ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS | Volume VIII Issue I January 2023

Design and Implementation of Automatic Smart Trash Bin for People with Disability

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Received: 03 January 2023; Revised: 11 January 2023; Accepted: 18 January 2023; Published: 13 February 2023

Abstract: - Dustbin Monitoring System is an automatic system, a new advancement in technology that can be used by all levels of society, particularly for people with disabilities. In this research, an automatic waste bin was designed and constructed using a series of components and electronics units such as Arduino circuit board, sensors and relays of different types and was programmed using C++. The system will notify the user when the fill level is reached to make cleanup or garbage collection. The system was designed with two ultrasonic sensors, one buzzer, LEDs, an Arduino microcontroller and a servo motor. This was achieved by placing one of the ultrasonic sensors in front of the trash can which measures the distance between the dustbin and the user, at the required distance (10m) the dustbin will open and close when the user walks in front and away from the dustbin while; the other ultrasonic sensor is placed at the base of the cover to buzz the buzzer and switches on the LED's when the fill level is reached. Interfacing of components and coding of the microcontroller was also implemented due to the purpose of the system.

Keywords*:* Arduino, microcontroller, sensor and garbage

I. Introduction

The integration of technology into our daily lives requires the introduction of an automatic and self-controlled system. The need for making life easy and convenient for the masses and also to maintain, and manage homes and the environment to protect us from the outbreak of disease being caused by indiscriminate disposal of waste. The world today is moving fast along with the rapid flow of technology Dharmveer, *et al*., (2018). Now with changing this, applications or products that are very useful for all segments of society without thinking of their status are needed to be produced. If seen in the market most of the dustbins are manually operated with the use of leg and hand to open the lid of the dustbin before disposing of trash which is very difficult for persons with disabilities to operate. This research proposes a solution that empowers the waste monitoring systems and waste personnel to timely collection of waste by notifying when the fill-level is surpassed. Various research has been carried out by various researchers and engineers, and many of these researchers did not see the need for automatic waste bins but also the consideration for the use of Arduino as the bedrock and the brain for the automatic waste bin.

Environmental problems are caused in modern cities by indiscriminate waste disposal and waste collection Fady, (2017). Therefore, smart waste management systems became important for cities to be able to manage waste and keep our environment free of waste. Recently, the trend is shifting towards automation and internet of things (IoT) systems to overcome common problems encountered in waste management. Optimizing the process of trash collection is the main purpose of the smart solution provided by the industry. However, the cost of applying the solutions is still relatively high Anitha *et al*., (2016). This work also looks into a way of designing and constructing a cost-effective and avoidable automatic trash bin for localized and small-scale cases, such as small parks, primary and secondary schools, Universities and hospitals. A proper waste management system is a must for a hygienic society in general and the world as a whole. Waste which is one of the sources and causes of environmental pollution has been defined under the Resources Conservation and Recovery act as any semi-liquid or contained gaseous materials discarded from industrial, commercial, mining or agricultural operations and community activities. Waste also includes garbage, Construction debris and commercial refuse.

Waste and Waste Types

Waste is an unavoidable by-product of most human activity. Economics development and rising living standards in the Asian, African and Pacific regions have led to an increase in the quantity and complexity of generated waste, whilst industrial diversification and provision of expanded healthcare facilities.

Waste is classified as:

- Municipal Solid Waste
- Industrial waste

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- Agricultural waste
- Hazardous waste

The Arduino Microcontrollers

The Arduino board was designed at the area interaction Design Institute and intended for students without a background in electronics and programming concepts. These Arduino boards started altering to adapt to new requirements and challenges separating its present from simple 8-bit boards to products IoT (Internet of Things) applications,3D printing, and wearable and embedded applications. Arduino boards are entirely open source, allowing users to build them separately and finally adapt them to their exact needs. Arduino board is not a microcontroller; it is an open-source electronics platform. The Arduino board is a PCB which has Microcontrollers LEDs and many other connections. Generally, it's used to do input and output operations like controlling a motor and reading from sensors and in small computations.

There are different Arduino boards which are the following:

- Arduino Uno (R3)
- Lilly Pad Arduino
- Red Board
- Arduino Mega(R3)
- Arduino Leonardo

Advantages of Arduino Board

- The Arduino boards are very easy to get started
- The Arduino boards are used in the automatic room light control
- On the Arduino, both software, hardware and IDE are open sources
- The Arduino boards are used in real-time applications.

