Development of Surface Cleaning Robot for Shallow Water

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Abstract Aqua pollutant (river, sea, lake, etc.) is one of the major problem that occurs around the world including Malaysia. One of the major cause of the pollution come from rubbish and illegal toxic waste dumping. This cause the destruction to the aquatic species and ecosystem. River cleaning is usually done when river pollution is in critical condition. This is due to the labor cost of each cleaning project, scheduling problems and shallow water environment. Therefore, the river cleaning system is crucial to ensure that rivers are clean and free from pollution. This project aims to design and develop river cleaning robot to enable real-time monitoring of water cleanliness. Inspired by Indian lake cleaning project, the Waste Hunter Surface Robot is smaller in size and portable. The Waste Hunter Surface Robot is tele-operated robot with two main functions, which are surface cleaning and water quality monitoring. It has a flexible design to clean the various impurities on the surface and below the river's surface and trench. By implementing an automation system, the system enables in monitoring 24/7 the cleanliness of the water. This project is expected to reduce labor costs and save a large number of states or districts of money.

Keywords Surface cleaning robot · Shallow water · Water quality monitoring

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1 Introduction

Malaysia and many develop country may be assume that most the local community are not care of rivers compare with the developed country such as Netherland. For the sake of the river that mainly used for drinking and daily household work, the government have taken a lot of initiative to maintain the cleanliness of the water. One of the initiative is the river of life program and one river one state program. Due to costing in order to maintain the cleanliness of the river, an automation system or robot is seen to be the best option for maintaining the river cleanliness compare with human workforce. According to the Malaysia Nature Society (MNS) vice-president Vincent Chow, pollution have made the river to become low-oxygen environment. This cause the destruction to the aquatic species and ecosystem [1–3] . A lot of initiative has been taken by the government and non-government agencies (NGO) to clean the river. According to the Star Online article on Monday 7 April 2014, over RM25 million were spent by the federal government and the number keeps increasing from year to years [4]. This is due to the labor cost, In order to reduce the cost, many initiatives taken, including usage of autonomous machine that are more efficient compared to traditional ways [5–7].

2 Surface Cleaning Robot

2.1 Concept

The river cleaning robot or Waste Hunter Surface Robot is a semi-automatic robot with three different main functions, which are surface cleaning, purification process and water quality monitoring. In this section, there will be an explanation on the working process of the robot and all input output (I/O) used. The robot is semi-automatic control robot where the robot will be turned on and off, makes a movement form the input gain from the user. Wireless based controller were used with WI-FI based communication protocol to communicate between the user and the robot. The remote control used is the smart phone apps called (Blynk) virtual button keypad as shown in Fig. 1. The Nodemcu microcontroller module is use to interface unit between the user and robot.

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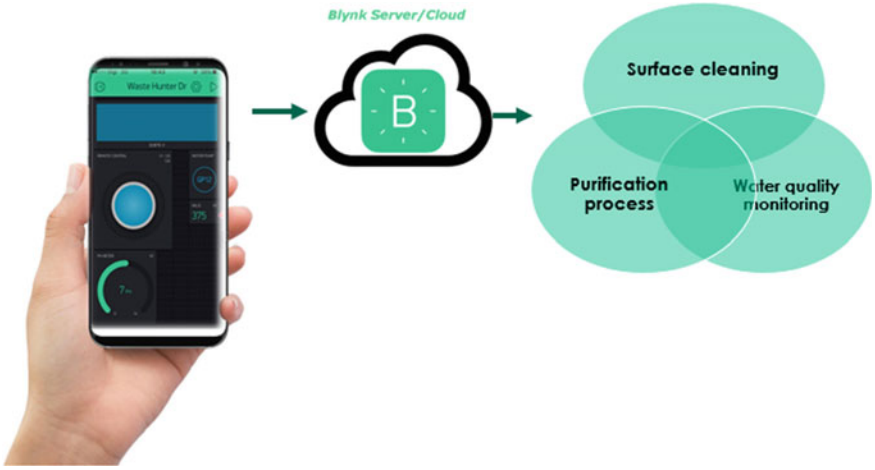

