Project Report for Winter Semester 2021

Solar Powered Trash Collector and Quality Analyser

Microprocessors and Microcontrollers (CSE2016)

by

NAME	REGISTRATION NUMBER
Swayam Prakash Pati	19BCT0161
Disha Jain	19BCT0219

Under the Guidance of

Dr.Yokesh Babu S

Department of IoT

VIT University, Vellore

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Swayam Prakash Pati   Disha

Swayam Prakash Pati
19BCT0161

Disha Jain
19BCT0219

EXECUTIVE SUMMARY

Water pollution has caused 1.8 million deaths in 2015, according to a study published in The Lancet. Every year, unsafe water sickens about 1 billion people. This project is conducted to help clean the environment, using renewable energy, the sun, as a more efficient power source. The present design of this prototype works on the objective of minimizing human efforts on manual picking of wastes, without risking their health and testing water quality, so that the consumer can ensure that the water is safe and clean.

“Solar Powered Trash Collector and Water Quality Analyser” collects the garbage floating on the surface of water and measures the levels of temperature, pH, turbidity and chlorine contents, to ensure the quality of water remains intact by integrating various sensors. This project involves an autonomous bot working on solar energy, saving the manpower and energy both.

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1. INTRODUCTION

1.1. Motivation

Rivers, lakes and aquifers are drying up or becoming too polluted to use. Over 80% of the waste generated on land finds its way into oceans; plastic forms a major part of the waste. In India today more than 25,000 tonnes of plastic waste is produced daily, of which 10,000 tonnes goes to landfill. In some least-developed countries, the figure tops 95 percent. Harmful bacteria from human waste contaminates water and makes it unfit to drink or swim in. Nutrient pollution, which includes nitrates and phosphates, is the leading type of contamination in these freshwater sources. Radioactive waste on the other hand can persist in the environment for thousands of years, making disposal a major challenge. Concern about water availability grows as freshwater use continues at unsustainable levels. Furthermore, the addition of new faces also needs food, shelter, and clothing, thus resulting in additional pressure on freshwater through the production of commodities and energy. Agriculture uses 70% of the world’s accessible freshwater, but some 60% of this is wasted due to leaky irrigation systems, inefficient application methods as well as the cultivation of crops that are too thirsty. Added to these thirsty crops are the fact that agriculture also generates considerable freshwater pollution – both through fertilizers as well as pesticides – all of which affect both humans and other species. The issue in focus gets severe as we go through more numbers. ***“Solar Powered Trash Collector and Water Quality Analyser” collects the garbage floating on the surface of water and measures the levels of temperature, pH, turbidity and chlorine contents, to ensure the quality of water remains intact by integrating various sensors. This project involves an autonomous bot working on solar energy, saving the manpower and energy both.***

1.2. Background

Currently, the trash cleaning systems are divided into static (autonomous , mechanical) and dynamic (autonomous , human based computation). There are efforts being executed by several countries in order to reduce and overcome plastic pollution.

Trash Cleaning System		
Method	**Region**	**Description**
Static - Autonomous		
Automatic trash removal system	India	It is powered by solar. The trash are collected by conveyor and the test field taken for testing were the canals and local water bodies [25].
Static - Mechanical		
Solar-powered water wheel	United State	It is powered by harnessing the energy from river current. Variety of trash were collected using conveyor and it took place in Baltimore's inner harbour [26, 27].
Dynamic - Autonomous		
Ocean clean-up project	Great Pacific Garbage Patch	It is floating barriers with 600 meters in length. It moves towards the pacific garbage with the help of natural current system and ocean's gyres [28].
Waste shark	Netherlands	It is a small aquatic drone used to collect floating trash near the Rotterdam port by patrolling around the river without oversight of human [29].
SeaVax	United Kingdom	It is a robotic vessel used to patrol the trash in the sea over a long distance. A remote command is used to guide towards the known gyre of plastic and then collected [30].
Automatic trash collection boat	China	An initiative to collect different kinds of trash including plastics, debris and construction waste [19].
Dynamic – Human-based Computation		
Buddy catamaran	United Kingdom	It is designed for cleaning marine debris as well as waterways maintenance especially marinas and harbours [31].
Trash skimmers	New York	It is a skimmer boat used for cleaning trash on both fresh and salty water surface with a low profile configuration for under lower obstruction. Able to retrieve both large and small objects by using the front conveyor [32].
Floating trash skimmer	India	It is a skimmer boat used for collecting trash and aquatic weed [33].
TrashCat	Malaysia	This skimmer boat is used to remove the floating trash and debris along the Klang River [20, 21].
Harvester	Thailand	A skimmer boat used to drag up waste mainly composed of aqua weeds and other types of debris along the Chao Phraya River [22].
Skimmer boat	Philippines	The boat is semi-mechanized and it scoop up the garbage from the water surface at Manila Bay [34, 35].
Trash robot	Chicago	It was designed with two functions; autonomous and human-based computation. It can also be controlled by using web browsing with camera installed enabling users to know their directions [36].
Ro-boat	India	It is a cleaning robot purposely created for Yamuna and Ganga River. This robot is capable of detecting pollutant such as metals, plastics and water chemical as well as ability to completely submerge under water to collect trash on the river bed [37].

Fig.1. Current Trash Cleaning Systems[1]

The techniques currently used in water purifying technology are Activated Carbon, Electrode ionization, Ion Exchange, Pressure, Reverse Osmosis, Sub-Micron Filtration and Ultraviolet Rays, and mainly man powered for water bodies.

2. Technical Specification

2.1 Block Diagram

The model is powered by a Solar panel and a battery for assisted power. The bot travels around on the surface of water. It has been equipped with an ultrasonic sensor in the front to detect any obstacle that comes in front of it. When an obstacle gets detected, the camera fitted on the front captures the image of the obstacle and processes it to detect if it is garbage or some marine creature, for which the machine gets trained beforehand. If the obstacle is not some marine creature, then the garbage collector gets activated which picks and dumps the garbage in the garbage bin at the bottom of the bot. If the detected obstacle is some marine creature then the bot behaves just like an obstacle avoidance robot and drives away using the thrusters, which are driven by the motor driver.

