

Multi-functional Weighing Intelligent Waste Bin System Based on Internet of Things

Qiang Song*, Liancheng Xian, Jianyi Zheng, Hao Chen

School of Computer Science and Software, Zhaoqing University, Zhaoqing, 526061, China

**Corresponding author*

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Abstract: Garbage classification is one of the important national policies, but the front-end recycling of garbage classification is very difficult, a large part of the reason is that the municipality cannot afford the cost of sorting transfer and post-treatment. In this paper, a multifunctional weighing intelligent garbage bin system based on internet of things technology is designed. The system integrates functions such as automatic weighing, automatic opening and closing of lids, intelligent voice interaction, garbage bin overflow monitoring and early warning, fire warning and remote control; The Blinker platform APP can be used to easily understand the real-time status of each waste can, receive early warning messages and issue remote control commands. The intelligent dustbin system has the advantages of simple structure, low cost, intelligence, convenient use, etc., which finds a feasible solution to achieve refined management of urban waste, further promote garbage classification and improve the appearance of urban streets.

1. Introduction

In the context of carbon neutrality, the green lifestyle of energy saving and emission reduction has become a new fashion. Garbage classification is a new fashion, the green, low cost and efficient household garbage classification and transportation system has become a new development goal, garbage classification is an important link in the field of garbage management, it has very important social significance and application value. Firstly, garbage classification helps to reduce the workload of recycling garbage, improve the utilization value of garbage, reduce the construction and operation costs of landfill, further reduce the degree of land occupation and environmental pollution caused by garbage, and achieve the purpose of protecting natural resources and improving the urban environment. Garbage classification can effectively reduce the harm of garbage to the environment and protect environmental health. With garbage sorting, recyclables waste, hazardous garbage and other garbage can be separately disposed, effectively reducing the pollution of garbage to the environment. Garbage classification helps to improve the utilization rate of resources. For example, recyclables can be reused and degradable garbage can be used for the development of biomass energy, thus reducing the waste of resources. Waste sorting can also boost the development of the waste treatment industry, creating more jobs for recycling and promoting economic development. At the same time, garbage classification also helps to improve citizens' quality, cultivate good environmental awareness, promote social harmony and build a green society.

However, the front-end recycling of garbage classification is very difficult. After garbage classification, the demand for transport equipments and staff increase, the management becomes more complicated, the transport efficiency decreases, and the transport cost will be doubled, resulting in great financial pressure on the government [1].

Therefore, garbage sorting and transfer need more refined, more scientific management, and smart dumpster is just to serve this purpose. Intelligent dustbin is equipped with intelligent Internet of Things electronic scales at the bottom of each dustbin. Through the Internet of Things technology, data such as weight of each point and all kinds of garbage can be obtained remotely and uploaded to the cloud, which provides the data basis for the classification and transport scheme with the shortest calculation path, the highest efficiency and the lowest cost. Garbage classification requires the participation of the whole people, and the operation steps of residents after classification are relatively complicated. Therefore, we redesign the structure of traditional garbage classification bins, combine intelligent technology, and give intelligent garbage bins automatic control, overflow monitoring and voice interaction functions, so that garbage classification becomes simple and convenient. At the same time, scientific and technological elements can also increase residents' attention to garbage classification. Play a role in publicity and education [2].

At present, garbage weighing mostly adopts metering and charging policies or rough statistical services, which are generally post-compression garbage truck weighing [3] or weightbridge weighing. This method is often inaccurate in measurement, and the data is not detailed. However, the scheme we adopt is to deploy the weighing system under the garbage bin of each garbage collection point to obtain the garbage production of various points in real time. In the later stage, it can be used as the data basis for the statistics of regional garbage production and the optimal transport plan. In recent years, garbage classification and placement tend to be intelligent [4], and a variety of intelligent garbage bins have appeared in the market, integrating automatic control, garbage identification, remote management and so on. For example, Faisal [5] proposed a waste management method combined with the internet of things to introduce the innovative function of advertising into the waste collection and management process. Folianto [6] designed a new trash bin system using wireless mesh networks and duty ratio technology. Kaleem [7] uses deep learning technology to design an intelligent waste management system that can divide waste into organic waste and recyclable waste. Renchao [8] proposed an intelligent environmental garbage can controlled by STC89C52 microcontroller, which can classify and transport metals and non-metals.

