A Water Surface Cleaning Robot

A Water Surface Cleaning Robot

E Rahmawati[*1], I Sucahyo[1], A Asnawi[1], M Faris[1], M A Taqwim[1], D Mahendra[1]

[1]Physics Department, Universitas Negeri Surabaya, Indonesia

*e-mail: endahrahmawati@unesa.ac.id

Abstract. This paper describes the design of a robot for cleaning rubbish floating on the water surface. Three important issues for designing the aquatic robots are a cost-effective solution along with robustness and durability. Due to the nature of the cleaning work, we designed the vehicle structure that can provide high stability, good ability in maneuver and can easily collect all the waste flowing in between. A pontoon shaped hull works best for this case and fulfils all the hydrostatic, structural stability criteria. For removal and collection of surface waste, a motor-driven collecting-arm system has been designed for collecting the wastes and redeploying it into a rectangular basket on the hull. This design provides simple and effective waste removal and accommodates large amounts of waste within a small space. For the prototype, the hulls were made up of styrofoam which is wrapped by fibre and then coated with waterproof and resin. It supported together by aluminum. This light and tough structure support the total weight of the system. The propulsion system based on a differential drive mechanism has been designed, which allows the robots to take a 360 turn on the spot and provides high thrust. Electronic circuit and motors have been placing inside the hull, in order to protect them from water. The robot is manually controlled by remote control based on Xbee Pro wireless modules. The testing of the robot prototype proved to be effective in waste collecting and removal. The maximum trash loads that robot can bear is up 16 kg.

1. Introduction

Waste is an environmental problem that always arises from year to year and still cannot be resolved entirely. We frequently found garbage from various places dumped into rivers, waterways, or reservoirs. The rubbish can clog the flow of water, causing water to become dirty and smelly so that it often overflows and causes disasters, including flooding. How to clean waste from water areas requires extensive resources, for example, by cleaning staff and using excavators [1,2].

This study aims to provide an alternative solution to the problem of waste in water areas by developing robotics technology capable of operating in water areas. The proposed applied research is expected to be an alternative solution to prevent disasters, especially floods. Robotics technology developed in the form of eco-robot with the main task of collecting waste. The robot is designed to be controlled r manually by remote control. The development method of this research refers to ADDIE. This method including of analysing of the robotic cleaning system, designing the robot, developing the robot, implementing robot to clean waste in limited water areas, evaluating the effectiveness of robot in cleaning up trash for the more extensive area. This article is focusing on the design and development of the robot.

Previously some robots have been built for cleaning water surface [3, 4]. A few results are available in the open references, which have discussed the development of such particular purpose robot [5, 6]. This work aims at developing a more versatile and efficient system by the usage of the aqua robot. This robot has an excellent opportunity to expand its functions in the future. Such conducting activities for removing algae, leaves and twigs; spraying of chemicals at the appropriate locations; checking the water quality as well as deploying payload are planned to be done autonomously. These functions may save a lot of human effort and provide a sustainable solution to the pervasive problem. For navigation and trash cleaning on the ground, many well-designed algorithms have been developed earlier for both single robotic systems as well as for swarms [7]. However, because of the difference in the dynamic environment, propulsion system, and the difficulty to accurately determine the current position based on relative velocity and acceleration, these algorithms cannot be directly used on aquatic surfaces. Also, the navigation algorithms developed

earlier for autonomous aquatic robots have not been designed with cleaning as an integral part of them [8,9].

2. Robot Design

The three crucial consideration for designing the robot is a cost-effective solution along with robustness, and durability. Consider the function of cleaning work, the robot structure is designed in order to provide high stability, excellent manoeuvrability and can easily collect all the waste flowing around. A pontoon shaped hull works best for this case and fulfils all the hydrostatic, seakeeping, and structural stability criteria [10]. For removal and collection of surface waste, a motor-driven arm-manipulator system has been designed for collecting the wastes in a section covered with a net. This design provides simple and effective waste removal and accommodates large amounts of trash within a small space.

Furthermore, as the collected waste floats on the water surface, the robot does not need to support its weight. The lower section of the belt is placed below the water level to take out the floating weeds easily. For the prototype (Fig. 1), the pontoon shaped hulls were made up of two shaped styrofoam. The styrofoam was wrapped by fibreglass matt and then was coated by aqua proof and resin. This design result in a light and strong pontoon hull, minimum risk of a leak. Two pontoon hulls supported together with the help of an aluminium truss. This light and robust structure support the total weight of the system. The design parameters of this prototype are given in Table 1. To navigate autonomously in small and constrained spaces, a propulsion system that can provide high mobility and short turning radius is needed. Due to its flat front and the central waste collection system, the robot is also required to overcome high form and skin drag given by:

$$F_D = C_D \cdot v^2 \tag{1}$$

which F_D is drag force in Newton, C_D is drag coefficient and v is the speed of the robot.