The bot is also fitted with various sensors to constantly monitor the water quality around.

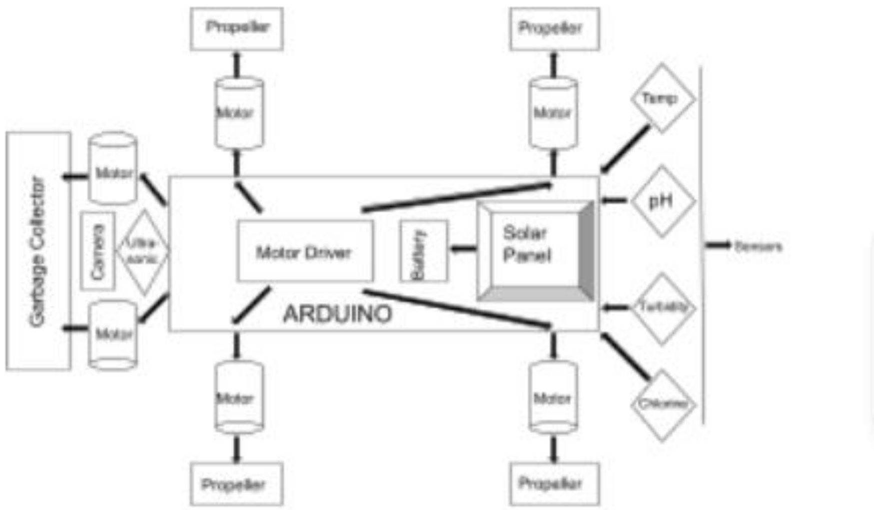

Fig.2. Diagram of the model

2.2 Circuit Diagram

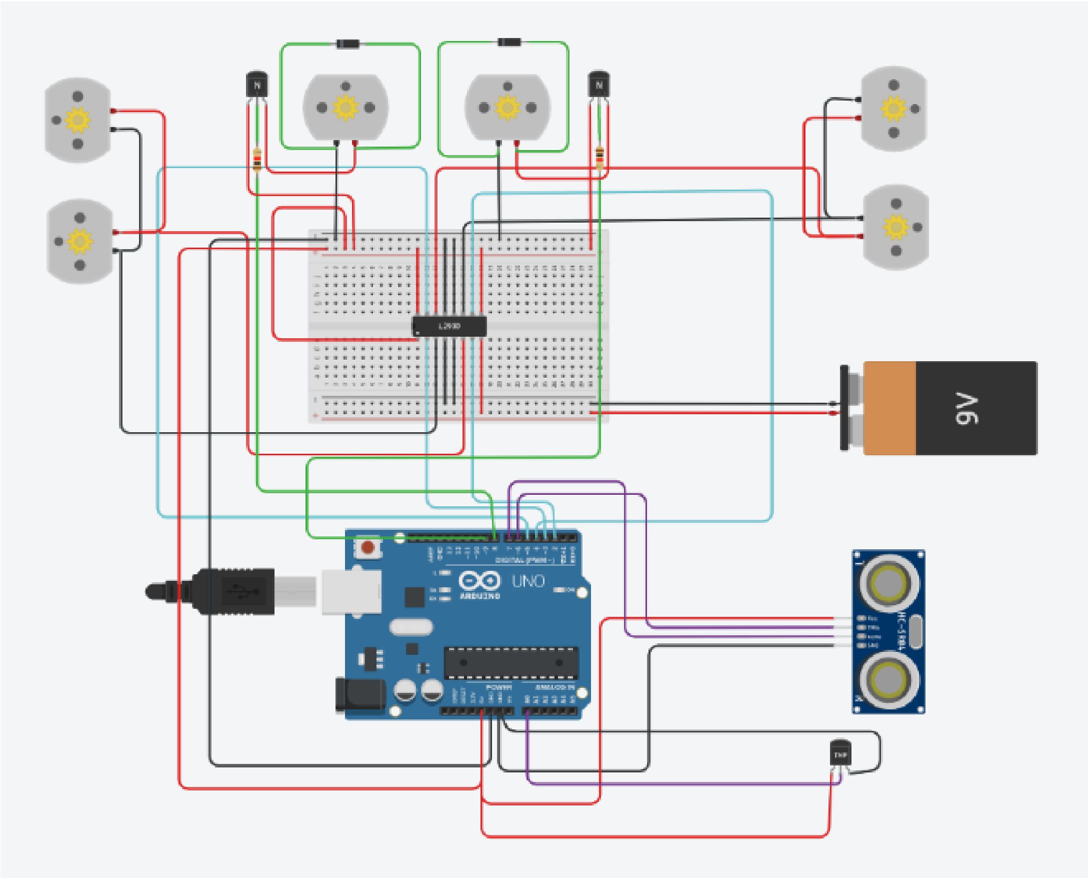

Fig. 3. Circuit Diagram of the model

3. Design Approach and Details

3.1. Material Used

3.1.1 Hardware Used

A. **Microcontroller / Arduino UNO** is the main component of the device because it is responsible for processing and storing the signals. Here we are using Arduino UNO microcontroller which is an electronic development board consisting of an open-source electronic circuit with a computer-controlled microcontroller designed to facilitate the use of interactive electronics in multidisciplinary projects. It has 14 digital input/output pins, 6 analog inputs, a USB connection, a power jack, an ICSP header, and a reset button. Figure 4 shows the microcontroller we are using.

Fig. 4. Arduino Uno

B. The **L293D** is a popular 16-Pin Motor Driver IC. As the name suggests it is used to drive motors. A single L293D IC is capable of running two DC motors at the same time; also the direction of these two motors can be controlled independently. Speed control is also possible. Motor voltage is about 4.5V to 36V. It has 16 digital pins.

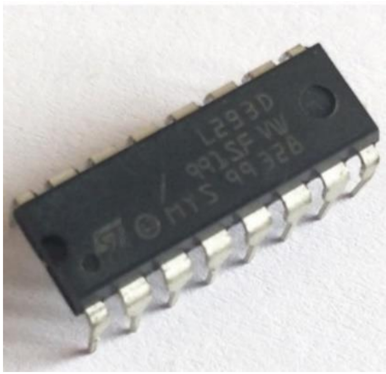

Fig. 5. L293D Motor Driver IC

C. Epoxy **solar panel** is a new technology solar panel that is very lightweight. It can be used for electronic projects, robotics, portable solar panels, solar bag, garden lights, and other small electronic products.