On the basis of the existing technology, the system optimizes the structure and function of the intelligent dustbin, and strives to make the intelligent dustbin more practical and cheaper in practical application.

2. System Functions and Hardware Components

2.1. Overall Framework

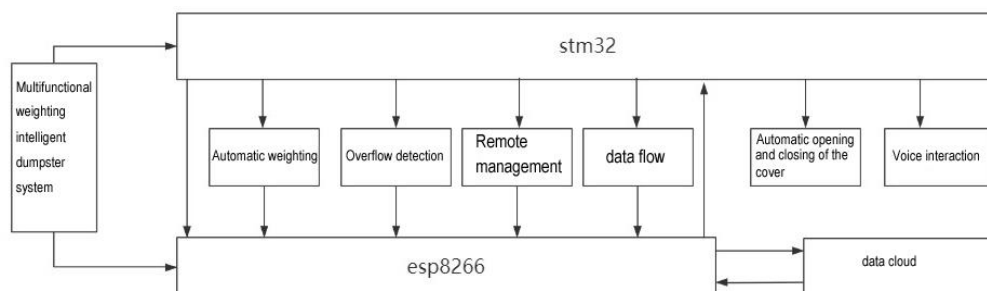


Figure 1: Functional module diagram of multifunctional weighing bin system

The intelligent dustbin realizes automatic weighing, overflow monitoring, automatic opening and closing of cover, voice interaction, data cloud and remote management through single-chip microcomputer, sensor and Internet of things module. The main control model adopts stm32 and connects to the network with esp8266 module. The structure diagram is shown in Figure 1.

2.2. Automatic Weighing Function

The weighing function of the system adopts high-precision strain type pressure sensor and 24-bit A/D converter module HX711. The system has dynamic weighing and cumulative weighing functions, and the maximum mass range can reach 70kg, fully meeting the needs of community garbage weighing. The weight data of each point and all kinds of garbage will be automatically obtained, and the data will be uploaded to the cloud storage through the network connection of esp8266 to provide data basis for later data analysis. The garbage statistics and application system based on big data can be used to explore the information value contained in garbage [9], such as: It can more accurately count the amount of all kinds of garbage, so as to provide scientific basis for the community garbage classification and recycling work. By monitoring the weight of garbage, we can also determine the frequency and law of different kinds of garbage, so as to make a garbage classification and recycling plan more in line with the actual situation.

By using the management mode of data upload into the cloud, system administrators can view the monitored data anytime and anywhere, which provides convenience for daily work.

In addition, the data analysis system can be used to find the relationship among the amount of garbage production and type of community population, economic level, lifestyle and other factors, which is conducive to community management and sustainable development.

In this way, garbage collected by community residents can also generate data, which can be used to improve the cleanliness of the community environment and plan community environmental improvement projects.

2.3. Overflow Monitoring Function

Based on all kinds of garbages are solid or solid-liquid mixtures, the dustbin cover is equipped with ultrasonic sensor HY-SRF05, which can judge the distance between the garbage surface and the dustbin cover. When the distance is less than the set value, indicating that the dustbin capacity is exhausted, it will immediately send wechat notification or SMS notification to the management, remind the management personnel to deal with it in time, and even stop the dustbin work, this can effectively prevent excessive accumulation of dustbins, avoid garbage overflow, keep the environment clean and tidy. In addition, this method can also help managers to determine the time of garbage emptying, better arrange the time and frequency of garbage disposal, and improve work efficiency.

