Aquatic Iguana: A Floating Waste Collecting Robot with IoT Based Water Monitoring System

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***Abstract*— Water pollution is a major problem worldwide. In order to tackle the pollution and keeping the water resources clean, this paper presents an affordable and advanced floating garbage removing robot called "Aquatic Iguana". The robot moves around the surface of the water and collects floating waste material such as plastic, packets, leaves, etc. Along with the waste-collecting system, the robot also includes water monitoring with pH, turbidity, temperature sensors, and a live streaming feature, increasing the capacity to a greater extent. We have developed this robot to ensure the cleaning of water resources and to create a strong data set of water quality for future predictions. The use of this technology will ensure the safety of all aquatic animals and plants.**

***Keywords*— robot, floating waste, IoT, water quality monitoring, remote controlled, water pollution, real time data.**

I. Introduction

Collecting floating solid waste material such as plastic, packets, leaves, cigarettes, plastic bags, food containers, bottle caps, etc. can be a great initiative for cleaning water waste and also preventing water pollution. The waste in the water is not only harmful to the living animals of water but also dangerous for humankind and the environment. Natural procedures to decompose the waste and clear the dangerous elements from water takes years, decades, centuries, or even forever [1]. Additionally, insufficient water quality monitoring may impose great hazards to public safety. "Any particular use will have certain requirements for the physical, chemical, or biological characteristics of water; for example limits on the concentrations of toxic substances for drinking water use, or restrictions on temperature and pH ranges for water supporting invertebrate communities" [2]. A pH level ranging from 4.0 to 6.5 and 9.0 to 11 in water can create discomforting zone for the fishes living in it [3]. Obtaining time to time water quality data such as pH, temperature, and turbidity can help to figure out the purpose of the water resource. Our public health system is extremely affected by water infrastructure [4]. As a result, millions of dollars are invested to clean the water resources and reform the infrastructure. According to Overture global, to remove an estimated 42% of the debris within The Great Pacific Garbage Patch (GPGP), 10-years of time was needed with the cost of $390 million [5]. National Oceanic and Atmospheric Administration (NOAA) program are also committed to finding science-based solutions to marine debris [6]. To augment the global effort, our proposed robot "Aquatic Iguana" has a more standard mechanism of both manpower and technology. The system includes a robot to collect waste from water, monitor water quality and a mobile application to get the live view of surroundings. "Aquatic Iguana", is manually controlled via an onshore operator. The mobile application can also be used to get reading on data which is constantly uploaded to ThingSpeak server. To provide a real-time view, the system also includes a surveillance camera that ensures the live streaming feature to help the operator to see the surrounding environment and to collect waste more efficiently from a distance place.

- **Our main Objectives:**

The proposed system works for cleaning water surface and monitoring water quality in water resources. Followings are the specific goals of the system:

- To assemble such a robot so that it can collect floating waste from water resources such as canals, ponds, lakes, rivers, etc.
- To collect water data through sensors to evaluate the quality of water sources.
- To provide a real-time view of the water source using surveillance camera for better control and proper waste collection to increase the performance level of the proposed system.

- To study the data to figure out the existing water related difficulties and also for future problems.
- To create a perfect water management system with the combination of three significant features including waste collection, water monitoring system and a live streaming option to surveillance the environment.
- To build a mobile application which incorporates live streaming and water quality data monitoring altogether and provides a more convenient experience for the user and operator.

II. LITERATURE REVIEW

After the massive climate change on earth, people are more aware of the need for clean water. As a result, several works, projects, and researches took place. Some developments are significant in the field of cleaning water resources from various types of garbage and for the water management system. One such work is "Development of an Autonomous Beach Cleaning Robot Hirottaro", developed by Tomoyasu Ichimura and Shin-ichi nakajima [7]. The paper describes a robot that helps to clean by collecting garbage like empty cans and plastic bottles from a small beach. The autonomous navigation mechanism of the robot is one of the significant works of this research.

Another work is "Design and Implementation of a Semi-Autonomous Waste Segregation Robot" done by Balaji Masanamuthu Chinnathurai et al. [8], where the authors build a semi-autonomous recycling bot. The main objective of the robot is to differentiate recyclable and non-recyclable garbage, for segregation purposes they used image processing to analyze the object with their previous data stored in their own database.

"A multipurpose drone for water sampling and video surveillance" is another notable work done by Pankaj Agarwal and Mukesh Kr. Singh in the field of water quality monitoring [9]. This work describes an efficient multifunction video recording capable drone which can be used to take a water sample for water quality monitoring and also the sensors can be used to perform air quality monitoring.

Besides these scientific works, there are some other remarkable projects which are done by some industrial people. One such work is "Waste Shark" made by Ran Marine Technology [10]. It is used to collect plastic and bio-waste from waterways. This water drone can be operated either manually or autonomously.

