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РАЗРАБОТКА УМНОГО УСТРОЙСТВА ДЛЯ УПРАВЛЕНИЯ ОТХОДАМИ

DEVELOPMENT OF SMART WASTE MANAGEMENT DEVICE

Аннотация. Управление отходами является одной из давних проблем, с которыми сталкивается человечество. Нынешний метод управления отходами, при котором на уборщиков возлагается обязанность периодически опорожнять мусорные баки. У такого плана есть много недостатков. Современная ситуация показывает, что мусорные баки, расположенные в нашей среде, часто переливаются из-за значительного увеличения количества отходов, образующихся ежедневно. Таким образом, создается нездоровая среда для человека и возникает неприятный запах вокруг такого места. В статье представлено интеллектуальное устройство для управления отходами на базе Интернета вещей, предназначенное для определения присутствия человека, открытия мусорного ведра и отправки SMS-оповещения о его заполнении, что позволяет осуществлять мониторинг в режиме реального времени. Для разработки использовались программирование на C++, Arduino Uno с ультразвуковыми датчиками HC-SR04, GSM-модуль A9, серводвигатели MG 99R, светодиоды и Li-Po аккумулятор. Тесты показали, что крышка открывается на расстоянии от 40 до 70 см, оставаясь закрытой за пределами этого диапазона. Однако, когда мусор достигает уровня 33 см от дна контейнера, через 30 минут отправляется SMS-оповещение, что помогает отслеживать уровень отходов в режиме реального времени.

Abstract. Waste management is one of the long-time challenges encountered by the human race. The present method of waste management, where cleaners are saddled with the responsibilities to empty the waste bins periodically. Such plan has a lot of demerits. The present-day situation shows that waste bins positioned in our environment are often times spilled over due to the significant rise in waste generated daily. Thus, creating an unhealthy environment for the citizens and producing foul odor around such location. The paper presents an IoT-based smart waste management device designed to sense human presence, open the bin, and send SMS alerts when full, allowing real-time monitoring. C++ programming, Arduino Uno with HC-SR04 ultrasonic sensors, A9 GSM Module, MG 99R servo motors, LEDs, and Li-Po battery were used for the development. Tests revealed that lid opens at distances between 40cm and 70cm, remaining closed beyond this range. However, when trash reaches a level of 33cm from the bin bottom, an SMS alert is sent after 30 minutes, aiding in real-time waste level monitoring.

Ключевые слова. Отходы, IoT, мусорное ведро, умный, разработка

Keywords. Waste, IoT, bin, smart, development

Introduction

Waste management is one of the long-time challenges encountered by the human race. In fact, it's as old as the human existence itself. Due to the fast pace of urbanization, waste management is becoming a bigger issue each day in each developed and developing countries (Norfadzlia *et a*l., 2018) and Nigeria is not an exemption. Ayodeji *et a*l., (2020) believed that the fight for a sustainable future will be lost or won in the cities. Precisely, how we collect, dispose, treat and manage waste generated (UN, 2019). The urge for smart sustainable cities, technological advancement in the nations of the world, rise in population, increase in human activities and pattern of production and consumption has given rise to generation of huge volume of waste that must be properly disposed, treated and managed to ensure sustainable environment and a decent living for the increased population (Likotiko, 2018).

The waste created from various sources will lead to environmental pollution arising without an effective and well- organized solid waste management. Besides, this can also bring to serious health hazard and lead to the spread of infectious diseases. An effective solid waste management practices need to be updated to suit the current waste quantity and composition (Norfadzlia *et a*l., 2018). As a matter of fact, Jože *et a*l., (2022) affirmed that The World Bank predicts that the amount of waste generated annually will increase from 2.01 billion tons in 2016 to 3.40 billion tons in 2050 (Kaza *et a*l., 2018). However, the need to sustain a clean and healthy environment is a global concern (Sarkis *et a*l., 2017). Sonawane *et a*l., (2019) stated that population increase translated

to increase in waste generation in our environment and waste management has turned out to be a global challenge. Waste management in this present-day require taking the right decision and approach in tackling the challenges. The change in people's lifestyle has also led to an increase in the generation of waste (Kumar *et a*l., 2017).

In one lifetime, an individual produces on average 600 times as much waste as that person weighs (Jože *et a*l., 2022). Daily activities aimed at reducing waste collection in landfills and at recycling and waste prevention can help solve the problem (Polajnar *et a*l., 2015). Human use products and these products become wastes after their uses and needed to be dumped. The waste ranges from solid (refuse) to liquid (sewage) waste. In this research, however, the focus is on solid waste and more importantly waste generated in offices and places of work. In offices of the Usmanu DanFodiyo University, Sokoto, common waste includes but not limited to used papers, tin cans, plastic bottles, water sachets, plastic bags(nylon) and et cetera.

