DESIGN AND IMPLEMENT OF BEACH CLEANING ROBOT

H.M.R.G. Herath
Faculty of Engineering Technology
University of Vocational Technology
Ratmalana, Sri Lanka
hmravindugherath@gmail.com

G.C.B. Weerasinghe
Faculty of Engineering Technology
University of Vocational Technology
Ratmalana, Sri Lanka
chamalbuddhi63@gmail.com

M.W.S.B. Jayasooriya
Faculty of Engineering Technology
University of Vocational Technology
Ratmalana, Sri Lanka
shavindajayasooriya96@gmail.com

K.K.N. Dharmarathna
Faculty of Engineering Technology
University of Vocational Technology
Ratmalana, Sri Lanka
kalananirmal560@gmail.com

***Abstract*— This research project is designing and fabricating a Wireless Beach Cleaning Robot. The coastlines of Sri Lanka are one of the country's most popular tourist destinations. That is polluted due to irresponsible human behaviors. Although the Sri Lankan local government institutions have cleaned up the coast, some areas are neglected for various reasons. Cleaning is complex and requires a considerable amount of time and resources. Sewage sedimentation caused by coastal breezes has become a significant issue. That makes identifying the contamination challenging. Workers find itdifficult to clean up as they dig the beach to collect that waste.Some organizations and government agencies take steps to remove the debris accumulated along the coast effectively. Many local and foreign tourists are often attracted to the beach for relaxation. People usually throw plastic on the beach without knowing the consequences. It dramatically affects the marine environment. The design of the robot uses wireless technology, such as Radiofrequency applications and the Internet of Things (IoT). The source of power for the robot is the 12VDC lithium-ion polymer battery. This system uses the real-time dashboard to monitor the level of the garbage bin. An IoT system is an interconnected network of intelligent devices that can sense and communicate with other systems. The Arduino IDE gathers the sensor data from the Ultrasonic sensors. The robot also indicates the level of the garbage bin through the blynk mobile application. It helps an operator to monitor the garbage bin level. This research workaims to design and fabricate a wireless beach cleaning robot with less human effort. The machine is constructed with a simple, economical design for easy maintenance and use. The machine is environmentally friendly and can operate in any beach condition.**

Keywords-Beach pollution, Internet of Things, Beach Clean, Cleaning robot

I. INTRODUCTION

Maintaining a healthy and clean environment is essential for sustaining the ecosystem. Every healthy environment, including the beaches and shores, should be limited and less exposed to the hazardous chemicals and pollution that may adversely affect human health. Thus, by definition,the concept of this project is being able to help clean the beaches and shores filled with human waste such as garbage and plastics.

The beach cleaner robot project was designed to help society and the environment to sustain a clean and healthier life. The concept of the project was to design a robot which can clean the beach by itself without human intervention. Beach sides were surveyed to understand the disposal of plastics and many other plastics debris thatharm marine and coral life. The beach Cleaner seemed the most practical and promising project to help a specificenvironment and many other places worldwide. Hence, the project is reassuring and will help to save time and effort. The team was more encouraged because manufacturingthis concept would be beneficial. As a result, our task is exceptionally adaptable and expandable.

The beach cleaner robot is the world's environmentally friendly, remote-controlled beach cleaning equipment, capable of moving on wet and dry sandy soil while collecting rubbish and other waste. The power source of the robot is the 12VDC lithium-ion polymer battery. The robot has the real-time feature to monitor the level of the garbage bin. The data communication through the WeMos uses WIFI to interconnect the cloud and the robot. The Arduino IDE gathers the sensor data from the Ultrasonic sensors. The robot also indicates the level of the garbage bin through the blynk mobile application.

II. RELATED WORKS

There are very few systems that have been developed so far. Our approach is based on a mechanical mechanism to collect rubbish and monitor the level of waste for human operation. Some systems consume much energy and do not offer remote monitoring or several operating modes.

