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Real-Time Monitoring System for an Aquatic Surface Cleaning Robot using MIT App Inventor

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Abstract: Nowadays, certain water resources in Malaysia have been polluted by garbage and also industrial trash due to the irresponsibility of some individuals and organizations. The polluted water has destroyed the aquatic ecosystem in the area. Normally, cleaning is done using big and bulky machines or using a manual operator to clean the water surface. The issue of cleaning with bulking machines, it will destroy and interrupt the existing ecosystem. For manual methods, sometimes it is dirty and dangerous. Even worse with the presence of sewage. Therefore, to overcome this problem, a portable surface cleaning robot is proposed. This device will help to clean the surface of the water and it also will be on a very wide controllable range. The Aquatic Surface Cleaning Robot is one of the initiatives to reduce the polluted water issue by cleaning unwanted foreign objects such as plastic products on the water surface. It will conduct activities such as removing algae, foreign objects and monitor water quality. In addition, the platform is embedded with a real-time vision monitoring system for better user interaction to control and longer range of control signals. Furthermore, it enhanced the overall design.

Keywords: Aquatic Surface Cleaning Robot, Polluted Water, Real-Time Vision Monitoring System

1. Introduction

Ever since the epidemic hit Malaysia a few months ago, certain water resources in many rivers in Malaysia have seen a growing trend in new pollutants that particularly consist of hand sanitizer bottles, face masks, and gloves. A recent study demonstrated that live SARS-CoV-2 was isolated from the feces and urine of infected people, which would then enter the wastewater treatment system through sewage

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pipe networks and determine whether there are potential SARS-CoV-2 carriers in certain local areas [1].

Therefore, it is crucial to develop an efficient transportable system to help cleaning and sample the water status. To overcome this problem, a portable surface cleaning robot is proposed. This device will help to clean the surface of the water and it will also be on a very wide controllable range [2]-[3]. Aquatic Surface Cleaning Robot is one of the initiatives to reduce the polluted water issue by cleaning the unwanted foreign objects such as plastic products on the water surface [4]. It will conduct activities such as removing algae, foreign objects and monitor water quality [5]-[8]. Such a good approach could provide near real-time and continuous data and serve as an early warning sensing system to help non-government agencies and local governments make effective interventions to isolate potential virus carriers and prevent the spread of the epidemics.

There is some drawback when using bulky machines or using manual operators for aquatic cleaning, it will interrupt and destroy the existing ecosystem and sometimes it is dangerous for manual methods. Therefore, a portable surface cleaning boat robot will help to ensure the surface of the water is clean and it also will be on a very wide controllable range. The drawback of the existing platform, it is difficult to monitor the working environment from afar and the propulsion system works at extremely low speed. Therefore, the platform will be upgraded to embed a real-time vision monitoring system for better interaction to control and a longer range of control signals. In addition, the overall design will enhance.

It will be focusing on how to improve the existing portable surface cleaning robots in terms of GUI and portable apps. Moreover, this project is also able to monitor water status in the selected aquatic environment. By developing the graphical user interface system for Android Operating Systems, MIT App Inventor will be used as the communication platform. This project will be capable of monitoring wirelessly in an aquatic environment. The real-time monitoring system can provide live feed, capture pictures, detect water pollution and as might be expected to collect waste on the surface of the water.

2. Materials and Methods

In order to sketch the real-life project design, SketchUp software was used to show the 3D model of the development project design. For the development of the project design concepts were applied to minimize space and to make the project portable. The overall architectural design of the proposed aquatic surface cleaning robot is shown in Figure 1. The top view of an aquatic surface cleaning robot consists of an electronic box that will secure all the electronics components inside of it from any possibility of danger that could happen during the operation of the robot. At the bottom of the aquatic surface cleaning robot there are a couple of cylinder Styrofoam that have been implemented to the robot.

