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IOT Based Automated Waste Segregation System

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ABSTRACT

Waste segregation and management has become a massive challenge in our rapidly growing country. Therefore, we aim to create a low-cost system to automatically segregate the waste into wet and dry wastes at the household level. Reduction in human effort and prevention of diseases due to improper waste disposal methods is our primary goal. Also, incorporating this system eliminates the need to tolerate overflowing bins and the stench that accompanies it. The IoT based automated waste segregation system uses a Node MCU to collect all sensor data, and control the motors in the system perform the actuation that is needed. By leveraging Internet of things, the system can be made to communicate the levels to which the bins are _filled. With this information, the concerned officials can be informed to take the necessary action. A further insight into the idea is given in the sections that follow.

Keywords : Node MCU, IOT, IDE, HC-SR04 Utrasonic sensor, SG90 Servo Motor.

I. INTRODUCTION

The biggest hindrance to developing smart cities or smart homes is the absence of an efficient waste management system. Lack of proper segregation due to human error or indifference leads to mixing up of biodegradables with recyclables causing the need for human intervention to segregate the same, leading to skin infections, respiratory disorders and increase of rodent, dog and other vermin bites. Another issue that needs focus is the overflowing bins. Improper and inefficient collection methods are the root cause. This leads to disruption of the aesthetics of the environment and outbreak of diseases.

In public places such as airports, train stations and shopping malls, etc. there are a large number of dustbins placed throughout the area. Monitoring when they need to be emptied out is done manually, and hence succumbs to human error or indifference.

The IoT based automated waste segregation system is capable of segregating wet and dry wastes and concurrently monitoring the level of garbage filled. The waste material is placed on a collapsible plate. A self-made capacitive sensor mounted on the plate gives the necessary data that helps distinguish wet from dry waste. The concept used to compare between wet and dry waste is that of dielectric constant. Due to the moisture content present in wet waste, it has a much larger dielectric constant. Using a simple RC circuit, we can obtain the time constant T = R*C. Based on this data, the waste is classified into wet or dry waste, and dropped into the appropriate bin.

With the use ultrasonic sensors placed facing the bins, we can get real time information of the fill-level. Once a particular level is reached, the user gets notified by means of push notifications to clear out the bin. The notification service employed is called PushBullet. The PushBullet service allows a user to

receive notifications on multiple devices simultaneously.

To trigger the PushBullet notifications, we use the IFTTT (If This, Then That) service, which allows the integration of the Maker Webhooks service with PushBullet. The Maker Webhooks allows the creation of a https link, which can be used to perform some action. When integrated with PushBullet using IFTTT, it causes a PushBullet notification to be sent to the users registered devices.

II. METHODS AND MATERIAL

The main goal of the system is to create a reliable and smart platform for segregating dry and wet waste and sending a message to the user. The basic block diagram of the IoT based automated waste segregation is shown in Fig.1 below.

The overall connections are as shown in the block diagram. The control unit contains the core circuitry that interfaces the various sensors with the MCU of choice NodeMCU. The Ultrasonic sensor positioned on top detects if an object has been placed. The capacitive sensor identifies if the waste has to be segregated to the wet or dry bin. The capacitive sensor, here, is made up of 2 plates of conductive metal sheet (Al) wrapped around an insulating material and is placed in such a way that the waste dropped is in contact with both plates. One of the plates acts as a sensor plate, and the other is a grounding plate.

The servo motor tilts the segregation plate to either direction appropriately based on the capacitive sensor reading, to drop the waste into the respective bins. The 2 ultrasonic sensors placed facing downwards towards the bin measure the level of waste in these bins, only when a new object is thrown into the bin, the level is measured and if the level in any of the bins crosses the 75% mark, the concerned user is notified by means of a push message using the PushBullet API service.

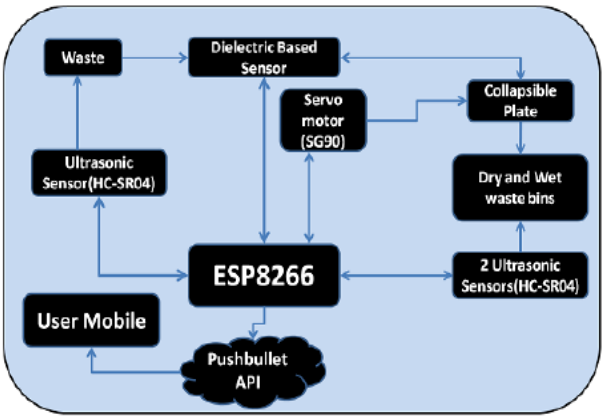

Fig 1. Diagram of IoT based automated waste segregation System

Node-MCU 1.0- ESP8266

The Node-MCU is a development board that has ESP8266 Wi-Fi chip on board, and can program the ESP8266 just like any Arduino or PIC, it can readily connect to the Internet via Wi-Fi. However, the ESP8266 board has limited pins although the chip itself has a lot of output ports.