Beach cleaning bot [1] designed for in the case of an unclean beach, a robot designed for in the case of an unclean beach, a robot controlled wirelessly via an Android application could be helpful. A robot capable of collecting rubbish on a beach could help save workers. Using a camera to detect debris can allow the bot to consume less energy and collect garbage more intelligently. Garbage detection was accomplished using high-efficiency tensor flow models, while control of the bot and other operations were performed using a RaspberryPI

Prometeo beach cleaner robot mobile [2] describes the system of the mobile robot concept. It was created as a robot to address this problem of environmental pollution. Itcan navigate the beach, collect garbage discovered in the zone, and deliver it to a deposit. Each differential wheeled robot was powered by a DC motor and was based on a chain system. It had a servo motor-driven excavator arm, an embedded computer, and a 3D camera that performed stereoscopic algorithms to determine scenario bounds and the object's position and shape.

Another cleaning machine [3] describes the challenges in manually cleaning the beach; this project devised equipment that not only gathers. It also separated garbage, making waste disposal uncomplicated. Fossil fuels power the entire process. The waste was collected along with the sand that fell through the holes on the conveyor back to thesand bed; the waste material was separated using the density difference technique. It comprised two hoppers where different types of garbage were gathered, allowing for easy waste disposal. As there was no wireless module, this device could be use manually. The system is complicated and costly.

According to semi-automated wireless beach cleaning robot vehicle [4] was a remote-controlled river cleaning machine. The automation of river cleaning with a motor and chain drive arrangement was done in this work. To regulate the cleaning machine, an RF transmitter and Receiver were employed. They used the permanent magnetDC motor. It had a 30rpm center shaft DC motor geared to a DC motor that was high quality and low in cost. Its gears and pinions were composed of steel to ensure a longer life and resistance to wear and tear. The gears were machined to a mirror finish and mounted on steel spindles. The driveshaft spins in a bushing made of the plastic substance.A plastic ring covered the assembly. Spur gears were also used to mount spur gears in parallel shafts. The wheel was designed to rotate on an axial bearing. The wheel was the essential component of the wheel and axles. Wheels and axles were used in machines to transport or move a large load, support a load, and do work.

The beach cleaning machine [5] is a vehicle. It used an Arduino board and created an app that allows us to control the machine's activities over the standard Bluetooth of IEEE 802.15.1. It had a range of 10m covering range. The fabrication of the primary frame was ASTM 106 Grade B MS pipes. The design was converted into a 3-D model, and an analysis has been carried out. The designed machine was a low-cost, high-efficiency vehicle that is also user- friendly.

III. METHODOLOGY

Make a Beach Cleaning Robot that picks up the garbage along the beachside have intended. The robot can clean the beach on a real-time basis. It can distinguish between garbage and human. It can detect the garbage at any location nearby the front end of the robot. This project eliminates the use of human resources for cleaning thebeach. Also, fast and efficient cleaning can be attained. The structure of the robot is of utmost importance. For this purpose, the robot's body is made up of acrylic material and a track belt. The structure is designed to quickly pick up the garbage using the shovel and place it in the bin. Thisrobot uses radio communication and IoT forcommunication between the user and the robot. It also senses the presence of a human on the beach. When the binis complete, the message will be displayed on the terminal, and the user will guide the robot back to the dumping area.

A. Design Mechanical System

Assemble the machine chassis using the box bar with the difference between arc welding and oxyacetylene welding. The Box bar is light and strong. Therefore, the box bar is most suitable for chassis. Chassis is one of the central parts of this robot. The chassis was designed and made as to the first step in robot making. All of the parts ofthe robot are connected to the chassis. Figure 1 shows the chassis drawing and Figure 2 has the concept model drawing. drawing.

