ACMD – Aquatic Condition Monitoring Drone

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Abstract- In the modern times pollution is a common issue faced by the people. One of the most troublesome form of pollution is the water pollution. Since Sri Lanka is a country that relies a lot on agriculture, the farms and field mainly use the water from the lakes and other water reservoirs. Therefore it has become necessary to protect those. This project is intended to produce a Water Drone which will help to monitor for water pollution such as chemical dumping and disposing garbage in water bodies. This project will also help to monitor the fish population to ensure that their habitat is not threatened. The Drone will be equipped with GPS for tracking as well as remote controller for manual control.

Index Terms – Water Drone, Sonar sensors, pH sensors, GPS tracking, Water pollution, Under Water mapping, live video stream, Ardunio Based Drone.

1. INTRODUCTION

Lakes and other water reservoirs which harbor aquatics plants and animals needs to be protected from any possible threats. Covering Large water masses with technologies require much resource to work with. Which includes high maintenance and labor cost. Therefore a drone with capabilities of moving around a large water body was decided to be made, which would be much more cost efficient than implementing a large scale system throughout the water body.

From the days of yore Sri Lanka was known for its agriculture, one of the main reasons for the British to capture Sri Lanka was for the moist land it had along with the rain fall. Agriculture was something which was carried out generation by generation and still is continued, one of the main resource for agriculture is water, and one of the main ways of getting water was from rain, but then rain doesn't pour frequently in these lands and an alternative way of supplying water for agriculture was needed, and that's when the importance of lake was found. Whenever water was needed during a drought, water from the lake was diverted and used for agriculture.

As days passed industries, hotels and residents started growing and kept on increasing which made the waste to be diverted into lake to keep the land clean, and little did they know polluting lakes will lead to destruction of aquatic beings which leads to the breakage of the food chain, decrease of oxygen emitted by the water plants and destroying the natural beauty, As an example in Sri Lanka is the Beira Lake which is situated at the heart of Colombo which was used during the Portuguese era, but now several industries have been established around this lake which has made it resemble a green color and gives out a bad odor due to the pollution made by the industries surrounding it. This gives out great discomfort for people travelling or living in that area.

As a cost efficient way onitor the lakes, this drone was made with sensor technology to monitor the water resources. Along with the hardware unit with a pH sensor which reads the pH wherever the drone is. An algorithm had to be developed to map the whole lake and get the difference using sonar technology. A hardware unit to capture the location of the drone and let the user know where the drone is and a hardware unit to capture videos of what is below the drone and transmit it to the user. The main idea was to build the drone at a low cost so it would be easily affordable.

Therefore this project was implemented to monitor lakes and detect water pollution. The system was tested in Lake Gregory, Nuwareliya, Sri Lanka.

2. LITERATURE REVIEW

The literature review is done based on several components related to our proposed Aquatic Condition Monitoring Drone. So that we could identify and differentiate our product among the other related products in the market. The study is based on the following topics which is Sonar Technology, GPS technology, pH Sensor, Live streaming camera, Arduino Boards technology and also about similar existing systems.

An approach for deriving a terrain model from sensor data is presented for autonomous underwater vehicles using a side scan sonar system. The project [1] proposes us in using a geometric reflection model and information about shadows and highlights to derive as estimated bottom contour. It also discusses some general aspects of the type of data and filtering techniques to improve it as well as several techniques of surface reconstruction and their limitations are presented.

Using an autonomous Underwater Vehicle equipped with various sensors such as DVL, IMU, Sonar this project [2] presents a novel integrated approach of creating a 3D surface of map of seabed terrain. Acoustic sensors mounted on AUV helps overcome the unfavorable underwater conditions like low visibility. Down-facing multi-beam sonar sensors are used to capture the terrain data. The Long Baseline (LBL) localization system and PID controllers are used to drive the AUV to the set-points given by the navigation controller. The collected data is then used offline to construct a 3-D map of seabed using alpha shapes.

There is a nationwide issue of fishermen cross the country border. Using technologies like Global Positioning System

(GPS), ZigBee (Transmitter) and Peripheral Interface Controller (PIC).The project (GPS Based System for Detection and Control of Maritime Boundary Intruding Boats) [5] proposes a solution to the problem faced by the fishermen. This is a GPS based boat tracking system which would safe guard the fishermen from the potential dangers they might face, by giving them pre-warning in case of trespassing. Instead of one or more people monitors the all boats continuously, this system sends information only about trespassing boats to the person in control room. Navigations were given to the boats from the control room to get back to the safe region. In the system the boundary is detected using GPS in real time and the retrieval was followed by vital information being sent to the PIC for taking corresponding actions.

