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# Development of a Radio Frequency Remote-controlled Amphibious Solid Waste Collecting Mobot

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***Abstract***

*Robots in general are used to aid people in different tasks from simple activities to activities that prevent also people from harm. In fields of Robotics it is important that these robots are not complete replacements of humanity but mere tools that will improve human lives and more so save lives if possible. In this paper, the group presented a remote-controlled mobot with amphibious capabilities. The system is accessible through a radio frequency transmitter and receiver which there is an executable file that allows the mobot to be controlled. The characterization of the system and its performance are presented here as well.*

***Keywords****: Amphibious Mobot, Remote Controlled, Solid Waste*

## 1. Introduction

The Philippines is rich in natural resources [1]. Being an archipelago, it is surrounded mostly with marine waters and has a wide-array of inland freshwater. However, there is a growing concern for water pollution, specifically solid wastes floating on the surface of water. Unclean water threatens not only the life of humans, but also the marine biodiversity. With this in mind, the researchers propose to construct a Radio Frequency Remote-Controlled Amphibious Solid Waste Collecting Mobot.

The Radio Frequency Remote-Controlled Amphibious Solid Waste Collecting Mobot is built to help in today's growing concern towards water pollution. Its goal is to help in collecting solid wastes in coastal shorelines without disrupting the ecosystem within the water area.

## 2. System Overview

The system is composed of the remote controller and the amphibious mobot as shown in Figure 1 and Figure 2. The controller acts as the base line of controlling the robot from a distance in respect to the specs of the antenna of the radio frequency transmitter which in tests is 160 meters. The controller is a end-user component allowing the user to control the mobot to move in certain directions and collect solid waste using the fetch system. The user approaches the solid waste using the controller moving the mobot near the waste and when it is on range the user controls the fetch system allowing the robot to collect the waste and then transport it to the storage mechanism. It also informs the user on the voltage levels if its near critical or on a low voltage level. In addition to the voltage level it also informs the user of the accumulated weight being carried by the storage mechanism if it is in the range of 10 lbs to 50 lbs; whenever, it exceeds 50 lbs it will only show a 50 lbs mark.

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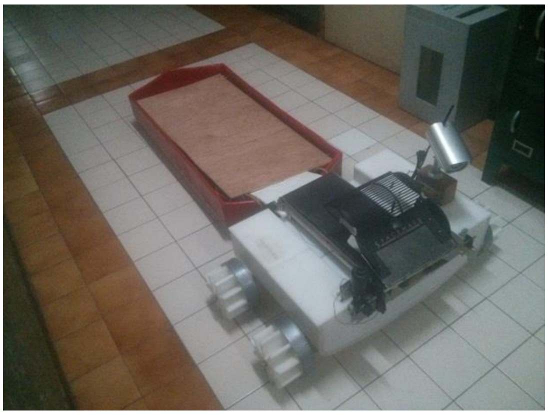

Figure 1. Actual prototype isometric view

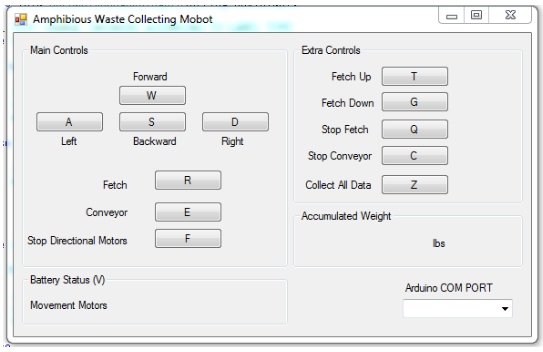


Figure 2. Mobot control panel on the remote control

The mobot is designed by the group of students involved in this paper which based its calculations through variables that concern amphibious support. The entire mobot was able to move on land and water. With restrictions of the fetch mechanism incapable of being effective on land. The system is found to last long on water for around 2 hours or more runtime while being dependent on good weather conditions.