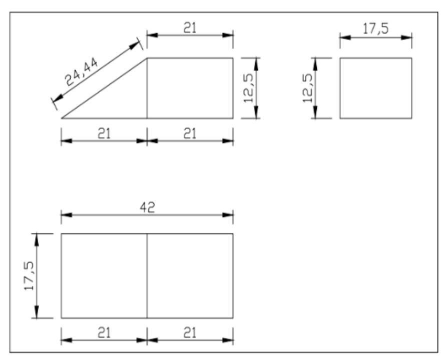

Figure 1. Chassis drawing

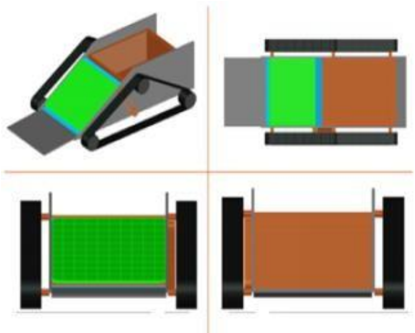

Figure 2. Concept model drawing

The reserved waste is transported to the garbage bin by the conveyor belt. Ball bearings have been used for the conveyor pulley. When the bearings are used, friction is low and reduces surface contact. The conveyor belt is the best method to carry garbage to the bin. High torque low rpm dc gear motor is used for this conveyor.

Figure 3. After chassis assembly

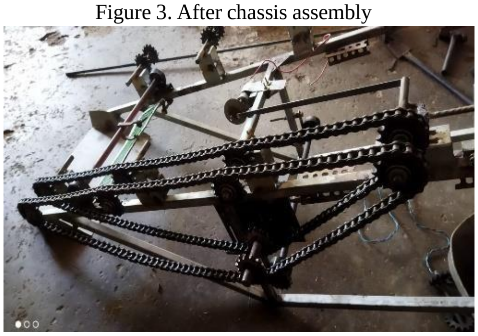

Figure 4. Undercarriage track

The undercarriage track is difficult to travel on the sand with low wheels, so the undercarriage track is used instead of the wheel. The undercarriage track is made by the motor-bicycle chain, bearing and sprocket wheel. When the sprocket wheel is milling, a bearing is fitted to the sprocket. Then sprocket is smoothly rotated. It is very entirely used for easy travelling. Figure 4 shows the undercarriage track during the manufacturing process.

The robot needs to be able to move around on thebeach. The robot is in a hostile environment for robotics due to saltwater, dirt, and corrosion. Due to these environmental factors, the locomotion should not involve complex motion and have as few moving axes as possible. A frictionless wheel does not need the energy to keep rotating at the same velocity.

A continuous band or Undercarriage track of treads driven by a series of wheels is used when the wheels cannot be used. Several scenarios, such as moving over uneven terrain or when high traction is required, can be added to this section. Continuous tracks are typically employed for the power efficiency feature. Continuous tracks outperform wheels in terms of performance and traction, which is advantageous in power delivery efficiency. Even on slick surfaces, traction is excellent. The robot can navigate tough terrain, but its wheels may become trapped. The continuous band of treads can alsouse to climb and descend stairs, overcome obstacles, and traverse ditches. The weight of the robot with continuous tracks is distributed throughout the full track surface [1].

B. Power Requirements For the Robot

Wheels on a hard surface are more efficient than soft-ground tires. We shall analyze their rolling resistance on the sand to generate a valuable estimate of the power consumption of wheeled versus continuous track locomotion. The contour of the contact surface significantly impacts rolling resistance in the sand. The robot's wheels will sink into loose sand, reducing efficiency and possibly stranding it. On the other hand, Tracks exert less pressure due to their broad footprint and stay on top of the sand.
The rolling resistance in the form of a dimensionless constant C_r given by

$$C_r = A + B_v \tag{1}$$

A and B are constants, with typical tread values of 0.025 and 0.0009, respectively. The rolling resistance force Fr in Newtons is calculated by multiplying C_r by the weight.

$$F_r = C_r\, mg \tag{2}$$

where m denotes the robot's mass in kilograms and g denotes gravity of 9.81 N/kg.

$$P_r = F_r .\, v \tag{3}$$

The required power to overcome rolling resistance in Watts, assuming the robot is traveling at a constant speed,is given by

$$P_r = (A+B_v)\, mgv \tag{4}$$

where v is the velocity once more. P_r can be rewritten using the above equations,
For C_r is expected to be around 0.3 for typical tires on loose sand. The following figures 5 and Figure 6 show the resulting friction powers for both continuous track and wheels on sand for a robot weighing 25 kg.

