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SUNBIN: A Cleaner Technology for better Waste Management

Abhinav Chadha[1], Ronica Gupta[2], Pranav Kumar Rai[3], Shubham Abrol[4]

[1, 2, 3, 4]Department of Electrical Engineering, Punjab Engineering College (Deemed to be University), Chandigarh, India

Abstract: ***This document presents a smarter and innovative use of technology in corporate or medium sized dustbin like one installed in public places like bus stands, railway station etc. The use of Arduino as a microcontroller to control the movement of the motor ultimately connected to a plate compressing the waste present in the dustbin to increase the capacity of dustbin by decreasing the volume occupied by the waste present already. The main contribution of this dustbin is basically to reduce the frequency of the waste collecting vehicle, visiting these dustbin sites. Use of the GSM module ,eases the work by letting waste collector personal know which dustbin is full, and needs to be cleaned up.***

Keywords: Environmental science computing; Internet of Things; Arduino; Sensors; Waste management; GSM/GPRS; Green products; Smart cities

1. Introduction

As the population of our country India is increasing at an enormous high rate, so is the man's day to day consumption. As a result the amount of waste is also increasing. For this, though municipal corporations have installed large number of dustbins in every city, but these aren't enough. These overflowed garbage bins can create an obnoxious smell and make an unhygienic environment. This leads to the rapid growth of bacteria and viruses which can cause different types of diseases *[1]*. Inopportune managing of garbage is recognized to be the sole reason for over 22 human diseases that causes premature death every year *[2]*. Improper waste management easily paves route for air pollution and soil contamination which in turn poses adverse effect to health of mankind and in addition to environmental deteriorations.

And thus we, here present the solution to this problem by an innovative dustbin named SUNBIN.

SUNBIN is a dustbin of same dimensions as of a commercial dustbin but will have capacity thrice as the normal, which ultimately will reduce the municipal's task of cleaning the dustbin to one third of the present frequency. Also being solar-power sustained, it is renewable, and hence more eco-friendly.

Not only this, but by the use of LED indicators we tend to make this bin more user friendly. The green LED glows when the user can put in waste inside the dustbin while the red LED indicates the bin is full. This makes the municipal corporation of that locality to clear the bin. Once the bin is cleared the bin resumes its normal operation of compressing the waste once the bin is full.

2. Modelling

2.1 Basic principle and working

This dustbin basically compresses the garbage down, i.e. pushes it using multiple-motor controlled plate. The dustbin contains an infrared obstacle sensor to indicate the garbage level to the processor unit. When the sensor lights-up, i.e. if dustbin is full, the DC powered motors will start rotating and hence the plate attached to it, will make linear motion to push the garbage down.

The system which checks the waste level over the dustbins use Sensor module. Once it is detected immediately this system alerts to concern authorized through a text using a GSM module *[3]* will be sent when the infrared obstacle sensor has lit up more than thrice, to Municipal Corporation inferring the dustbin is full to its maximum level. After which the sensor as well as motor will stop working, until the dustbin has been cleared out. These sensors and motors will be interfaced with Arduino in the prototype model.

2.2 Component Description

1) Arduino UNO R3 ATmega328PU

The microprocessor used in the control circuitry of the Sunbin is Arduino UNO, and it is powered by a DC source 12 V battery via L298N, the motor driver. Arduino UNO has 14 input / output digital pin (6 of which can be used as PWM outputs), 6 analog inputs, an oscillator crystal 16 MHz, a USB connection, a power jack, an ICSP header, and a reset button *[4]*. Its designs comprises of assistances that supports the microcontroller in every possible way. In order to get to work with it one has to simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery *[5]*.

It receives signal from Infrared sensors, which lit up when the bin is full, and it gives the desired output to L298N by operating the motors. Along with this, it is also connected to the GSM module, which sends text message to the saved

phone number when the infrared sensor lit up more than three times.

2) L298N: Dual H Bridge Motor Driver IC Module

L298N Dual H Bridge DC Motor Driver IC requires a terminal supply voltage in the range of 7V to 35V, and provides a terminal output peak current of 3A. Control signal for this module is treated low for voltage level below 1.5V and high above 1.5V.