Fig. 6. Solar Panel

D. 12V 1.2Ah **Rechargeable Lead Acid Battery** is normally used for robots in competition. Wired or Wireless Robots run for a long time with high speed with this type of battery. Seal Lead Acid (SLA) Rechargeable battery is the most common general purpose battery. We recharge it using solar energy.

Fig. 7. Rechargeable Battery

E. Here **DC Motor** is used to rotate the panel in the required direction. In our project we have used four DC motors which are connected to the Arduino using an L293D motor driver and two more directly connected to the Arduino.

Fig. 8. DC Motor

F. The TMP36 **temperature sensor** is an easy way to measure **temperature** using an **Arduino**. The **sensor** can measure a fairly wide range of **temperature** (-50°C to 125°C), is fairly precise (0.1°C resolution), and is very low cost, making it a popular choice.

Fig. 9. DS18B20 Temperature sensor probe (water proof) for Arduino, raspberry pi, esp8266

G. We use the **Turbidity Sensor** to determine the purity of the water body and extent of dissolved particles. Turbidity should ideally be kept below 1 NTU because of the recorded impacts on disinfection. This is achievable in large well-run municipal supplies, which should be able to achieve less than 0.5 NTU before disinfection at all times and an average of 0.2 NTU or less, irrespective of source **water** type and quality.

Fig.10. Turbidity Sensor

H. We use the **pH sensor** to determine acidity of the water body and to see if it is favourable. The normal range for pH in surface water systems is 6.5 to 8.5 and for groundwater systems 6 to 8.5.

Fig.11. pH Sensor

I. We use the **TOC Sensor** to measure the organic contamination of the water body.

Fig.12. TOC Sensor

J. The **HC-SR04** ultrasonic distance sensor is an economical sensor that provides 2cm to 400cm of non-contact measurement functionality with a ranging accuracy that can reach up to 3mm. Each HC-SR04 module includes an ultrasonic transmitter, a receiver and a control circuit.

Fig.13. Ultrasonic Sensor

K. **The HC-05 Bluetooth Receiver** is a very cool module which can add two-way (full-duplex) wireless functionality to the projects. We can use this module to communicate between two microcontrollers like Arduino or communicate with any device with Bluetooth functionality like a Phone or Laptop. There are many android applications that are already available which makes this process a lot easier. The module communicates with the help of USART at 9600 baud rate hence it is easy to interface with any microcontroller that supports USART.

Fig.14. HC-05 Bluetooth Module

L. The **OpenMV Cam** is a small, low power, microcontroller board featuring an STM32H743II Arm® Cortex® M7 processor running at 480MHz, which allows you to easily implement applications using machine vision in the real world. It is equipped with 32MB of SDRAM, 1MB of RAM, and 2MB of flash.

Fig.15. Digital Camera

3.1.2 Software Used

A. **Tinkercad** is a free-of-charge, online 3D modeling program that runs in a web browser, known for its simplicity and ease of use. Since it became available in 2011 it has become a popular platform for creating models for 3D printing as well as an entry-level introduction to constructive solid geometry in schools. Tinkercad uses a simplified constructive solid geometry method of constructing models. Circuits can also be simulated easily in this software.

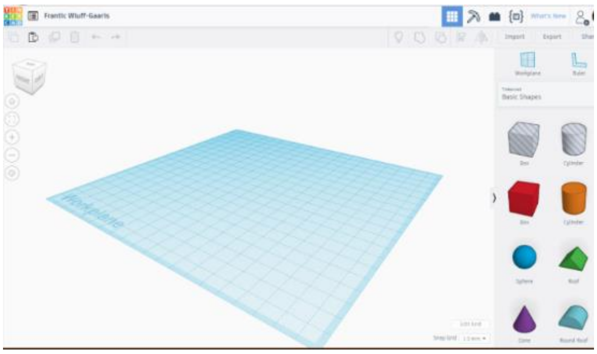

Fig.16. Tinkercad interface for 3D modelling

B. **Google Teachable Machine** is a web tool that makes it fast and easy to create machine learning models for your projects, no coding required. Train a computer to recognize your images, sounds, & poses, then export your model for your sites, apps, and more.

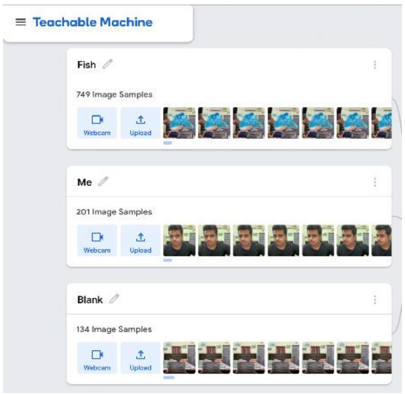

Fig.17. Interface of teachable machines

3.2. Methodology

The prototype of the device was formed using the circuit diagram. The power supply, which is a rechargeable battery, feeds the microcontroller with power to generate the AC signals and to supply the component with DC, also feeds the motors and the sensors. The battery is charged using the Solar Panel. The microcontroller which is an Arduino Uno stores the signals from the sensors attached in its memory and those signals can be adjusted according to the program. The image processing area controls the movement of the garbage collector using the help of the camera and the microcontroller.

