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IoT based Smart Dustbins for Smart Cities using Google Maps

Yuvaraj R, Syed Mohammad Omar S

Department of Electronics and Communication Engineering, Sri Krishna College of Technology

Coimbatore, India

Department of Electronics and Communication Engineering , Sri Krishna College of Technology

Coimbatore, India

ABSTRACT: In many places, Dustbins are not cleaned at proper time this leads to different kinds of diseases, large number of insects and mosquitos then managing the garbage becomes an issue. To avoid such situation we are planning to design “Internet of Things (IoT) based Efficient Garbage Management System” the concept in which surrounding objects are connected to Internet with wired or wireless network without any user interference. Here, we will describe a smart dustbin based on Arduino Uno board which is interfaced with GPS modem, GSM module and Ultrasonic sensor place on smart dustbin which will measure the status of the dustbin. When the level reaches to the threshold value, the device will inform to the concerned authority and action will be made to clean the dustbins. We are using Google map to find the location of dustbin.

KEYWORDS: IoT, Google maps, navigation, smart cities

I. INTRODUCTION

Management of garbage is a serious issue that the state is facing and making all possible measures to fight it. With the advancements in IoT where we make objects communicate in a confined network of their own enables us to effectively them to counter the problem of waste management. The idea is to get signals on the garbage hotspots set up in the cities whenever they get filled. By this way the city corporation will clear the area of the wastes, thereby maintaining a hygienic environment. By incorporating chemical sensing elements, we would enhance this system to be able to sense bio-degradable wastes from hazardous plastics.

II. LITERATURE REVIEW

From the previous studies done by eminent professors, it has been found that intimation of the position is not shared with the concerned people (in our case, the city corporation) [5]. We feel the location provides the easy access to the people to reach and clear the dustbin for further usage by the public. When using IoT, the sensors can be incorporated in multiple ways depending upon the requirements and overall cost. Taking these two factors into consideration we have provided a better cost effective solution. IoT implementation can result in higher expenditure for the sensors and software purposes [2] and our system has reduced most of the unnecessary expenses by keeping the structure simple and user friendly.

The proposed system does not make any adjustments or modifications to the structure of the currently available dustbins. This allows the management to implement our system in the existing dustbins. The regular clearance of the dustbin thus reduces the littering of garbage on the roads, thus keeping the environment clean and hygienic. As mentioned before, the proposed system is simple and uses Google Maps for the navigation purposes instead of sending the coordinates of the position [14]. By this way, anyone with the basic knowledge of using a smartphone will be able to identify the location from the map.

The display provides the following data:

1. Dustbin number
2. Level of garbage
3. Location of the dustbin in the smart city

These details are displayed on the LCD monitor as well, which allows the person to cross-verify manually of the intimation was true or due to a malfunction, which is rare.

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Our objective here is to counter the problem of waste management in the cities by creating a system that senses the filling of garbage at hotspots and signaling the corporation through an SMS that contains the location link of the dustbin hotspot. This link redirects to the webpage showing location on Google maps and the level of garbage present.

An advancement which can be included is the segregation of the garbage based upon their nature. In this case the dustbin must be designed to segregate the waste and incorporate different sensors for the different sections. This isolates the bio-degradable wastes from plastics and other particles matter which require different recycling techniques. Since the corporation vehicles are not specifically assigned to collect specific garbage, we have not included this concept in our system.

III. SYSTEM ARCHITECTURE

Arduino Uno

The controlling unit in the system is the Arduino Uno board with a powerful ATmega328P microcontroller. Arduino being an open source tool helps in easier configuration of the system. Following the RISC architecture, this 8 but microcontroller provides better code efficiency than CISC microcontrollers.

The ATmega328/P provides the following features: 32Kbytes of In-System Programmable Flash with Read-While-Write capabilities, 1Kbytes EEPROM, 2Kbytes SRAM, 23 general purpose I/O lines, 32 general purpose working registers, Real Time Counter (RTC), three flexible Timer/Counters with compare modes and PWM, 1 serial programmable USARTs , 1 byte-oriented 2-wire Serial Interface (I2C), a 6-channel 10-bit ADC (8 channels in TQFP and QFN/MLF packages) , a programmable Watchdog Timer with internal Oscillator, an SPI serial port, and six software selectable power saving modes.