L298N Dual H Bridge DC Motor Driver IC is used to control the motors which are ultimately connected to a rack and pinion linear joint *[6]*. The battery source connected to it is 12V in this project. The peak value current supplied to this motor is 2A. The signal current peak value by Arduino UNO is 36mA.

3) GSM Module

SIM800 support Quad - band MHz, it can transmit Voice, SMS and data information with low power consumption. The operating voltage for the GSM module is 12V. The SIM800 GSM Modem is a complete GSM / GPRS / Bluetooth development board which is used to send SMS text messages to the number registered in the Arduino UNO code (Preferably of municipal corporation) as At present, GSM system is one of the most popular digital cellular telecommunications systems in the country, which is widely used in the whole world *[7]*.

4) Side Shaft Johnson Geared DC Motor

High performance DC geared motors with robust metal gear box for heavy duty applications. Full load current is 1.9A, and no load current is 0.1A. The motors involved in this project are run at 12V DC, 30 RPM and torque of 15 Kg-cm. These motor are driven by L298N when it is signaled by Arduino.

5) Obstacle Sensor Module

When the module detects obstacles in front of the signal, the circuit board green indicator light level, while the OUT port continuous output low-level signals, the module detects a distance of 2 to 10cm, detection angle 35°, the detection distance can be potential adjustment with adjustment potentiometer clockwise, the increase in detection distance; counterclockwise adjustment potentiometer, the detection distance decreased. The sensor active infrared reflection detection, target reflectivity and shape of the detection distance of the key. Infrared sensors can be used in obstacle detection because of their high resolution, low cost and faster response times *[8]*. This sensor detects the level of garbage when the garbage is at its maximum, and sends signal to Arduino. An obstacle sensor can detect all types of obstacle (e.g., metal, wooden based object, concrete wall, plastics, rubber based product, transparent object, etc.) and it is not affected by poor lighting condition *[9]*.

6) Solar panel

The solar panel used for charging 12V battery is of rating 12V 10W, which provides a charging current of 0.7A.

The panels are connected in parallel to battery.

The current provided by solar panel: Solar Panel Wattage/ Solar panel Voltage = 10/12= 0.833A.

Capacitor of 0.1uF protects from the static discharge. Diode protects from the reverse polarity, while Shottky diode prevents battery from reverse charging. The drop across the LM317T voltage regulator is 2-2.5V, the Adjustment is made to 14V, and the current received by the battery is approximately 0.7A.

7) LM317T Voltage regulator

This monolithic integrated circuit is an adjustable 3-terminal positive voltage regulator designed to supply more than 1.5A of load current with an output voltage adjustable over a 1.2 to 37V. It employs internal current limiting, thermal shut-down and safe area compensation**.**

8) DC Lead Acid Battery 12V

12V lead acid battery is used in this project. The output current is 1.2A.

2.3 Circuitry

1) Motor Connections to battery via controller

The motor terminals are connected to L298N DC output terminals. Signal Input for L298N is given via Arduino UNO board, Power Input for L298N via Battery. GSM and Obstacle sensor are powered via Arduino. Arduino is powered via 5V generated at L298N power terminals. Ground is common to all by Arduino ground terminal and is shorted to battery negative terminal.

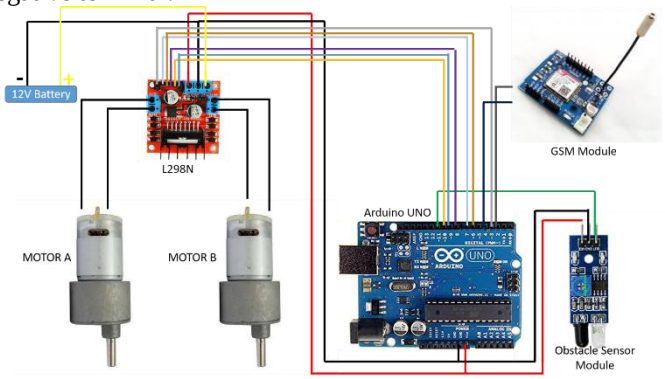

Figure 1: Basic connection of components in prototype model

2) Charging Circuit using Solar Panel

The solar panel used for charging 12V battery is of rating 12V 10W, which provides a charging current of 0.7A. The circuitry involved in solar charging the battery is shown below:

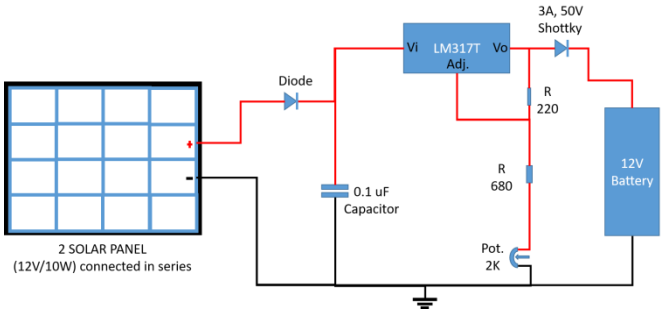

Figure 2: Solar panel connection to battery in prototype model

2.4 Physical Setup

The physical setup will consist of a large size dustbin, generally employed for paper waste, nearly of 56 liters capacity with a lateral area of 600 cm^2. The apparatus will consist of same components with a comparable larger rating. The microprocessor unit will be same. The sensors used will be the same, although number of sensors will be increased to 4. The motor used will be DC geared Johnson motor of a torque rating of 40kg-cm and use of pulley-gear system will be used. The power required to operate the system will be delivered by 24V lead acid battery charged using 24V solar panels (4 in number, in parallel). Current drawn by the motors will be around 4A. Charging current delivered by solar panel is 1.5A. The compression plate is weighed 8 kg, and will be stainless steel (density g/cm^3 7.8) of thickness 15mm.

3. Flow of Operation

The basic principle of the SUNBIN is to reduce the volume of waste already present to accommodate more volume of waste than usual. When in use, a green LED is on indicating that the bin is empty and ready for use. Initially it accommodates waste according to its capacity. Once the bin is full, the infrared sensor is obstructed and it send a signal to the Arduino, which in turn send a signal to the motor driver to rotate the shaft so as to lower the plate to compress the volume of the waste. This same process is repeated three times. After the waste has been compressed thrice and the volume of the bin is full, the green LED goes off and the red LED is turned on indicating that the bin is full and cannot be used. Alongside, the GSM module sends a text message to the municipal corporation to clear the bin. Once the bin has been cleared, the green LED is back on again and the bin is ready for use.

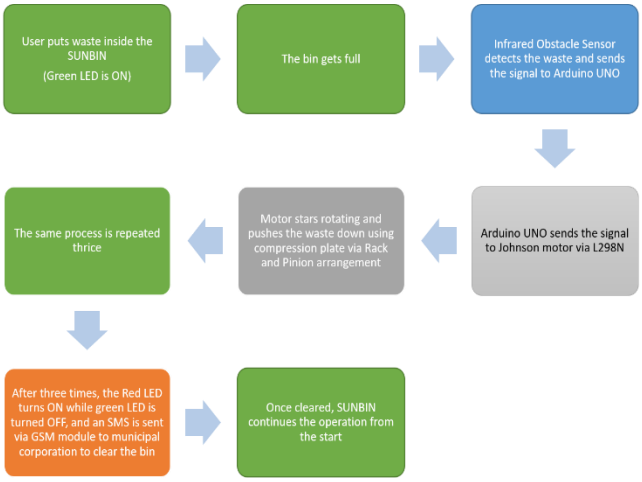

Figure 3: Flowchart depicting the working methodology

4. Experimental Setup

The dustbin as shown in figure below will be divided into two parts, the upper one will be the main driving part, and it will consist of all the circuits and motor. The DC Johnson motor will be mechanically connected to gears to drive the plate using rack and pinion arrangement. Solar panels will be on the outer surface of the bin to gain solar energy. The lower part of the dustbin is like a regular dustbin where all the paper waste will be thrown. Level of garbage is measured using obstacle sensor situated at the sides in lower half. Waste collection is made by real-time monitoring the level of bin's fullness through sensors placed inside the containers *[10]*. Compression plate for the prototype model is made of aluminum plate with a thickness of 1.5mm. The dimensions of compression plate are 20cm X 20cm. The total size of the bin is 23cm X 23cm X 50cm.

