

EE297FZ Signals and Systems Integration Project

<<An IoT Garbage Monitoring System For Effective Garbage Management >>

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Declaration

We hereby certify that this material, which we now submit for assessment on the program of study as part of bachelor's qualification, is *entirely* our own work and has not been taken from the work of others - save and to the extent that such work has been cited and acknowledged within the text of our work.

We hereby acknowledge and accept that this thesis may be distributed to future second year students, as an example of the standard expected second year projects.

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Abstract—Nowadays, with the increasing output of municipal waste, the pressure of municipal waste treatment is increasing. The need for an efficient and inexpensive modern waste treatment system to solve municipal waste is increasing day by day. Using low-cost, low-power Internet of Things (IoT) technology to improve urban waste management has become a popular trend. This paper proposes a new type of waste management system for urban communities – Garbage Manager. Garbage Manager aspires to create an energy-efficient and real-time waste detection solution based on the IoT. It assists communities in optimizing waste management and recycling. This project produces IoT a intelligent garbage can. Based on The NODEMCU chip, it uses high-precision ultrasonic sensor to measure the height of garbage in the bucket and transmits the data to the database through A Cloud IoT platform. This project creates web pages, visualize database data, and displays real-time garbage cans. And provide the shortest path to recycle garbage, reduce the journey time.

Index Terms—IoT, ESP8266, Garbage Bin, Simulated Annealing

I. INTRODUCTION

As the world's population continues to grow, the problem of waste disposal is becoming more serious. The world generates 2.01 billion tonnes of municipal solid waste annually. China also generates thousands of waste every year. The Chinese waste production is shown in Figure 1. The world will be surrounded by waste if we don't improve our waste disposal capacity. In recent years, technology ushered in the vigorous development. It is playing an important role in all walks of life. As more and more people begin to apply modern technology to waste disposal. The waste problem has been alleviated to some

extent. Sorting garbage properly is the first step. An IoT-enabled waste disposal system was proposed to recognize the type of waste [1]. The system could guide people to the nearest available container. Safety issues in garbage disposal also need to be addressed. A mathematical model based safety process is designed to ensure the safety of work [2].

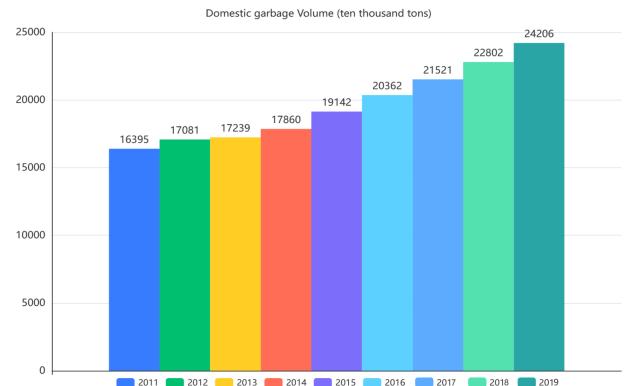


Fig. 1. Domestic garbage volume

Governments have set up a large number of traditional bins in public places, which are scattered all over the place. The garbage collectors can not know the exact situation of each garbage. They can only go to the corresponding location at a fixed time to check in turn. This kind of garbage collection system not only takes up a lot of human resources, but also

causes the problem of garbage not being cleaned in time. So researchers began to design smart garbage can that can display the status of the bins in real time. Garbage collectors can choose to collect the bins that are already full and improve their work efficiency.

This paper constructs a garbage monitoring system called Garbage Manager. The functions of it is shown in Figure 2. Garbage Manager implements LAN interconnection and data upload through WIFI Module. It implements data processing and visualization through Ali Cloud platform, and the dashboard of municipal management systems. Then, Garbage Manager constructs a strong database to store garbage data. It presents the information through a beautifully designed website. Ultimately, this project realizes a IoT-based garbage monitoring system, which can efficiently help workers manage municipal waste and maintain the green environment of the city. The flow char is illustrated in Figure 3.

