Implementation of Filtering-Waste Robot for Improved Wastewater Management Control using Arduino

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Abstract: To address the issues regarding solid wastes in rivers and lakes, the inefficiencies and labor intensive in the cleanup and overall effects of water quality being contaminated by them, a solid waste filtering robot for shallow waters was designed to help the process. The robot basically sucks in the wastewater, filters the solid wastes and pumps out clean water back. The use of tactile sensors and wireless communication to help transverse, measure the water quality and weight of the wastes collected, send the data gathered from prototype, and clean the area simultaneously. Additionally, it would let out a loud buzzer noise to indicate if the wastes collected has reached a certain amount. The prototype would be using a pump that would be capable of sucking waste from the water to be filtered out, and it would be able to attain a speed of three (3) miles per hour given a constant time and distance. It would be able can handle a weight of the solid waste and wastewaters of approximately thirty (30) pounds.

Key Words: Lakes and Rivers; Improved Water Quality; Solid-Waste Filtering Robot

1. INTRODUCTION

Water pollution has been an increasing problem in the country, especially in flood prone areas. It has caused issues regarding health hazards, safety hazards, lack of sanitation and marine life environment and could develop if left unchecked (Crisostomo, 2017).

Water pollution is indeed not just harm water species but also reduces the quality of life of human beings (Woodford, 2017). It is simply due to a chain of cycle into what lies into this world. Specifically, harmful substances when mixed with water will produce contaminated water and can suffer various diseases from it. The people depend on the environment for their natural needs so if people would pollute the environment it practically reduces the essence of the environment in giving good health and lifestyle to people.

An alternative solution that works alongside the pre-existing guidelines and regulation against polluting existing water bodies must be implemented to lower the chances of water pollution by developing a river-cleaning robot. The paper aims to determine the efficiency of the robot in terms of the amount of waste being separated out from the clear water per operation, and compensating the river flow, and other characteristics that may affect amount of waste being dispatched out of the water. Since a similar robot is already existing, based on the researches and problems found, the group would like to create a new version by adding more features such as deeper surge for the trash pile, more water filtered out and more wastes to be taken out from the bodies of water.

2. METHODOLOGY

2.1 Block Diagram

The two main modules will be the transmitter part and the receiver part. The main boat contains the transmitter part consisting of motors, sensors and transmitter module. The control unit is the receiver part containing the receiver module, wi-fi module.

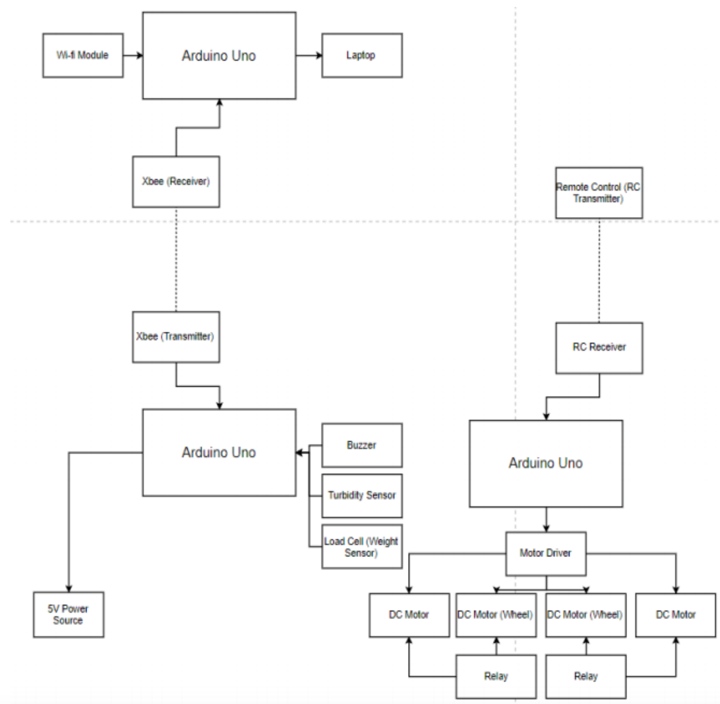

Fig. 1. Full block diagram of the prototype with components installed

2.2 Schematic Diagram

The schematic diagrams are divided into three parts. The two are from the boat which are the motor part (Fig 2) and the sensor part (Fig 3). The third one is the schematic diagram of the receiver part (Fig 4).