TABLE 1 : Connections between Arduino and the Sensors

S. No.	Sensor Name	Sensor Pin	Arduino Pin
1	Ultrasonic Sensor	Trig, Echo	A0
2	Temperature Sensor	V_{out}	A1
3	Turbidity Sensor	V_{out}	A2
4	pH Sensor	V_{out}	A3
5	TOC Sensor	V_{out}	A4

TABLE 2 : Connections between Arduino and other components

S. No.	Component Name	Component Pin	Arduino Pin
1	L293D	I1, I2, I3, I4	2, 3, 4, 5
2	Motor 1 (for collection)		8
3	Motor 2 (for collection)		9
4	Bluetooth Receiver	Tx, Rx	0,1

Fig.18. Interconnections with the Arduino

3.3 Codes and Standards

The purpose of the project is to detect the garbage on the surface of the water and collect it in the collection tray provided. The connection could not be shown between the image detection algorithm and online simulation, thus we used serial input for differentiation between garbage and marine creatures during simulation. Due to unavailability of originally used sensors, we use demo sensors instead.

```
//code for the model

long cm;

long duration;

const int echoPin = 7;

const int trigPin = 6;


const int lm1 = 2;
```

```
const int lm2 = 3;

const int rm1 = 4;

const int rm2 = 5;

const int tm1 = 8;

const int tm2 = 9;

int pinTemp = A1;


String name= "";

void setup()

{

  pinMode(lm1, OUTPUT);

  pinMode(lm2, OUTPUT);

  pinMode(rm1, OUTPUT);

  pinMode(rm2, OUTPUT);

  pinMode(tm1, OUTPUT);

  pinMode(tm2, OUTPUT);

  pinMode(pinTemp, INPUT);


  pinMode(trigPin, OUTPUT);

  pinMode(echoPin, INPUT);


  Serial.begin(9600);

}


void loop()

{


  // measure the temperature ahead
```

```
 int temp = analogRead(pinTemp);

//Read the analog pin
 temp = temp * 0.48828125;
// convert output (mv) to readable celsius
//print the temperature
Serial.print("Temperature:");
Serial.print(temp);
Serial.println("C");
//print the temperature status

// measure the distance ahead
digitalWrite(trigPin,LOW);
delayMicroseconds(2);           digitalWrite(trigPin,HIGH);
delayMicroseconds(5);
digitalWrite(trigPin, LOW);
duration = pulseIn(echoPin, HIGH);
cm = duration*0.034/2;
// print the distance
Serial.print("Distance:CM ");
Serial.println(cm);

if(cm < 20)
            {
    //check if object is garbage
    //if yes, start the conveyor motor
    //if no, turn to the left
            stop_bot();
```

```
            image_processing();
            if(name=="1")
                        {
                        conveyor();
                        }
            else
                        {
                                                reverse();
                        }
            }
  else
            {
            go_straight();
            delay(1000);
            }
}

//  Here are the functions that are used in the program
void image_processing()
{
            Serial.println("Enter number");
            while (Serial.available() == 0)
            { //Wait for user input
            }
            name = Serial.readString(); //Reading the Input string from Serial port.
}

void conveyor()
```

```
{
	digitalWrite(tm1,HIGH);
	digitalWrite(tm2,HIGH);
	delay(10000);
	digitalWrite(tm1,LOW);
	digitalWrite(tm2,LOW);
	go_straight();
}

void go_straight()
{
	digitalWrite(lm1,HIGH);
	digitalWrite(lm2,LOW);
	digitalWrite(rm1,HIGH);
	digitalWrite(rm2,LOW);
}

void go_back()
{
	digitalWrite(lm2,HIGH);
	digitalWrite(lm1,LOW);
	digitalWrite(rm2,HIGH);
	digitalWrite(rm1,LOW);
}

void stop_bot()
{
	digitalWrite(lm1,LOW);
```

```
        digitalWrite(lm2,LOW);
        digitalWrite(rm1,LOW);
        digitalWrite(rm2,LOW);
}

void go_left()
{
        digitalWrite(lm1,LOW);
        digitalWrite(lm2,LOW);
        digitalWrite(rm1,HIGH);
        digitalWrite(rm2,LOW);
}

void go_right()
{
        digitalWrite(lm1,HIGH);
        digitalWrite(lm2,LOW);
        digitalWrite(rm1,LOW);
        digitalWrite(rm2,LOW);
}

void reverse()
{
      stop_bot();
      delay(2000);

      go_back();
      delay(2000);
```

```
    stop_bot();
    delay(1000);

    go_left();
    delay(1000);
}
```

4. Project Execution

4.1 Circuit Simulation

When the distance is less than 20cm, the motion of the device stops and the controller asks for input (signifying waiting for the input from the ML machine on whether the object is garbage or not). For the code, input 1 is the signal to use the garbage collector, thus the motors used to collect garbage start on the input 1, while the other motors stand still.

