

Autonomous Waste Management System: A Design Approach with Embedded Systems

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Abstract

The Collection of waste is a very much needed municipal service that requires huge expenditures and execution of this operation is high-priced. The high pricing is due to the various factors such as man power, navigation of vehicles, fuel, maintenances and environmental costs. The implementation and execution of the intelligent smart bin for proper management of waste. The work focused on the implementation based embedded system which integrates Radio Frequency Identification (RFID), Sensors, Arduino controller for waste bin and truck monitoring system with their performance measured in real time environment. Web based android applications were developed to interface with a web server to intimate the municipality regarding the cleaning process performed by the workers.

The system provides a database of the information of bin status, amount of waste in the bin, time of the collection of waste are transmitted to monitor and efficiently manage the waste collection strategies. We use an RFID sensor to access the garbage to open the bin They can be opened only by using the RFID card provided by the management. So it is easy to determine the wastage of individual count. Basically, we are automating the method of identifying the amount of food wastage in the areas, where we are sure that the amount of food waste can be decreased by the analysis of food wastage by every individual and awarding them with rewards and prices by the reports generated by the system.

Keywords: Embedded system, RFID, Smart dustbin, Arduino, Sensors

1. Introduction

Traditional waste collection systems focus on providing a more complex method of waste disposal which operates based on RFID and web server interface to alert the municipality when the dustbin is filled, i.e., if the volume of trash reaches a particular level of the sensor, and for this an external power supply is very much necessary, this basically is a disadvantage, as, if there's no power, it won't be able to function [1].

Also, in some of the systems they basically concentrate on making the communication between the Garbage trucks and the dustbins smarter, if the garbage level detected is at high or at a dangerous level, it basically provides an optimized path or route to collect maximum waste with less cost and fuel, which is pretty much inefficient as there can be sensor flaws, which may lead to wastage of fuel and time, if the dustbin is empty at the end [2].

Technology is expanding rapidly. The use of pervasive computing technology has brought to a completely new level of improved waste management systems. This Smart Recycle Bin takes a Conceptual approach at Waste Management with Integrated Web based Systems. It basically calculates the weight of the amount of trash and converts it into point, and then stores it onto an RFID card. This RFID based system is integrated with a web-based information system at the host server. This approach basically tracks the amount of garbage and tracks if it's completely filled via a web-based interface. This could be improved by a few analytical algorithms applied to the data [3] [4].

2. Embedded system (ES)

An embedded system is a special-purpose computer system designed to perform one or a few dedicated functions, sometimes with real-time computing constraints. It is usually embedded as part of a complete device including hardware and mechanical parts [5]. In contrast, a general-purpose computer, such as a personal computer, can do many different tasks depending on programming. Embedded systems have become very important today as they control many of the common devices we use [6].

In general, "embedded system" is not an exactly defined term, as many systems have some element of programmability. For example, Handheld computers share some elements with embedded systems — such as the operating systems and microprocessors which power them - but are not truly embedded systems, because they allow different applications to be load and peripherals to be connected [8].

An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is specifically designed for a particular kind of application device. Industrial machines, automobiles, medical equipment, cameras, household appliances, airplanes, vending machines are among the myriad possible hosts of an embedded system. Embedded systems that are programmable are provided with a programming interface, and embedded systems programming is a specialized occupation [9]. Certain operating systems or language platforms are tailored for the embedded market, such as Embedded Java and Windows XP Embedded. However, some low-end consumer products use very inexpensive microprocessors and limited storage, with the application and operating system both part of a single program. The program is written permanently into the system's memory in this case, rather than being loaded into RAM (random access memory), as programs on a personal computer [8].

3. Smart Dustbin

The smart Dustbin works on the basis of IR or Infra-Red sensors. Since Infrared is basically a light that has a wavelength longer than visible red light. The ranges of infrared include near infrared, mid infrared and far infrared, spanning wavelengths from about 710 nanometers (near infrared) to 100 micrometers (far infrared).