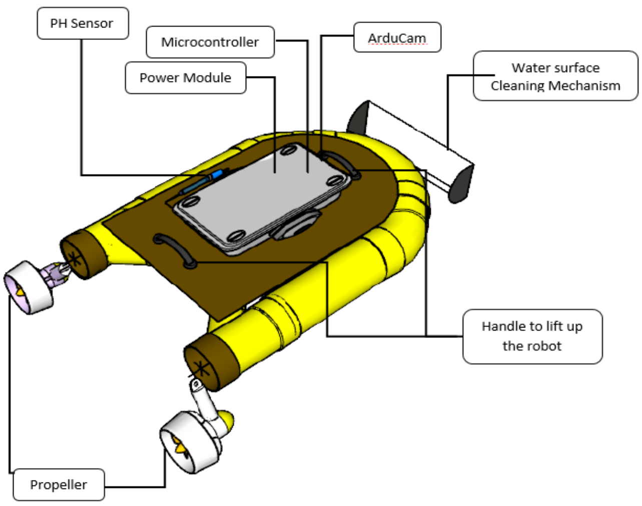

Figure 1: Overall view of the positions of all components of surface cleaning system

2.1 Materials

There are three main modules in this real-time monitoring system for an aquatic surface cleaning robot. The aquatic surface cleaning robot weighs 6.8 kg and its dimension is 1.42 m (length) x 0.97 m (width) x 0.38 m (height). The aquatic surface cleaning robot architecture is composed of, water surface cleaning system, monitoring module and propulsion system.

The controllers that are used by this system are ArduCam UNO board and NodeMcu. The ArduCam UNO board is used only for the camera system that was implemented to give vision for the user. Then, the NodeMcu is used for controlling some features that are two sets of thrusters and electronic speed controller (ESC) for the maneuverability, control and four channel relay that function to change the rotation of the motor such as clockwise or anti-clockwise.

2.2 Methods

The aquatic surface cleaning robot that tele-operates with three different main functions, that are surface cleaning, collection via camera and detecting water pollution. A wireless based controller was the chosen controller that used Wi-Fi based communication protocol for communication of robot with user end. The remote control used is a smartphone IOT platform called MIT App Inventor. The NodeMcu microcontroller module is used to act as an interface unit between robot and user. Figure 2 shows overall project system.

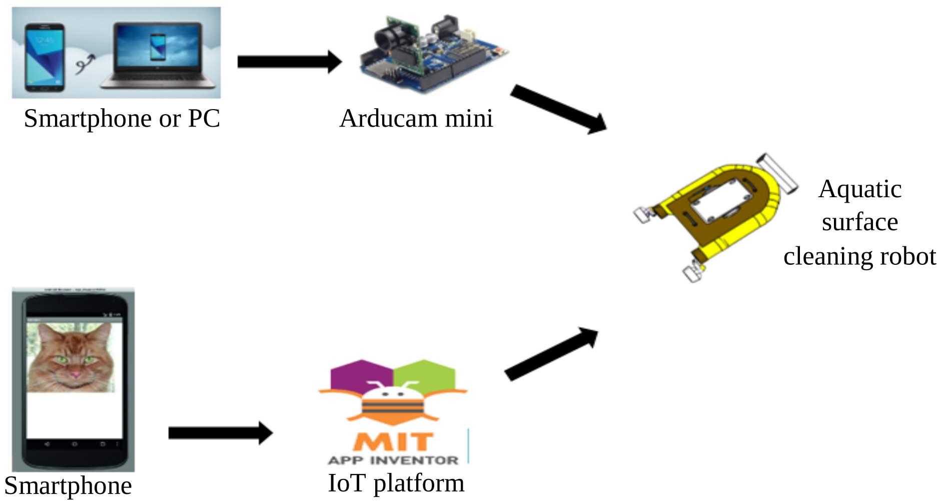

Figure 2: Overall project system

Based on Figure 2 the MIT app Inventor is an IoT platform that is suitable for this project and it also provides several functions to control and monitor the robot activity. Furthermore, the MIT app Inventor is one of the platforms that are more suitable to use in terms of suitability in industry instead of the Blynk app. The features that are used in the app are 5 buttons for controlling the robot movement via thrusters, one value display widget for the pH sensor.