2.2.1 Transmitter Side (Motors)

Figure 2 shows the motor part consisting of four DC motors, four relays, RC receiver and two external sources connected to an Arduino microcontroller.

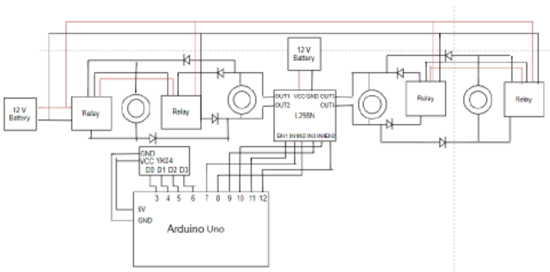

Fig. 2. Schematic Diagram of the Transmitter Side containing the motors

2.2.2 Transmitter Side (Sensors)

Figure 3 shows the sensor part consisting of load cell, turbidity sensor, buzzer, Xbee transmitter module connected to an Arduino microcontroller. Figure 2 and Figure 3 had to be connected in to separate microcontrollers to manage the current load for the VCC and GND pins without using an external source and to reduce complexity of wirings into a single microcontroller.

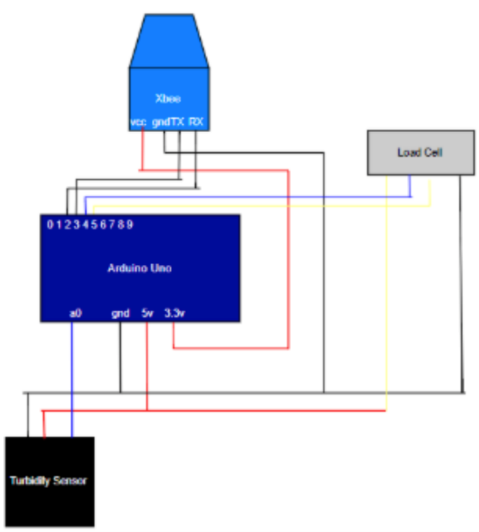

Fig. 3. Schematic Diagram of the Transmitter Side containing the sensors

2.2.3 Receiver Side

Figure 4 shows the receiver part consisting of the Wi-fi module, Xbee receiver module connected to an Arduino microcontroller.

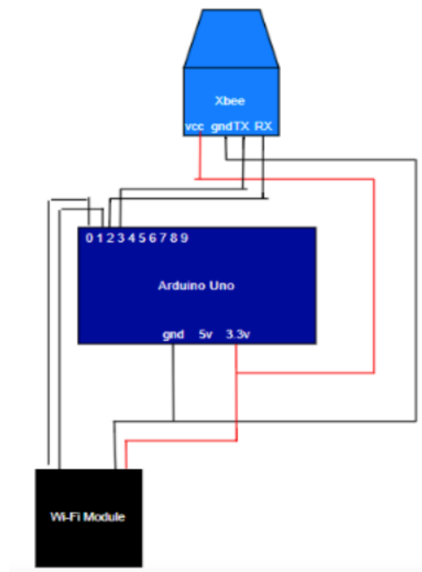

Fig. 4. Schematic Diagram of the Receiver Side

2.3 Flow Chart

Figure 5 shows the operation of the robot where it would first initialize the control system, where the user will control the movement of the direction using a remote controller transmitter. The remote control receiver will then receive the signal to operate the motors to move. The motor would then suck in waste water through the pump and then filter out solid waste to output clean water. A weight sensor was used to monitor the correct weight of the bucket until the it reaches the value thirty pounds (30 lbs), before a buzzer will sound.