## 3. System Design

### 3.1. Amphibious Mobot

#### a. Motor System

The motor system of the amphibious mobot is a 4 wheeled mobile robot (see Figure 3). The body is composed of ½ inch thick High-density polyethylene (HDPE) with each motor supported by stainless steels and all wheels are also HDPE material. The axles are stainless steels connected to the wiper motors. The mobot follows the principle of the differential drive motor but using only 3 motors instead of the conventional 4 motors. The frontal wheels are being held by a stronger wiper motor compared to the other wheels as the frontal motor will act as the free wheel while the other 2 motor will be the directional motors. The mobot uses up a relay system which is controlled by the Arduino microcontroller powering up the whole system.

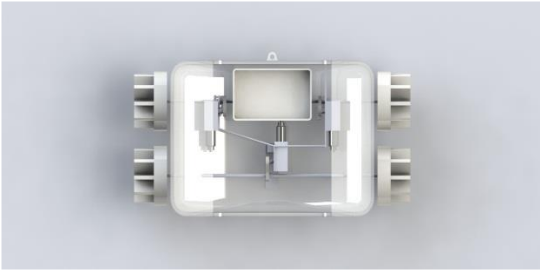

Figure 3. Motor driver design top view

**b. Fetch Mechanism**

The fetch mechanism has two parts the first part being the main fetch which will collect solid waste from the water and will carry it to the conveyor belt or sometimes directly to the storage. The conveyor belt is the second part of the fetch as some waste is too heavy for the fetching mechanism to be directly sent to the storage; thus, put on the conveyor belt. The fetching mechanism is controlled by a wiper motor which is controlled by a relay connected to the main Arduino board.

**c. Store Mechanism**

The store mechanism is composed of a separate boat or as called as a tug boat. It is a boat being tugged around by the main amphibious boat. The purpose of the tug boat is to carry all solid waste that is collected by the fetch mechanism and is placed on the tug to determine the accumulated weight of the solid waste and notify the user.

**d. Radio Frequency Transmitter**

The Radio Frequency Transmitter is the communication point between the amphibious mobot and the remote control. It is used for the user to use the remote control to operate the amphibious mobot.

**e. Voltage Checker Module**

The voltage checker module is composed of a voltage divider circuit which divides the voltage of the input battery of 12V dividing it that the microcontroller is able to compute the actual voltage of the amphibious mobot. This allows the amphibious mobot to alert the user that the battery is on a critical or on a low voltage level.

**f. Main Controller Unit**

The main controller unit is an Arduino Mega 2560 microcontroller of the mobot. It handles all transmission and computations to be done by the mobot in order to compute the voltage and accumulated weight and then sends it to the user. It is also the main controller of all relays that controls all motors in the amphibious mobot. It is the sole controller of the whole operation undergoing in the amphibious mobot.

### 3.2. Software Components

**a. Mobot Software**

The Arduino Mega 2560 which was the main controller unit of the mobot was programmed by the Arduino Enhanced Release 1.0.5 using the C programming language. This allowed the program to execute on the microcontroller.

**b. Remote Control**

The GUI and the programming language used in the remote control is C++ this was used to use the other RF Transmitter to transmit commands to the receiving end of the transmitter. Upon, receiving data it receives it and then lists and updates the GUI. This is the end-user program that allows the user to control the amphibious mobot from a distance as seen in Figure 3.

## 4. Data and Results
### 4.1. Movement Results

Movement tests were done differently with all land tests having it tested on different terrain for the forward and reverse movement. The first 39 tests were done on tiles, while the succeeding 35 tests were done on concrete, and lastly the remaining 25 tests were done on grassland. All tests data were collected through a stopwatch which will stop when the mobot has reached a 5 meter mark. All tests on different terrain were done with two test runs with each test run having it resolve maintenance issues.

Meanwhile the right turn and left turn land test were all done on tiles. In getting the quantitative data of the turning the group decided that it will collect it through time for every 90 degree turn it has made the timer will stop the time and record the time. This was done in four tests runs with each test run having it resolve maintenance issues.