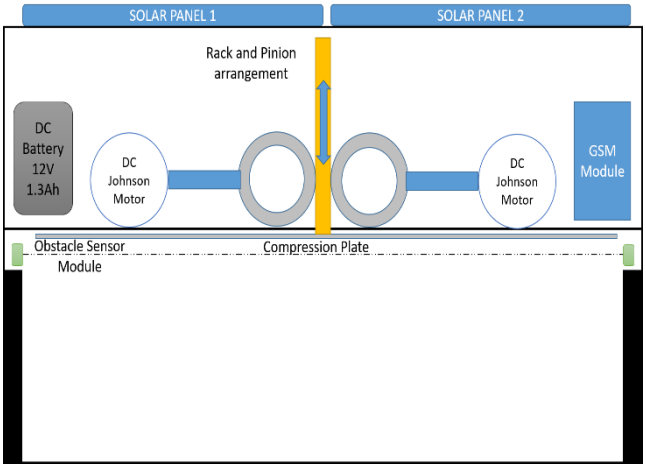

Figure 4: Prototype model drawing

5. Experimental Findings

Following results were observed after repetitive trials of the prototype:

1) Type of Garbage: The compression percentage of different kinds of garbage was tested and observed. Below tabulated

are the findings of the trials:

Table 1: Percentage compression for different type of waste

S. No.	Type of Garbage	Percentage compression
1	Paper cups	31
2	Soda cans	17
3	Plastic bottles	12

2) Optimum Compression Duration: The bin was tested against different garbage levels and time taken to compress was observed. The optimum time for efficient operation was observed as 7 seconds.
3) Time taken to prompt the user: Once the bin was full to the maximum capacity a message was sent to the user. The time taken to notify the user, averaged out to be 6 seconds. This time may vary depending upon the Network Service Provider and battery voltage.
4) Time taken to reset the bin: To clear out the waste from the dustbin and resetting the controller took approximately 2 minutes.
5) Battery Efficiency and Life: 12 Volts battery used in the prototype lasted up to roughly 28 operations on a single charge.

6. Project Economics

a) Prototype Model

Table 2: Cost analysis of prototype model

Component	Quantity	Price (INR)	Amount (INR)
DC battery	1	850	850
DC Johnson Geared Motor	2	725	1450
Gears	2	95	190
Rack	1	30	30
Solar Panel	2	620	1240
LM317T	1	25	25
Diodes, resistances and capacitor	1	75	75
Obstacle Sensor	2	60	120
GSM Module	1	750	750
Al Compression Plate	1	200	200
Outer frame	1	500	500
		TOTAL	5430

b) Real time Model

Table 3: Cost analysis of real time model

S. No	Component	Quantity	Amount
1	Dustbin	1	4000
2	SS plate	1	1400
3	DC Johnson motor	2	2000
4	Pulley gear system	2	800
5	Microcontroller setup	1	1000
6	Solar panel	4	3000
7	Battery	1	1600
		TOTAL	13800

This bin has an average compression efficiency of 24 percent.

Assuming a daily cost for fuel usage for collecting waste per day is 100 rupees, and bin is cleared daily, then Conventional dustbin will have one time cost of 4000 rupees and 100 rupees recurring per day.

Sunbin will have one time cost of 13,800 rupees and 100 rupees recurring cost after every three days.

Breakeven will be achieved after, 147 days.

And will generate a fuel saving profit of 10,000 rupees after 150 days from breakeven.

7. Future Scope

Basically, the project decreases the land pollution by decreasing the space occupied by waste in a normal dustbin. However the bin being composed of relatively expensive technology makes is suitable for use only in commercial purpose. Also the compression rate is dependent on the length of the shaft which makes it very clear that the upper half needs to be exactly same size as that of the bin compartment. However, if we are able to reduce the size of shaft by using a zig-zag shaped shaft instead of linear one which can be motor controlled this makes the project an innovative way to reduce the pollution.
In this project infrared sensors are used to detect the garbage level and are placed on the bins. These sensors compare the depth of the level of garbage with the bin depth. We can upgrade this system with placing some chemical sensors which are designed to detect the chemical reactivity nature of the wastes and by this can differentiate between biodegradable and non-biodegradable wastes *[11]*.

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