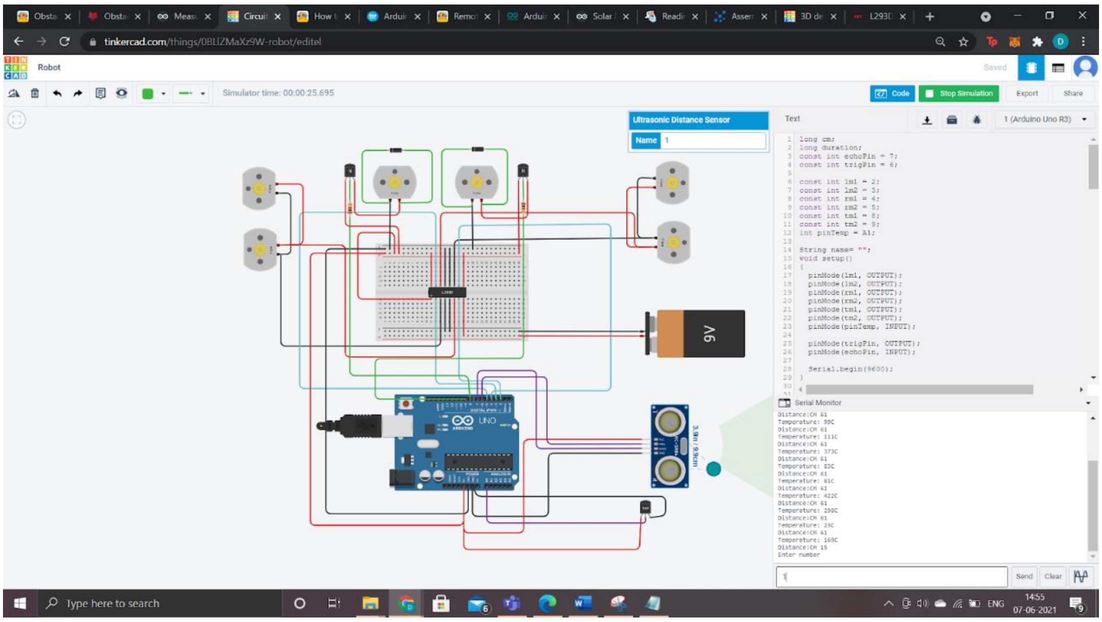

Fig.19. When distance<20cm and the input is 1

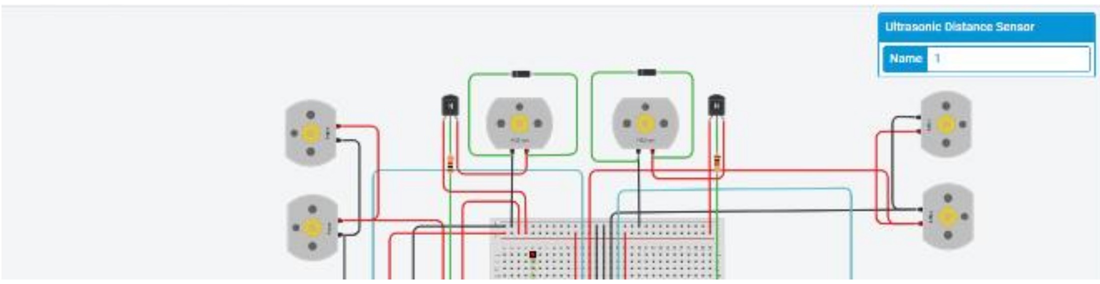

Fig.20. Zoomed in view of motors

For any input other than 1, the controller assumes that the object is not garbage and takes a left turn after going back first. Here the motors responsible for collection do not move.

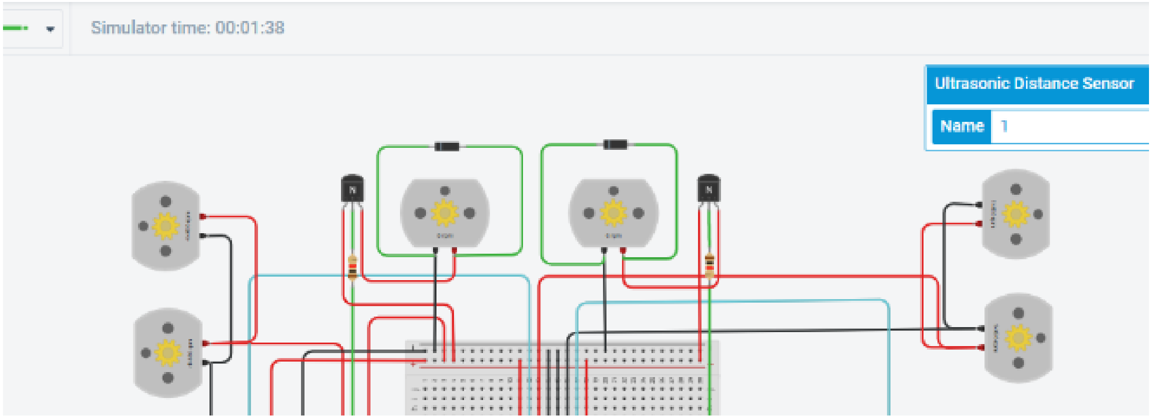

Fig.21. Zoomed in view of motors when input is any number but 1

For distances more than 20cm, the device keeps moving forward.

