

The Intelligent Trash Can Design Using the Internet of Things Technology

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Abstract

With the development of the society, much attention has been paid to garbage disposal problems for public trash efficient management and timely recycling, solving the existing trash odor problems such as cleaning, this paper is based on the Internet of things technology and WeChat small program design an intelligent trash can detection equipment, cleaning personnel can according to WeChat small program query to the capacity of the corresponding trash can and location, facilitate timely cleaning, also increase the trash sterilization, automatic cover and automatic classification function, using special structure to reduce the smell of public trash can, provide people with better community environment, and design cartridge, battery box and fan barrel body. The active carbon package is placed between the hollow sealing cover and the identification area, and the adsorption of the gas molecules is used to realize the air purification inside the trash can. The double-layer garbage bag is used to reduce the drainage of wet garbage. The inner layer of the double-layer garbage bag is a fine mesh, and the outer layer is an ordinary garbage bag with piston at the bottom. When recycling, the management personnel only needs to recycle the inner garbage bag, open the piston to discharge the sewage accumulated from the outer garbage bag, and can recycle the wet garbage.

Keywords

Intelligent trash can; Automatic control; Environmental protection.

1. INTRODUCTION

The disposal problem of garbage has become a global problem. With the maturity of artificial intelligence technology and the improvement of people's living standards, people are also increasingly pursuing an intelligent life. Smart home and smart city are developing rapidly, and trash cans, as one of the indispensable tools in life, have not been rapidly improved with the development of smart city. Many public places still use traditional large trash cans. Traditional trash cans are placed in the open air. If they are not cleaned in time after filling, they are easy to emit peculiar smell and breed bacteria, and even pollute the environment. At present, the intelligent trash cans on the market, such as automatic flip trash can, kick touch induction trash can, automatic full trash can, they have single function, expensive, and small scope of application, most of them are only satisfied with the home. In addition, cleaning personnel always face many problems such as dirty and messy when recycling public garbage cans. The problems caused by broken garbage bags and misclassification bring great obstacles to the work. In view of the above problems, this paper designs a public garbage can based on intelligent management.

Secondly, the design survey was carried out, and SPSS software was used to analyze the data results. Finally, the design scheme of public trash can with user needs as the entry point was summarized.

Table 1. Analysis of the multiple responses

	respond		
	project	yes	no
Whether the number of trash cans is sufficient	85	61.18%	38.82%
Whether the cleaning is timely	85	77.65%	22.35%
Whether the trash can should be intelligent	85	94.12%	5.89%
Whether the trash can smells bad	85	58.82%	41.18%
Need a deodorant trash can	85	81.18%	18.82%
Familiar with garbage classification	85	50.59%	49.41%
total	510		

2. DESIGN SCHEME

This design mainly has the functions of positioning, automatic cover opening, automatic sorting, and judging whether the trash can is full. The micro-controller interacts the number, status and other information of the trash can with the server through the ESP8266 module. Then, the WeChat mini-program obtains the data of the server and displays the status information on the user end. The sanitation department can know the status of the garbage can by visiting the WeChat mini-program.

System hardware mainly Arduino chip as the main control, 1 trash divided into four parts, respectively for recycling bin, kitchen waste, non-recycling bin, harmful trash, is equipped with a steering module, four capacity detection module, four ultraviolet disinfection module, LCD display touch module, automatic open module, automatic classification module and power supply module, the trash can use a steering module, each part use a capacity detection module and ultraviolet disinfection module. The steering gear module is responsible for controlling the opening and closing of the trash can lid, the capacity detection module is responsible for the real-time detection of the capacity of the garbage in the bucket, and the ultraviolet disinfection module is responsible for sterilizing the environment in the trash can. The whole system is supplied by the solar charging module and power supply module.

The system takes the single chip microprocessor as the main control chip, combined with the human infrared sensor and mechanical electronic drive system to realize the automatic opening of the trash can lid. Use the built-in temperature sensor and the ultrasonic module on the bucket cover to detect the status of the trash can. The communication module regularly uploads the status information of the trash can to the server, and the module displays the temperature and internal space in the trash can. Users can view the status information of the trash can through the wechat applet. When the voltage of the lithium battery built in the smart trash can is insufficient, the solar panels will automatically charge the lithium battery to meet the electricity demand of the trash can. Write deep learning neural network, mainly through embedding Raspberry PI recognition: using Raspberry PI as the main controller, using related models and image algorithms to judge the type of garbage in the image.