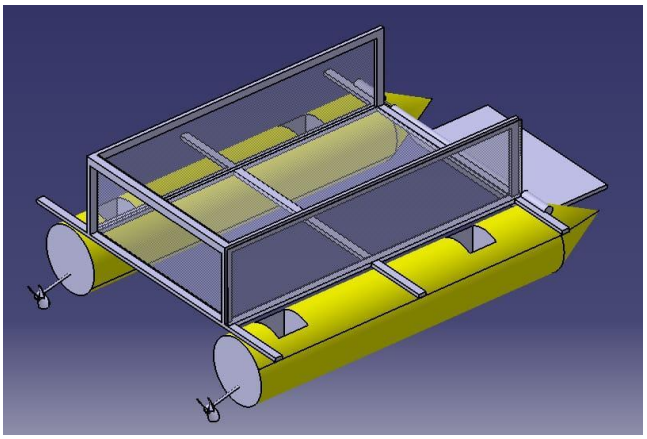

Figure 1. Robot prototype

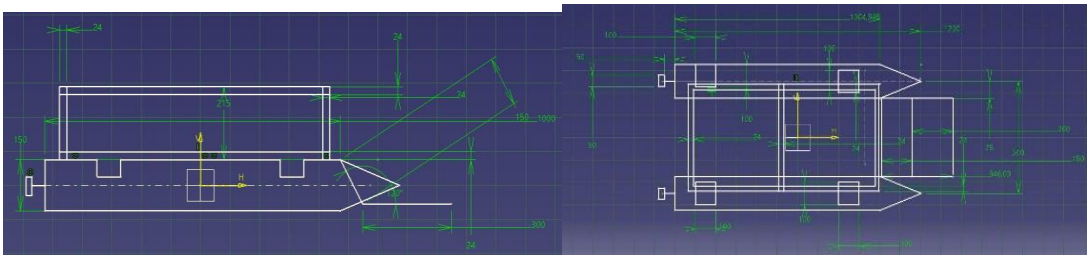

Figure 2. Dimension of robot

Table 1. Robot specification

Design parameter	*Value*
Dimensions (overall)	1200mm x 800mm x 500mm
Net weight (only robot)	8 kg
Maximum weight (with load)	28 kg
Average battery while cleaning	1 hour
Propeller type	three blades
Control system	manual (remote control)
Drive motors	Motor Driver BTS7960 43A
Wireless module	Xbee Pro S2C ZigBeeBP24CZ7WIT-004

Placing the electronic circuits, drive motors, batteries, and motors inside the hull, in order to protects them from water leakage inside its casing. As the robot is designed to traverse manually, it is remote controlled based on Xbee Pro S2C modules. The electronic circuit is relatively simple. It consists of an Arduino based microcontroller, three motor drivers, two DC motors which were attached to the flexible shaft and propellers, one power window DC motor. Power window motor has been used for arm manipulator which collects trash and raise it to basket. The basket has been attached on the hull.

Robot has been controlled by remote control through Arduino UNO which send data (command) to transmitter. The data from transmitter has been received by receiver. Receiver send data to Arduino UNO. Arduino UNO send data to motor DC, then motor DC will act refer to data or instruction.

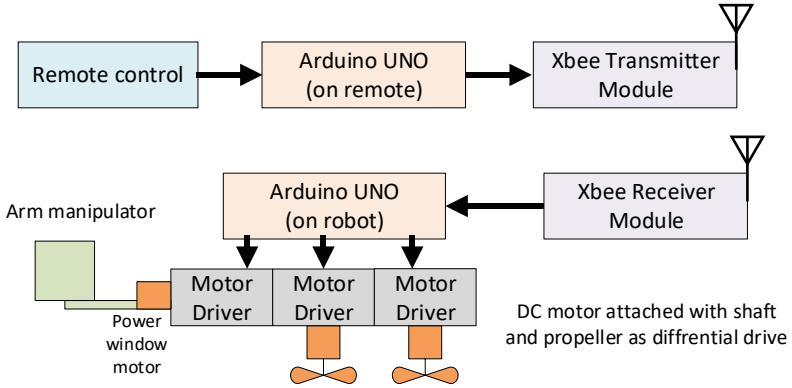

Figure 3. Control system for differential drive of robot

3. Results

Consider designing the hull of the robot; there were several technical matters that are geometric design, reducing hydrodynamic resistance, minimizing weight and preventing drown because of leakage. The primary requirement of the hull design is to generate a sufficient force suspending the robot in water. To overcome the problem, the robot developed by us uses two pontoons hulls to suspend the robot. The payload of the two pontoons is 20 kg, and their weight is 8kg. How to achieve static balance in the water is an essential issue in designing the robot. For increasing the payload, previous research adds more pontoons [10]. While the waste container is full or empty, there must be no difficulties for a robot Iie in water steadily. The robot is made symmetric along the moving direction. The two pontoons are placed so that the centre of the floating force is located at the symmetric axis. The weights are placed at the centre of mass of the robot.