In order to improve the mobility of the traditional video surveillance system, thispaper [11] puts forward a design of embedded video surveillance system based on 3rd generation mobile telecommunications. This system using Arm11 as the core processor which has high performance data processing and it uses embedded Linux as the operating system. Here the research group used CMOS camera to capture video and used 3G wireless network to transfer video data instead of traditional wired network. C++ is chosen as the development language for both server side and client side application and ARM11 is composed of the main controller module. 3G module is used that is produced by HUAWEI which can transfer video data over a wireless network and this system realize video capture, H.264 compression, and some other functions.

This paper [4] introduces a camera surveillance system in wireless communications. The system contains three major modules, PTU (pan-tilt unit) camera control for surveillance video capture, cross-layer control for data compression and transmission, and error concealment for video quality enhancement. The architecture of the wireless video surveillance system is transmitter is responsible for video capture and data transmission and camera is controlled by both the commands from a remote control unit and the local tracking result. The captured video is recorded by the local tracker and is sent to the data processing center and video is processed at the data Centre for compression and transmission over the wireless network. The remote control unit performs error concealment on received data and provides necessary feedback to the transmitter.

A wireless passive sensor for remote in vivo milk pH measurement is proposed in this project (A wireless passive pH sensor for real-time in vivo milk quality monitoring) [14] sensor consists of iridium oxide and a silver chloride electrode. The sensor is attached to the side wall of a container or packet and the frequency given out from the container is captured, the pH is measured using the voltage difference across the electrodes. An impedance analyzer and an interrogator coil are also used to get the resonant frequency from a distance. This doesn't go in contact with the milk which doesn't affect the milk in any ways.

A fiber pH sensor pH sensor based on an air-gap long period fiber grating in a multi-modes fiber is proposed in the project (Fiber pH sensor based on long period gratings) [15] different sensitivity levels are given for acid solutions and alkaline solutions. Whenever there is a change in index the wavelength shifts due to the core and cladding layers. This simple system can be used in long-term monitoring of pH values in drinking water or testing solutions.

3. METHODOLOGY

Prototyping Methodology was selected as the methodology in order to develop the "Aquatic Condition Monitoring Drone". Designing and Implementation Phases were done concurrently and iteratively until the system met all functional and nonfunctional requirements. The initial prototype was built with minimum features and only the base function of each component was programmed. There upon each stage of the prototype the components were integrated and complete list of features were added one by one.

A. Planning

Planning phase was starting at the beginning of the project the system to be built, scope of the system and possible risk that may arise were discussed and identified. A feasibility analysis was done to make sure the project was feasible.

B. Requirement Gathering and Analysis

Analysis phase focused on gathering information and analyzing the difficulties faced by the authorities in maintaining the lakes and other water reservoirs. The data sources used for analysis was categorized as primary and secondary data sources. As primary data source an interview was held with the irrigation department authorities in charge of lake and reservoir maintenance. The gathered data from primary source was more helpful to accurately determine the requirements for the system. The Secondary data source was the past research journal and internet articles on the topic which helped us confirm the requirements and understand the possible risks involved in the development of the project.'

C. Design

The primary objective of design phase is to create a design that satisfies the requirements. Initially the overall design was based on the High level diagram (Figure 1). From there a blueprint was drafted for the drone upon which the initial prototype was built. The sonar, camera, pH sensor and GPS tracker are the components attached to the drone, they will read the transmit data through the drone Wi-Fi module, which will be received by the System.

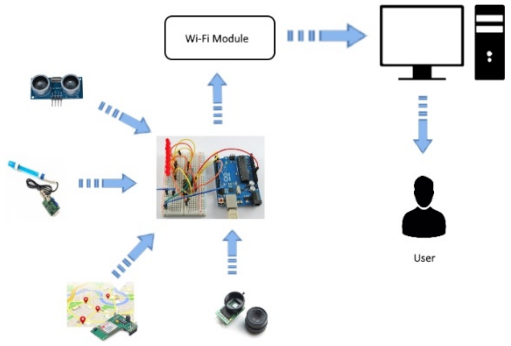


Figure 1 : Over view diagram

The System will then use the data obtained from the sonar sensors to generate a contour map allowing users to better understand the lake. The Camera will allow the user to live monitor the lake when needed with an ability to detect anomalies with water through object identifier. The equipped pH sensor will continuously transmit the pH data in order to monitor the toxicity of water in the lake and alert the user if it reaches a threshold set by the user.
The interface will display the current location of the drone and allow the user the control the drone manually if needed as well as display the information processed using the data to the user allowing him/her to make necessary decisions.