C++ Programming Language

C++ is a high-level programming language that allows a software engineer to efficiently communicate with a computer and is highly flexible and adaptable creation in 1980, it has been used for a wide variety of programs including firmware for micro-controllers, operating systems, applications, and graphics programming. (Wikipedia). C++ is designed as a bridge between the programmer and the raw computer. The idea is to let the programmer organize a program in a way that he or she can easily understand. The compiler then translates the language into something the machine can use. Computer programs consist of two main parts: data and instructions. The computer imposes little or no organization on these two parts. After all, computers are designed to be as general as possible. The idea is for the programmer to impose his or her organization on the computer and not the other way around and the data in a computer is stored as a series of bytes. C++ organizes those bytes into useful data. (Stroustrup,1997). Assembly language organized programs in a way that was easier for the programmers to understand. However, the program was more difficult for the machine to use. The program had to be translated before the machine could execute it. This was the start of a trend. Programming languages became more and more convenient for programmers to use and started requiring more and more computer time to translate them into something useful for computers and over the years a series of high-level languages has been devised. (Steve *et al*,2000).

II. Methodology

The work put a design for a smart trash bin along with the construction of the system, the system used active and passive devices units and integrated circuits (IC). It also, explains the used hardware parts and how it's connected. The software is then written and illustrated as the flow chart Figure 1.0. The fullness of the bin is determined by calculating the distance between the lid of the bin and the trash by a sensor and alarm connected to it to notify the users of disposal. The distance threshold was set according to the dimensions. When the distance measuring sensor indicates that the bin is full, then an alarm connected to the system indicates by coming ON.

III. Design

The system design is cost-effective and user-friendly. Here follows the designed flow chart

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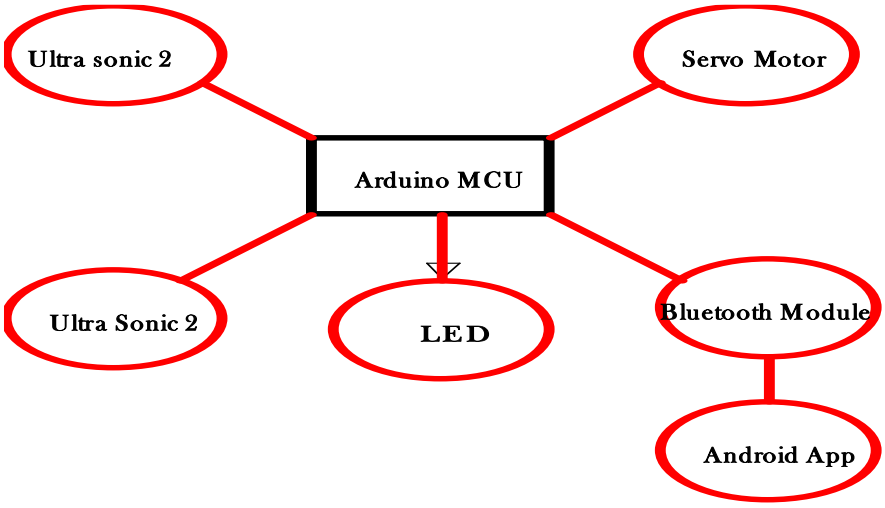

Figure 1.0: Flow Chart for the waste Bin showing

Hardware

Ultrasonic Sensor

An ultrasonic is an active component that measures the distance of an object with the help of sound waves and It has four pins. Two are VCC and GND which will be connected to the 5V and the GND of the Arduino while the other two pins are Trig and Echo pins which will be connected to any digital pins of the Arduino. It measures by distance sending out of a sound wave at a particular frequency and listening for that wave to bounce back. In another word, the sensor head emits an ultrasonic wave and receives the wave that is reflected from the target Monisha *et al*., (2015) and Olabisi *et al*., (2019).

The distance can be calculated with the following formula:

$$Distance = \frac{1}{2} \times T \times C \qquad \text{Equation 0.1}$$

$$\frac{time\ x\ speed\ of\ sound}{2}$$

Where, T =is the time between the emission and reception,
C= is the speed.

Figure 2.0: Ultrasonic Sensor

Arduino Board

The Arduino board in (Figure 3.0) has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analogue inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. There are various kinds of Arduino boards available depending on the different microcontrollers used. However, all Arduino boards have one thing in common: they are programmed through the Arduino internal development environment.

