

Smart Dustbin for Waste Management System

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Abstract: Approximately 36.5 million tons of garbage is produced by the country annually. If dustbin is not maintained then these can cause an unhealthy environment and can cause pollution that affects our health. The main objective of the project is to design a smart dustbin which will help in keeping our environment clean and reduce human interaction. This smart garbage bin is built using IoT and Robotics. It consists of hardware such as microcontroller, motor driver IC, Wi-fi module, servo motor, battery, etc. which is controlled by remote. The arms of the dustbin move with the help of the servo motors.

This project aims to be a better and updated version of the current technologies by adding the robotic arms and mobile nature. For society it will help toward health and hygiene and can be used in smart city projects. This project will be made available for all sections of the society as well as all the possible places.

Key Word: IoT, robotics, Arduino; microcontroller; Motor driver IC; servo motor.

I. Introduction

The exponential rise of the human population offers a tremendous challenge to the garbage collection system and, as a result, to keep the environment clean. Poor waste management has put many cities across the world in jeopardy. Buildings and campus facilities go through a lot of wear and tear on a daily basis. The number of sites on campus that need to be cleaned is long, including cafeterias, restrooms, dormitories, classrooms, administrative buildings, corridors, and lawns. When it comes to establishing a secure and healthy learning environment, no stone should be left unturned. Every day, hundreds of thousands of students, teachers, and visitors pass through the gates of colleges and universities, pouring waste all around, thereby making the campus dirty. Given the magnitude of the problem, it has become imperative to take action to address the mismanaged waste. As a result, the notion of a "SMART GARBAGE BIN" is offered, which would aid in the creation of a clean, healthy, and positive image of the institution by assuring the prompt removal of unsanitary materials and rubbish that has been strewn about for extended periods of time. Thus, the initiative intends to eliminate unsanitary conditions, minimize human resources and efforts, and improve the concept of a smart city.

II. Literature Review:

India confronts significant environmental challenges due to garbage generation, insufficient trash collection and improper transportation, treatment, and disposal. India's current waste management systems are unable to cope with the increasing amounts of waste generated by an expanding urban population, posing a threat to the environment and public health. The obstacles and challenges are substantial, but so are the potential. We are inspired by the Swachh Bharat Mission. In this rapidly changing environment this project, "A smart garbage dustbin by using Arduino" is designed. Smart garbage bins, according to the currently existing technology, have the capability to detect the level of bin filling in order to avoid waste overflow by emitting an alarm signal via an ultrasonic sensor[1]; to separate garbage into biodegradable and non-biodegradable waste[2]; and to provide information about the location of the garbage bin[3]. This project sought to change the system so that it becomes entirely automated, reducing human labor to a large amount and paving the way for a healthy lifestyle because no one is involved in waste collection and disposal, keeping him from becoming contaminated. Not only that, but it would also ensure the timely removal of waste that would otherwise remain scattered and untreated for a long time due to the negligence and carelessness of public or authorities, promoting a healthy environment by preventing the spread of foul odors and insect breeding, which leads to dreadful diseases. The project's concept is inspired by the saying "Cleanliness is next to godliness, and a clean city is near to heaven."

In order to implement what's desired, a remote-controlled SMART GARBAGE BIN is developed to adapt the aforementioned system, where the operator views the garbage through the smart bin's camera and directs the bin towards it. The bin collects rubbish and deposits it inside itself with the help of robotic arms. One of the sensors monitors the level of garbage in the bin using an ultrasonic signal, and if it exceeds the predetermined point, an Arduino program sends a warning signal in the form of an LED indication to the

operator. As a result, the project accomplishes its goal of reducing unmanaged waste while avoiding the need for human cleaning.

III. Material And Methods

This has been observed in many research papers and found under the existing technology, smart garbage bins have the functions to detect the level of bin filled so as to avoid its overflow by giving an alarming signal with the help of an ultrasonic sensor which runs on solar power[4]; to separate the garbage into biodegradable and non-biodegradable waste[5], to give information about the location of the garbage bin[6] and to open and close the top of the bin with the help of servo motors whenever a person approach towards it[7].