The concept of the robot cleaning mechanism is that it will capture the waste on the surface and trap it, especially the waste in front of the robot. The robot uses a tele-operate control system, it requires the user to navigate the robot towards the waste for the cleaning process. New feature has been added to the system of the aquatic surface cleaning robot, this system will be able to give a vision for the robot during the cleaning process. The vision feature also can be effectively used to collect data in the cleaning process such as pictures and recorded video for future reference in the cleaning area.

Other than that, another improvement on the feature has been added to the system of the aquatic surface cleaning robot, this system will be able to detect water pollution. The NodeMcu is used to send data wirelessly of the polluted area using a pH sensor and at the same time the robot process can be monitored.

The user will be able to control the aquatic surface cleaning robot using a mobile device via MIT app Inventor. Two underwater thrusters were used in this project for the maneuverability of the robot.

The real-time monitoring system enables the user to control and monitor the cleaning process through the ArduCam mini camera module.

At the beginning step to develop this aquatic surface cleaning robot the design phase should be conducted first before the implementation of this system as discussed in the previous subtopic. A real-time monitoring system for an aquatic surface cleaning robot uses MIT app inventor as the platform to control the robot, the process of the project is allocated into a few phases as shown in figure 3. Second stage is the project development. This process includes the development of an algorithm to implement the real-time monitoring system into the aquatic surface cleaning robot by using Arduino IDE software. Moreover, this process also includes the improvement of the connection on electrical parts and algorithms of existing projects to make it suitable to implement the real-time monitoring system on the existing project circuit board. Figure 3 shows the general plan structure to implement the system and also improvement of the aquatic surface cleaning robot.

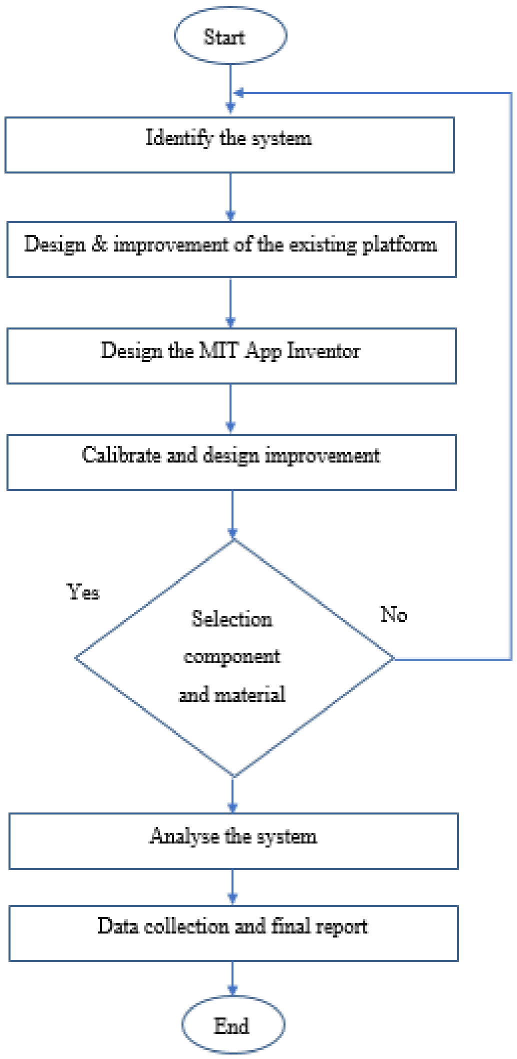

Figure 3: General project flowchart

2.2 Hardware specification

The aquatic surface cleaning robot is a robot that has more than one feature. Thus, the robot required a specific type of hardware. The selection of hardware based on the requirement that was needed. Table 1 shows the list of hardware used for this project.