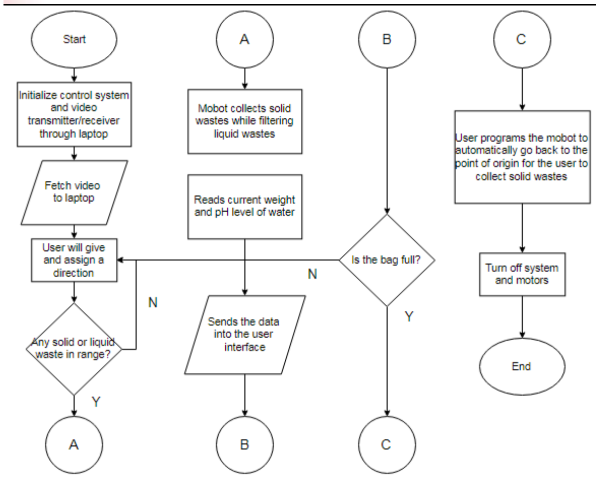

Fig. 5. Flow Chart of the Prototype

2.4 Buoyancy Equation

In order to determine if the boat will float or sink, the group computed for the buoyancy force of the boat (F_b). Equation 1 will be used.

$$F_b = \rho g V \qquad \text{(Eq. 1)}$$

where:

ρ	=	Density of the liquid (kg/m^3)
g	=	Gravity (m/s^2)
V	=	Volume of the material/water displaced (m^3)

F_b = (1000 kg/m^3)(9.81 m/s^2)(0.2147 m^3)
F_b = 2106.21 N

The group will also compute for the gravitational force of the boat, including the components' force acting on the boat. Equation 2 will be used. Maximum value will be used for the waste.

$$F_g = (m_{boat} + m_{carbattery} + 2 * m_{minibattery} + m_{pump} + m_{inverter} + 2 * m_{motor} + m_{waste})(g) \qquad \text{(Eq. 2)}$$

where:

m	=	Mass of an object (kg)
g	=	Gravity (m/s^2)

$F_g = (17 + 10 + 2 * 1 + 5 + 2 + 2 * 2 + 18.18)(9.81)$
$F_g = 570.75$ N

Since Fb is greater than Fg, the boat will float.

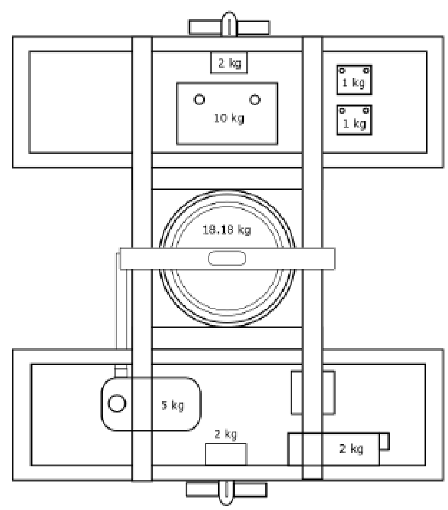

Fig. 6. Top view of the prototype with significant masses added

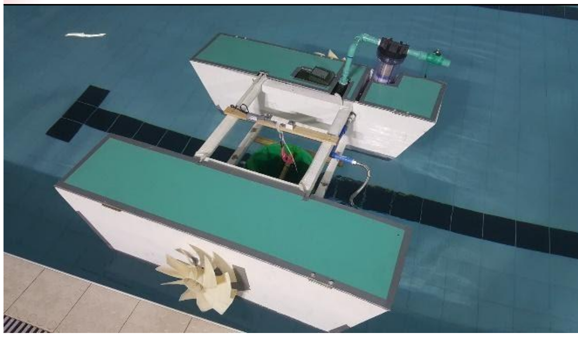

Fig. 7. Actual Image of the Prototype

2.5 Turbidity Equation

For the turbidity testing, it is simply the obtaining the direct value of voltage from the turbidity sensor and using a formula to convert it into turbidity and total suspended solids. The turbidity results obtained from the pool are more accurate than those in the river because there are more acceptable values that are less than 50 NTU when being tested in the pool than in the river.