To modify the above system, a remote-controlled SMART GARBAGE BIN is designed where the operator observes the waste through the camera connected to the smart bin and directs the bin towards the garbage with the help of wheels connected to the bin which works with the signal given by the controller through an IOT application. With the help of robotic arms, the bin collects the waste and dumps it inside itself. One of the sensors uses an Infrared signal to monitor the level of garbage in the bin so that if the level exceeds the set point, a warning signal is sent to the operator based on an Arduino program. Hence, the project serves the purpose of removing unmanaged waste without requiring manual cleaning.

Hardware Description: The whole project has been divided into four sections and their corresponding hardware are mentioned along them:-

Wheels Section:

Node MCU: As shown in figure 1 Node MCU is an open-source Lua based firmware and development board specially targeted for IoT based Applications. It includes firmware that runs on the ESP8266 Wi-fi SoC from Espressif Systems, and hardware which is based on the ESP12 module.



Fig1. Node MCU



Fig2. DC Motor



Fig3. Dual Channel Relay

DC Motors: A DC motor is any of a class of rotary electrical motors that converts direct current electrical energy into mechanical energy as shown in figure 2. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronics, to periodically change the direction of current in part of the motor.

FL-3FF-S-Z relay module: As shown in figure 3, relay is also a switch that connects or disconnects two circuits. But instead of manual operation a relay is applied with electrical signal, which in turn connects or disconnects another circuit.

Arms Section:

L293D motor driver: The L293D is a popular 16-Pin Motor Driver IC. As the name suggests it is mainly used to drive motors as shown in figure 4. 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.

HT12E encoder IC and HT12D decoder IC: By using the paired HT12E encoder and HT12D decoder we can transmit 12 bits of parallel data serially as shown in figure 5 and figure 6. HT12D simply converts serial data to its input (may be received through RF receiver) to 12 bit parallel data.



Fig4. Motor driver



Fig5. HT12E Transmitter



Fig6. HT12D Receiver

Camera Section:

CP2102 USB module: CP2102 chip a single chip USB to UART bridge IC as shown in figure 8. It requires minimal external components. CP2102 can be used to migrate legacy serial port based devices to USB. This module helps all those who are comfortable with RS232/Serial Communication protocol, to build USB devices very easily. This module helps in providing power supply to the Wi-fi camera.

ESP32 WiFi CAM: The ESP32-CAM is a very small camera module with the ESP32-S chip that costs approximately 800 rupees. Besides the OV2640 camera, and several GPIOs to connect peripherals as shown in figure 7, this camera also features a microSD card slot that can be useful to store images taken with the camera or to store files to serve the clients.



Fig7. ESP32 cam

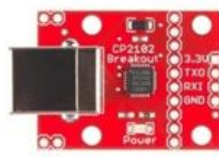


Fig8. CP2102 Module



Fig9. Arduino Uno



Fig10. IR sensor

Capacity check section:

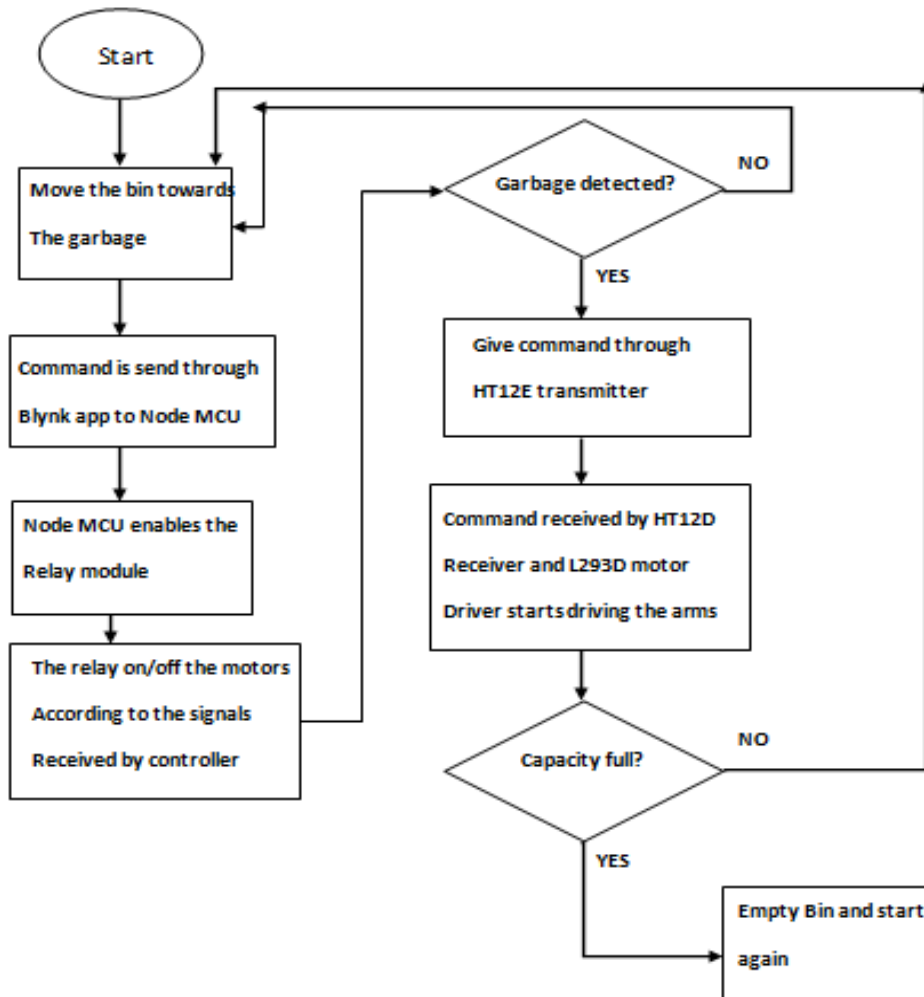
Arduino Uno: Arduino Uno is a microcontroller board based on the ATmega328P (datasheet). This board has 14 digital input/output pins, 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button as shown in figure 9.

IR Sensor: An infrared (IR) sensor is an electronic device that measures and detects infrared radiation in its surrounding environment. An IR sensor can measure the heat of an object as well as detects the motion as shown in figure 10.

IV. Procedure Methodology

The overall methodology behind this project and the updations which have been done with respect to the existing technologies which serves the purpose of waste removal without manual cleaning is discussed below in the form of flow chart. The complete working and the step by step procedure of the project has been mentioned in the flowchart below:

Flowchart:

