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Internet of things-based garbage monitoring system integrated with Telegram

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ABSTRACT

This paper presents the development of smart garbage monitoring system using internet of things (IoT) to keep the environment clean thus reducing cleaners' burden. The present era is characterized by smart cities, where precision and organization are the norm. This initiative was launched because population is progressing rapidly, increasing more garbage hence esclating cleaner's frequency of dustbin checking daily whether the dustbin is full or not which mean more labour costs. The main purpose of this research is to develop a systematic garbage monitoring system which can help cleaners schedule their work in monitoring and picking up garbage from dustbins. It used node microcontroller (NodeMCU) ESP8266 Wi-Fi module as the main controller to control ultrasonic and rain input sensors and provide notifications via Telegram. A limit switch is used to detect whether the lid is open or closed. When the lid is closed, the ultrasonic sensor is activated and measures the garbage distance depending on the amount. If an overrun of the maximum amount is detected, the red-light emitting diode (LED) will turn on that connects to the Wi-Fi module, which sends notification to the cleaners. As a result, the IoT based garbage monitoring system was fully functioned and accomplished its objectives.

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1. INTRODUCTION

As the population grows, waste disposal also increases and waste management is becoming more and more important. Particular focus should be targeted on waste collection either from residences or education instituions associations. If waste is not collected from time to time, people tend to dump anywhere from the side of the road to a remote area. These piles of garbage then accumulate and pollute the surrounding area causing air and soil pollutions and sometimes water pollution too. It is also known that rotting waste emits toxic vapours into the air, which mix with the air itself creating an unpleasant smell which can result in a variety of airborne and waterborne diseases. Solid waste is a serious environmental issue that has an impact on several communities all over the world. Improper management can have a number of detrimental effects, including pollution, health hazards, habitat destruction and so on. An effective garbage collecting system will be discussed in this paper. In the proposed system, residents or waste analysts of a certain area are informed before the arrival of garbage vehicles. They can throw the garbage into that particular vehicle. To get rid of it, it need not necessarily be left on the side of the road. If waste is collected properly, it can be separated and dealt with more effectively. This also aids in protecting the scenery and beauty of nature.

Internet of things (IoT) is defined as IoT that refers to the use of devices and systems intelligence to collect data from sensors and actuators. IoT also refers to the concept of connecting machines and other physical objects to the internet. It is an integration of sensor, computing, and communication technologies [1]. They can exchange data, communicate with one another, and gather information from external sources through the IoT where it is quickly encroaching on a wide range of industries, including smart mobility, Industrial 4.0, environmental monitoring, home automation, and personal health care [2]. With the potential offered by IoT to deliver solutions with improvements in energy efficiency, security, health, education, decision-making and productivity for enterprises, IoT is expected to spread rapidly over the coming years and this convergence will unleash a new dimension. IoT also can be separated into three categories. The first category is people to people, next category is people to machine and the last category is things to machine or machine to things, interacting through internet [3]. IoT is not only about a single technology, but it is a mixture of different hardware and software technologies. Up to date, there are several research works that fully utilized the IoT technology to enhance different system as in [4]–[6].

As stated before, the major challenge is solid waste management. Garbage collection in traditional solid waste management has difficulty in monitoring and scheduling the collection of rubbish in an area. There are many floors in a building with bins that should be monitored and one has to pay attention to each and every level dustbins. Main problem is when each bin is fully loaded yet the picking up schedule has not arrived. These employees occasionally failed to check the dustbin to see if it was full on time. This is because there are too many dustbins and it is very tedious for the workers to manually check the rubbish in all the dustbins. The second problem is that when the dustbins are fully loaded, the waste flows out of the dustbins and leads to unhygienic conditions in the surroundings which sometimes caused diseases and pollution. So this project is about developing a garbage monitoring system via IoT that can monitor the garbage in the rubbish bins through a wireless network. This project also will helps the cleaner to set up a more systematic schedule for collecting the garbage, as the garbage monitoring system via IoT will only notify the cleaner who is responsible for emptying the rubbish bins according to its set schedule.