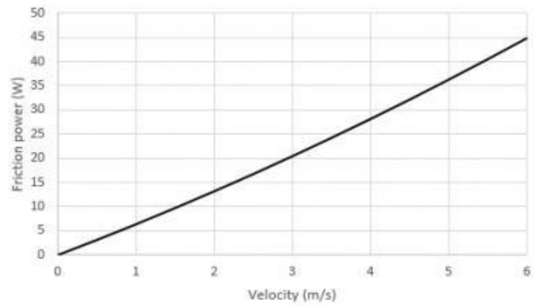

Figure 5. Friction power of a 25kg robot on treads.

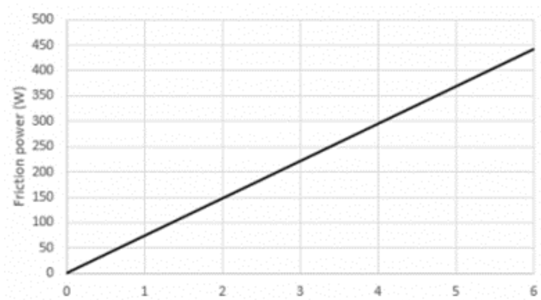

Figure 6. Friction power of a 25kg robot on wheels.

Compared to continuous track, it is evident that wheels on loose sand are an order of magnitude less efficient in this condition.

High self-discharge rates will be only an issue if the robot is not using for an extended period. The battery can be easily recharged or replaced if this is to happen. As a result, self-discharging properties do not take precedence when choosing a battery type. Because of their low energy density and environmentally dangerous qualities, nickel- cadmium and lead-acid batteries will not be used. Because of their excellent energy density, lithium battery packs appear to be the best choice for this application. Another benefit is that, as the number of electric vehicles using this battery chemistry grows, the cost of rechargeable lithium batteries drops.

C. *Electrical System*

Figure 8 shows the flow diagram of battery power distribution. As power needed by the beach robot is provided by an onboard battery pack consisting of two Li-Polymer 5000 mAh batteries. A single battery consists of 6 cells and weighs 772g. The maximum discharge rate is 25 ^{o}c. Many consumer electronics products now use lithium polymer ("LiPo") batteries. Over the last few years, they have grown in favour of the radio control sector, and they are currently the most preferred choice for anyone looking for long run times and high power. The structure of the electrical system is shown in Figure 7.

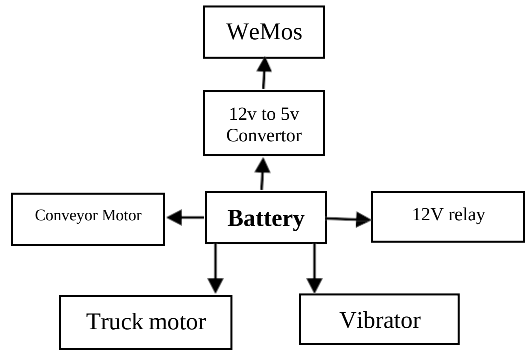

Figure 7. Flow diagram of battery power distribution

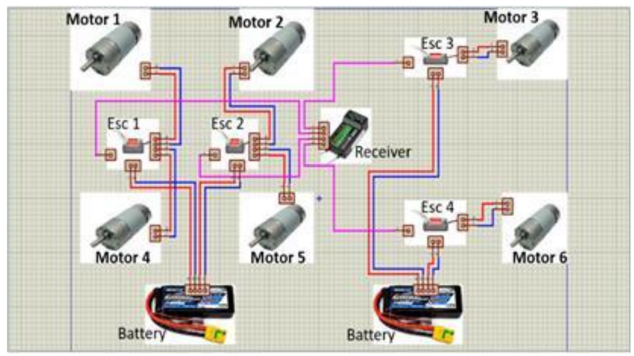

Figure 8. Structure of electrical system

D. *Sensor Architecture*

Figure 9 shows the sensor architecture and the relation between the project's WeMos Mini and ultrasonic sensors. It is fundamental to comprehend and understand the sensor architecture of this project because it shows the representation of the sensor inputs and output from the WeMos board. The project combines hardware, specifically in mechanical and electrical and software that includes coding the Arduino. Figure 2 shows the sensors and output connection with the microcontroller board. Also, there is an all-power connection of the sensor architecture system of the beach cleaning robot.