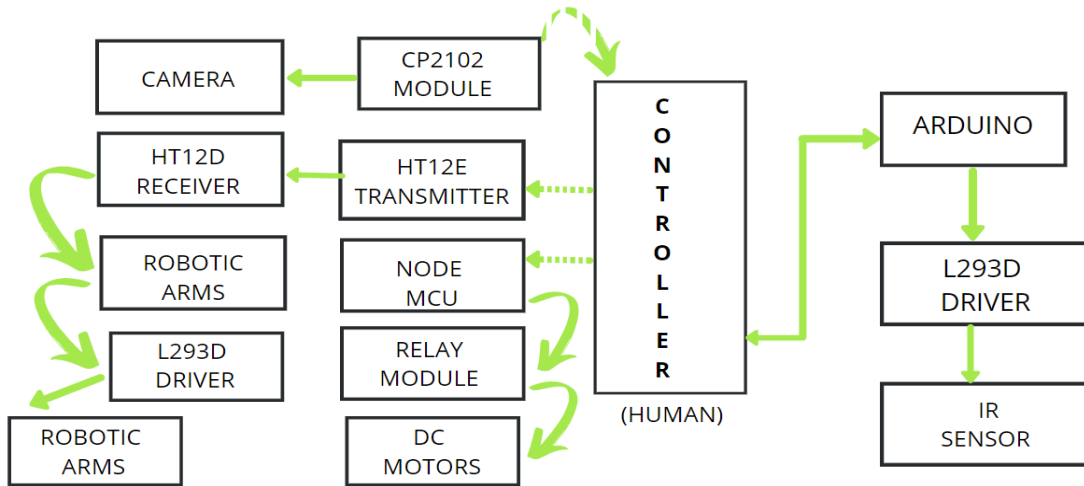


The project is divided into two sections i.e., Transmitter side and the receiver side. The transmitter side consists of the remote control and the receiver side consist of the circuit built inside the garbage bin. So, the receiver circuit acts as the output side where the output shows the motion of the robotic arms, DC motors, the camera and the IR sensors.

The complete receiver side of this project consists of the circuitries of various functions like the motion of wheels which comprises of DC motors, Node MCU and relay, the arms section which comprises of servo motor, HT12D receiver and L293d motor driver, the capacity check section comprises of Arduino UNO, IR sensor and a LED.

Block Diagram:

BLOCK DIAGRAM



Below is the detailed implementation of the project along with the corresponding sections i.e. Arms, wheels, camera and capacity check:

V. Implementation

Arms Section:

Transmitter: The transmitter section of arms consists of HT12E transmitter. The HT12E transmitter has an inbuilt antenna which transmits the signals to the receiver section and it has four switches which act as the button for giving the command to the receiver as shown in figure 11.

Receiver: The receiver section of arms is made up of L293D motor driver and HT12D receiver as shown in figure 12. The receiver IC also has an inbuilt antenna which receives signal from transmitter and gives it further to the motor driver which enables the servo motor to rotate[8].

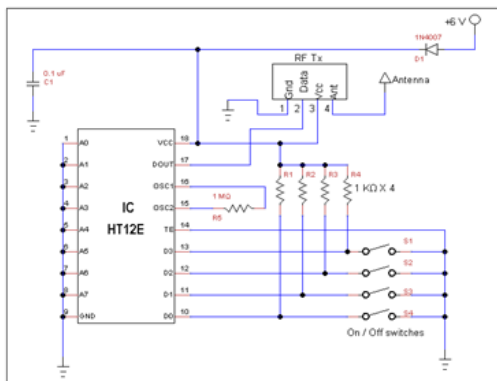


Fig11. HT12E transmitter

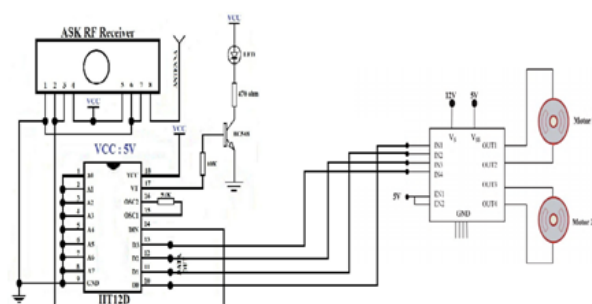


Fig12. HT12D Receiver

Wheels Section: This section is made up of Node MCU and relay as shown in figure 13. The Node MCU is connected with Blynk application through IoT and through blynk app, signals are sent to the Node MCU which turn ON/OFF the relay respectively, helping in the motion of the DC motors (wheels).[9]