Another outstanding work is done by the Urban Rivers community where they built a "Trash robot" to clean the trash of their floating gardens in Chicago River [11]. One of the most flexible features of this robot is that it can be controlled by anyone via a website.

III. TECHNICAL DESCRIPTION

The body structure and overall system of "Aquatic Iguana" was designed in a very precise way. Fig 1 shows the overall structure of the robot.

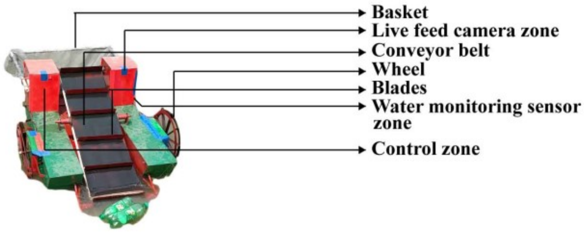

Fig. 1: Body structure of Aquatic Iguana

Three systems were merged to make the robot as efficient as possible.

A. *Control System & Garbage Collection*

The most significant part of our project is to collect floating garbage from water resources. To be able to collect the wastes, the robot can move around the surface and collect wastes using a conveyor belt. In Fig 2 the simulating circuit diagram is shown to highlight the working mechanism of "Aquatic Iguana".

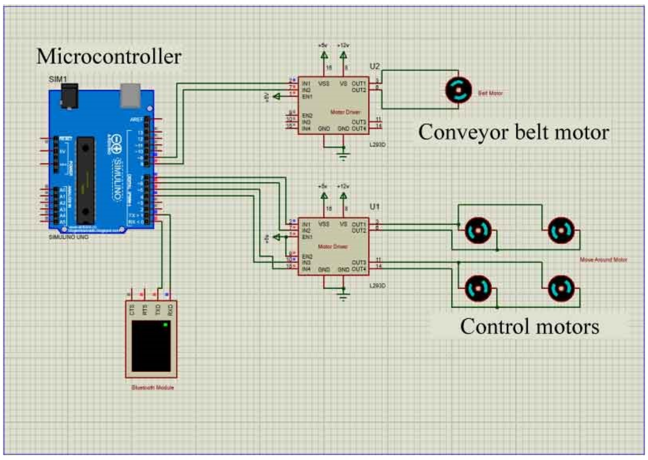

Fig. 2: Circuit simulation of Aquatic Iguana.

To communicate with the robot we have used 'Flysky 2.4G FS-CT6B 6CH Remote Control', which is a 6 channel radio controller and to power up the garbage collection system we have used two 11.1V 1500 mAh lithium batteries, one 5V 4 channel relay module for the driving mechanism and one 5V 2 channel relay module for controlling the conveyor belt. Both of the relays are active high and are capable of providing up to 230V and 10 amp. We have used our radio controller to control the movement of the robot and also to control the conveyor belt. The controlling mechanism is very straight forward and depends on the frequency received from the transmitter attached in the radio controller. Briefly to state, around 1500 Hz frequency from both channels used for controlling allows the robot to remain in neutral position, and increasing the frequency of channel one over 1700 Hz throws a command to move forward and decreasing the frequency less than 1300 Hz makes the robot move backwards. Likewise, increasing frequency more than

1700Hz over channel two, turns the robot in right direction, and decreasing it to less than 1300 Hz makes it turn left. All these frequencies are controlled over the stated 6 channel radio controller. Along with movement on the surface, the robot is capable of rotating 360º on the water surface. The wheels of the robot are built in such a way so that it can cut through water hyacinths and other soft wastes.

To make it easier to collect wastes several blades are attached to the belt. To collect wastes from the surface the robot is taken towards the waste using the driving mechanism and as soon as the robot is close enough the conveyor belt pulls out the waste from the water surface and puts it on to the basket attached behind the robot.

B. Live streaming

The root purpose of live streaming is to make it easier to navigate and collect waste for the operator. Fig 3 shows the basic diagram of the live streaming feature of "Aquatic Iguana". For this, we have used a raspberry pi and pi camera module to create a frame transmitting station. The camera is capable of capturing in 5MP resolution and the raspberry pi can communicate in 2.4 GHz over its WiFi channel.

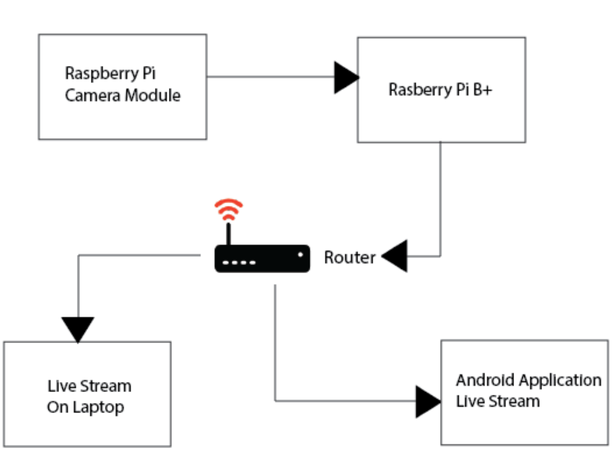

Fig. 3: Diagram for live streaming.