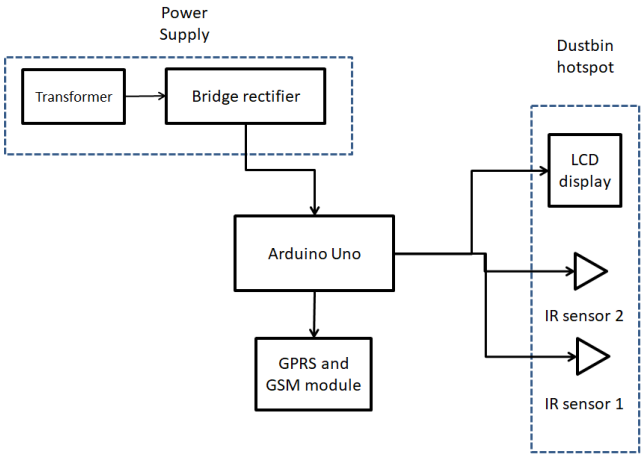

Fig. 1: Architectural Diagram

The Idle mode stops the CPU while allowing the SRAM, Timer/Counters, SPI port, and interrupt system to continue functioning. The Power-down mode saves the register contents but freezes the Oscillator, disabling all other chip functions until the next interrupt or hardware reset. In Power-save mode, the asynchronous timer continues to run, allowing the user to maintain a timer base while the rest of the device is sleeping. The ADC Noise Reduction mode stops the CPU and all I/O modules except asynchronous timer and ADC to minimize switching noise during ADC conversions. In Standby mode, the crystal/resonator oscillator is running while the rest of the device is sleeping. This allows very fast start-up combined with low power consumption. In Extended Standby mode, both the main oscillator and the asynchronous timer continue to run.

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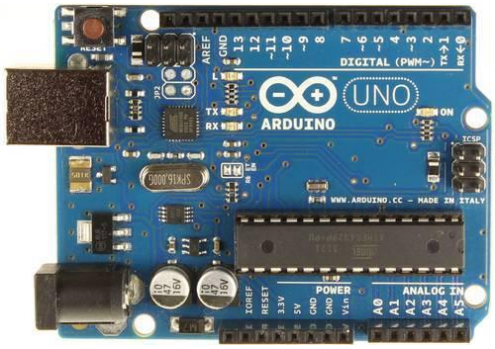

Fig. 2: Arduino Uno

The ATmega328 on the Arduino Uno has a pre-burned boot loader that allows you to upload new code to it without the use of an external hardware programmer. To read the reference files, the library functions, the Arduino Uno follows the STK500 protocol. Bypassing the boot loader is possible and you can manually code the microcontroller through the ICSP (In-Circuit Serial Programming) header.

Powering the Arduino Uno can be done through an AC adapter or by connecting it to a PC as it consists of a Universal Serial Bus (USB) port. Programming through their own IDE is one of the advantages to choose Arduino as it supports C and C++. Apart from these, there is a 16 MHz quartz crystal and a reset button to support the microcontroller.

GSM module

Global System for Mobile communication is the protocol that we use to send the signals to the corporation, intimating them of the filling of the garbage. Following a Time Division Multiple Access technique and having a unique mobile number, GSM provides features such as encryption, SMS services and Multi-party conferencing much like a mobile phone. Since it is the European-Asian region, GSM operates at a 900 MHz band.

Major advantages of GSM over CDMA carriers is that it allows swapping SIM cards and also covers more remotely and sometimes even without roaming charges all over the world. Unlike analog FM cellular phone systems which can be readily monitored, it is virtually impossible to eavesdrop on a GSM radio transmission. The privacy is made possible by encrypting the digital bit stream sent by a GSM transmitter, according to a specific secret cryptographic key that is known only to the cellular carrier. This key changes with time for each user. This high grade security might be optional for our system yet it proves why GSM is preferred all over the world.

The power supply is something to take into consideration when we talk about GSM terminals. The necessities here are high current peaks in a short period of time. It is important to make sure ripples and drops on the supply voltage must be reduced and not to exceed a certain limit.

Fig. 3: GSM module

The GSM module has a booting mode which has the following characteristics:

- Low during reset: download mode. (Here the handset action is what people experience in normal phone call software.)

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- High during reset: normal-working mode.

The following are the specifications on the antenna that is being used in the GSM module:

- Frequency band: Quad band GSM 850 MHz, EGSM 900 MHz, DCS 900 MHz and PCS 1900 MHz.
- Impedance: 50 ohm.
- Radiation gain: 0 dB.

The system uses a module that comprises of GSM and GPRS together in a single module. The GSM is the base to communicate with the corporation. The intimation is done through SMS.

The purpose of GPRS is for the dynamic communication with the webpage. The server dynamically gets the values of the dustbin through a TCL protocol where data is sent as packets, one packet at a time. The disadvantage here is that a packet might take some time to reach the server and if lost will take considerable time to the next packet.

These are very important as the environment that we work in is composed of multiple obstacles that we encounter on a daily basis. The efficiency of the antenna and the longevity of the antenna determine how the module can disposed for the good use of the community.

LCD display

This entire display is constituted of pixels and the better resolution is created with the maximum number of pixels. There are two matrix grids where it is either passive or active and an LCD display consists either one of them.

The active matrix contains a thin film transistor for every cell. The prime advantage of using an active matrix is the display produced is sharp and better than using a passive matrix.

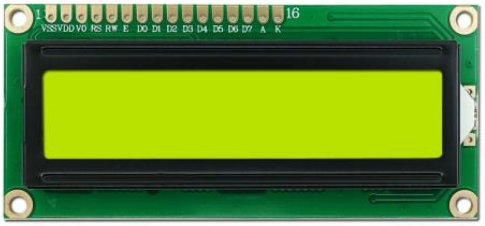

Fig. 4: LCD Display

The LCD display is placed at the junction of every hotspot that is used to indicate the level it has reached at a particular point. 5X8 dot arrangement along with a blinking cursor that operates with a +5V power supply, the LCD display is compatible for small and large scale purposes. Since there will be minor variations in temperature at its operating point, there will be no change in the response time and the color of display. LCDs have a built in controller usually ST7066 or its equivalent.