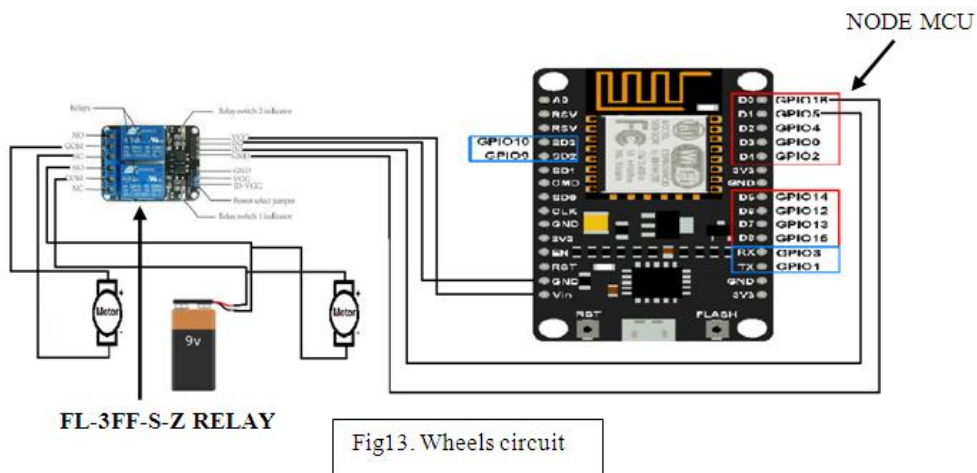


Fig13. Wheels circuit

Camera Section: This section comprises of an ESP32 Wi-fi cam and a CP2102 USB module as shown in figure 14. The CP2102 module helps the camera to get a power supply and the ESP32 camera is enabled with Wi-fi which gives visual on a des

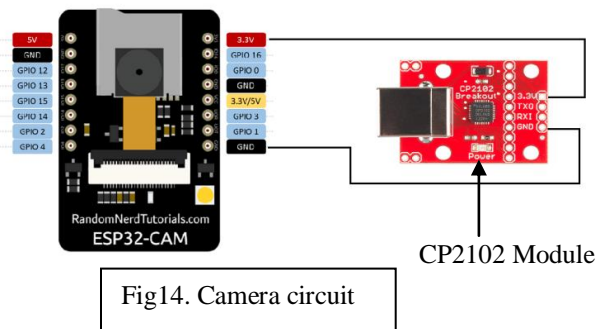


Fig14. Camera circuit

Capacity check section: In this section, an Arduino Uno is used in accordance with an L293d driver, IR sensor and LED as shown in figure 15. The arduino is equipped with c coding which takes the input from IR sensor and as soon a object comes in front of the IR sensor, a LED turns ON which indicates the controller about the filling of the bin.

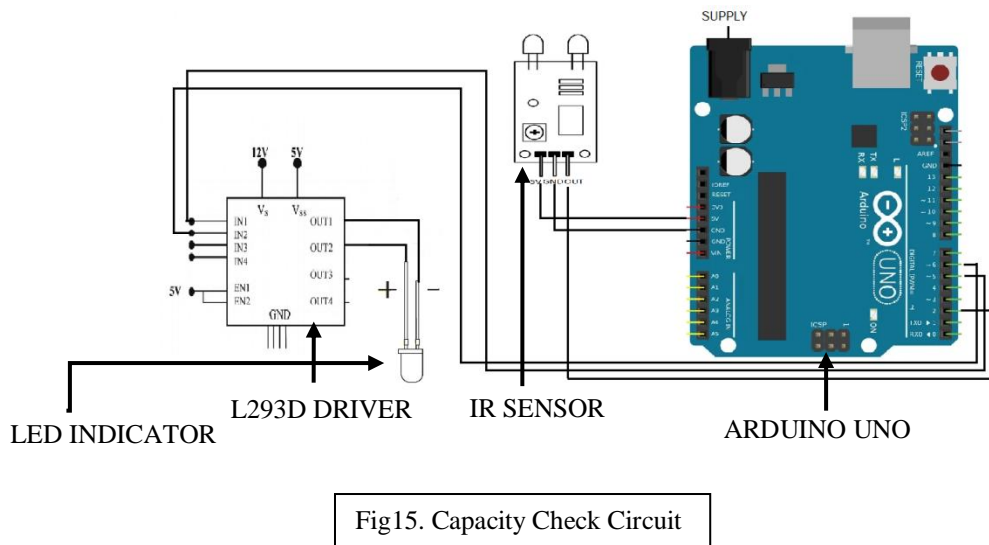


Fig15. Capacity Check Circuit

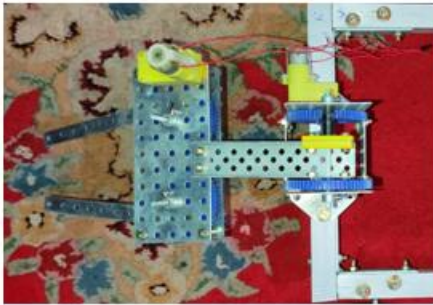


Fig16. Arms Implementation



Fig17. Actual Project

VI. Result

After the testing of the project for one week we have observed the following performance of the bin along with the specifications of the hardware used:-