Arduino was born out of the combination of many prototyping cultures. It was developed at the Interaction Design Institute Ivrea, a small school in northern Italy offering a Master's degree in interaction design. Interaction-Ivrea's curriculum focused on-screen interfaces, physical objects, and services, emphasized hands-on work, encouraging designers to create their ideas, and repeatedly test and refine them Brain *et al*., (2007).

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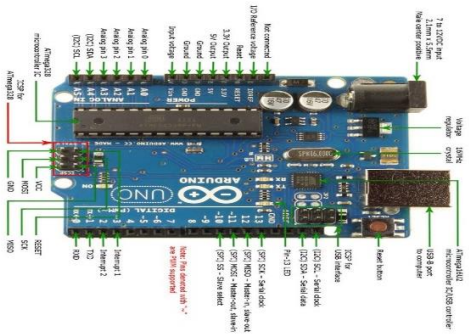

Figure 3.0: Arduino Uno integrated circuit

Servo Motor

Servo motors may be classified according to size or torque as a passive device, unlike dc motors, with servo motors you can position the motor shaft at a specific position (angle) using a control signal. The motor shaft will hold at this position as long as the control signal is not changed. Standard servo motor control using Arduino is extremely easy, this is because the Arduino software comes with a servo library and The third pin accepts the control signal which is a pulse-width modulation (PWM) signal. It can be easily produced by all microcontrollers and Arduino boards. (Seema *et al*., (2016) and Thompson *et al*.,(2020)). The picture of a servo is shown in Figure 4.0 below:

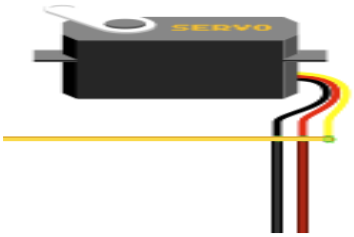

Figure 4.0: Servo Motor

Table 1.1: System Specification and parameters

Specifications	**Parameter**
Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Digital I/O Pins	14
Analogue input Pins	6
Flash Memory	32kb
SRAM	2kb
EEPROM	1kb
Clock Speed	16MHz
DC Current per I/O Pin	40mA
DC Current for 3.3V Pin	50mA

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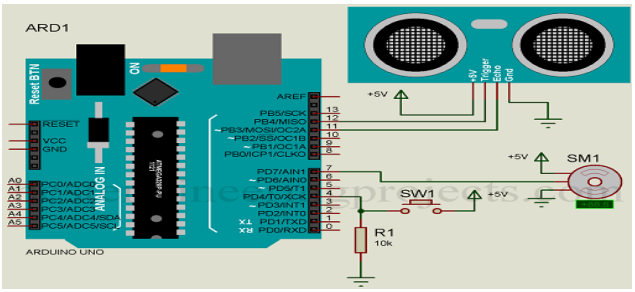

Figure 5.0: Complete Circuit System

Figure 6.0: Constructed System under test

Figure 7.0: Picture showing connected cables

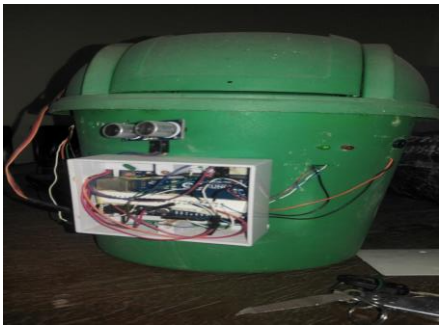

Figure 8.0: Coupled Smart dustbin

IV. Working Principle of the System

The working theory of the system is shown in Figure 8.0, the waste bin performs the opening and closing action an Ultrasonic sensor was used as an input device that tends to measure the distance between the human approaching and the waste bin in which a fixed distance as to be determined before it sends a signal pulse to the microcontroller. Ultrasonic sensors were placed at the front of the dustbin container and inside the dustbin with the two ultrasonic sensor probes facing downwards to detect the fill level of the waste bin, a distance of 14 cm and less than was implemented to keep the trash inside the bin checked when this level is breached the ultrasonic sensor sends the signal to the microcontroller which triggers the buzzer to buzz and the LED to switch ON by sending out a signal to the two-component.