In addition, this function can help city management department to better plan for garbage collection and disposal. By monitoring the use of garbage bins, they can determine which areas are producing more garbage, so as to increase the allocation of garbage collection trucks in advance and improve the collection efficiency. At the same time, waste treatment plants can be adjusted based on monitoring data to ensure adequate waste disposal capacity.

This method will also help the government to better understand the use of rubbish bins, effectively prevent rubbish bin abuse, such as unreasonable waste accumulation and misuse of rubbish bins, and provide statistical data to evaluate the effectiveness of waste management and environmental protection programmes.

2.4. Function of Automatic Opening and Closing Cover

Dustbin base bracket is also equipped with ultrasonic detection, real-time monitoring whether someone puts garbage inside, dustbin opening and closing cover device adopts mechanical transmission structure, when the ultrasonic monitoring to someone, sends a signal to the single chip microcomputer, the single chip microcomputer drives the motor to work, the motor drives the connecting rod to realize the open cover action, after the people leaves, the driving motor stops working, and the dustbin top cover is driven by the spring automatically. The function of automatic opening and closing cover realizes opening the cover when people arrives, and cover closing after people leaves, compared with the traditional manual switch cover, this can be well isolated odor, and avoid cross pollution when people throwing garbage.

In addition, this kind of garbage bins with automatic opening and closing cover can also improve the efficiency of garbage collection. Since the cover opens automatically, the operator does not need to open the lid to drop the trash by himself, saving time and reducing the wait time for the trash dumping. Also, since the lid closes automatically, it prevents litter from falling around.

The self-opening and self-closing cover can also improve the sanitation of garbage collection. Since the lid of the trash can is automatically closed, it can prevent the garbage in the trash can from oozing odor, and prevent the garbage from being affected by the external environment, which can ensure the sanitation of garbage collection.

2.5. Voice Interaction Function

Intelligent voice interaction uses Tianwen ASRPRO-01 module to achieve accurate speech recognition and instant interaction. The voice interaction module can identify the voice content, match and analyze the voice content, and give feedback to the main control chip and respond to the interacting side after combining the garbage types. Voice interaction is divided into voice prompt, voice question and answer. Before opening the dustbin lid, there will be corresponding prompt tone to remind the residents to put in according to the classification. For example, when detecting someone in front of the dustbin, there will be similar voice prompt like "This is the kitchen waste bin, please put inside according to the classification", and then the dustbin lid is open. Before placing, the smart bin can be asked questions, such as "What kind of waste is a plastic bottle?" The smart bin will answer "plastic bottle is recyclable" and other relevant voice, then the recycling bin will automatically open.

Voice interaction allows users to operate more easily, without using manual operation or other complex operations, can easily complete the task. It can improve the interactive experience and make users feel more natural and comfortable. Intelligent speech recognition technology can improve the accuracy of speech interaction and reduce misoperation. The use of voice interaction function is helpful to improve users' understanding of garbage classification knowledge, improve users' attention to garbage classification, and enhance users' awareness of responsibility.

2.6. Cloud and Remote Management of Data

The data cloud is the foundation of later data processing. Based on the esp8266 network connection, the device is connected to the cloud through OneNET, the internet of things cloud platform of China Mobile, the weighing data is uploaded to the cloud for storage, and the remote control and monitoring of the device status are realized through the Blinker platform. The managers of the community can check the real-time capacity of the garbage bin and the number of the day's delivery through the mobile terminal, and can view the historical data, but also remote-control lighting system switch or set timing switch. The details are shown in Figure 2.