Our live streaming station simultaneously captures frames in 640x480 resolutions making it easier for the station to capture. After capturing the frames the station transmits the frames to the localhost server continuously. So the mobile connected to the same WiFi can easily watch the streaming in real-time using our custom-built Android application. After the robot gets a little far from sight it gets tough for the operator to see if there is any object in front of the robot to collect, the live streaming feature comes in handy here.

C. Water quality monitoring

As our life depends very much on water, maintaining its quality is a critical part as well. To avoid fatal circumstances a support system in water pollution scenario should give dependable and on-time information [12].Keeping the purpose in mind three sensors pH, temperature, and turbidity sensors are used to accumulate data from water resources.

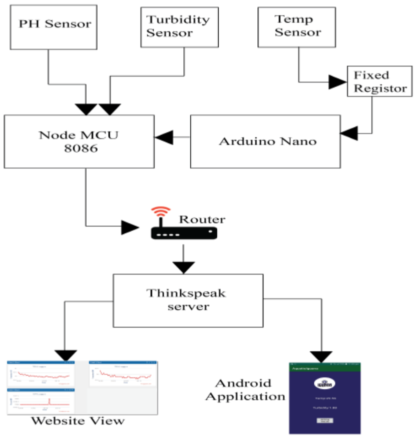

Fig. 4: Workflow of water quality monitoring system

The diagram in Fig 4 shows the overall mechanism of the water monitoring system in "Aquatic Iguana". Sensor values are processed by NodeMcu, Arduino Nano, and sent to ThingSpeak server every 30 seconds. Finally, the graphical representation of sensor data is visible through the ThingSpeak server in real-time, as shown in Fig 5.

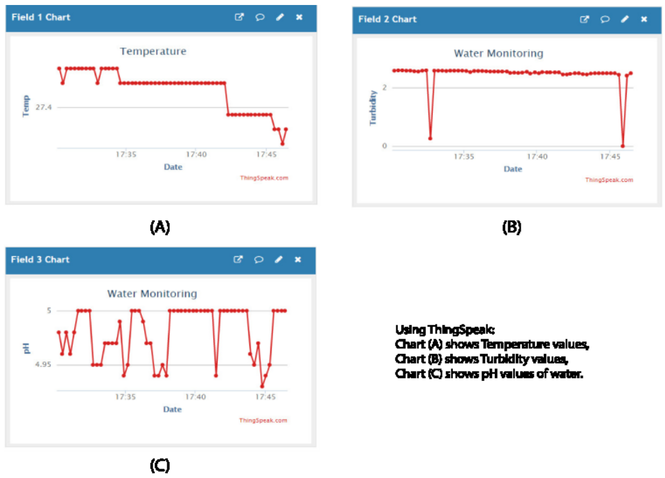

Fig. 5: Graphical representation sensor data in real time

The mobile application used in the system also depicts the last inserted data in the server and we can get the overall processed data from ThingSpeak server in a different format to be used in future predictions using AI and machine learning.

IV. EXPERIMENTAL ANALYSIS

The experiment was performed in various series of sequences to implement and assemble the whole system so that it can collect waste and monitor the quality of water resources. We implemented some initial levels of testing on various features to evaluate the performance of the system.

A. Testing phase of Aquatic Iguana Structure

At this phase, we experimented with three tests and for every testing purpose of this phase we used the nearby lake which is "Hatirjhil Lake, Dhaka". At the very beginning, we tried to experiment whether the robot can float properly on different water surface. After the successful trial, we assembled the overall connection mechanism with a surveillance camera and again tried to test whether the robot can move forward, backward, left, and right using the controller on the water surface. For the final test of this phase, we implemented the water quality monitoring system with pH, temperature, and turbidity sensors and tested these sensors in two separate scenarios: One is by using household water and the other one is by using water taken from "Demra pond".

B. *Testing phase of Aquatic Iguana waste collection and water quality*

Aquatic Iguana was at first tested in the nearby lake to observe its efficiency. After that, we finally tested the whole system in a pond near Demra, Dhaka. The robot collected bottles, woods, coconut shells, and hyacinths. The test results are shown in Table I and II, which proves the efficient mechanism of Aquatic Iguana.