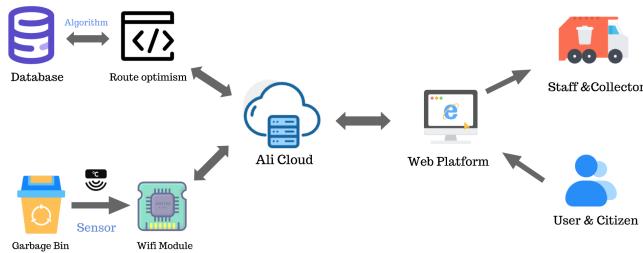


Fig. 2. Functions of the system

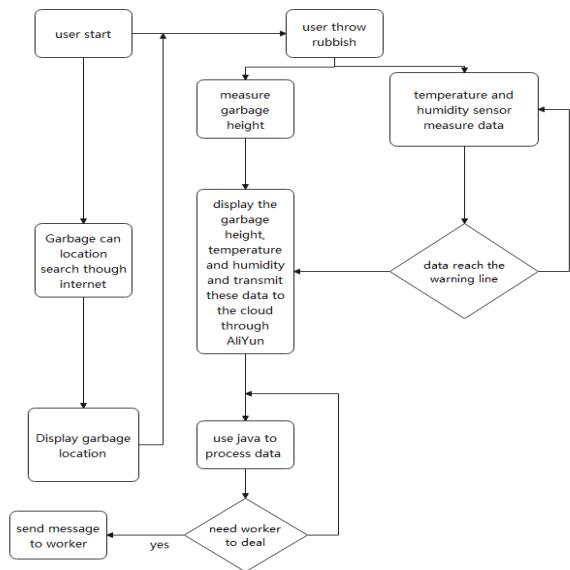


Fig. 3. Flow chart

II. LITERATURE REVIEW

IoT technology has a wide range of applications for waste disposal systems. Eunice et al [3] has analyzed household

waste disposal using smart bins equipped with a variety of sensors. Combining levels of garbage information through the Internet of Things, the study found that household garbage disposal behavior depends on the amount and content of garbage. Mohammad et al [4] informatively adopted machine learning in the application of garbage classification in the Internet of Things. By using machine learning model, garbage is divided into biodegradable and non-biodegradable, reducing labor costs and ensuring the effectiveness and reliability of classification results.

G.Kalyan et al [5] developed an intelligent garbage monitoring and treatment system, and notified the garbage level accumulated in the garbage can to the cleaning personnel for disposal through android mobile application, and provided the shortest path to the position of the garbage can that was almost full. Thus improved the traditional garbage collection system using a large number of manuals, inefficient and tedious operation process. To help the city's sanitation system function better.

Aswin et al [6] design a IoT garbage monitoring system which is powered by solar energy. The system actually reduce the consumption of energy. The system uses Zigbee to implement function like transmitting huge amount of data over the ad-hoc network. The air quality index (AQI) is an indicator of daily air quality report that shows how air quality affects a person's life in a very short time. In order to ensure the safety of garbage bin, Savla et al [7] design a IoT and ML based garbage monitoring system. The system could ensure the protection and safety of people by reducing the risk of fire.

III. DESIGN METHODOLOGY

Traditional trash cans have many problems, such as: unreasonable configuration and low efficiency. Waste disposal is not timely caused by waste overflow, impact on urban construction and people's health and safety and other problems. This project aims to establish an efficient waste disposal system. The components of this system is shown in Figure 3. The IoT system is applied to the construction of smart city to solve various problems existing in urban garbage recycling. Nodemcu is a low-cost open source IoT platform. It initially included firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which was based on the ESP-12 module. Memon [8] and Badve [9] show the excellent application of Nodemcu in the IoT. They use Nodemcu to save a lot of time and achieve a lot of functions. Therefore, the system is also based on Nodemcu chip to implement functions. According to the requirements and verification of Paavan[6], the ultrasonic module HC-SR04 was selected in this paper to measure the height of garbage. The core of HC-SR04 ultrasonic distance module are two ultrasonic sensors. One serves as a transmitter, converting electrical signals into 40 KHz ultrasonic pulses. The receiver listens for the transmitted pulse. If they are received, it generates an output pulse whose width can be used to determine how far the pulse travels. The height of the remaining space in the garbage collection