The schematic diagram was first drawn on how the components would be placed on the Arduino microcontroller board before considering which component would be controlling any other components, the efficiency of components was also put into consideration for the system, and the block diagram was drawn to indicate which of the components would be sending a signal to the microcontrollers and those that would be receiving a signal from the microcontrollers and Components where interfaced due to the major importance of the system which is opening and closing of the dustbin, buzzing the buzzer when the fill level is reached and separate codes were written since the system is a microcontroller base system, the Arduino ATmega chip embedded on the Arduino board is programmed through the Arduino IDE which is uploaded to the board through a USB cable.

An ultrasonic sensor is placed in front of the waste bin, this particular ultrasonic sensor controls the servo motor at a certain distance which opens and closes the waste bin when the user walks in front and walks away from the waste bin, the second

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ultrasonic sensor is placed at the base of the lid of the waste bin which measures the distance between the trash inside the waste bin and the lid when the fill level is reached it buzzes the buzzer, switches on the LED's and sends a message to the user phone if it's connected simultaneously.

A soldering iron was used to drill holes at the side of the container where the buzzer, LED and ultrasonic sensor were placed while the Arduino board was placed inside the waste bin along with the other ultrasonic sensor placed at the top side of the waste bin jumper wires were used to connect each of the components to the Arduino board inside the waste bin.

The signal input of the servo motor, buzzer and LED is connected to pins 9, 12 and 13 while the ultrasonic1 sensor trig and echo pin are connected to pins 10 and 11, ultrasonic2 sensor trig and echo pin are connected to pins 3 and 2 with all GND and VCC pin connected to the Arduino board GND and 5v pin. The board is powered through the Universal serial bus (USB) when plugged into a computer or 9v battery and through the same USB is the sketch or code uploaded to the board; any component not properly inserted or wrongly declared on the Arduino IDE will not work until its rectified. The serial monitor which is the tether between the computer and the Arduino allows sending and receiving of text messages and is also handy for debugging and controlling the Arduino from the keyboard. This is a separate pop-up window in the Arduino ID, which is a terminal that communicates by receiving and sending data.

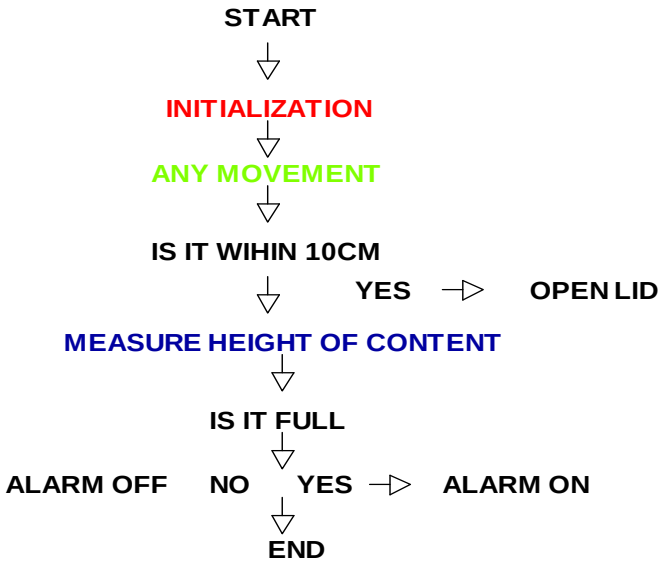

Figure 9.0: Flow Chart

V. Conclusion

At the end of the project, it could be concluded that the design is an open-source technology, a user-friendly system based on Arduino and the coding is done on the Arduino platform. The overall cost is low and can be easily operated with less power consumption the only conditions which will aid the opening of the waste bin are that the body affront the bin must be human; when the bin is opened and the user is within the range, the close command would not be given in as much the ultrasonic sensor is still sensing the human.

Managing in-house bins has been an unidentified but highly potential hazard for human-habituated areas. The current method of manually peeping through the bins and checking fill-level might lack comprehensiveness as it lacks to measure pungent gaseous content, and would be prone to forgetfulness. The developed system provides improved performance on real-time bin status determination and estimation of bin level. In this study, we proposed a classification approach for bin-level detection using an ultrasonic sensor also known as a distance meter to obtain the bin level.

VI. Future Work

Based on this, research work is ongoing on IOT based automatic dust bin for Uniuyo Community with two sensors monitored compartments for solid waste and liquid for cities and public places, which will allow the separation of waste and automatic monitoring from a central unit to overcome some of the limitations of the present work. Research under the University of Uyo WETLAND institute.

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