During Water movement tests the similar has been done on the previous land tests on its forward and reverse movement it was collected through a stopwatch which was stopped every time it has reached a 5 meter mark. All tests were done on a swimming pool. This was done with four tests run per test.

The right turn and left turn of the water movement was completed every time a 90 degree turn was done by the mobot. Which was also collected by a stopwatch. All tests were done on a swimming pool. This was done with four tests runs per test.

### 4.2. Land Movement

In land movement as mentioned above the movement was done in 100 tests for all movements. Knowing the time for every movement as the following results are in the Figures 4-5.

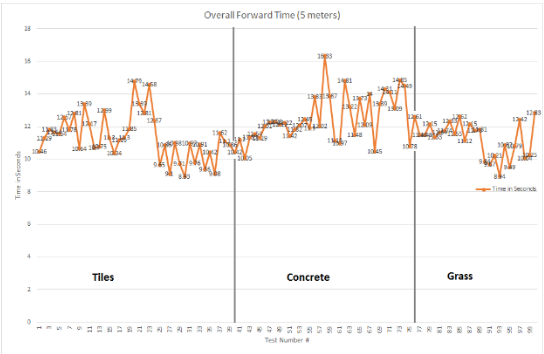


Figure 4. Overall time chart for forward movement

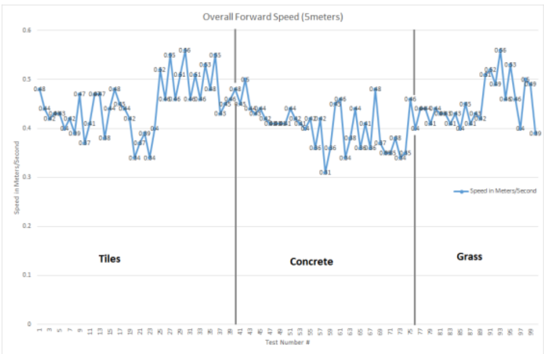


Figure 5. Overall speed chart for forward movement

As seen in Figure 4 and Figure 5 is the forward movement of the mobot on land. It was tested on three types of terrain particularly tiles, concrete, grass. Basing from the figure the speed is faster on tiles then grass but it runs slower on concrete. While grass being the most consistent land with less erratic change on values. The slower the speed the longer the time the mobot will reach the 5 meter mark. Overtime there is deterioration of the wheels material. The average speed of the mobot on forward is 0.433 meters per second, as shown in Figures 6-7.

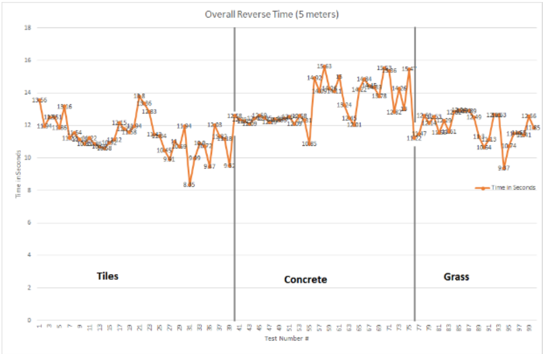


Figure 6. Overall time chart for reverse movement

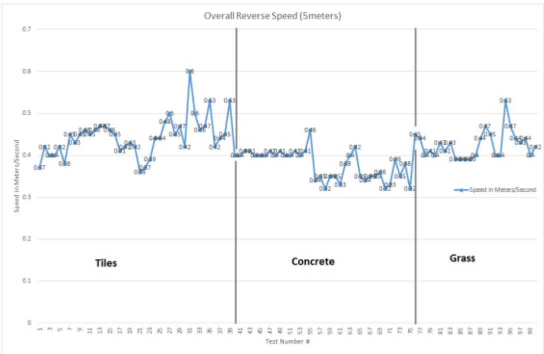


Figure 7. Overall speed chart for reverse movement

As seen in Figure 6 and Figure 7 is reverse movement of the mobot on land which was also tested on the three different terrains. Still the fastest speed was on the tiles while second on concrete while the slowest would be on concrete. Grass having the most consistent speed. Overtime there is also deterioration of the wheels material. The average speed of the mobot is 0.415 meters per second.