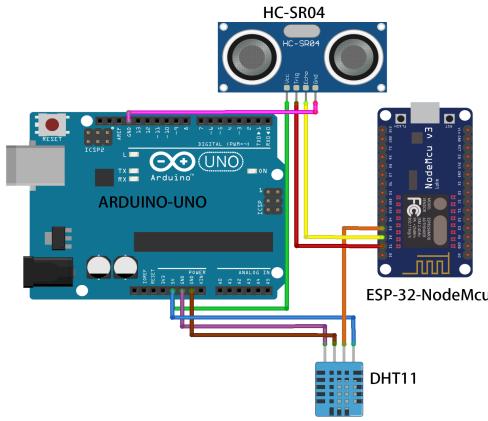


Fig. 4. The component

device is detected by ultrasonic wave. Calculate the current garbage level and send an alert signal to the server when the garbage level reaches the upper limit. Ali Cloud provides cloud computing services to online businesses and Alibaba's own e-commerce ecosystem. It also provides free service to students. This project select is data processing media for project deployment.

In this project, temperature sensors and humidity sensors are used to assist in obtaining other information. This project used DHT11 to measure the temperature and humidity in the trash can. When the temperature reaches the threshold value, it will sent the possible fire risk signal to avoid common waste fire incidents.

The project built a java-web platform in the back end of Ali cloud. After data classification, the project will store the data in the database for subsequent viewing and processing. The garbage level and garbage bin status information obtained from data processing will be reflected on the front-end website. The front-end through JavaScript data visualization and dynamic display, so that enterprises and employees can easily obtain relevant information.



Fig. 5. The web

IV. EXPERIMENT SETTING AND DATA ANALYSIS

In order to verify the effect of this product, we conducted an experiment on the trash cans in the living area of Fuzhou University. There are 6 dormitory buildings in the first living area, and each dormitory building has about 860 people. Each dormitory building is equipped with trash cans (1.5m*0.5m*0.8m), and there are special garbage cleaners. The property in the living area stipulates that no matter how much garbage is in the trash can, garbage collectors must clean up the garbage three times a day. The cleaning time is fixed at 8:00, 14:00, and 19:00. We randomly selected trash cans in three dormitory buildings (#2, #3, #5) for experiments. The device is installed in a transparent box in Figure 6. We fix the box in the center of the trash can cover in Figure 7 to measure the height of the trash in the trash can. We have agreed with the cleaners that when the trash in the bucket exceeds 80% of the height of the trash can, the website will alert the trash cleaners. We recorded the cleaning times and garbage overflow times of each garbage collector before and after the installation of the equipment for comparative analysis.



Fig. 6. Transparent Box



Fig. 7. The Experiment Garbage Bin

After six days of experiment, we obtained the cleaning times and overflow times of three garbage cans as shown in the following Table 1. The overflow times of garbage cans are recorded in Table 2. B in the table represent the garbage before equipping with device. A in the table represent the

garbage after equipping with device. Before equipped with our device, the average number of cleaning garbage bin is 3. After equipped with device, the average number of cleaning garbage bin reduce to 2.28 with a 24.07% drop in Figure 6. The average daily overflow times of garbage cans decreased from 0.67 to 0.11, a decrease of 83.33% in Figure 7. The experiments verify that our product could effectively reduce the burden of cleaning workers.