Table 1: Hardware description

Item	Description
Body length	1.42 meter
Body height	0.38 meter
Body width	0.97 meter
Weight	6.8Kg
Power	12V Lead Acid battery with 7.2AH
Communication type	Wi-Fi
Type of motor	970KV brushless motor
Body material	PVC pipe
Net material	HDPE
Number of thruster	2
Movement control type	Underwater thruster at the back of robot
Type of camera	ArduCam mini 2mp
Image size	640 x 480 (VGA)
Microcontroller type	ArduCam UNO board and NodeMcu
Sensor	pH sensor

3. Results and Discussion

This section will be focusing on the discussion of the result of a test and analysis for a real-time monitoring system for an aquatic surface cleaning robot. It will be discussed on the result and analysis of the software and the hardware of the project. The discussion will include the mechanism and structure of the robot, electrical and electronic design, and the controller part.

3.1 Mechanism and structure of the robot

The overall structure of the aquatic surface cleaning robot is finally developed from the combination of PVC pipe as shown in Figure 4.

Figure 4: Final result of the surface cleaning robot

The movement and the stability of the robot needs to be considered due to several major factors such as wind and water resistance. One of the advantages it is consists of a strong base and less resistance as shown in figure 4. This type of material will increase the buoyancy capability of the robot. Besides that, PVC material is lighter compared to other materials such as wood and metal. The electronic safety box is made of waterproof material with a seal and it will be implemented as the casing of the electronic device and components used such as the microcontroller, NodeMcu, ESC and battery. This safety box will be placed on top of the plywood that fits on top of the robot.

3.2 Real time monitoring system

There were three features that allow users to record video, access the live feed video and capture pictures during the cleaning process. By using the real time monitoring system it allows users to monitor the aquatic surface cleaning robot via live feed wirelessly. The ArduCam and ESP8266 ArduCam UNO board has been used to build the system. The system works by connecting the ESP8266 ArduCam UNO board with WiFi via station mode. The WiFi is used as an access point, all the devices that are connected to the same access point will be able to access the data through the selected medium. Figure 5 shows several pictures that have been taken by ArduCam by using the smartphone app which is the ArduCam app. Both of the pictures show that the quality is good and viewable.

Figure 5: Some captured picture by ArduCam

The real time monitoring system can also be implemented by using the MIT app inventor. The capturing picture and video recording can be taken by using the smartphone app which is the IP webcam app. The system will work by entering the IP address generated from the IP webcam application on the IoT platform. Next the start button is clicked in order to display the live feed video, capturing picture and recording a video. By referring to Figure 6 it shows that the system can be monitored and controlled at the same time. The split-screen method makes the aquatic surface cleaning robot perform the cleaning and monitoring process efficiently. The split-screen is provided for almost all android phones.

Figure 6: Split screen method

3.3 Water Quality Monitoring System

The implementation of a pH sensor in this project will help to maintain the river cleanliness compared to the human workforce. It helps to keep track of the water quality in a certain water condition at every lake, pond or river. Due to the lack of convincing methods, a full automation system or robot is seen to be the most effective method to maintain the river cleanliness compared to the human workforce.

Figure 7 shows the configuration in the MIT app inventor. To display the data from the pH sensor, Bluetooth module Hc-05 is connected to the Arduino UNO board along with the pH sensor. This process is conducted separately from the robot system which means it is tested to the pH module only. Unfortunately, the data is unable to show in the MIT app inventor configuration due to some deficiency occurring in the programming part of the Arduino.

However, the data for the pH value is successfully displayed by using another IoT platform which is the Blynk app. The process of taking the data is the same with the calibration process. This process is conducted in order to achieve the most accurate result from the pH sensor. The data taken is based on two samples of water which is the distilled water and alkaline water.