IR (infrared) sensors detect infrared light. The IR light is translated into an electric current, and this is detected by a voltage detector. One of the features of light-emitting diodes (LEDs) is

that they produce a certain wavelength of light when an electric current is applied, but they also produce a current when they are subjected to the same wavelength light. A pair of IR LEDs can be used as motion detectors or for moving objects based on the its readings. For example, let the first IR LED be wired to emit and the second be wired to transmit a signal when it receives an IR input. When an object comes within range of the emitted IR, it reflects the IR back to the receiving LED and produces a signal. This signal can be used to open electric doors, turn on a fan or set off an alert [1]. We basically use the IR sensors, to plot a path, the sensor inputs can be modulated into input for the motor drivers. The use of L293D Motor drivers helps us in controlling the motors in both clockwise and anti-clockwise directions. When we receive a buzzer input from the user, the data is relayed to the microcontroller; we are basically using an Arduino Uno, as it's the most basic, feasible and efficient microcontroller board. Realtime systems have become more popular and prominent these days. From data collection to analysis and processing, every process has become automated and real-time. One such system, is RFID based Realtime Smart Waste Management System, in which the RFID and load sensor technology is used to streamline and automate the waste management system, by contiguously classifying the waste into garbage, recyclable and green waste. Thus automating the process using RFID and load sensor technology. This technology can further be improved by including an alert mechanism, such that when the trash reached its threshold limit, the authorized person, may come and collect it. Also, a compressible pressure press can be used to compress the trash, on the spot, thus utilizing the volume of the dustbin more efficiently [5].

The smart technologies have been expanding their wide range of applications, one such technology is, the Smart bin – a Smart waste management system, in which data of the fullness of the litterbin is collected via sensors and sent to the server via wireless mesh network. This waste management system employs a duty-cycle technique, to reduce power consumption and maximize the operational time. It basically aims at increasing its productivity rate. The litterbin can be enhanced in all sorts of ways, the litterbin is basically a small module of the Smart Dustbin, it collects and alerts the responsible authorities when its full [6].

4. Existing System

The waste collection process is monitored by ultrasonic sensors. All dust bins would be equipped with sensors. The microcontroller will receive an indication when waste reaches the maximum level. GSM technology is used by the microcontroller to send messages to toss the garbage collection truck driver.

5. Proposed Method

In this method, the work begins with the identification of the amount of garbage-filled inside the container using a Proximity sensor or IR sensor. Once the trash is identified in the waste container the slider gets activated and further pushes the trash onto the conveyor belt. The conveyor belt operates with the help of a 12V DC motor. As all the trash passes onto the conveyor belt the metal elements present in the waste get segregated by an electromagnet and will be passed onto a separate bin. The dry waste is separated by a blower and is collected by

another bin. Now the left out waste is further passed onto the conveyor belt and now a separate bin collects all the ethanol- based garbage using which ethanol can be produced in further days. During this process, the LCD continuously displays messages about several varieties of wastes collected in several bins. The blower and electromagnet are under the control of the relay. Further, the circuit is provided with the appropriate voltage supply that assists in the effective working of the microcontroller ATMEGA32 circuit along with the entire system. The motor of the conveyor belt is turned on when the waste enters and starts moving across. Now all the sensors and motors are turned ON, including the microcontroller. Inductive proximity sensors detect whether the waste is metal or not, and if it is metal, M2 is turned ON, M1 is turned OFF and the garbage is dumped into the trash can. Also, counter 1 gets incremented According to the amount of moisture content in the waste, M1 determines the type of waste whether it is wet waste or dry waste if it does not come into contact with a metallic waste. If it is dry waste, then M1 stays ON and the garbage is moved into the dry garbage container. In the end, wastes are deposited in their respective bins to conclude the segregation process.