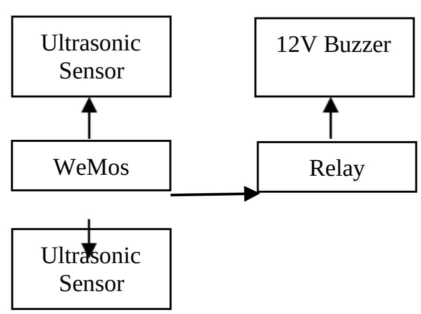

Figure 6. Sensor architecture

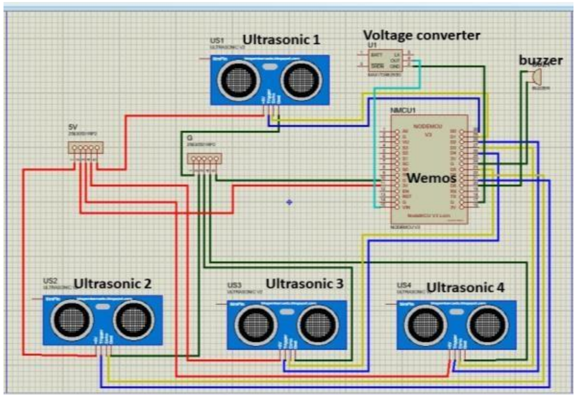

Figure 10. Input and output connection with WeMos

E. Hardware Requirement

This design is made using economically cost-effective equipment and easily available in the local market. For this, the following equipment were procured by conducting simple research in the market.

1) WeMos D1 Mini WIFI Board

WeMos D1 Mini is an ESP8266 12E based wi-fi development board. The functionality is similar to NodeMCU, except that the hardware is built in the Arduino UNO style. The D1 board can be configured to work in the Arduino environment using the board manager. The board has 11 Digital I/O Pins and one analogue Input Pin. The clock speed is 80MHz to160MHz.

Figure 11. WeMos D1 Mini board

2) Ultrasonic Sensor

The ultrasonic sensor (Figure 12) uses ultrasonic sound waves to detect the distance to a target object and converts the reflected noise into an electrical signal. The Transmitter which is generates sound using piezoelectric crystals. The Receiver encounters the sound after it has travelled to and from the target. The sensor measures the time between the Transmitter's sound emission and contact with the Receiver to calculate the distance between the sensor and the target [1].

Figure 12. Ultrasonic sensor

3) Electronic Speed Controller

The term "electronic speed control" refers to an electronic circuit that can adjust the speed of an electric motor and its path and function as a dynamic brake. These are commonly used on electrically powered radio-controlled models, with the change most usually used for brushless motors to provide an electronically created 3-phase electric power low voltage source of energy for the motor. Figure 13 shows the electronic speed controller.

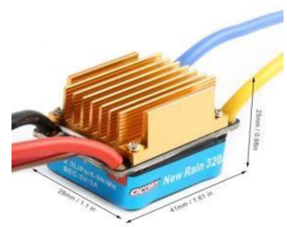

Figure 13. Electronic speed controller

4) 12V DC Regulator

This powerful step-up/step-down regulator efficiently provides a fixed 12V output from input voltages ranging from 3V to 30V, with output currents of up to 2A when the input voltage is close to the output voltage and typical efficiencies of 80% to 90%.

Its flexibility to convert both higher and lower input voltages make it suitable for varying lengths of power sources, such as batteries that start above but discharge below the regulated voltage. The DC regulator shows in Figure 14.

Figure 14. 12V DC Regulator

5) Li-Po Battery Pack

This beach clean robot uses the Protek R/C Li-Poly 2300mAh receiver battery pack with ultra-thick 20awg silicone wire. This ultra-light Li-Poly battery is made to power the electronics of 1/10th and 1/8th scale nitro race cars [6]. The primary advantage of using a Li-Poly receiver battery is that the battery voltage to your receiver andservos will remain constant during the race with the use ofa voltage regulator.