2. THEORETICAL BACKGROUND

This project focuses on keeping the environment clean and help the cleaners lighten their daily work. There are several references which had been used to support this paper. For a successful system, the research problem was studied again and again. The IoT/artificial intelligence (AI)-based garbage waste intelligent management system has been developed as a prototype, focusing on waste items, household dustbins, garbage bags, and a dedicated garbage collection vehicle [7]. The project begins with the flow of trash into the domestic trash bin and garbage bin, and it ends with garbage pickup trucks. Depending on the radio-frequency identification (RFID) technology, a new dustbin bag is placed in an integrated container. Using Arduino with IoT did overcome all the disadvantages to an extent of small-scale use, low cost, low fuel consumption, and a clean environment.

There are several studies on garbage monitoring system that implemented the IoT in their system as in [8]-[28] with different sensors in the system. An intelligent waste management system designed for urban environments emerged from the efforts of Cai *et al.* [8]. The system's core objective is to achieve real-time waste detection through the utilization of IoT and data visualization technology, all while promoting energy efficiency. The measurement of garbage bin fill levels is achieved using a NodeMCU chip integrated with an ultrasonic sensor, and the collected data is seamlessly sent to the database through the Ali-cloud IoT platform. This system employs a cutting-edge technique in which waste monitoring and disposal assistance are automated. Smart garbage monitoring and disposal support system (SGMDSS) was developed by researchers in [10]. SGMDSS monitors garbage bins situated at various places and tells cleaning employees about the level of waste gathered in the garbage bins via an Android mobile application for disposal, as well as providing the shortest path to the garbage bin site that is almost full. This data is also fetched to the homepage, and full database is kept and accessible via the cloud. An alarm message is also notified to the worker.

Chowdhury *et al.* [12] proposed an IoT based approach for garbage monitoring and its disposal using ultrasonic and MQ4 sensors. The level of rubbish whether biodegradable or nonbiodegradable in the dustbin were monitored using an ultrasonic sensor while MQ4 sensors measure the odour level for the biodegradable rubbish. The use of an IoT prototype fitted with sensors that can read and transmit bin volume data over the internet is used to introduce a waste-gathering technique based on delivering smart bins which proposed in [18] while the study in [21] proposes an IoT-based smart waste clean management system that uses sensor systems to check the trash level above the dustbins. Once discovered, this system quickly changed to concern permitted by GSM/GPRS. The microcontroller was employed as an interface between the sensor system and the GSM/GPRS system. To monitor and combine the desired information connected to the varied levels of garbage in different locations, an Android application is developed. This has resulted in a greener environment and support for cleanliness. The study on IoT-based trash checking system built with an Arduino or Raspberry Pi

board and an open IoT platform was developed by researchers in [22]. An Arduino microcontroller, an ultrasonic sensor, a Wi-Fi module, and a heap battery are all part of the suggested structure. The Arduino microcontroller is used to collect data from the ultrasonic sensor and burden cell. The depth of the garbage in the compartment is determined using an ultrasonic sensor, and the weight of the waste receptacle from the heap cell is also estimated. The research developed in [26] combined LoRa wide area network (LoRaWAN) communication networks (IoT networks) with garbage sorting equipment to produce a system that provides automated garbage can operation, environmental monitoring, and graphical interface monitoring.

In this paper, this project is to measure and detect both fullness and leakage inside and from the dustbin. The objectives are to develop a systematic garbage monitoring system that can help cleaners schedule their work in monitoring and picking up garbage form dustbin by using Telegram application through IoT and to monitor the fullness and leakage of garbage in the dustbin with an ultrasonic sensor, rain sensor and NodeMCU ESP8266 as microcontroller. According to previous work, the garbage management system overall used IoT and sensor to detect the level of trash in the dustbin.

The difference of this paper from previous works is that the dustbin automatic close since it used limit switch to detect whether the lid is open or closed. The function is to make sure the lid of the dustbin container is always closed to avoid excessive odours. Furthermore, the rain sensor is used to detect the level of humidity in the dustbin to avoid any harmful odour. The ultrasonic sensor will activate after the lid of the dustbin is close thus it will lead to effective management of the system. Once the system detected maximum amount of trash in the dustbin, notification will be received via Telegram ensuring the system performance.