Infrared sensor

An infrared sensor uses the concept of infrared sensing that emits IR rays in order to sense some aspects of the surroundings. An IR sensor detects the motion of any object. Usually, in the infrared spectrum, all the objects radiate some form of thermal radiation. These types of radiations are invisible to our eyes that can be detected by an infrared sensor. The emitter is simply an IR LED and the detector is simply an IR photodiode that is sensitive to IR light of the same wavelength as that emitted by the IR LED. When IR light falls on the photodiode, the resistances and the output voltages will change in proportion to the magnitude of the IR light received.

Infrared waves are in the invisible spectrum. In the electromagnetic spectrum, infrared radiation can be found between the visible and microwave regions. The infrared waves typically have wavelengths between 0.75 and 1000µm.

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Fig. 5: Infrared Sensor

In our system, we use two infrared sensors which are placed at two different positions of the dustbin. The dustbin along with the IR sensors and the LCD display together represent the dustbin hotspot. The bottom sensor is placed at position where the dustbin reaches 50% of its capacity and the top sensor is placed at a position where the dustbin will reach a capacity of 75%. This mechanism is favored as during the time interval of intimation and the arrival of the truck, the overflow of the dustbin is avoided.

If the sensor was placed at 100% capacity, then during the time interval the probability that the dustbin will overflow and pollute the surroundings is very high.

The common applications that people use infrared technology are in night vision devices, infrared astronomy and tracking systems.
The reasons to choose an IR sensor the cost as IR sensors are cheaper yet deliver the same performance compared to ultrasonic sensors.

Chemical Sensor
Chemical sensors measure the chemical composition of a component usually an environment. The environment that we have taken here into consideration is the garbage dustbin where we are in need of segregating the bio-degradable wastes like perishable foods from the hazardous plastics that could cause serious amount of land and water pollution. This is an optional sensor to include in the module hence it was skipped during the testing of our prototype.

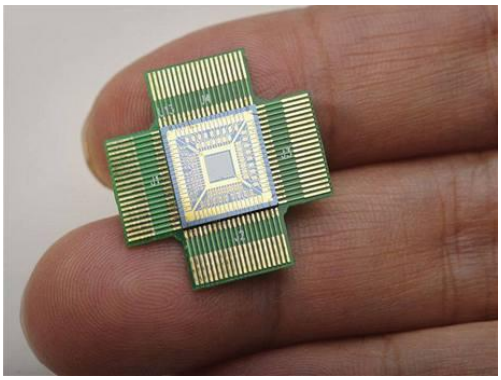

Fig. 6: Chemical Sensor

The typical construction of the sensor is made in such a way that it measures the presence, absence or the exact quality or the quantity of the chemical compound in the environment. Another alternative to choose over a chemical sensor is a biosensor where the biological compound used binds with the target molecule which in our case the chemical exhaust from the dustbin.

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If to choose an alternative, a variety of gas sensors used widely in environmental protection and monitoring are highly valued, which are the mainstays of three mainstreams of chemical sensors. High sensitivity, miniaturization, integration, and low cost are still the development tendency of the gas sensors.

IV. SIMULATION ENVIRONMENT

The two images shown here are about the circuit structure and the outline of the Google maps where the navigation is done. The display is what appears in the LCD display about the details of the dumpster number and the level of garbage.

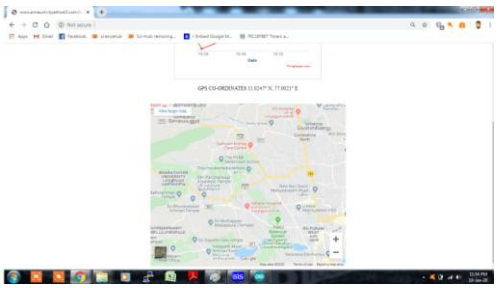

Fig. 7: Webpage displaying Google maps

The terminal display provides the html page that redirects to the navigation page by opening Google maps. The advantage here is Google maps is universally accessible by anyone which makes users to go to the pointed location from any place.

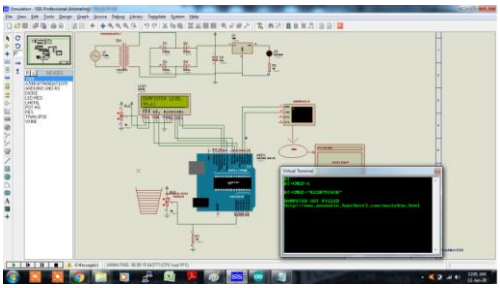

Fig. 8: Simulation diagram of the system

The below image contains the graph that shows the day to day performance of the system. The level of the garbage is shown for every day and once it touches the threshold, the intimation is made to the terminal. This graph proves to be quite useful if a manual overriding is necessary so that people have the exact reading at any given point in time.

Fig. 9: Webpage displaying the dynamic graph reading the dustbin readings

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