Fig. 1 Waste Hunter concept

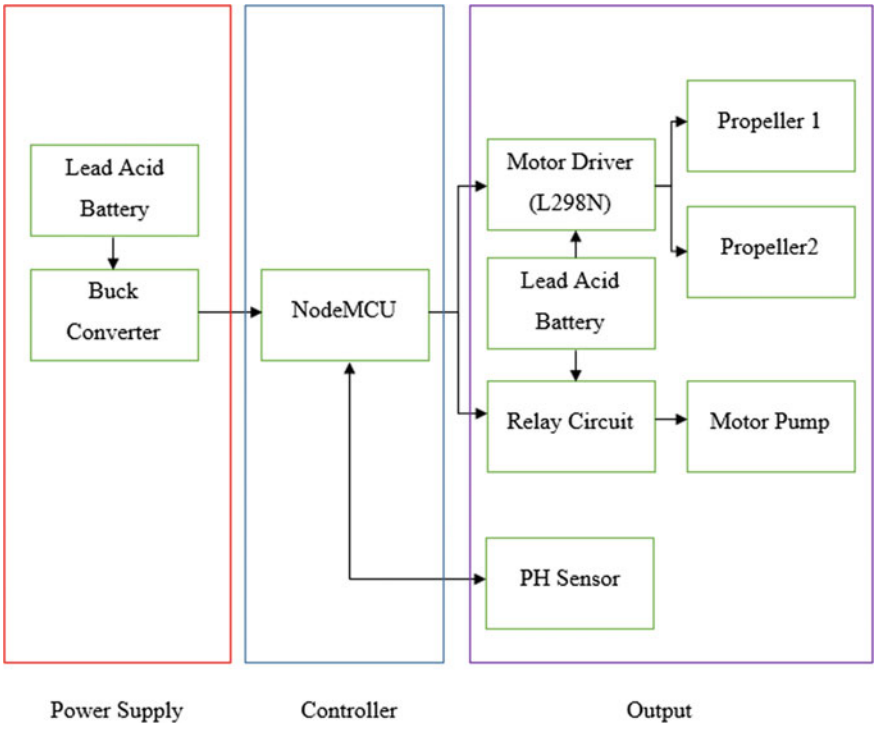

Fig. 2 Waste Hunter Surface Robot system architecture

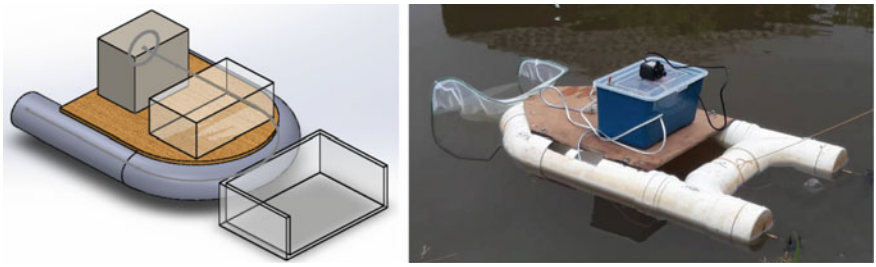

Fig. 3 Waste Hunter Robot

2.2 Design

The cleaning mechanism is inspired from the Ro-Boat where the cleaning system is surface cleaning. The concept is the robot will capture the waste on the surface and trap it. This robot features are not advancing mode where it does not have any intelligent visionary in order to detect and differentiate between waste or not waste on the water surface. The system is tele-operated, where the user need to control it and clean up the waste by controlling the robot and trap it to the trapping unit.

The robot is added on with some additional function, water purification system. The systematic use two stage filtering unit, at the first stage there will be sediment filter, the sediment filter will filter the con-termination that can be seen by the naked eyes. At the second stage the use of carbon filter will help remove the heavy iron that contains inside the water in order to increase the quality and stabilize the water PH. Figures 3 and 4 shows the design of the Waste Hunter Robot and the Virtual Joystick.

3 Result and Discussion

Initially, the trapping unit is used to trap the solid waste on the surface of the water. The trapper was installed at the front of the robot and it submerged a meter below the water surface in order to trap waste that submerge below the surface of water. The trapper is made up from the nylon net. If the net is broken or torn out, it is easy to replace and cheap in price. The nylon net is chosen due to the material strength is tough, water resist, and free from oxides compared to metal net that can easily rust and get broken.

Fig. 4 Virtual Joystick (V1)

3.1 Surface Cleaning

Since the robot is only surface cleaning, it only can trap and catch only waste that a on the surface of water only. Figure 5 show the robot taking waste on the water surface, first waste is plastic bottle and second waste is plastic bag. It is easy to trap plastic bag since half of its body are trap below the water and the movement is minimum compared with plastic bottle.

Fig. 5 Waste Hunter surface cleaning

Fig. 6 Two stage filter unit

Fig. 7 Filter water before and after

3.2 Purification Process

Figure 6 shows the filtering unit that will be used with the robot. The filtering unit is a combination between two different types of filter material. At the present time the material used for the filter is from readymade material. For the carbon filter, the target material is active carbon. However, for time being it will use charcoal and for the sediment filter the material will change to filter mate.

The result for the filtering unit is as shown in Fig. 7. Due to the filter is still on the prototype stage, so the filtering efficiency is not to excellent as predicted. However the filter capable to reduce contamination in the water and improve the colour of water and smell.