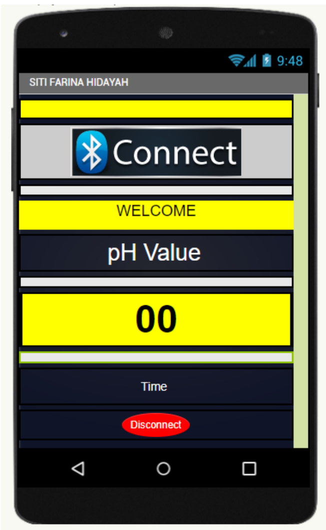

Figure 7: Result from MIT app inventor

3.4 Controller part

The ESC brushless motor is used in this project for the robot movement and controlled wirelessly using five virtual buttons in the IoT platform. It has been connected to virtual pin 8 (V8), virtual pin 6 (V6), virtual pin 5 (V5), virtual pin 4 (V4) and virtual pin 3 (V3). The system provided the robot to move left, right, forward and backward.

The movement of the robot can be controlled by using the buttons that have been introduced in the IoT platform. The parameter that takes into consideration in this part is the distance and speed *(m/s)*. By using the formula of $d = s/t$ *(m/s)* the speed of the robot can be calculated during the testing and data collection process.

Figure 8 shows the button used to initiate all of the robot movement. Based on Table 2, to initiate the robot to move forward, the left and right motor need to turn clockwise. To make the robot initiate the backward movement, both motors need to turn counter-clockwise. The robot will move backward with the counter-clockwise rotation of the motor. The robot will initiate left movement when the left motor is turned counter-clockwise and the right motor is turned clockwise. The counter-clockwise rotation of the right motor and clockwise rotation of the left motor will make the robot initiate right movement. In order to stop all the motor movement, the right and left motor has to stop turning. By clicking on the stop button, both motors will stop and the robot movement will be in steady state.

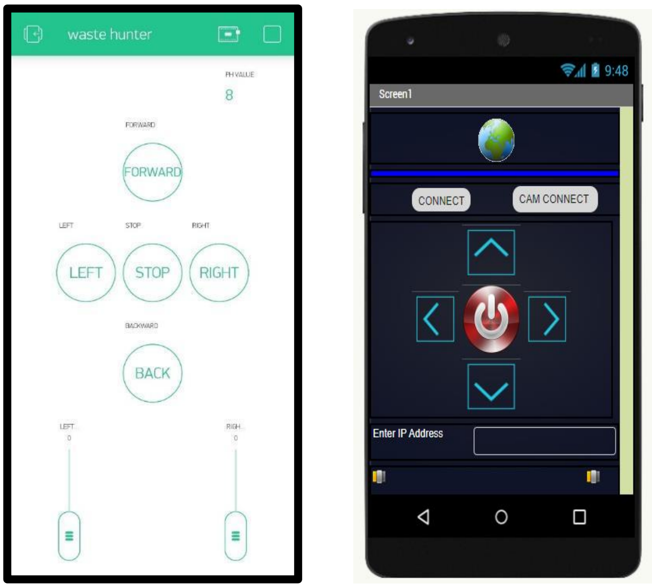

Figure 8: Layout for the robot movement

Table 2: Robot movement

Robot Movement	Left Motor	Right Motor
Right	Clockwise	Counter-clockwise
Left	Counter-clockwise	Clockwise
Forward	Clockwise	Clockwise
Backward	Counter-clockwise	Counter-clockwise

4. Conclusion

To improve and develop a wireless vision live feed real-time monitoring system for aquatic surface robots is one of the aims of this project apart from enhancing the surface cleaning robot maneuverability. Some of the objectives of this project are achieved even though the project has not reached the full testing phase. There are a lot of improvements required for this aquatic surface cleaning robot in order to create an excellent final product. As a result, the robot managed to do all the movements successfully. The speed of the robot can be controlled by using the IoT platform that has been created. As a result, the robot can perform all the movements as expected and it can be controlled by the IoT platform. This robot gives good maneuverability even when there is a fast water movement and higher air resistance. Last but not least, the real-time monitoring system provides three main features which are, live feed video, video recording and picture capturing. With all the points that have been made in this section it is stated that this system works as expected in the desired phase which is the testing phase in order to capture picture, record video and to perform live feed. However, it still needs to be improved in order to provide users with a good quality of picture.

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