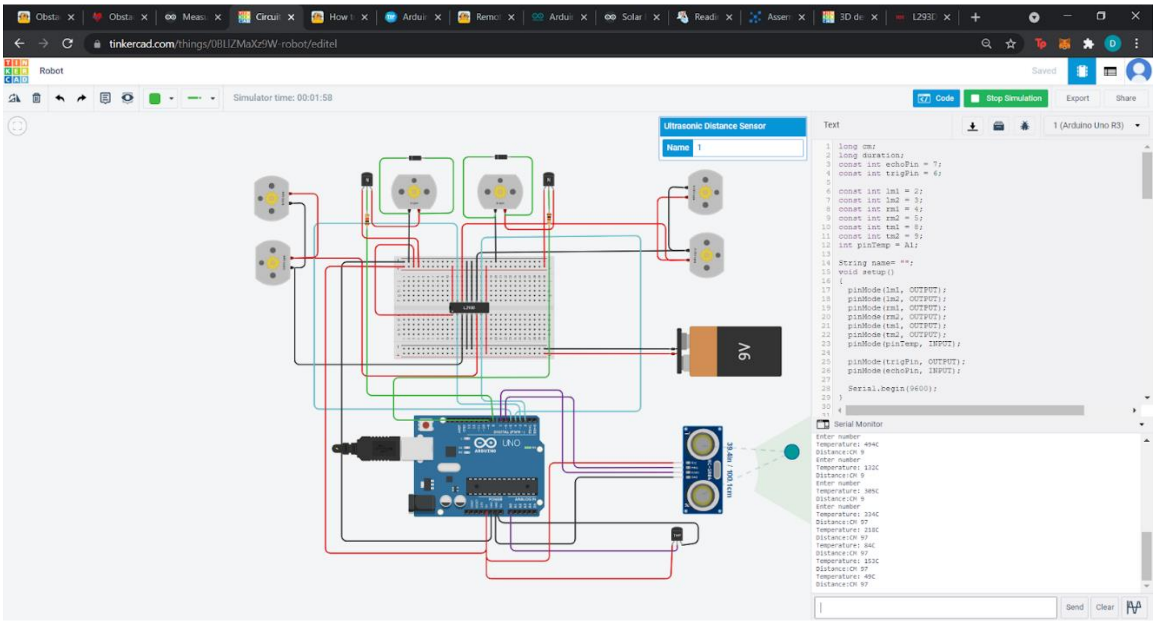

Fig.22. When distance>20cm

4.2 3D Model of the project

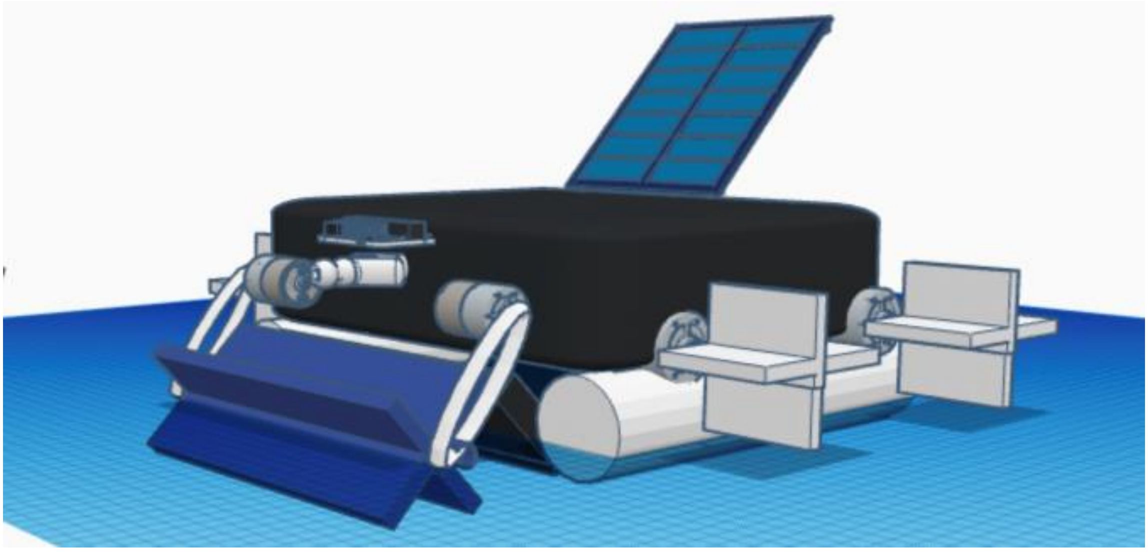

Fig.23. Side view of the model

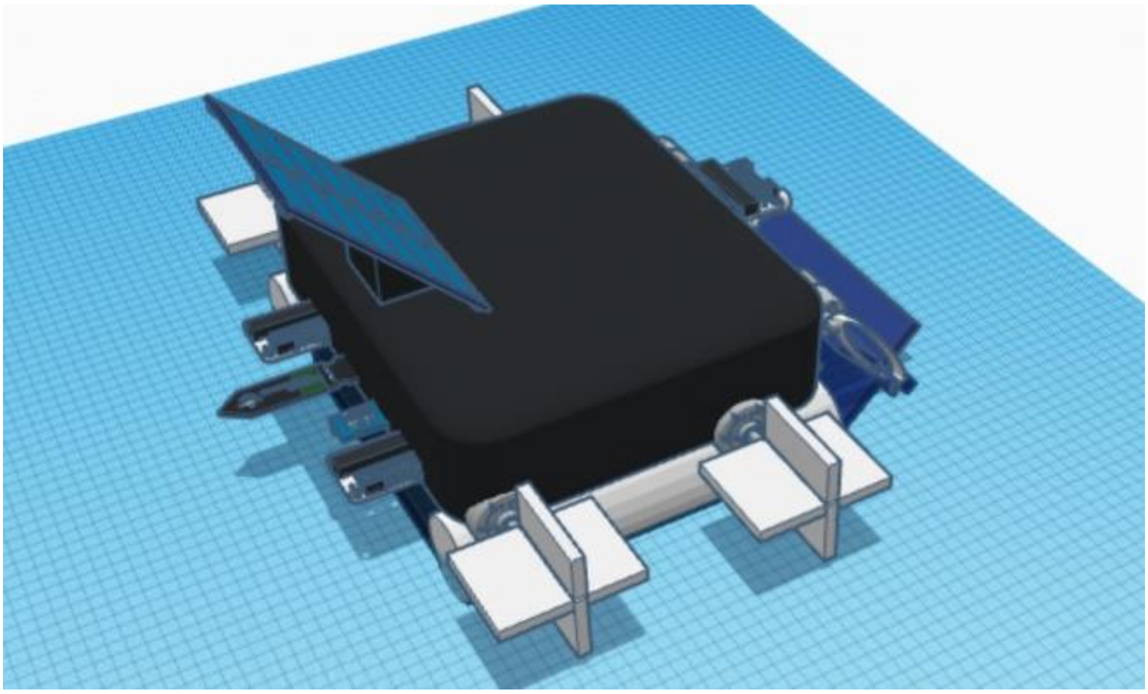

Fig.24. Top view of the model

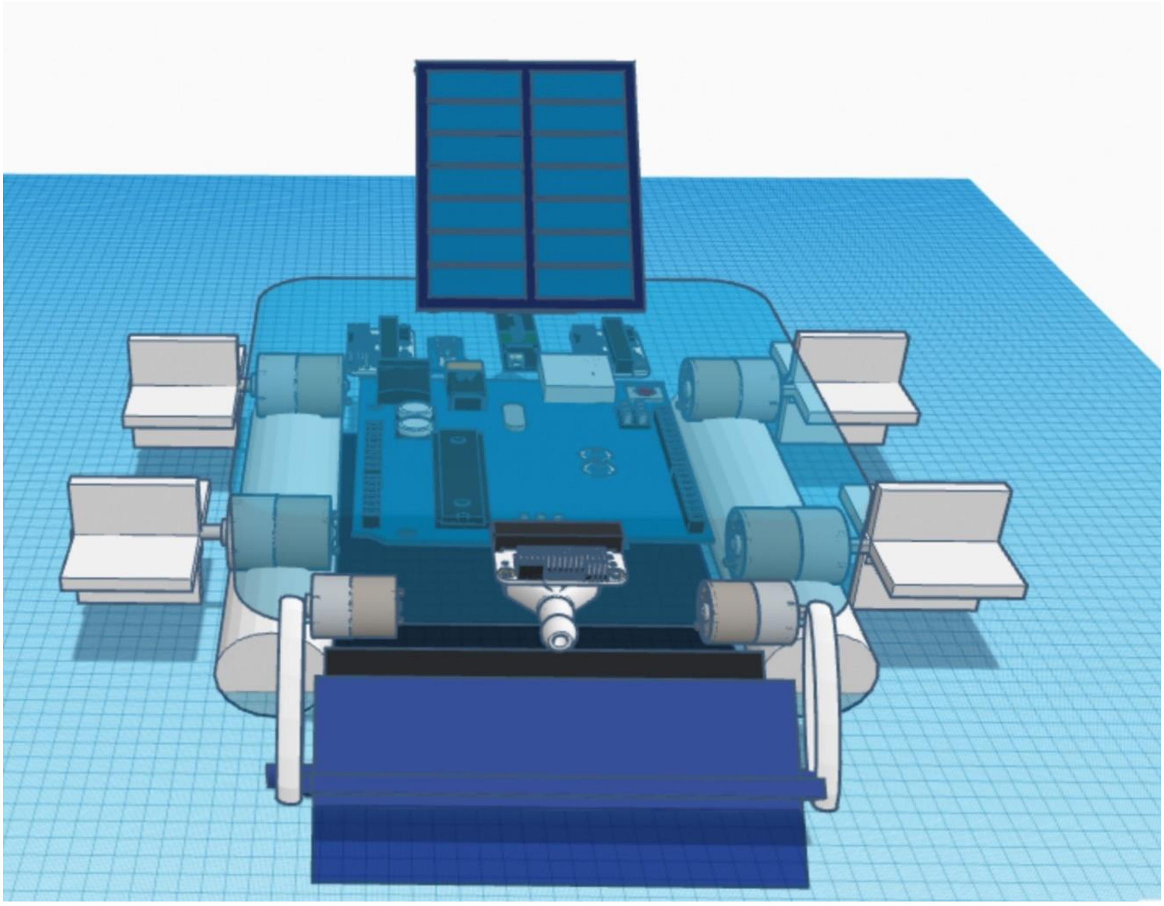

Fig.25. Front view of the model (transparent view)

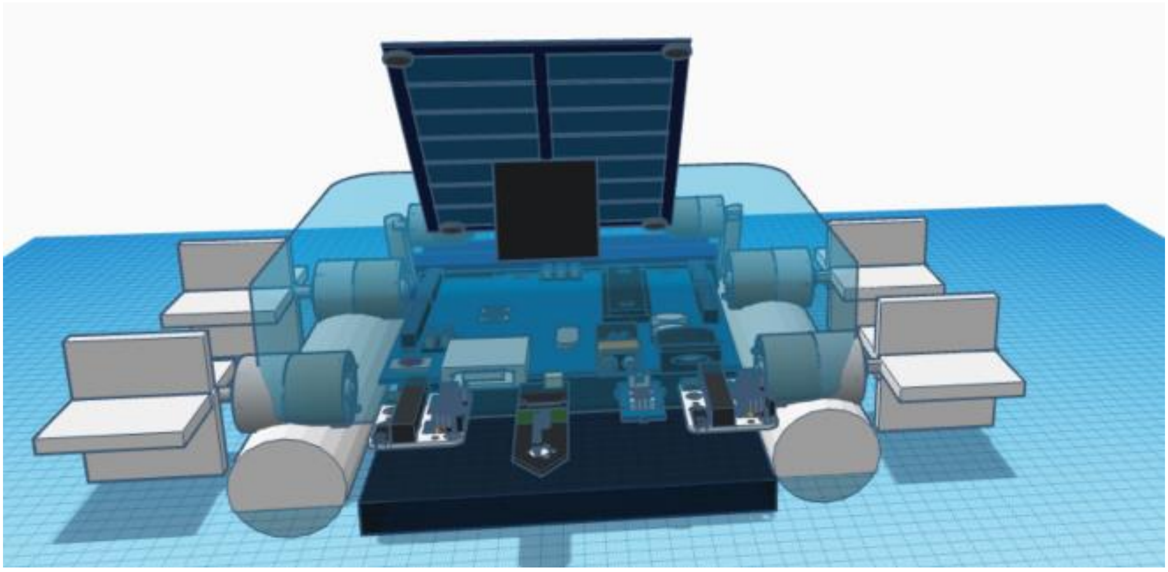

Fig.26. Back view of the model (transparent view)

4.3 ML Model for Image Processing

Tensorflow Code:

```
import tensorflow.keras

from PIL import Image, ImageOps

import numpy as np


# Disable scientific notation for clarity

np.set_printoptions(suppress=True)


# Load the model

model = tensorflow.keras.models.load_model('keras_model.h5')


# Create the array of the right shape to feed into the keras model

# The 'length' or number of images you can put into the array is

# determined by the first position in the shape tuple, in this case 1.

data = np.ndarray(shape=(1, 224, 224, 3), dtype=np.float32)


# Replace this with the path to your image

image = Image.open('test_photo.jpg')


#resize the image to a 224x224 with the same strategy as in TM2:

#resizing the image to be at least 224x224 and then cropping from the center

size = (224, 224)

image = ImageOps.fit(image, size, Image.ANTIALIAS)


#turn the image into a numpy array

image_array = np.asarray(image)
```

```
# display the resized image
image.show()

# Normalize the image
normalized_image_array = (image_array.astype(np.float32) / 127.0) - 1

# Load the image into the array
data[0] = normalized_image_array
# run the inference
prediction = model.predict(data)
print(prediction)
```