Turbidity is the measure of relative clarity of a liquid caused by suspended solids that are usually not seen by the eyes. Total Suspended Solids (TTS) is the quantity of material suspended in a known volume water. It is important when trying to determine the quality of water. The higher the turbidity, the higher the total suspended solids are in the water.

To check if the turbidity values varied on different clarities of water, it is tested manually by the turbidity sensor. At *Volt* = 4.2V, using Equation 3, the output turbidity is is 0 NTU. This is the basis to determine whether or not the turbidity measured was correct.

$$Turbidity = 1120.4^2\,(Volt) + 5742.3(Volt) - 4353.8 \qquad \text{(Eq. 3)}$$

2.6 Kinematic Equation

The group will also determine the possible terminal or the maximum velocity the boat can reach using Equation 4.

$$Vf = \sqrt{\frac{F}{\frac{1}{2}\rho C A}} \qquad \text{(Eq. 4)}$$

where:

F = Boat force (N)

ρ = Density of the liquid (kg/m^3)

C = Drag force coefficient

A = Area of contact

$$Vf = \sqrt{\frac{(2)(400.12}{(1000)(1.08)(0.0999)}}$$

$$Vf = 2.72\ m/s$$

3. RESULTS AND DISCUSSION

3.1 Speed Results

Table 1 shows the results for a sample run of the boat, with a constant distance of 10m. Time was obtained and the speed is computed.

Table 1. Speed testing results based on distance and time

Distance (m)	Time (s)	Speed (m/s)	Speed (mph)
10	7.67	1.30	2.91
10	7.71	1.29	2.90
10	7.54	1.32	2.96
10	7.43	1.34	3.01
10	7.50	1.33	2.98
10	7.38	1.35	3.03
10	7.54	1.32	2.96
10	7.52	1.32	2.97
10	7.63	1.31	2.93
10	7.55	1.32	2.96

3.2 Turbidity Results

Table 2 shows the test for turbidity or the clarity of the water after it passes through the pump based on the amount of total suspended solids in it. The lesser NTU, the clearer the water. The boat was tested in a Valley Golf river in Cainta, Rizal.

Table 2. Filtered Water Test Results

Voltage Reading (V)	Turbidity (NTU)	Total Suspended Solids (mg/L)
4.214	0.00	0.00
4.193	25.63	87.70
4.224	0.00	0.00
4.204	0.00	0.00
4.205	0.00	0.00
4.197	11.00	37.64
4.201	0.00	0.00
4.210	0.00	0.00
4.207	0.00	0.00
4.213	0.00	0.00

3.3 Weight Reading Results

Table 3 shows the test for weight reading to determine the accuracy of the load cell attached to the prototype. This value will be compared to the actual weight of the solid wastes, which is initially measured using a weighing scale.

Table 3. Weight Reading Results

Load Cell Reading (lbs)	Actual Weight (lbs)	Error Percentage (%)
13.62	15	9.20
13.62	15	9.20
13.62	15	9.20
13.62	15	9.20
13.62	15	9.20
28.24	30	5.87
28.32	30	5.6
28.12	30	6.27
28.18	30	6.07
28.24	30	5.87

4. CONCLUSIONS

The group was able to construct a prototype that clears out solid wastes and filters wastewater while getting the required values such as speed, turbidity and weight. It also transmits these values into the Xbee module. The design capability of the robot was properly and successfully evaluated. It collects up to 30 lbs. of solid waste, can achieve an average of 1.5 m/s of motor speed and send out real-time data to the user. The robot has an error per test of 2.84% on total actual weight of solid wastes gathered vs. total computed weight of trashes for the test.

One of the future recommendations include further calibration or full replacement of a new model for a specific type of sensor, and a more efficient pump for greater pressure and to suck in wastes faster.

5. ACKNOWLEDGMENTS

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