The Node-MCU has 10 General Purpose IO pins each capable of using PWM, I2C and 1- wire interface.

Fig. 2. Node-MCU 1.0

HC-SR04 Ultrasonic Sensor

Ultrasonic sensors used to measure distance by emitting ultrasonic waves and receives the reflected wave back from the target. Ultrasonic Sensors measure the distance to the target by measuring the time between the emission and reception.

The HC-SR04 Ultrasonic sensor module has 4-pins, Vcc, Trigger, Echo and Ground respectively. A 5V supply is provided to the Vcc pin. To trigger the sensor, we need to send a HIGH (5V) pulse of 10 microseconds on the trigger pin. Then, we can read the signal from the sensor: a HIGH(5V) pulse on the echo pin, whose duration is the time in microseconds from the sending of the signal to the reception of its echo to an object.

Fig 3. HC-SR04 Ultrasonic Sensor

CAPACITIVE SENSOR

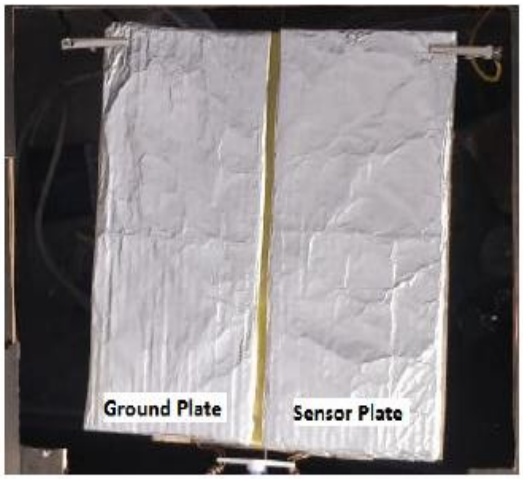

Fig 3. Capacitive Sensor and Ground Plate

The Capacitive Sensor library turns two or more Node-MCU pins into a capacitive sensor, which can sense the electrical capacitance of the waste material. All the sensor setup requires is a medium to high value resistor and a piece of wire and a small (to large) piece of aluminium foil on the end.

The physical setup includes:

1. A medium to high value (50K-50M) resistor between the send pin and the receive (sensor) pin.
2. The receive pin is the sensor terminal. A wire connected to this pin with a piece of foil at the end makes a good sensor, i.e. the receive pin connects to one of the capacitor plates.
3. A ground plate is needed to resolve the issue of dynamic capacitance offered by the persons hand. This second plate is directly connected to the GND of the microcontroller. Thus, an object is to be placed such that it touches both plates to get different readings for different objects (based on their dielectric values).

SERVO MOTOR

The SG90 servo motor is a small and less weight motor with high output power and can rotate approximately 180 degrees.

Fig 4. SG90 Servo Motor

Servo motor works on by the principle of PWM (Pulse Width Modulation), its angle of rotation is controlled by the duration of pulse applied to its control pin. It has 3 wires are out of a servo: positive, ground and control wire. A servo motor is controlled by sending a pulse width modulated (PWM) signal every 20 milliseconds through the control wire. The width of the pulses determines the position of the shaft. The operating voltage is 4.8V, and has a max torque of 1.9kgf/cm. It is a very light weight motor, weighing just 9g.

A. CIRCUIT DESIGN

The various connections required are as follows. We use the digital IO pins of Node-MCU to connect to all of the sensors and motors used. The circuit Fig 5 is shown below.

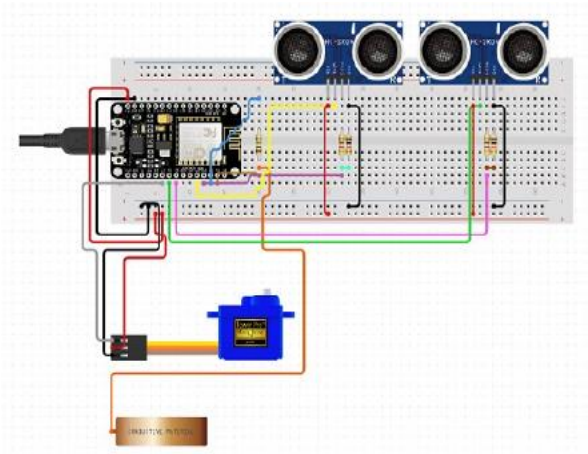

Fig 5. Circuit Diagram

The above diagram shows the connection for 2 Ultrasonic sensors, the servo motor and the sensing capacitive plate. In addition to this, another capacitive plate connected to ground is required, and a third ultrasonic sensor is to be connected.