3. METHOD

3.1. Block diagram of system

Figure 1 shows the block diagram of garbage monitoring system. This garbage monitoring system is a project that applies the IoT. This project can help the cleaner to keep the dustbin always clean and tidy in a faster way compared to the traditional garbage collecting process.

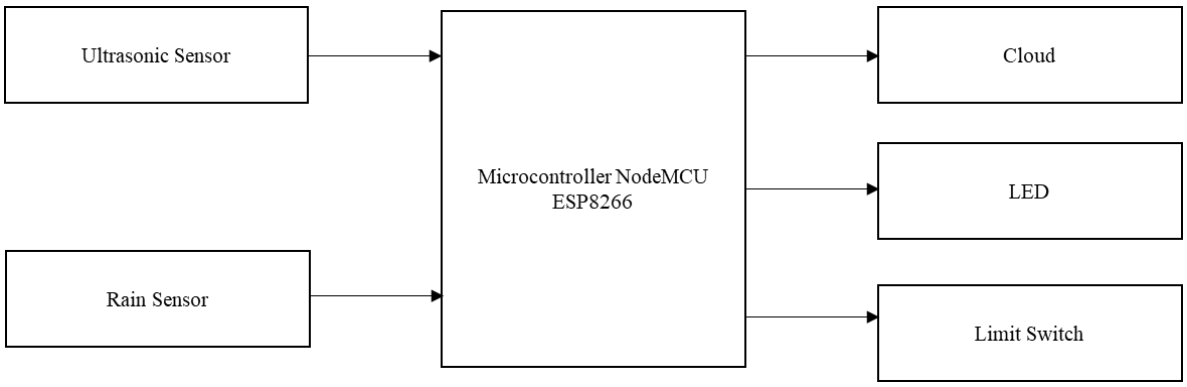

Figure 1. Block diagram of the system

In this garbage monitoring system, several sensors are used to assist and complete the function of the system. Limit switch, ultrasonic and rain sensors function as the inputs, while light emmitting diode (LED) will acts as the output of the system. The ultrasonic sensor works by sending out sound waves at a frequency that is inaudible to humans, waiting for the sound to be reflected, thus measuring a distance depending on the amount of time needed. The measured distance will be used to predict the amount of garbage or waste that is currently in the dustbin. This will indicate that the trash bin is full or not. A shorter distance means a fuller bin and vice versa. The rain sensor, on the other hand, works by sensing, measuring, and reporting the humidity level in the dustbin. If the sensor detects the presence of liquid in the dustbin, it will notify the cleaner to clean the dustbin. A predetermined figure will be established to notify staff members when it is time to empty the garbage. The system used NodeMCU microcontroller with Wi-Fi capability which uses an ESP8266 Wi-Fi module so that remote monitoring of the data can be monitored by the authorized administration. Proteus software was used in this system to provide simulation process before the system being developed. The functions of every component are clearly outlined and presented in Table 1.

Table 1. Component of the project

No	Component	Function
1	NodeMCU with ESP8266 Wi-Fi with CH340C	Microcontroller to program the specific values for humidity and distance thus run the system
2	Rain sensor	To detect the humidity level in the dustbin
3	Ultrasonic sensor	To detect the level of garbage in the dustbin
4	LED	To alert the cleaner to clean the garbage in the dustbin if the LED is red
5	Limit switch	Make sure the lid of the dustbin container is always closed to avoid excessive odours

3.2. Flowchart of garbage monitoring system

The flowchart of the system is shown in Figure 2. The IoT applied in garbage monitoring system is a system which can be used widely especially in a higher education institution. The system starts when the cable is linked to the Arduino through the laptop. According to flowchart of the system in Figure 2, at first, the NodeMCU ESP8266 will declare and initialize the input and then it will receive the data from sensors to start the system. The ultrasonic sensor will detect the fullness of the trash in the dustbin. This ultrasonic sensor will only operates when the lid of the dustbin is close. The limit switch on the other hand will make sure the lid of the dustbin is always close. If not, the ultrasonic sensor will not function. If the lid is open, then the system will not obtain any result from the sensor. If the ultrasonic sensor detects more than or equal to 80% of the garbage level in the dustbin, the red LED will turn on. However, if the ultrasonic sensor detects less than 80% of the garbage level in the dustbin, the red LED will turn off. After that, the rain sensor will activate. When the rain sensor detects the presence of water, it will notify the cleaner that the dustbin has a bad smell which might be unpleasant. Then it will notify the cleaners through Telegram about the fullness of the dustbin which requires the cleaners to empty the dustbin. However, if the rain sensor does not detect water, the notification for both sensors is reset and the entire system is restarted.