3.3 Real Data Monitoring

One of the main objective for this work is to measure and view the water quality on real time. The data measure is the water PH values. The PH value is the easy way to decide either the water is suitable or not for aquatic live to live inside the water. All the data collected will be sent to the user in real time monitoring by using Blynk apps as shown in Fig. 8.

The sensor data were send to the microcontroller and user can read the value in the gauge meter as shown above and the data will be update and auto refresh for every two second since the push notification algorithm is used. Standard value for

Fig. 8 PH monitoring indicator in real time

the PH will be display from 0 to 14; (0–6) for acid, (7) neutral, (8–14) for alkali. The sensor read the voltage changes in mV at the pin A0 and the microcontroller convert it to the standard PH value reading ranging from 0 until 14.

3.4 Maximum Range and Operating Time

The maximum range can be achieve by this robot is depend on the internet strength connectivity. At the first stage of testing the internet connection use is the personal hotspot from mobile phone. The limitation of this method is the short range of the connection which is only 20 m. The personal hotspot introduce problem in term of connection since the connection is unstable when disturbance exist. In order to increase the maximum range, portable Wi-Fi hotspot is used which extend the control range to 150 m.

In term of operating time, the maximum operating time using one lead acid battery is 7 A per hours as shown below

Battery rating = 7 A/h
2 × Motor current usage (with load) = 0.6 A × 2 = 1.2 A

Fig. 9 Location 1 (Taman Bistari Indah trench)

Motor Pump (maximum volt) = 0.4167 A × 1 = 0.4167 A
NodeMcu (Wi-Fi module) = 0.5 A × 1 = 0.5 A
Operating Hour (full load) = 7 AH/(1.2 A + 0.1467 A + 0.5 A) = 3.8 h.

4 Operational Test

The operational testing were carried out in three shallow water environment. During the test, the surface cleaning robot is examined with four movement condition which are forward, backward, left and right movement. These test is important to investigate the surface cleaning robot motion behavior. The tests were performed near Batu Pahat area as shown in Fig. 9 until Fig. 11.

As shown in Fig. 9, the length of the testing point is only 5 m length. The flow rate sensor indicate almost zero flowrate reading. Second testing location is at the Lake at UTHM as shown in Fig. 10. The flow of water in this location is range of 0.3 m/s to 1.3 m/s due to light wind breeze.

Third testing location is near Taman University trench as shown in the Fig. 11. The trench is width is about 2 m. From the observation, the surface vehicle encounter difficulty to perform left and right rotation. Several adjustment are made to get the desired output for the motion. Each data were tested five times. Table 1 shows the summary of the movement performance.

The result shows that surface cleaning robot were able to reach the desired location under minimum wind condition. However, the surface cleaning robot is hard to move in open environment with strong water compare clam water environment. This may due to the open environment which allow higher wind resistance.

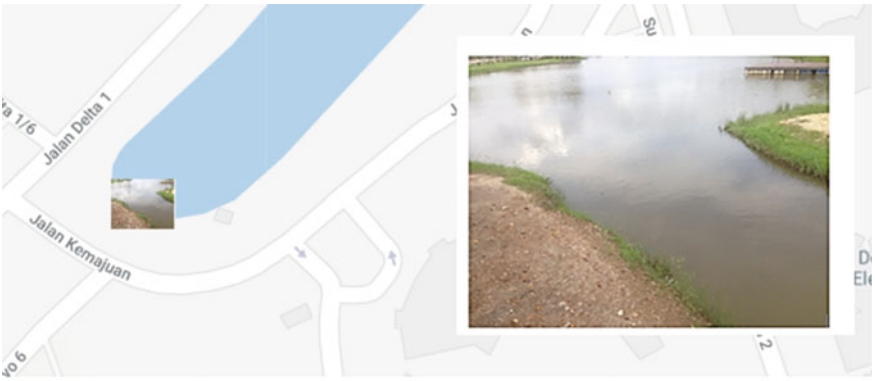

Fig. 10 Location 2 (UTHM Lake)

Fig. 11 Location 3 (Taman Universiti)

Table 1 Summary of different environment and movement

Location	Distance (m)	Time (s)	Movement			Speed (knots)	Connectivity
			Forward	Backward	Right/left		
UTHM Lake	15	105	√	√	360°	0.3	√
Taman Universiti	7	47	√	√	360°	0.26	√
Taman Bistari Indah	5	23	√	√	360°	0.25	√

5 Conclusion

This project aim to design and develop river cleaning robot to enable in real-time monitoring for cleanliness of water. By implementing automation system, the system enable in monitoring 24/7 the cleanliness of water and can trap the physical waste that flow on the water.

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