As the Node-MCU is a 3.3V board, and the ultrasonic sensor sends a 5V echo pulse, we use a voltage divider circuit, to prevent burning the IO pins of the MCU. The trigger pins can be triggered using 3.3V output directly, as the TTL logic for a 5V Vcc will consider a 3.3V pulse as HIGH, hence we connect the trigger pins of the ultrasonic sensors directly to the Node-MCU pins.

The Node-MCU is provided with a 5V supply voltage, either through the USB port or through the Vin pin. As it has an onboard 3.3V regulator, it is safe to supply 5V to the board.

The servo motor is powered using the 5V supply given to the Node-MCU, as are the ultrasonic sensors used. The servo motor PWM control is provided using one of the digital IO pins of the Node-MCU. Again, we are able to connect the motor control pin to the MCU pin directly as the 3.3V output provided by the boards IO pins, is considered as HIGH in a 5V TTL logic.

The capacitive sensor consists of 2 plates, a sensing plate and a grounding plate. The grounding plate is directly connected to GND pin. The sensor plate requires 2 Node-MCU IO pins, a send pin and a receive pin. A 100k resistor is connected between the send and receive pins. The receive pin is also connected to the sensing plate, as shown in the circuit diagram.

Since the object placed on the sensor acts as a dielectric medium, it affects the value of capacitance C. Wet waste tends to have a much larger dielectric constant, due to the moisture content. Hence, a threshold can be set to differentiate wet and dry waste.

B. WORKING

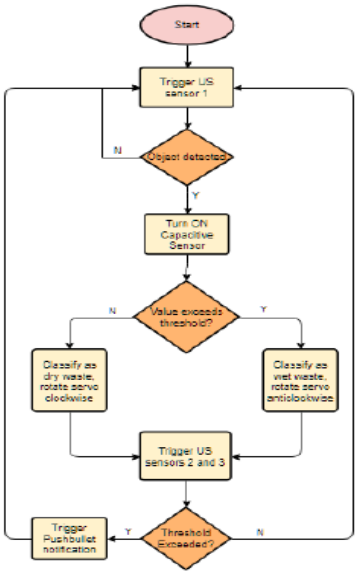

Fig 6. Flowchart of working

The working of the system is depicted in Fig 6. The ultrasonic sensor placed on top (US sensor 1), is positioned to detect when a new object is placed on the sensor plates. When this sensor detects an object, the Node-MCU turns on the Capacitive sensor by making the send pin HIGH. Based on the value calculated, it checks if the threshold set for dry waste has been exceeded or not. If the threshold is exceeded, the object is classified as wet waste, and the servo motor is made to rotate anticlockwise, causing the object to fall into the wet waste bin placed below.

If the threshold is not exceeded, the object is classified as dry waste, and the servo motor is made to rotate clockwise, causing the object to fall into the wet waste bin placed below.

Whenever a new object is sent to the dry or wet waste bins, we need to check if the level of the bins has crossed 75%. To do this, we trigger the ultrasonic sensors which a positioned to face the dry and wet waste bins. These are US sensors 2 and 3 in Fig 6.
If either bin has exceeded its limit of 75%, the Node-MCU connects to the configured Wi-Fi station and sends a HTTPS request to the configured IFTTT API which will send a notification on the users registered devices, notifying that the level of the bins is nearing their maximum capacity.

This ow was designed such that the system is efficient in terms of power consumption. The capacitive sensor only turns on when US 1 detects that an object has been placed. In turn, the US 2 and 3 are triggered only when a new object is placed in the bin, as the level of waste will remain constant till something new is added.

C. IMPLEMENTED SYSTEM

Fig 7 and 8 shows the capacitive sensing and grounding plates, along with the servo motor. The Node-MCU and PCB is enclosed in the control unit casing

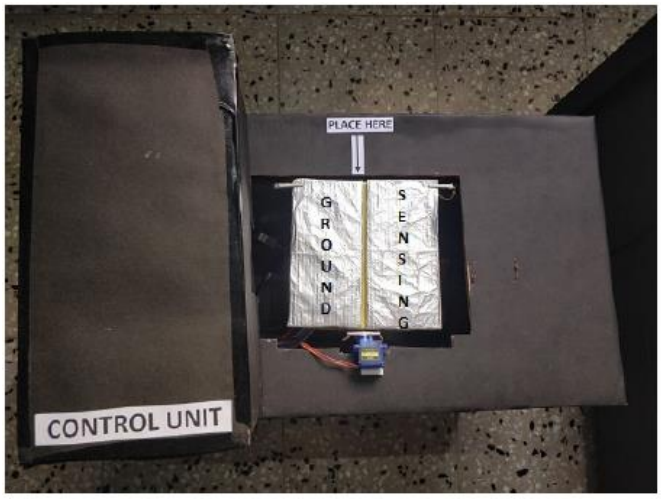

Fig 7. Top view of Implemented System

Fig 8. Front View of System

III. RESULTS AND DISCUSSION

The block diagrams were implemented; IoT based automated waste segregation is carried out using Node-MCU, Servo motors and Ultrasonic and Capacitance sensors. The applications are:

1. Can be an effective replacement of the currently existing bins that simply use labels to coerce users to manually segregate waste.
2. It is an effective waste segregation system to be employed in airports, households and offices where there is a high chance of mis-segregation due to negligence.