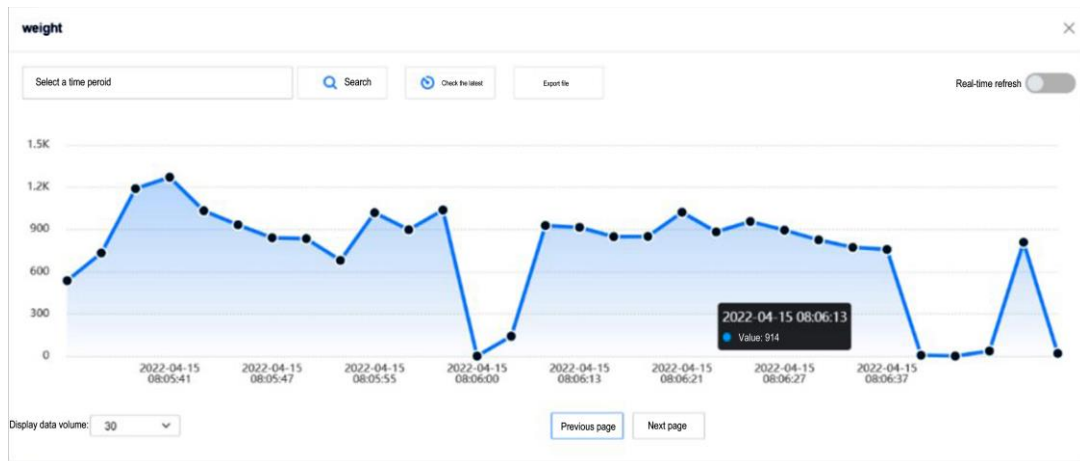


Figure 2: Variation curve of garbage weight

By uploading data to the cloud, the management terminal can view and analyze data at any place at any time, improving the accessibility and availability of data. Remote control and monitoring can save the cost of manual monitoring and maintenance. Management personnel can also check the capacity and number of delivering through the mobile terminal in real time, the garbage bins can be cleaned and maintained according to the actual situation to improve work efficiency. The personnels can view the historical data, analyze the use of the dustbin, for the future planning and adjustment to provide a strong reference. On the other hand, they can remotely control the lighting system switch or set the timing switch to effectively save energy and emission reduction.

3. System Software Design

3.1. Program Design of Automatic Weighing Function

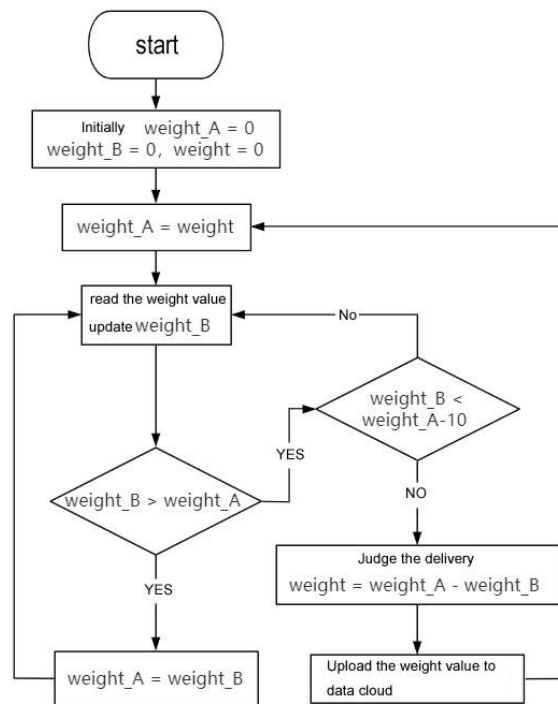


Figure 3: Flow chart of automatic weighing function

Automatic weighing uses a high-precision strain type pressure sensor and a 24-bit A/D converter module HX711 to collect weight data. It is designed that the initial weight data weight_A is zero and the current weight is weight_B. If weight_B was set bigger than weight_A, then weight_A is set equal to weight_B. When weight_B was suddenly smaller than weight_A-10, it was judged that garbage was transported. The weight of transferred garbage was recorded as weight = weight_A - weight_B, and the weigh data was reported to the cloud. The specific process is shown in Figure 3.