D. Implementation

Implementation is the fourth stage of SDLC where the project team transformed the design into a working system. Visual Studio was the IDE used to develop the System and many libraries were used to achieve desired functions as well as improve the performance of the System and ease of application development.
Since the data needed for processing has to be stored for processing of map and comparison of pH values, a database was created. MYSQL database was used for this and PHP was used to communicate with the database.
The Sonar and pH sensor will transmit the data which will be stored in the database, the system will then retrieve the collected data to create the contour map using the depth data taken from sonar and the longitude and latitude data transmitted through GPS Module to create a contour map of the desired lake. pH values stored in the database will allow for comparing of values in the lake to assess the situation of the lake. The camera will use an IP address to directly transmit the data to the system in order to avoid delays along with GPS to monitor the location of the drone.

4. RESULT AND DISCUSSION

The Aquatic Condition Monitoring Drone desktop application is created using C# language. Using this application, User can control the drone and get information from it.

This application allows the user to control the drone. Figure 2 shows the implementation of this functionality.

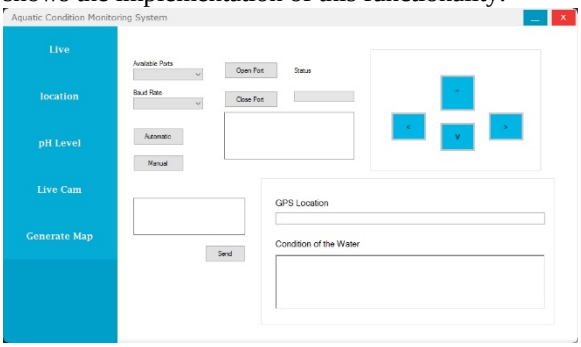


Figure 2: Desktop Application (Live Page)

The location of the drone can be identified using GPS location page and also the movement of the drone also can be tracked using the desktop application. Figure 3 show the implementation of this functionality.

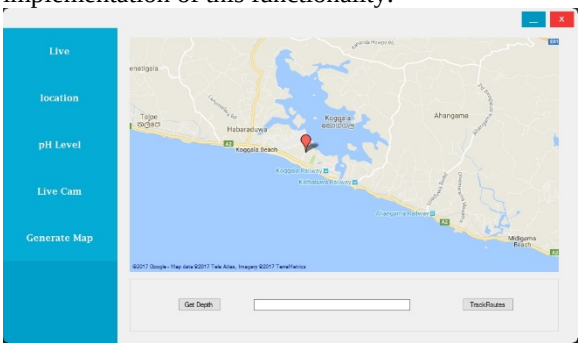


Figure 3: Desktop Application (GPS Location page)

Desktop application allows the user to get live feed of the lake from the camera attached to the drone and to detect the floating objects using the color. Figure 4 shows the implementation of this functionality.

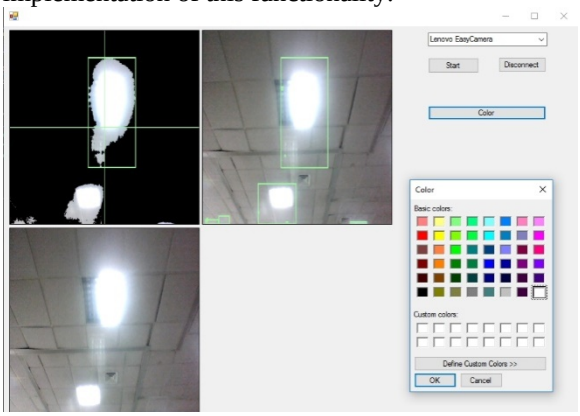


Figure 4: Desktop Application (Live video Page)

pH value of the water can be checked using the pH value page. Figure 5 shows the implementation of this functionality.