Figure 15. Li-Po Battery pack

6) Gear Motor

The gear motor is the sole component that connects an AC or DC electric motor to a gear reducer. In terms of gear motors, the unique factor are speed (rpm), torque, and efficiency. Gear motors can provide high torque at low speeds and low horsepower. On the other hand, Wormgears are ideal for low torque reductions and high-speed reductions. A worm gear is a screw attached to a spur gear with teeth that are slightly angled and curved. The plane of movement also changes due to the position of the worm on the worm Wheel, which modifies the rotational movement by 90 degrees. Figure 16 shows the gear motor. The gear motors used in the beach robot are as follows.

- Metal gear box
- Output shaft is self-locking due to the worm gear's characteristic
- Rated voltage: 12V DC
- Rated output speed: 150 RPM
- Rated output torque: 117mN.m
- Stalled torque: 196mN.m (2kgf.cm)
- No load current: 60mA

Figure 16. Gear motor

IV. TESTING AND RESULTS

In the final testing of the robot the small pebbles, shards of glass to larger debris, like seaweed and driftwood, floating waste like bottles and plastic cans on the beach are grabbed into the machine with the operation of the shovel in front of robot. The vibrator operates the preparation of garbage segregation. Through the part, it can segregate garbage and sand. The conveyer motor it transfers the segregated garbage to the garbage tray. Debris is collected into the garbage tray. The beach cleaner is travelled by the under-carriage track motor.

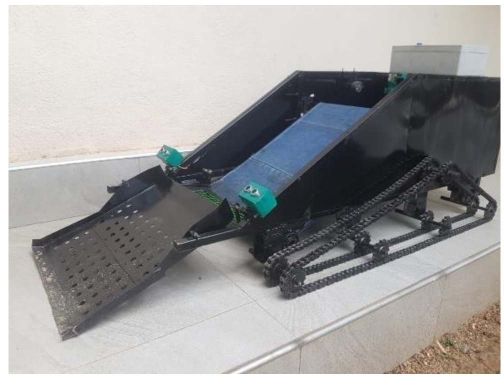

Figure 17. After assembly beach cleaning robot

Figure 18. After assembly

Figure 18 shows the after assembly of the beach cleaning robot. The RC Transmitter generates a modulated radio frequency carrier sent to the RC Receiver, which is tuned to detect the Transmitter's carrier frequency. Crystals are commonly used to ensure the accuracy of sending and receiving frequencies. The Receiver detects modulated carrier data, decodes it, and sends it to the relevant motor driver. Figure 19 shows the wiring connection of sensors.

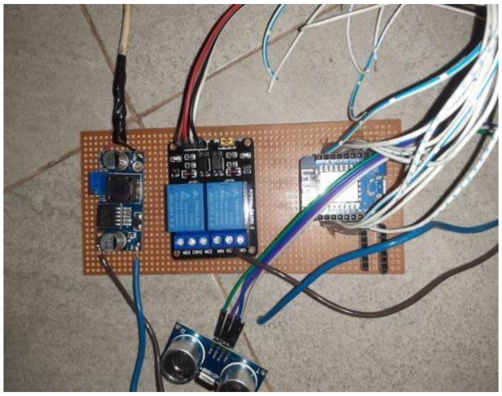

Figure 19. Connection with sensors and microcontroller

The buzzer's sensory hardware system works when the barrier detects the ultrasonic sensor. When the buzzer is working on the beach, the cleaner machine can stop by the machine operator. The garbage bin ultrasonic sensor gives the garbage bin's level and sends the level to the app, and the machine operator can see the level of the garbage bin. Using the WeMos D1 mini, it can transfer details given by the level of the garbage bin. One of the main parts of this project is this IoT-based garbage level monitoring.

Figure 20. Blynk interface

An IoT platform is required for real-time data transmission. To do this, the project used the blynk platform, an open-source platform. It is user friendly, and using this platform can display the real-time values of the garbage level. At first, we did some research, and we managed to connect to the Blynk and display the level of the garbage bin. Blynk application is installed on smartphones, and the level of the bin is a real-time update displayed in the blynk application. Figure 20 shows the Blynk interface on the mobile phone. Garbage tray full notification shows in the Figure 21.