Method and materials

As the smart waste bin tailored for office spaces, factors such as the optimal bin height and capacity to ensure suitability within office environments were evaluated, for corrosion resistance and aesthetic appeal stainless material was selected.

Design Calculations

The design underwent some important calculations from the cover and base area calculation, volume of the container calculation to the electrical and automation calculation.

The Cover and the Base Area*:* The cover and base are in circular form. Therefore, the area will be computed using

$$A = \pi r^2$$

Where: A = Area

r = radius of base and cover = $d / 2$

Therefore,

$$A = \pi\left(\frac{34}{2}\right)^2,$$

$$A = 907{,}92\ cm^2,$$

$$A = 0{,}09079\ m^2.$$

Hence, the area of the cover and base is approximately 0.09 square metre or 908 square centimetre.

The Volume of the Container**:** The volume of the trash container can be calculated using the formula of the volume of cylinder as follows:

$$V = \pi r^2 h.$$

Where: V = volume of cylinder;
r = radius of base and cover; and
h = the height of the cylindrical container.
Therefore,

$$V = 0,04086\ m^3 .$$

Therefore, the maximum volume of the trash containing cylinder is approximately 0.04 cubic metre or 41 Litre.

Automation and Electrical Calculations

Servo motor capacity: 1/4 hp = 186.5 W DC
Power source ratings: 10,000 mAh
Input DC: 5.0 V, 2.1 Amps.
Output I (DC): 5.0V, 2.1 Amps.
Output 2 (DC): 5.0V, 2.1 Amps
The power is calculated from the formula

$$P = I \cdot V .$$

Therefore,

$$P_{output\,1} = 2,1 \times 5 ,$$

$$P_{output\,1} = 10,5\,W .$$

Similarly,

$$P_{output\,2} = 2,1 \times 5 ,$$

$$P_{output\,2} = 10,5\,W .$$

Hence,

$$P_{total} = P_{output\,1} + P_{output\,2} ,$$

$$P_{total} = 10,5 + 10,5 = 21\,W .$$

Where: $P_{output\,1}$ = DC Power of output 1,

$P_{output\,2}$ = DC Power of output 2,

P_{total} = Total power.

Sensor1 (trash level detector) =33cm
Sensor 2 (Human approach detector) = Between 40cm and 70cm
Cylindrical shape, height= 50cm–5cm (power bank spot) = 45cm
Diameter of the lid = 34cm = 0.34m
Motor blade rotates from 0°– 175/180°, Lid rotates from 0° – 85°/270°

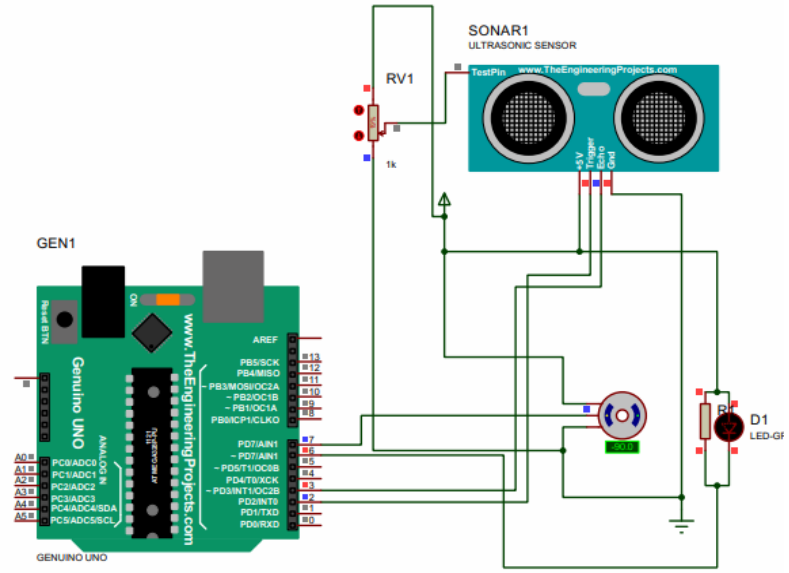

Figure 1 – Principle of Operation of the System

The system works by following the signal from the microcontroller incorporated with the sensors and other components. When a person approaches the bin (Figure 1*a*), the first ultrasonic sensor (comprises two speakers for sending and receiving signals) placed in front of the bin detects the human presence within the range of 40cm and 70cm. The first of the two speakers sends a wave signal that bounces back to the second after hitting a barrier (i.e. the dumper). If the person is within the range of 40cm and 70cm, the green LED pops up, the buzzer makes sound and consequently the bin opens (Figure 2*b*). If the dumper is not within this range- either closer than 40cm or farther than 70cm, the bin remains closed. Once the waste has been dumped and the dumper recedes outside the stated range (i.e. 40 to 70cm), the bin closes on its own without help from anyone.

