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Intelligent Waste Sorting Mechanism with real - time Waste Monitoring for Dynamic routing of Waste Refuse Lorries

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Abstract— *The objective of the research-based project is an embedded system prototype, which shall include two domains of Embedded system and Networking. The functioning of the prototype consists of GSM/GPRS based alerting system for the municipal authorities when the dustbin(s) is full/nearly full; the authorities will be provided the exact location of the full dustbin via GPS navigation system. The prototype aims at sorting of wet and dry waste at source. The research aspect of this project is to sort wet and dry waste by implementing laws of electronics using resistance/capacitance as the governing factor(s) and the dust – bin shall show the amount of moisture content in the waste collected using sensor technology. This will allow the busy metropolises to monitor the amount of waste being dumped from domestic and commercial edifices which in turn help in reducing the amount of fuel and budget invested in regular or timely round-robin waste/garbage collection. Sorting of dry/wet waste at source is governed by a moisture detector sensing plate which is the research aspect of this paper. The project aims at – resolving the issue of mismanagement of waste, enhance recyclability of disposed waste and, implement dynamic routing of waste refuse Lorries using sensors and GSM/GPS technology. The project is a prospect which proposes a return on investment model by attaining a waste to energy system by converting the organic (wet) waste freely available, into manure or biogas and contributing towards the benefit of the farmer ecosystem and in turn the environment.*

Keywords— *Smart Dustbin; Waste Sorting; Economic waste management; Connected Dustbin(s); Waste to energy; Waste reduction; Sensors*

Abbreviations and Acronyms

GSM – Global System for Mobile Communication
GPRS – General Packet Radio Service
GPS – Global Positioning System
IR – Infrared
ADC – Analog to Digital Converter
PCB – Printed Circuit Board
SMS – Short Message Service
RFID – Radio Frequency Identification
NFC – Near Field Communication

I. INTRODUCTION

Human civilizations began waste sorting by hand and it is still prevalent in today's era but the enormity of waste and garbage disposed with the flattering growth of human population has led researchers around the world to come up with automatic waste sorting mechanisms which reduce dumping and ageing waste disposal techniques, and enhance the recyclability of the waste that is collected. With the limited resources available to man, recycling of waste is the only way forward. In recent times governments around the world, especially the European Union have been very strict in the case of dumping of waste and they have effectively zeroed down on dumping grounds by investing in technology which can efficiently segregate waste and also extract resources that can be used further as well as the remaining eligible waste is converted to energy. Waste Segregation means separating dry and wet waste from the mixed Municipal Solid Waste (MSW); usually wet waste refers to organic waste generated by domestic edifices such as homes, societies, restaurants, etc. which is heavier than dry waste due to dampness and the same wet organic waste is quite useful for biogas plants. Also, landfills are a pressing issue as limited land resources become available on the face of the earth with the volume of waste not compromising to reduce; segregating waste is not just an environmental concern but of economic concern too.

In order to tackle the alarming situation of Waste Mismanagement, technology must be employed at a domestic/household level. A simple idea of employing technology at roots level is of sensors embedded in Rubbish bins from commercial premises to detect when nearly full, enabling dynamic routing of refuse Lorries; this will enable predictive data analysis of waste produced in a particular area [1].

Municipal Waste comprises of 2 major categories, wet waste, and dry waste. The wetness of a waste is calculated by its overall moisture content. Electronics employed in a moisture sensing plate can be employed in existing rubbish bins to detect wet/dry waste disposed of and thus can be sorted in respective sections of the bin.

The technology to be employed at domestic/household level should be easy to use for the unskilled user [4]. Thus a portable system must be made to replace during maintenance rounds.

II. PROPOSED SOLUTION

A prototype is made with a portable assembly of an electronic circuit with modules attached to it. This assembly can be connected with any existing waste rubbish. The solution promises waste sorting at source along with intelligent waste monitoring mechanism using sensors. Such a solution is a frugal method to sort waste into dry waste and wet waste by measuring wetness of a waste sample. It also acknowledges with an interactive message playback to encourage users to dispose waste into dustbin. The level detection based sensing enables dynamic routing of waste refuse Lorries.

III. METHODOLOGY

A. *Waste detection & Sorting mechanism*

The Prototype involves a moisture detection plate and an IR sensor. First, the IR sensor monitors the action of waste disposal which activates waste sorting mechanism. This process of step – by – step activation helps saving of battery power, thus optimum power consumption is fulfilled.

The detected waste is monitored by moisture detection plate via communicating Analog Resistance values to the microcontroller. The level of Analog value is converted to corresponding Digital level (value) and thus the comparison is carried out by the microcontroller to infer it as dry waste or wet waste. The samples tested are as delineated in Table I. along with their Digital values as calculated by the microcontroller.

Once, confirmed as dry waste or wet waste. A motorized platform actuated by servo motor is set to a position to slide the waste in respective containers of the Dry waste section and the Wet Waste section.

In order to make sure correctness of waste sorting for each instance of waste disposal, a blower is attached to the plate to clean it dry and restore it to the default level, marked as the ideal position.

The Moisture Detection sensor, the research aspect of this paper was etched on a copper PCB which is as shown in Fig. 1.

B. *Record & Play Module*

In order to encourage users to dispose of waste in dustbins, the prototype has embedded a record & play module which will be activated when waste is detected during disposal. This will ensure an acknowledgment to the user for being a responsible citizen towards the environment.

C. *Real-Time waste monitoring system & Dynamic Routing of Waste Collection vehicles.*

Once the waste is collected in respective sections of the rubbish bin, long range IR detectors are employed for stationary waste level monitoring. Once the waste reaches, the desired level of the container, a GSM/GPRS triggered message is sent to the monitoring station. The message contains data of the waste collected, identifying code of Dustbin and GPS location of the Dustbin via GPS modem.