The application of the control system using XBee wireless to the robot motion system has been successfully carried out by utilizing the control method by wireless communication with the serial data transmission format. The control system is examined by giving instructions on the remote that are well received by the robot with the appropriate motion response with the commands written on the program. The robot is controlled s moves supposed moving with the trajectory as in figure 3 and collects garbage along the path. The robot can operate well and able to accommodate garbage loads up to 20 kg.

Figure 4. Path of Robot motion during testing

4. Conclusion

A water surface cleaning Robot was a relative success, the team has created an outline for future improvement in terms of research and theory, and implementation. On a high level, more research should have been done regarding the interfacing between module so the robot not only has single task but also multi task such as selecting trash refer to its material and also monitoring water quality. Consider designing the hull of the robot; there were several technical matters that are geometric design, reducing hydrodynamic resistance, minimizing weight and preventing drown because of leakage. The primary requirement of the hull design is to generate a sufficient force suspending the robot in water. To overcome the problem, the robot developed by us uses two pontoons hulls to suspend the robot. The payload of the two pontoons is 20 kg, and their weight is 8kg. How to achieve static balance in the water is an essential issue in designing the robot. For increasing the payload, previous research adds more pontoons [10,11]. While the waste container is full or empty, there must be no difficulties for a robot Iie in water steadily. The robot is made symmetric along the moving direction. The two pontoons are placed so that the centre of the floating force is located at the symmetric axis. The weights are placed at the centre of mass of the robot.

The application of the control system using XBee wireless to the robot motion system has been successfully carried out by utilizing the control method by wireless communication with the serial data transmission format. The control system is examined by giving instructions on the remote that are well received by the robot with the appropriate motion response with the commands written on the program.

The robot is controlled s moves supposed moving with the trajectory as in Figure 3 and collects garbage along the path. The robot can operate well and able to accommodate garbage loads up to 20 kg.

References

[1]. Savitri P A, Purba W S and Zulkifli M 2018 Pengelolaan Sampah di Indonesia *Statistik Lingkungan Hidup Indonesia 2018* Badan Pusat Statistik
[2]. Griffiths G 2003 *Technology and Applications of Autonomous Under- water Vehicles* (UK:

Taylor and Francis)
[3]. Ramos P, Cruz N, Matos A, Nevesand M V, Pereira F L 2001 *Monitoring an Ocean Outfall Using an AUV. Proc. MTS/IEEE Oceans'01* Honolulu
[4]. Saravana K G, Kumar S, Ragavan R, Balakrishnan M 2016 *IJSRP* **6** (4) 525
[5]. Dandan K, Albitar H, Ananiev A and Kalakov I 2015 *Int. J. Adv. Robot Syst.* **12** (12) 1
[6]. Nurlansa O, Istiqomah D A, and Pawitra M A S 2014 *IJFCC* **3** (5) 367
[7]. Yuyi Z, Yu Z, Huanxin L, Yunjia L and Liang L 2013 Cleaning Robot. *Int. J. Adv. Robot Syst.* **10** (5) 1
[8]. Attamimi M, Araki T, Nakamura T and Nagai T 2013. Visual Recognition System for Cleaning Tasks by Humanoid Robots *Int. J. Adv. Robot Syst.* **10** (11) 1
[9]. Ruangpayoongsak N, Sumroengrit J, Leanglum M 2017 A Floating Waste Scooper Robot On Water Surface *17th International Conference on Control, Automation and Systems (ICCAS 2017)*
[10]. Wang Z, Liu Y, Yip H W, Peng B, Qiao S, and He S 2008 Design and Hydrodynamic Modeling ofA Lake Surface Cleaning Robot *Proceedings of the 2008 IEEE/ASME International Conference on Advanced Intelligent Mechatronics* China
[11]. Agrawal P and Bhattacharaya B 2013 Aquatic Multi-Robot System for Lake Cleaning *Nature-Inspired Mobile Robotics* **171**