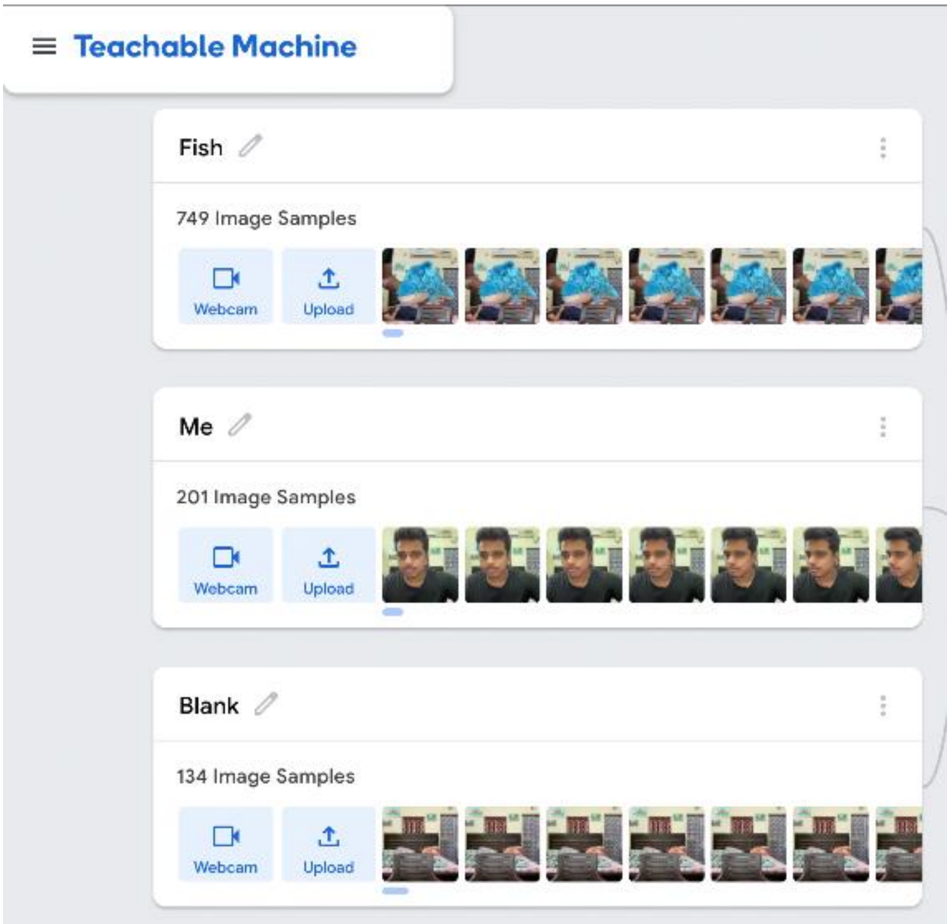

Fig.27. Training data set

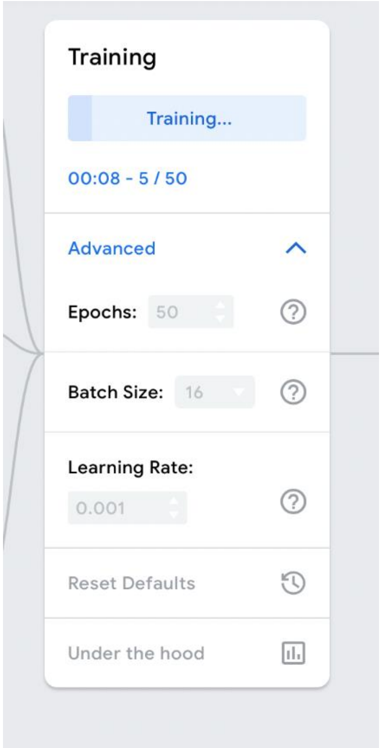

Fig.28. Training the model

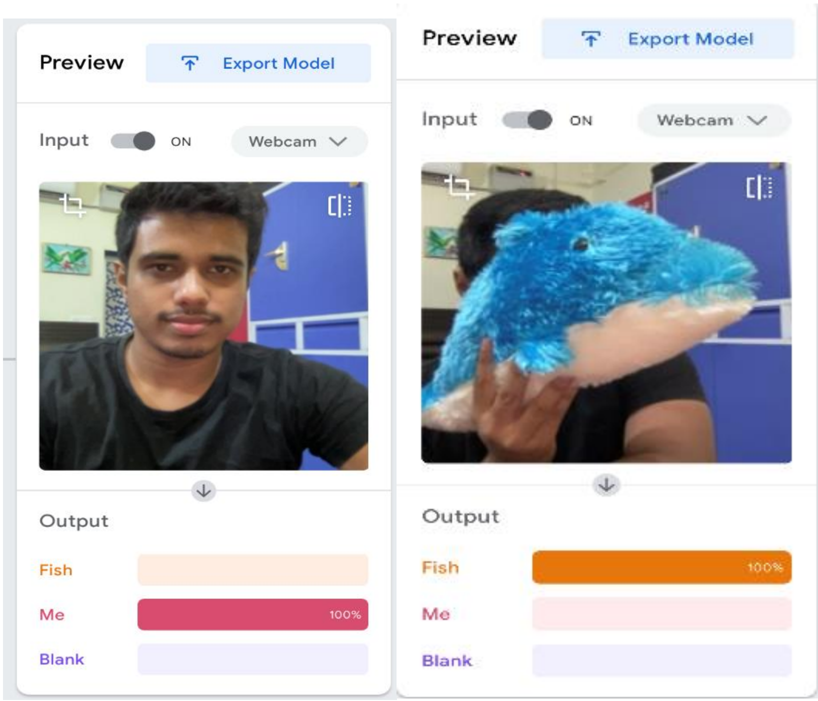

Fig.29. Results of trained model

Link for testing the model online: https://teachablemachine.withgoogle.com/models/Z9Wpws-Xu/

5. Results and Discussions

In this project, we made a solar panel powered trash collector and water quality analyser. Image processing was successfully implemented using teachable machines and so was the simulation. The information of the sensors was also successfully displayed on the serial monitor. We could use the Wifi module, to serially transfer the information received by the sensors to the user through an app designed for the same.

The 3D design of the model was made and can be implemented in reality as well.

6. Scope of Future

An app can be developed for receiving the information received by the sensors via a Wifi module. The device motion can also be controlled by the same app. It can be responsible for both the objectives and can be built easily for an efficient user experience.

The device we have developed has certain limitations. It can only be used for small lakes and rivers. We could modify it for bigger lakes and rivers. With that implementation, it could cover larger parts of the water bodies, removing a lot of manpower which was our objective in the first place.

Source of power can be modified accordingly to gain more power.

7. Conclusion

Solar Powered Trash Collector and Water Quality Analyser" collects the garbage floating on the surface of water and measures the levels of temperature, pH, turbidity, chlorine to ensure the quality of water remains intact by integrating various sensors. It can be modified to achieve better efficiency and reduce unnecessary manpower by covering large areas.

The objectives were achieved in the project.

8. REFERENCES

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