This enables monitoring station to channelize limited vehicles to collect waste thus restoring a dynamic routing system for waste collection.

The feature is appropriate for remote areas where frequent waste collection rounds may lead to excessive consumption of fuel.

IV. IMPLEMENTATION

The waste sample enters the dustbin in such a way that it falls on the moisture detection plate, upon arrival it is detected by IR sensor (high range) to activate the moisture detection plate sensor. Until the activation by IR sensor, moisture detection sensor ignored all values of resistance due to the absence of waste sample(s). Upon presence of a waste sample, moisture detection sensor enters test mode and tests the resistance value of the sample. The analog resistance value

is fed to the (Analog to Digital converter) ADC of ATMega32 8 – bit microcontroller which converts into a digital value. The analog value is distributed over 1024 levels of digital value due to 10 bits of ADC. As per trial and error as shown in the sample test table (Table I) the threshold of wetness is kept below 500 decimal value (of the 1024 decimal values of a 10 bit ADC). Any dry waste sample will have a higher resistance value than the threshold value, thus confirming dry waste.

Upon successful detection of the respective type of waste, the servo motor will turn the moisture detection plate over to the respective container of the waste sample. For turning over to respective waste section, the servo motor will get a pulse width required for the angle of rotation. If the waste sample is a wet waste sample, the moisture detection sensor will be cleaned by a blower until it restores the ideal level of resistance.

When the waste was dumped in the dustbin, the record and play module is triggered to playback a pre – recorded acknowledgment message for interacting with the user.

The waste container sections are embedded with level detectors which are high – range IR sensors. A set level of fullness of waste containers is continually monitored by these level detectors. When the waste containers overflow the set level of fullness, level detectors trigger an SMS alert via the microcontroller. The SMS contains information of the type of waste container that has been filled – up and the exact location of the Dustbin is provided by a GPS module interfaced with the system which enables authorities to divert waste refuse Lorries according to heat-mapping of zones where dustbins have been detected ready to be emptied. Once the waste container has been emptied, the system automatically resets with the intelligent level detection method.

A processing 16 x 2 character LCD is employed with the prototype which shows the detected resistance readings in decimal value and also show process of SMS alerts. LCD also gives information of resistance values getting restored to threshold of wetness when Blower is activated due to presence of wet waste.

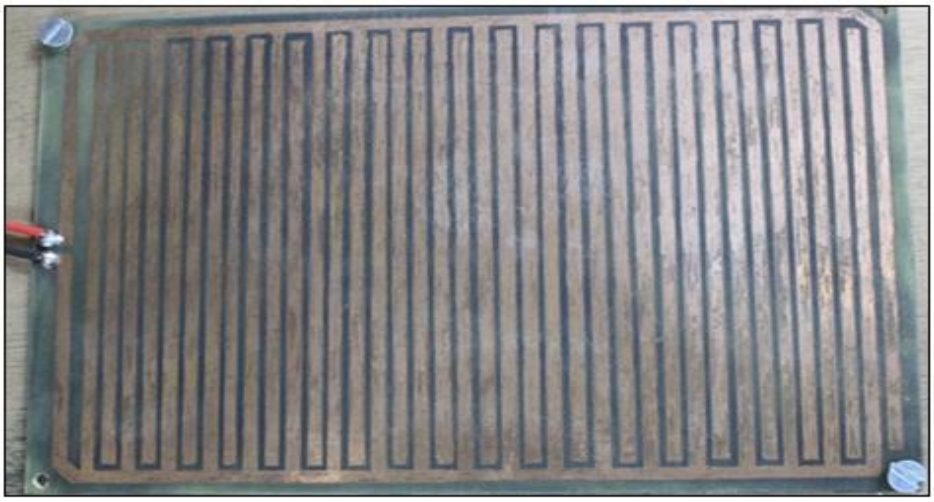

Fig. 1. Moisture Detection Sensor etched on a copper PCB

Fig. 2. Moisture Detection Sensor etched on a copper PCB

V. RESULTS

Commonly disposed waste samples were tested with the prototype which are listed in comparison with their detected ADC values and detection result in Table I:

TABLE I. TEST OF WASTE SAMPLES

Serial No.	Resistance Values of Waste Samples		
	Waste Sample	***Detected Digital Resistance Level (Decimal Value)***	***Detection Result as per sensor rotation***
1.	Banana Peel	396	Wet
2.	Paper	657	Dry
3.	Wet Cloth	188	Wet
4.	Dry Cloth	702	Dry
5.	Onion Peel	691	Dry
6.	Plastic Bag	823	Dry
7.	Rubber	605	Dry
8.	Pencil Shavings	783	Dry
9.	Food Waste	297	Wet
10.	Stapler Pins (Metal)	202	Wet

Waste sorting by resistance based testing gave 90% of accuracy as per commonly used waste samples as per above.

VI. CONCLUSION

Waste sorting is a vast field where innovation at grassroots level is imperative. As per the system implementation, future scope of the proposed solution opens up innovation in waste sorting techniques by which we can sort mixed waste into metallic/non – metallic waste, dry/wet waste, plastics/non – plastics and organic/inorganic waste types [5]. Further, waste can be treated at source by employing composting mechanisms to convert organic waste collected into manure.

A financial model can be setup by which acknowledgment of disposing waste into dustbin can be in the form of utilities such as drinking water, free internet data usage, cash points in RFID/NFC cards swiped while disposing waste, et al [2] [3]

The proposed solution promises to be a contribution towards development of Smart cities around the world.

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