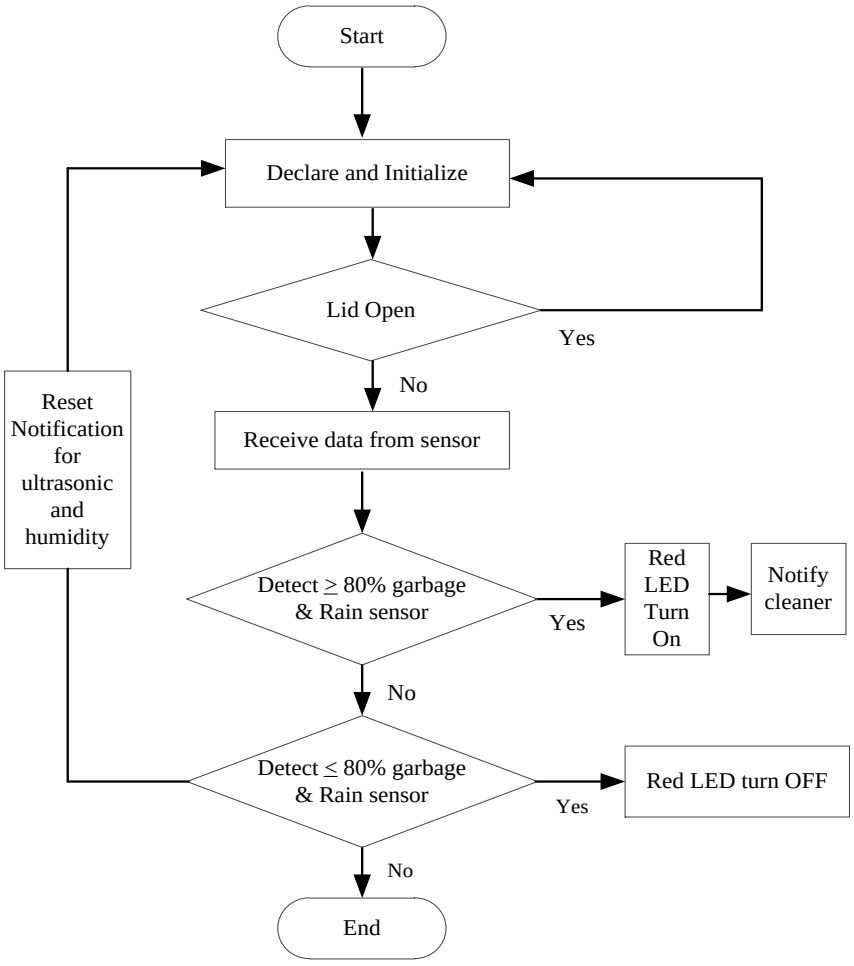

Figure 2. Flowchart of the system

The notification, which is received through Telegram will help an IoT, especially for the cleaner who are working at that time. This will make it simpler for the workers to monitor the garbage. The system offers various advantages for the cleaner workers and efficiency of the system itself. The detection of trash in the dustbin is very accurate since it will directly notify the cleaner workers through Telegram which fully utilizes IoT technology. This system arrangement enhances solid waste management thereby offering innovative technologies for waste management thus promoting environmental care for sustainability of ecosystem and maintaining the natural environment for future generations.

4. RESULT AND DISCUSSION

The components used are ultrasonic and rain sensor, limit switch, NodeMCU with ESP8266 Wi-Fi module and LED. The NodeMCU with ESP8266 Wi-Fi module has 17 general-purpose input/output (GPIO) pins. The ESP8266 module is a very affordable board with a large and rapidly growing adoption rate. Most components operate using a 5 V. The ESP8266 will function as both a microcontroller and a Wi-Fi network, allowing the cleaner workers to get notifications through Telegram. While Figure 3 shows the output or notifications appearing through Telegram after the ultrasonic sensor detects more than 80% of the rubbish in the dustbin. Upon receiving these notifications, cleaners can immediately take action to clear the dustbin, thus making their job more effective and energy saving.