3.2. Program Design of Automatic Opening and Closing Cover and Overflow Monitoring Functions

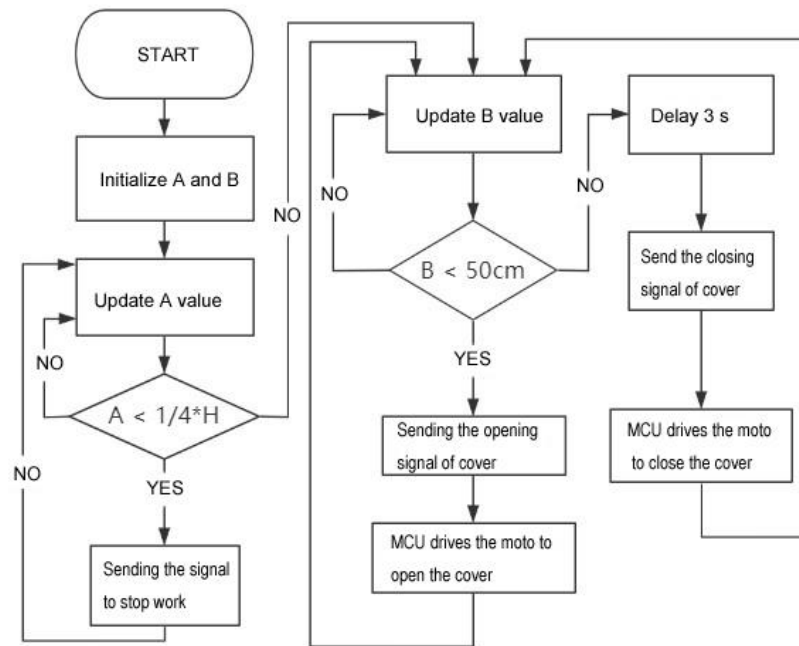


Figure 4: Overflow monitoring function

Each bin is fitted with two HY-SRF05 ultrasonic sensors A and B, A determines the capacity of the bin and B determines whether someone is putting out waste. When the distance detected by A is less than a quarter of the height of H (dustbin height), it is judged that the dustbin capacity is used up. The module sends a signal to stop working to the MCU, and sends the overflowing information to the management terminal through the network. If the distance detected by B is less than 50cm, the module sends the cover opening signal to the MCU, which drives the motor to open the cover. When B returns to more than 50cm, the delay time is 3 seconds, and the driving motor stops working. The specific process is shown in Figure 4.

3.3. Program Design of Data Cloud and Remote Management

MQTT message queue telemetry transmission protocol is adopted in the cloud for data uploading. Esp8266 is connected to the wireless network. Through mqtt protocol, the data is uploaded to OneNET [10], the cloud platform of China Mobile internet of things, so that the weighing data can be viewed and saved. Remote control and management of smart bins is conducted through Blinker. Community managers can check the real-time capacity of garbage bins and the number of times of the delivery through the mobile phone terminal, view the historical data, and remotely control the lighting system switch or set the timing switch. The specific process is shown in Figure 5.