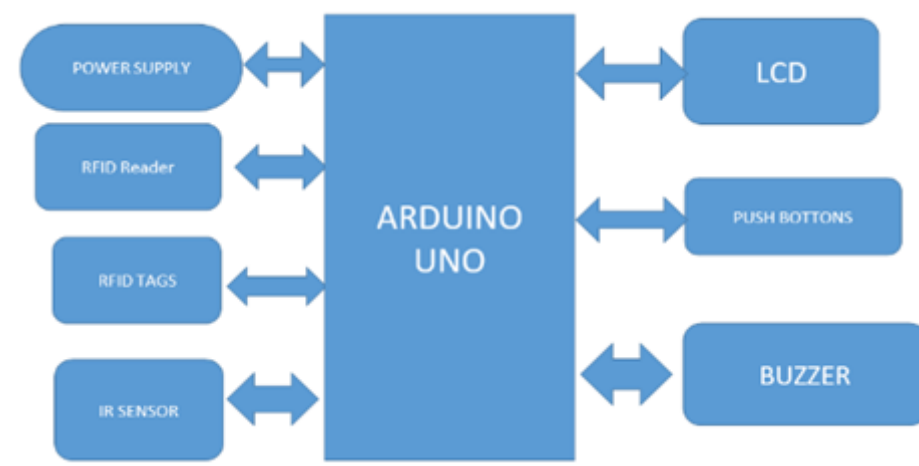


Figure 1: Block diagram of the proposed method

6. Hardware & Software Employed

Arduino Uno Micro Controller:

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started [8]

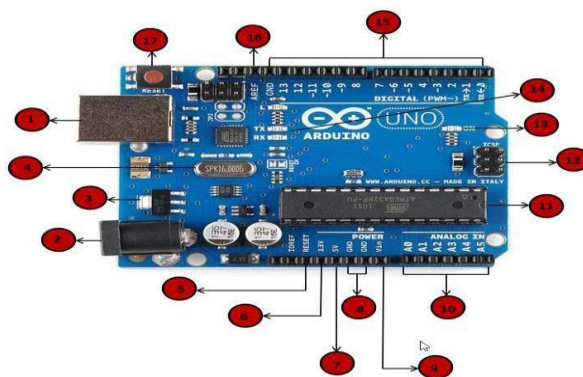


Figure 2: Arduino Board

IR Sensor

An Infrared (IR) sensor is a device that can detect infrared radiation, which is a type of electromagnetic radiation with longer wavelengths than visible light. IR sensors are widely used in various applications for detecting motion, presence, temperature, and more. They work by detecting changes in the infrared radiation emitted or reflected by objects in their surroundings. Overall, IR sensors play a vital role in a wide range of applications due to their ability to detect and measure infrared radiation emitted by objects [7].



Figure 3: IR Sensor

RFID Reader EM18 module

Radio frequency Identification i.e., RFID is a wireless identification technology that uses radio waves to identify the presence of RFID tags [2]. Just like Bar code reader, RFID technology is used for identification of people, object etc.presence.

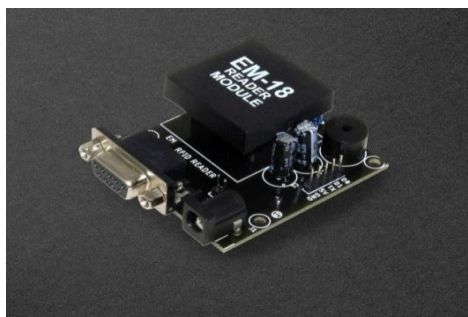


Figure 4: RFID Reader EM18 Module

LCD

A liquid crystal display (LCD) is a thin, flat display device made up of any number of color or monochrome pixels arrayed in front of a light source or reflector [4]. Each pixel consists of a column of liquid crystal molecules suspended between two transparent electrodes, and two polarizing filters, the axes of polarity of which are perpendicular to each other.



Figure 5: 2x16 LCD Display

Arduino IDE:

Arduino is a prototype platform (open-source) based on an easy-to-use hardware and software. It consists of a circuit board, which can be programmed (referred to as a microcontroller) and a ready-made software called Arduino IDE (Integrated Development Environment), which is used to write and upload the computer code to the physical board.