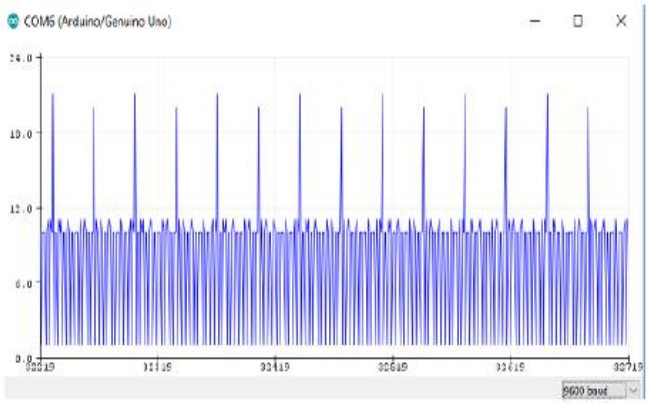

Fig 9. Dry waste plot

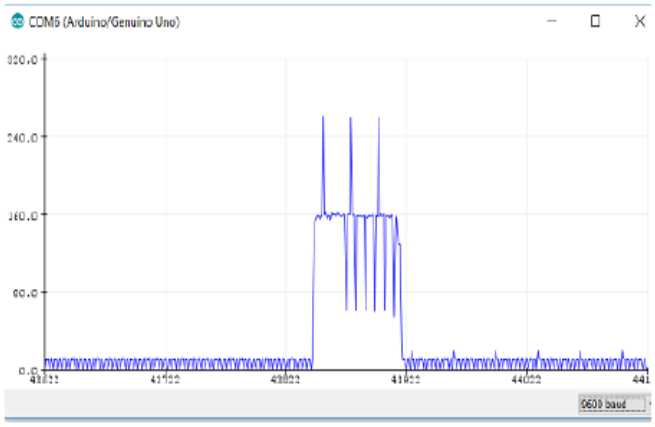

Fig 10. Wet waste plot

The capacitive sensor designed is capable of differentiating between wet and dry waste, as can be seen by the values on the y-axis in figures 9 and 10. A threshold of 100 was set, such that any object giving a value lower than threshold was classified as dry waste, and any object with a value exceeding the threshold was classified as wet waste.

The notification service using IFTTT and PushBullet is shown in figure 11 and also shows the serial monitor output during the triggering of the HTTPs request.

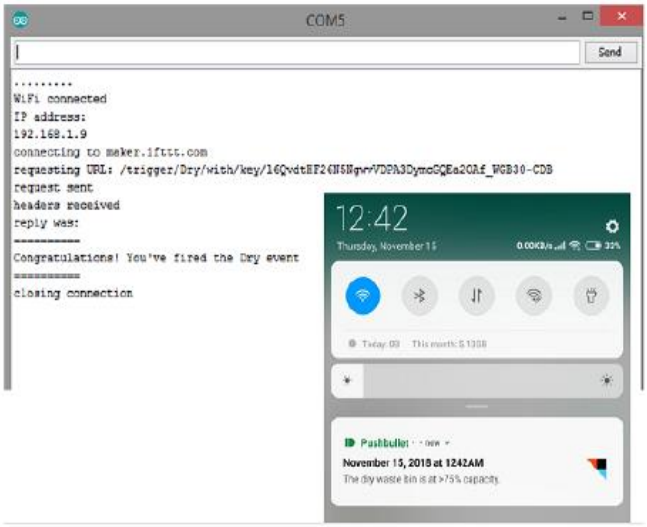

Fig 11. Notification Screenshot

IV. CONCLUSION

To conclude, our work is a carefully designed solution that solves the social issue of waste segregation. We target to optimize the first level of segregation which is the most essential aspect of modern waste management. The automated mechanism identifies the dynamic capacitance of material being thrown inside it and segregates it into Wet or Dry Waste. This enables separate processing and treatment of the segregated waste without manual segregation. The Ultrasonic sensor along with PushBullet application also keeps the user notified of the levels of individual bins to avoid over flowing of waste.

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