The right turn was indicated by time as seen in Figure 8. Time was the main indicator as distance varies over time on every run all tests were done on tiles and average time for the mobot to take a right turn was 16.088 seconds.

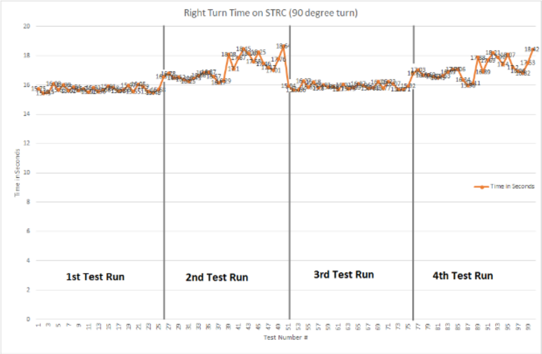


Figure 8. Right turn time chart

Similarly to Right Turn Time the left turn time indicated in Figure 9 was also checked when it has made a complete 90 degree turn on tiles. It varies over time as material deterioration was found to be an indicator. The average time for it to take a left turn is 11.298 seconds.

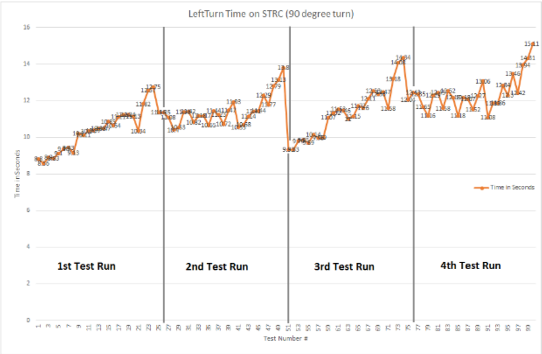


Figure 9. Left turn time chart

## 5. Water Movement

In comparison with land movement, water movement is slower. Movement is lessened as the difference of running on land and water is different. The mobot moves over water relies on the wheels where it will paddle through the water. In the Figures 10-11 will show the time and speed of every movement.

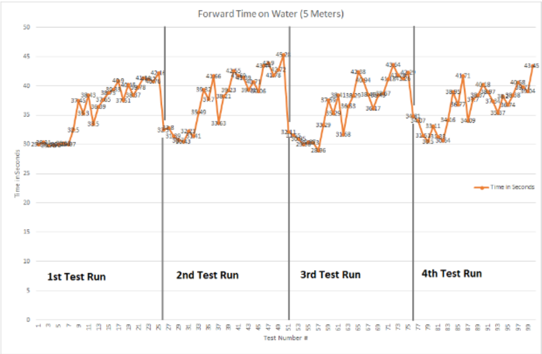


Figure 10. Overall time chart for forward movement

As noticed on the tests in Figure 10 and Figure 11 it is more consistent on water as the speed of the mobot lessens every test run this is in comparison if the speed is dependent on the weather conditions and the condition of the mobot. In forward movement the average speed is 0.14 meters per second.

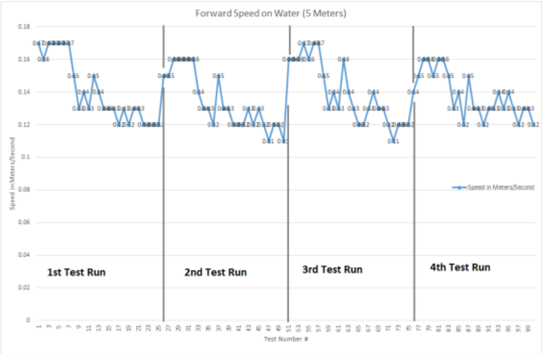


Figure 11. Overall speed chart for forward movement

As seen on Figure 12 and Figure 13 the speed of the mobot is consistently getting slower over time due the same issues found in the water as it dependent on weather conditions and the condition of the mobot. In reverse movement the average speed is 0.12 meters per second.