Furthermore, the second ultrasonic sensor placed inside the bin, using the same principle as above monitors the waste level. At the height of 33cm of the waste level, in incorporation with the SIM module sends SMS to the person in charge for offloading. At this point of the filled level, the red LED remains ON. This will sensitize the person that wants to dump that the bin is filled up.

a *b*

Figure 2 – Developed smart waste bun device closed (*a*) and opened (*b*)

Results and discussion

From the test performed, the lid opens at distances between 40cm and 70cm, remaining closed beyond this range. Additionally, when trash reaches 33cm from the bin bottom, an SMS alert (Figure 3) is sent after 30 minutes, aiding in real-time waste level monitoring. Compared to existing systems, this IoT-based solution stands out, offering comprehensive waste management capabilities. From the test performed on the waste bin it was discovered that:

i. At a distance of $x > 70$cm, the cover of the waste bin remains closed (Plate 4.1a.)

ii. At a distance of $40\text{cm} \leq x \leq 70\text{cm}$, the bin cover opens and remains open (Plate 4.1b.)

iii. At a distance $x < 40$cm, the waste bin cover closes back and remains closed.

iv. At the height of $x \geq 33$cm from the bottom of the container, the trash detecting sensor senses the waste and sends SMS to the collector.

v. The green LED appears when the dumper is within the range and the bin will open and goes off when the dumper recedes.

vi. The red LED will appear continuously when the bin is filled up and hence sensitizes the dumper of its status.

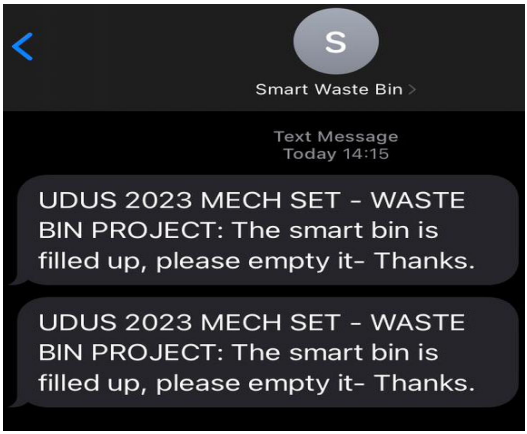

Figure 3 – SMS alert sent to the collector

Conclusion and recommendations

The device was modelled using 3-D modeling AutoCAD software and simulated using Auto-desk Fusion-360. Stainless steel was for the fabrication with rivetted joints. After testing and evaluation for its efficiency, it found that the lid opens at distances between 40cm and 70cm, remaining closed beyond this range. Additionally, when trash reaches 33cm from the bin bottom, an SMS alert is sent after 30 minutes, aiding in real-time waste level monitoring. Based on the results of the study, recommendations were suggested as follows:

i. The bin can be made to segregate waste into biodegradable or non-biodegradable waste to enhance recycling.

ii. Facility for mobility of the waste bin can be incorporated with remote control to enable one move the waste bin closer to him or her for convenience purpose.

iii. Facility for categorization of waste products can be incorporated to classify waste product according to their types for better management.

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УСОВЕРШЕНСТВОВАНИЕ ПРОЦЕССА ПРЕДПОСЕВНОЙ ПОДГОТОВКИ ПОЧВЫ С ПРИМЕНЕНИЕМ РАБОЧЕГО ОРГАНА С ГИБКИМ ЭЛЕМЕНТОМ

Аннотация. Цель исследований – создать схему рабочего органа для предпосевной подготовки почвы с применением гибкого рабочего органа в виде троса. На основе анализа различных типов и принципов действия рабочих органов составлена принципиальная схема рабочего органа с гидровибратором, в которой применен гибкий элемент в виде троса.

Abstract. The purpose of the research is to create a diagram of a working body for pre-sowing soil preparation using a flexible working body in the form of a cable. Based on an analysis of various types and operating principles of working bodies, a schematic diagram of a working body with a hydraulic vibrator was drawn up, in which a flexible element in the form of a cable is used.

Ключевые слова. Рабочий орган с гибким элементом, гидровибратор, компенсатор, винтовой механизм, дроссель-расходомер.

Key words. Working body with a flexible element, hydraulic vibrator, compensator, screw mechanism, throttle-flow meter.

Качество предпосевной обработки почвы является одним из основных факторов. Влияющих на получение своевременных дружных всходов семян и в конечнем стчете высокого полноценного уражая сельскохозяйственных культур.