Arduino programming structure

In this chapter, we will study in depth, the Arduino program structure and we will learn more new terminologies used in the Arduino world. The Arduino software is open-source. The source code for the Java environment is released under the GPL and the C/C++ microcontroller libraries are under the LGPL.[10]

6. Results

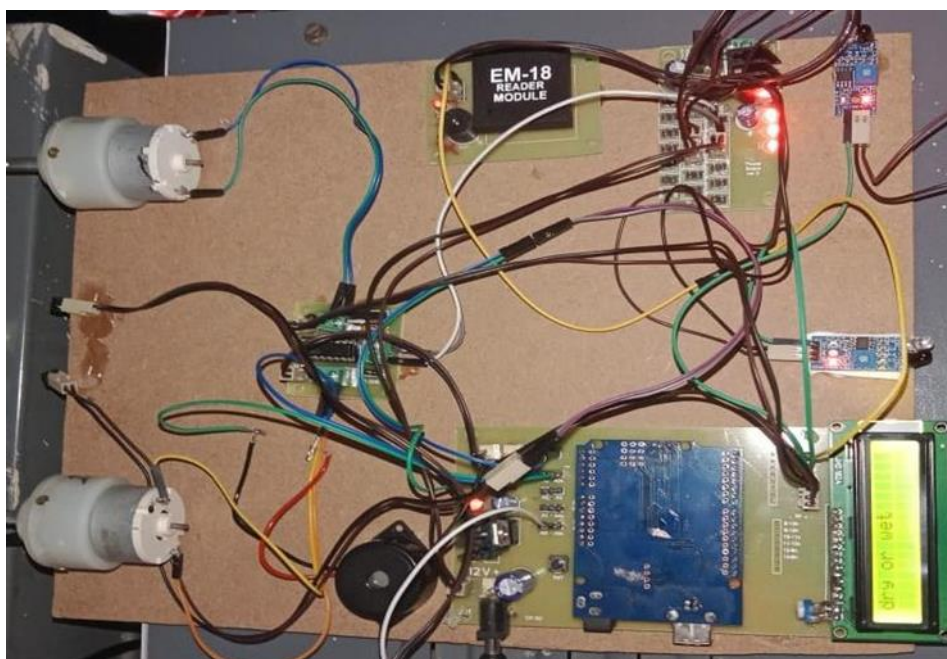
The implementation of the Autonomous Waste Management Project has yielded significant improvements in the efficiency, sustainability, and overall effectiveness of waste management processes. The integration of embedded systems, coupled with advanced technologies, has brought about transformative changes across key components of the waste management lifecycle.

In this work, our intention is achieved to separate the garbage into Metallic, Dry, and Wet Waste, consequently attaining our favoured outputs. Based on the things discussed above, we can conclude that many methods and techniques are found to manage the waste effectively and encourage waste monitoring techniques. Solid waste management and segregation remain a huge threat in the present scenario, and the above, mentioned techniques have their disadvantages in their effective usage. Improvising the methods for SWM will further facilitate the management and disposal of solid waste. The traditional schemes were inefficient. In this paper, an alternate strategy was proposed to collect wastes effectively by monitoring their levels, which reduced human effort and resulted in a healthier environment. The prototype of the proposed

management of waste method is effectively implemented. In this work, we help people to discover the management of waste control areas and expand the study techniques for future works. The above- mentioned method facilitates the segregation of wastes at the very basic level which reduces helps to reduce the amount of pollution caused by the traditional ways of separation of garbage at the level of origin. It is easily transformable into a completely functional model for the enhancement of developed cities and nations.



(a)



(b)

Figure 6: Prototype model for Autonomous Waste Management System

7. Conclusion

The Smart Dustbin project focuses on making the garbage waste collection process a lot simpler, by using intellectual technologies and thereby easing the hectic process of waste collection and dumping. The usage of Internet of Things has helped a lot by automating almost every dustbin and garbage collector in the area, by establishing a form of connection.

Autonomous waste management represents a promising and innovative approach to tackling the growing challenges of waste disposal and environmental sustainability.

In conclusion, autonomous waste management holds great promise for addressing the pressing global issues of waste disposal, environmental sustainability. As technology continues to advance and becomes more accessible, the implementation of autonomous waste management systems is likely to become more widespread, offering a path toward more efficient, safer, and environmentally friendly waste management practices. However, a careful balance between technological progress and human welfare must be maintained to ensure that the benefits are equitably distributed and that privacy and security concerns are adequately addressed.

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