- Battery: Orange 2200mAh 2S 30C/60C Lithium polymer battery, Weight: 115.0g, Voltage 7.4V
- Arduino Uno: Operating Voltage: 5V, input Voltage (recommended): 7-12V, input Voltage (limits): 5-20V
- HT12E & HT12D transmitter & receiver: supported frequencies modules: 433Mhz, range up to 30 metres, operating voltage: 5V DC, digital output: logic one (+3.5V DC) logic zero (0V DC)
- L293d driver: Operating voltage (VDC): 4.5 to 12 Peak Current (A): 600 mA
- Relay: Triggering input voltage 3.3V – 5V, AC Control Voltage: 250V @max.10A, DC Control Voltage: 30V @max. 10A
- ESP32 cam: Built-in 520 KB SRAM, external 4MPSRAM, Up to 160MHz clock speed, Summary computing power up to 600 DMIPS.

Table no1 shows the range of different modules used in this project and their performance along with the weight they carry.

Table no 1 : Range of different modules used in this project

	ESP32 Cam	HT12D & HT12E	Node MCU	Arduino Uno
10 meter	works	works	works	works
15 meter	works	works	works	works
20 meter	works	works	works	works
25 meter	works	works	works	works
30 meter	works	Partially works	works	works
35 meter	Partially works	Partially works	Partially works	works
40 meter	Partially works	Did not work	Partially works	Partially works

Below is the table showing the variation in the speed of the arms and the weight. The maximum torque of the motors is 0.8 kgf cm and maximum RPM is 150.

$$\text{Angular speed} = (2 * \pi * \text{RPM}) / 60 \text{ (radian/s)}$$

$$\text{Linear speed} = \text{angular speed} * \text{Radius (m/s)}$$

$$\text{Radius of arm} = 23 \text{ cm or } 0.23 \text{ m}$$

Table no 2: The variation in the speed of the arms and the weight

	10gm - 20gm	20gm – 30gm	30gm - 40gm	40gm - 50gm	50gm - 60gm
Angular Speed	14.6 rad/s	13.2 rad/s	12.03 rad/s	10.67 rad/s	9.62 rad/s
Linear Speed	3.358 m/s	3.036 m/s	2.76 m/s	2.45 m/s	2.21 m/s

VII. Conclusion and Future Scope

Smart Garbage Dustbins help the people to manage the waste effectively and help them reduce the work of calling or waiting for the specific person to make the area clean. They won't be any kind of diseases and the people will be fit and are not prone to diseases caused by these waste materials. The mission Swachh Bharat can also be implemented easily. In a broader view these smart garbage dustbin can be installed in metropolitan cities so the municipal council does not have to worry about the waste. We hope this system will help to encourage people to categorize the waste and manage the waste efficiently. The government can establish this system to overcome several problems such as improper waste management, waste collecting, waste disposal etc.

Future enhancements: The existing prototype can be enhanced for better waste management using GPS tracker and more efficient module. The few enhancements that can be done are:

1. The implementation of more collective bins placed side by side where it automatically detects the type and waste and places it in the correct bin color which is assigned for that type.
2. These dustbins can be placed with a GPS tracker where the dustbins in a particular locality can be located easily and the waste can be emptied.[10]
3. The range of the wireless transmitter and receiver can be increased by using more efficient IC's and modules.
4. This method can lead to a Smart Waste Monitoring System.

This project has been done and implemented using the methodology explained above in the paper and it claims to be a better and best option for the existing technologies for smart dustbins which lack in various updations which this project has been equipped with.

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