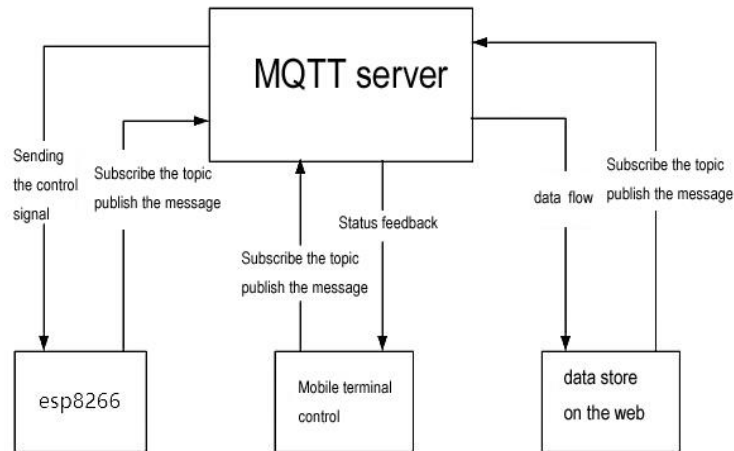


Figure 5: Remote management flow chart

4. Conclusion

Garbage classification is an important part of national environmental protection and resource management, which can effectively relieve the pressure of urban garbage disposal. With the increase of urban population and the improvement of living standards, the amount of urban garbage is also increasing. By sorting rubbish, recyclable rubbish and hazardous rubbish can be disposed separately, reducing pollution to groundwater and soil and easing the pressure on urban waste disposal. Garbage classification can effectively save resources, recycle recyclables, reduce the demand for new resources and the impact on the environment. Garbage sorting helps boost the economy. Garbage classification can promote the development of circular economy, improve the efficiency of resource utilization and bring economic benefits. In addition, garbage sorting can also help raise the awareness of environmental protection among the people. By participating in garbage classification, all people can better understand how to protect the environment, be responsible for their own behavior, and improve the awareness of environmental protection of all people.

The development of multifunctional weighing intelligent dumpster system provides more management means for garbage classification, such as intelligent scheduling according to the real-time weight data of dumpster, which makes the collection and transportation efficiency higher; According to the use of rubbish bins, intelligent deployment makes the distribution of rubbish bins more reasonable. According to the real-time data of the garbage, intelligent monitoring can avoid the occurrence of overflow phenomenon, so as to better protect the living environment of residents; According to the use of rubbish bins, intelligent analysis can be carried out to better understand the residents' living habits and environmental awareness, so as to better educate and promote the green and environmental lifestyle. The development of multifunctional weighing intelligent garbage bin system provides technical support for a green and environmentally friendly lifestyle, but also provides more management means for the government, so that garbage classification becomes more convenient, efficient and safe.

At present, smart garbage bins are still not widely used, mainly because of the high cost, which is generally only available in government-mandated garbage sorting demonstration communities. Multifunctional weighing intelligent garbage bin system applies automation technology, sensor technology, and internet of things technology to realize automatic opening cover, overflow

monitoring, voice interaction and remote management, etc. The technical solution has low production cost and high stability, and can be extended to every residential district, school, park, and even the family in the future.

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References

- [1] Chengyi L. *Research on Marketization Reform and Government Regulation of Municipal Waste Treatment Industry*. Dalian: Dongbei University of Finance and Economics, 2014.
- [2] Yiyi D. Information "black technology" helps efficient implementation of garbage classification. *Shanghai Information Technology*, 2019(08):34-37.
- [3] Xi L, Hui S., Mengyuan M. *Research on Weighing System of post-compression garbage Truck*. *Southern Agricultural Machinery*, 2020, 51(07):100-102.
- [4] Ming Z., Yuyan H. *Research on intelligent classification of household waste*. *Digital Design*, 2017, 6(04):184-187.
- [5] Faisal T, Awawdeh M, Bashir A. *Design and development of intelligent waste bin system with advertisement solution*. *Bulletin of Electrical Engineering and Informatics*, 2021, 10(2):940-949.
- [6] Folianto F, Yong S L, Yeow W L. *Smartbin: Smart waste management system// 2015 IEEE tenth international conference on intelligent sensors, sensor networks and information processing (ISSNIP)*. IEEE, 2015.
- [7] Kaleem M B, Ahmad G, Khan B S, et al. *IoT based intelligent waste management system (IIWMS) empowered with convolutional neural network// 2nd international conference on computer science and allied technologies (ICCSAT-2019)*. 2019.
- [8] Renchao Z., Xiaolan C., Fangtian F. *Design of Intelligent Environmental Garbage Can based on MCU Control*. *Electronic Testing*, 2019(15):4.
- [9] Yongsheng P., Wanqiang L., Guanghui Y. *Waste statistics and application system based on Big Data*. *Internet of Things Technology*, 2016, 6(09):56-57.
- [10] Xiaozhong X, Xiangguang C. *Application of MQTT Protocol in OneNET Internet of Things*. *Woodworking Machine Tool*, 2021(02):10-13.