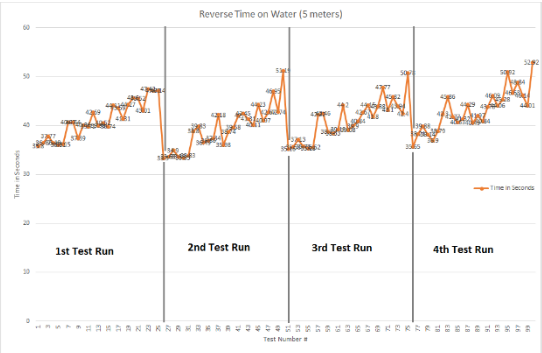


Figure 12. Overall time chart for reverse movement

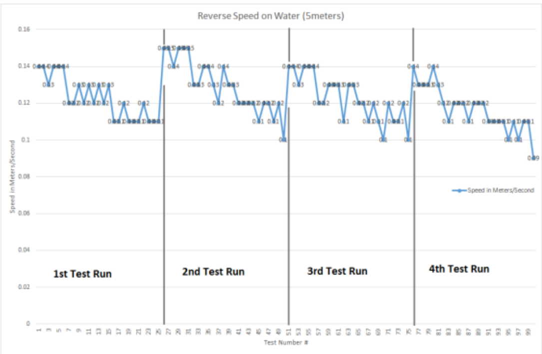


Figure 13. Overall speed chart for reverse movement

As seen in Figure 14 the right turn time was checked similar to the land test. It was checked through time as distance varies over time. It is more erratic in nature but it has an average time of 37.78 seconds to take a complete a right turn

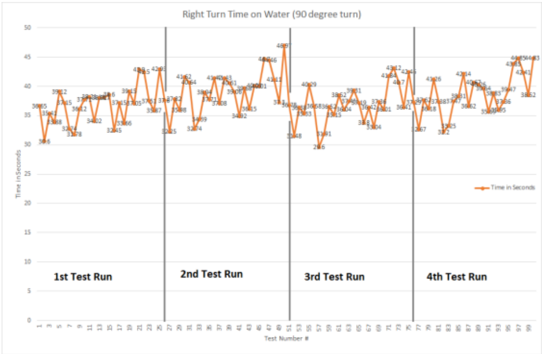


Figure 14. Right turn time chart

As seen in Figure 15 the left turn time was checked similar to the land test. It was also checked through time as distance varies during tests. It is consistently getting slower over time with an average time of 27.64 seconds.

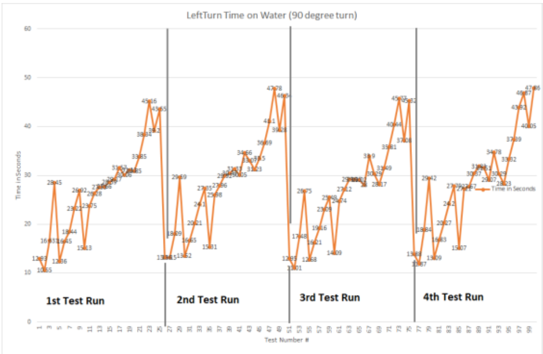


Figure 15. Left turn time chart

## 6. Analysis, Conclusion and Recommendations

The testing of the robot showed that it was capable of its strength and was mobile on boat land and water. Discrepancies between speeds of movement are found but this would not affect its overall performance. Having passed most of the test the weight module just requires a small calibration to correct its proper value with respect to the actual weight. The tests done on the voltage checking shown discrepancies due to the voltage reference being drained out easily thus permitting percentage error. However the range checking shows great success at it was able to work near its maximum range of 200 meters without obstructions. The tests show remarkable progress that the it can be used for its purpose on land and water. From the data gathered, it can be said that the amphibious mobot was successfully designed as the system is capable to perform its tasks properly only requiring a few upgrade on its antenna for range and its battery for longer usage. The resulting tests show that the systems are capable to perform its purpose.

**Acknowledgment**

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