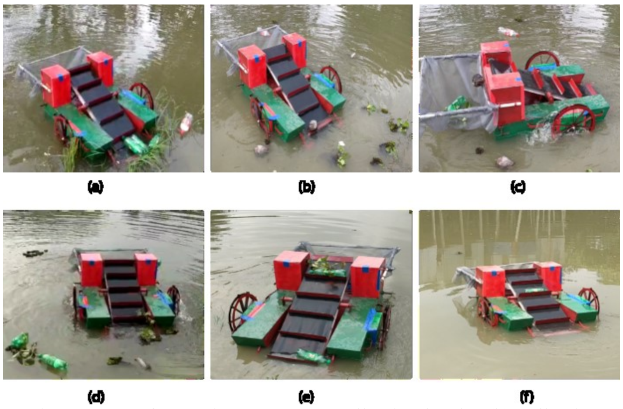

Fig. 6: Test of Aquatic Iguana. (a) Collecting bottles (b) collecting coconut shell (c) dumping the waste in its garbage box (d) collecting hyacinth (e) dumping hyacinth and bottle (f) collecting more bottles.

In the meantime, we also successfully collected data from the pond and visualized those data in the mobile application via the website. We observed different results of pH, temperature, and turbidity of the water as time changed.

V. RESULT ANALYSIS

The existing procedure is very tedious and human dependent [13]. "Aquatic Iguana" has gone through different experimental analysis to come up with the best possible solution in waste management and water monitoring.

A. *Waste management and load capacity*

The full system can carry around 15Kg of waste materials at a time in the waste bin at the back. The conveyor belt has the capacity to pull a maximum of 20Kg of floating waste materials at a time. The use of glass motor has allowed the robot to be more cost-effective and at the same time has increased load capacity. "Aquatic Iguana" was finally tested at Demra pond where it was able to collect 2Kg floating waste in the first 10 minutes.

B. *Water monitoring system with respect to waste management*

Apart from the main waste collecting system, water monitoring and live streaming solution play a crucial part in overall system analysis. Results of temperature and turbidity sensor values are presented in Table I and Table II.

TABLE I. TEMPERATURE ANALYSIS FROM EXPERIMENT PLACE

Place	**Temp(°C) average [each row avg of 25 data]**	**Standard Temp (°C)**	**Temp(°C) average [avg of 125 data]**	**Comment**
Demra Pond	27.75522	18.8-24.5	27.578	Temperature above standard
	27.71783			
	27.48826			
	27.51304			
	27.41565			

Table I reflects the temperature sensor data in °C of Demra pond.

TABLE II. TURBIDITY ANALYSIS FROM EXPERIMENT PLACE

Place	**Turbidity (V) average [each row avg of 25 data]**	**Standard Turbidity (V)**	**Turbidity (V) average [avg of 125 data]**	**Comment**
Demra Pond	2.55	4.2	2.572	High Level of turbidity
	2.57			
	2.58			
	2.57			
	2.59			

Temperature, turbidity and pH sensor values are sent to ThingSpeak Server. As pH and turbidity sensor provide analog value through Arduino, it is then converted to voltage with the range of 0V-5V. Table II represents turbidity sensor data in voltage.

The conversion relationship between analog outputs to voltage as:

$$\text{Turbidity (V)} = TV * \left(\frac{5.0}{1024.0}\right) \quad (1)$$

$$\text{pH (V)} = PV * \left(\frac{5.0}{1024.0}\right) \quad (2)$$

Where TV is turbidity sensor value and PV represents pH sensor value.

Acquired voltage result from turbidity sensor is then converted to NTU (Nephelometric Turbidity Unit) to measure the clarity of the water. In the case of pure water, the output voltage is approximately 4.2V. As turbidity increases, the voltage decreases, and at 2.5V, turbidity is maximum. Similarly, the pH sensor voltage output is also converted to indicate the pH level of water.

Table I and II shows how floating garbage on the water surface is impacting the purity of Demra pond as the natural temperature is above standard and clarity of the water is very low. This can heavily impact the growth of fish and other plants of those surroundings. Round the year, 300 million metric tons of plastic is produced, among–which 8 million metric tons of plastic finds its last destination in the oceans [14]. Besides plastic, much more floating garbage ends up polluting our water resources. Aquatic Iguana's easy controlling, waste collecting system, and reusable waste bin allows it to gather much more waste material than any other existing system. A combination of a water monitoring system, live streaming along with waste collecting capability increases its strong performance possibility over time.

VI. CONCLUSION

In order to keep the water resources clean, we have introduced "Aquatic Iguana", a floating waste-collecting robot. Apart from waste-collecting capability, the fusion of water monitoring system and live streaming feature makes it more effective than conventional ones.

Throughout the paper, we have demonstrated the technical aspect and performance capability of the robot. At present time, since the cleaning of the water surface is labor-intensive, use of this technology is sure to reduce the cost to a great extent and at the same time, the system's ability to gather valuable data on the water quality makes it more effective process for water waste management.

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