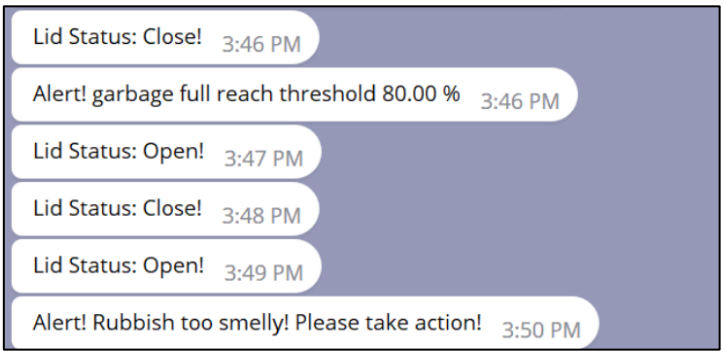

Figure 3. Notification alert from Telegram for garbage monitoring system

Table 2 shows the notifications after the rain sensor has detected the presence of water. If the rain sensor detects the presence of water, it notifies the cleaner that the dustbin is smelly and needs to be cleaned. However, if the rain sensor does not detect water, the cleaners will not receive any notification. While Table 3 shows the notifications according to the percentage detection of the ultrasonic sensor. If the ultrasonic sensor detects more than 80%, the cleaners are notified to clean the dustbin. However, if the ultrasonic sensor detects less than 80%, the cleaners are not notified.

Table 2. Result of the rain sensor of smart garbage monitoring system using IoT

A rain sensor detects the presence of water	Notify the cleaners
Yes	YES ‘Alert! Rubbish too smelly! Please take action!
No	No

Table 3. Result of the ultrasonic sensor of smart garbage monitoring system using IoT

Percentage of the ultrasonic	Notify the cleaners
=>80%	Yes ‘Alert! garbage full reach threshold 80.00%’
=<80%	No

Figure 4 consists show the overall prototype of the system. Figure 4(a) shows the hardware part of garbage monitoring system and Figure 4(b) depicts the prototype of its overall system. This system planned to be applied at higher learning institution’s waste management. Table 4 shows the percentage of the distance detected by the ultrasonic sensor as well as the state of the LED and limit switch. These percentages shown are

based on the distance inside the dustbin in every 100 mm. The dustbins used here are the green colour, 0.8 m height as in Figure 4(b). The LED lights up when the distance is more than 80% upon the lid of the dustbin is closed. If the lid of the dustbin was still open, the ultrasonic sensor does not function to detect the distance inside the dustbin. However, if the ultrasonic sensor detects less than 80%, the cleaners are not notified.

(a) (b)

Figure 4. The overall prototype of the system (a) connection of the system for and (b) prototype of the system garbage monitoring

Table 4. Result of the ultrasonic sensor, LED and limit switch of smart garbage monitoring

Distance (mm)	Percentage detection by ultrasonic (%)	Led (on/off)	Switch (on/off)
800	100	On	On
700	87.5	On	On
600	75.0	Off	On
500	62.5	Off	On
400	50.0	Off	On
300	37.5	Off	On
200	25.0	Off	On
100	12.5	Off	On

5. CONCLUSION

In a nutshell, this smart dustbin idea can be used in busy places like colleges and shopping malls to keep things clean. Now the cleaners do not have to go through the trouble of checking all the dustbin, because this project developed a systematic garbage monitoring system that can monitor the level of the garbage in the dustbins in an effective way. The trips of the rubbish collectors can be planned more efficiently, so that overflowing garbage in the dustbin can be reduced and better public sanitation can be achieved. This system also allows cleaners to schedule their work in monitoring and picking up rubbish from the dustbin using the IoT. This garbage monitoring system is capable of monitoring the level and moisture of the garbage in the dustbin using the advantage of internet. This will surely bring a better and brighter future as it is one of the innovations that advantages people community.

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