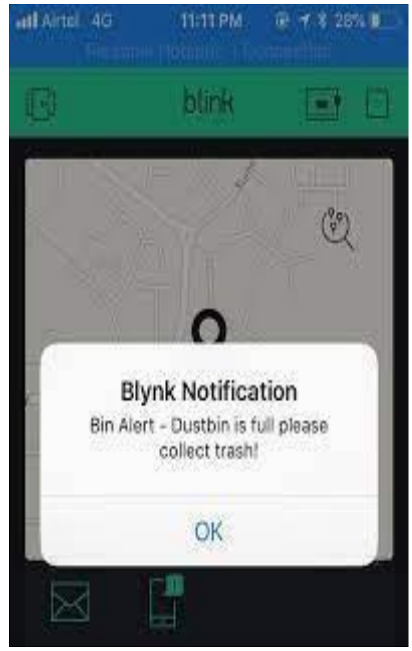

Figure 21. Blynk notification interface

V. CONCLUSIONS

Coasts are the main attraction of tourists, for attracting them, beaches must be kept clean. So, we have come up with cleaning equipment that helps us to clean the beach with less investing hours as today's era is moving towards being digitalized and automated. People in all generations want everything very easy and smart. They are gettingattracted to the latest technology. Nobody likes to wait for long to get good surroundings. To avoid this and add value to human labor, we have created a Beach Cleaner machine.This model is implemented to remove garbage and other debris from beaches and make them pleasant.

The Beach Cleaner robot machine was implemented successfully. The development of beach cleaners includes a high-performance electrical motor to drive the robot and using the IoT platform to indicate the level of the garbage tray remotely. It will help us to keep the coasts clean and save the ocean life from garbage pollution. This project does not need more human labor. Furthermore, this can reduce the direct contact of with human laborers with waste. So, there is no hazard for human laborers. We concluded that the cleaning process of the beaches needs tobe upgraded with the latest engineering system and, most importantly, to make beaches safe, comfortable andvisually pleasing for visitors.

ACKNOWLEDGEMENT

The authors wish to express their gratitude to all academic staff members of the Department of Electrical & Electronics Technology, Faculty of Engineering Technology, University of Vocational Technology for their support. Sincere thanks should go to Eng. Dilshan Ganegoda for supporting this study.

REFERENCES

[1] H. D. M. R. G. N. M. V. P. Walsh Tony Fernandes1, "BEACH CLEANING BOT," *International Research Journal of Engineering and Technology* , vol. 6, no. 7, pp. 7307-7313, June 2020.

[2] C. U. E. G. J. G. J. T. Oscar Cieza, "sistemaolimpo," 2018. [Online]. Available: http://www.sistemaolimpo.org/midias/uploads/d7abd08b1e341fcd029c5ca0e3ca2218.pdf. [Accessed 24 01 2022].

[3] O. D. A. K. S. T. R. P. Vivek Dhole, "DESIGN AND FABRICATION OF BEACH CLEANING MACHINE," *International Research Journal of Engineering and Technology*, vol. 6, no. 4, pp. 796-800, 2019.

[4] S. S. S. M.Bhavani, "Semi Automated Wireless Beach Cleaning Robot Vehicle," *International Journal of Recent Technology and Engineering,* vol. 8, no. 1S2, pp. 108-110, 2019.

[5] R. N. N. P. J. R. ,. N. M. N. K. B. Ramamoorthi R, "Design and Fabrication of Beach Cleaning machine," *International Journal of Innovative Technology and Exploring Engineering,* vol. 8, no. 12, pp. 1597-1602, 2019.

[6] P. A. K. M. A. Praveen, "Design experimental of RF controlled beach cleaner robotic vehicle," 2020.

[7] M. P. Alessio Carullo, "An Ultrasonic Sensor for Distance Measurement in Automotive Applications," *IEEE SENSORS JOURNAL, VOL. 1, NO. 2, AUGUST 200,* vol. 1, no. 2, pp. 143-147, 2001.

[8] R. kits, "Intorobotics," 13 11 2013. [Online]. Available: https://www.intorobotics.com/wheels-vs-continuous-tracks-advantages-disadvantages/. [Accessed 12 05 2022].