TABLE I
NUMBER OF GARBAGE BIN CLEANING

	#2 B	#2 A	#3 B	#3 A	#5 B	#5 A
day1	3	2	3	2	3	2
day2	3	2	3	2	3	3
day3	3	3	3	3	3	2
day4	3	2	3	2	3	2
day5	3	3	3	2	3	3
day6	3	2	3	2	3	2
total	18	14	18	13	18	14
average	3	2.33	3	2.17	3	2.33

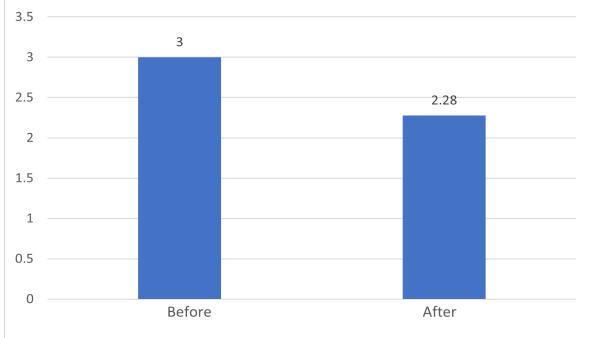


Fig. 8. Average number of cleaning

TABLE II
NUMBER OF OVERFLOW

	#2 B	#2 A	#3 B	#3 A	#5 B	#5 A
day1	1	0	0	0	1	1
day2	0	0	1	0	1	0
day3	1	1	1	0	1	0
day4	1	0	0	0	0	0
day5	1	0	0	0	2	0
day6	0	0	1	0	0	0
total	4	1	3	0	5	1
average	0.67	0.17	0.5	0	0.83	0.17

V. CONCLUSION AND FUTURE WORK

At present, the development of smart trash cans on the market is not good, the reasons are very complicated. They are expensive and poor areas cannot purchase them on a large scale. The threshold of use is high and the cleaners will not use it correctly. Installation is not convenient, it takes a lot of manpower to install and maintain garbage cans. Weak scalability and high difficulty in adding new sensors. Compared with the smart garbage cans on the market at

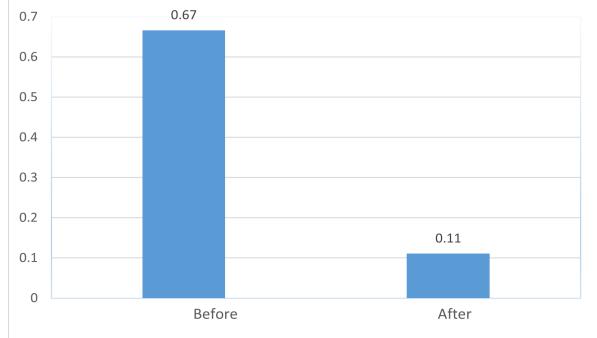


Fig. 9. Average number of overflow

present, the waste supervision system designed by this project solves the above problems well.

This project combined Nodemcu, Arduino Uno, HCR, DHT11, Ali cloud to implement a garbage bin monitoring system. The system can monitor the height, temperature and humidity of garbage in real time. Information from multiple garbage bins is integrated into the database through Ali Cloud. It is then displayed on a self-designed website through visual graphics. Garbage cleaners can check the status of the trash can through the website and clean up the garbage immediately. There are many advantages that other garbage bins don't have. High measurement accuracy: garbage height measurement error is $\pm 3\text{mm}$; temperature error is $\pm 2^\circ\text{C}$; humidity error is $\pm 5\%\text{RH}$. Cost-effective: cost-effective for \$30 to build the entire system, suitable for large-scale layouts. Data visualization: spam information through the graphic display on the website, easier to obtain information. The system has a high robustness, the system can automatically measure the initial height of the trash can, so it is suitable for a variety of sizes of trash cans. Multiple garbage bins can form a network of trash cans that reflect the garbage situation in an area.

The system will be further upgraded in the future. Higher levels of integration allow for smaller devices and more diverse mounting positions. The system will combine simulated annealing and shortest path algorithms, and the website will directly provide the shortest path to collect multiple trash cans, saving time. Developed a collection mobile platform so that mobile phones can directly display trash can information.

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