranbir Canal | 7.7-8.1  | 14.5°C      | 72 NTU          |

Table1. Data Samples recorded by Robot

4.2 Conclusion:
In the end, it can be fairly concluded that this project will monitor the water quality and is locomotive. This project will be used for the betterment of the planet as it is very much helpful for continuously monitoring local and large water bodies. The readings will be displayed on the website, which can be accessed by central pollution control board. Thus, monitoring can be done from anywhere by using robot. This project is cost effective and with the help of highspeed Wi-Fi, the robot can communicate from underwater which makes this project more efficient and self-reliant.

5. Applications:

5.1 The main application of this project is that it can monitor water quality from any remote location.
5.2 The analysis of water is done based on multiple parameters.
5.3 This robot makes monitoring easier and makes the environment healthy and hygienic in a cost effective manner.
5.4 It will transmit the data wirelessly and will alert the user whenever the parameter exceeds its specified limit via remote servers.

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