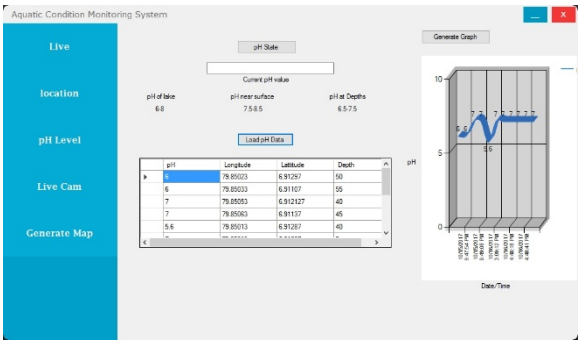
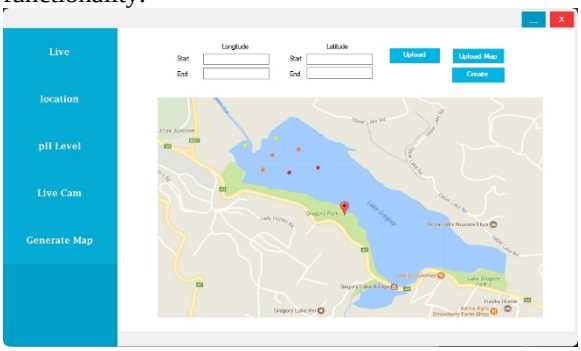


Figure 5: Desktop Application (pH value Page)

Desktop application allows to generate a map of the lake to identify the depth. Figure 6 shows the implementation of this functionality.



The "Aquatic Condition Monitoring Drone" was built with the overall objective of maintaining the local lakes which is preventing them from getting polluted.

While building the drone the team had to experience some technical issues the following are those issues along with how the team managed to overcome those issues.

The most important issue was the Wi-Fi module which was planned to be used for this drone, while building the drone the proper module could not be found to build the drone therefore in order to overcome this issue a Bluetooth module was used, another main drawback of the Wi-Fi module is that it has to use an online database where the data has to be sent to the online database via a channel and retrieved from the database which doesn't give data real time.

The Assumptions made when developing the drone are as follows

- User has to have a basic knowledge of using a computer and the standalone application.
- The User is nearby within the Bluetooth range.

5. CONCLTION AND FUTURE WORKS

Rapidly increasing population, urbanization and industrialization have been the major reasons for lake pollution. The Aquatic Condition Monitoring Drone gives the best solution by not letting the lake get polluted and identifying the pollution problem early on and fixing it. The Drone moves around the lake and every given interval the drone retrieves the co-ordinates of where the drone is, the pH value and the distance to collision, when moving around if collision is detected within 5cm the drone automatically re-routes to another direction. All the retrieved data are sent to the database and retrieved to a standalone system where the user can keep track of and watch each and every part of the lake. Based on the statistical analysis it can be concluded as the GPS and the sonar sensors are really important in navigating the drone around the lake, finally the project achieved to fulfill all the objectives of this system and wish this project would be a real benefit to the society and enrich living. The research team wishes that this study will be helpful for the researches who are interested in related topics. This project will give better ideas and more knowledge to implement similar kind of projects or hi-technical projects with more advance and costly tools.

Following are the limitations which were found out by the research team about the "Aquatic Condition Monitoring Drone"

- Wi-Fi Module
  Initial plan was to use a Wi-Fi module for the drone, while building the drone the proper module could not be found to build the drone therefore in order to overcome this issue a Bluetooth module was used, and another issue with the Wi-Fi module was an online database where the data has to be sent to the online database via a channel and retrieved from the database which doesn't give data real time.
- Underwater Camera
  As the cost for the underwater camera was high we could not afford an underwater camera but all the functionalities needed for the underwater camera had been implemented on a phone camera.
- Sonar Mapping
  A 3D map of the lake could not be generated.

Accordingly Aquatic Condition Monitoring Drone System has shown 80% of accuracy level and moderate rate of reliability level. The level of reliability has been achieved by testing different kind of water to ensure proper pH value monitoring. Monitoring of overall water monitoring process and retrieving to the desktop in real time makes Aquatic Condition Monitoring Drone system highly reliable. This real time process has been achieved through real time Bluetooth transmission. Cost effective GPS module and desktop application provides a reliable interface to the user. Rechargeable battery and battery life of the Aquatic Condition Monitoring Drone are some other reliable factors. The drone will detect collisionusing the ultra-sonic sensor which is attached to the drone. This is also a reliable factor.

Accuracy level of Aquatic Condition Monitoring Drone System has been calculated based on the accuracy of some major components. Accuracy of pH sensor, Accuracy of ultrasonic sensors, Accuracy of GPS module, Accuracy of Bluetooth module and live video streaming are major accuracy factors considered when calculating accuracy level of Easy Clean System. The GPS module used in the Aquatic Condition Monitoring Drone is cheaper module which is the reason for decreasing accuracy.

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