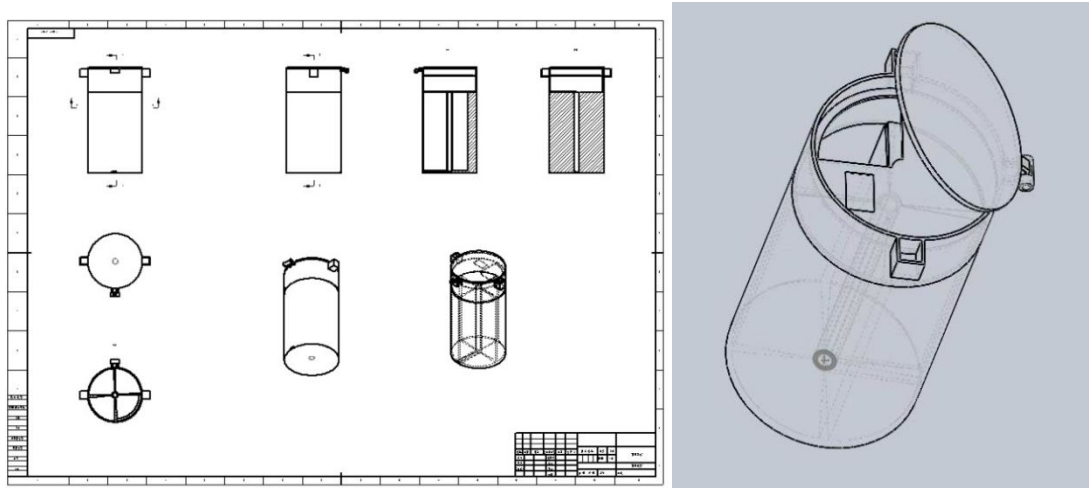


Figure 1. Phase analysis of arrangement

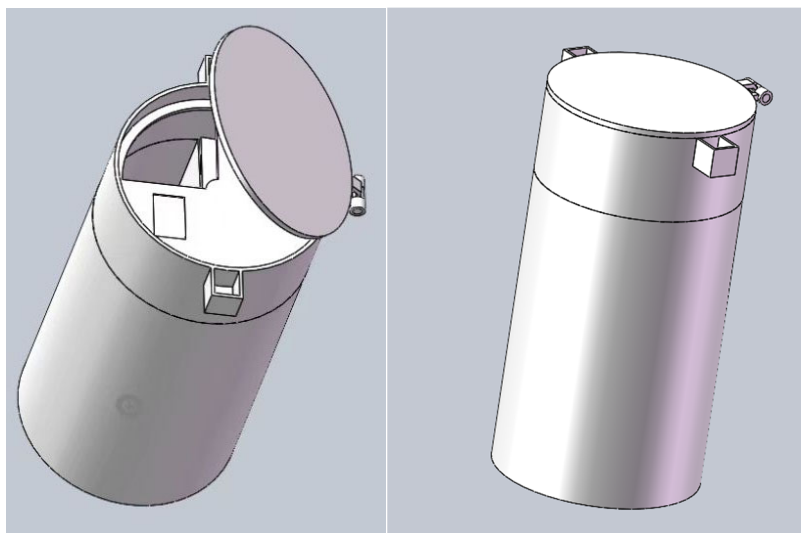


Figure 2. The trash can model

3. HARDWARE DESIGN

3.1. Automatic Open-cover Module

The structural design of this module is mainly to connect the structure of the rudder machine and the top cover of the intelligent trash can and the back board. Among them, the need to use the rudder engine attached swing arm. First, component 1 (Figure 3) is a part that connects the steering gear to the top cover of the smart trash can, and component 2 (Figure 4) is a part that connects the steering gear to the back plate of the smart trash can.

The intelligent trash can senses the action of people through the ultrasonic range measuring module, and inputs digital signal (1 or 0) to the Arduino development board when the signal is "0"; and when the signal is "1", it is judged as "someone is throwing away garbage" through the program written in the MCU. At this time, the "countermeasure" given is to output the analog signal to the steering machine, make the steering machine open the lid of the trash can at a certain Angle, and the trash can automatically close the lid after walking. The hardware list is shown in Table 2. In this process, pedestrians do not need to touch the trash can, effectively avoiding bacterial infection.

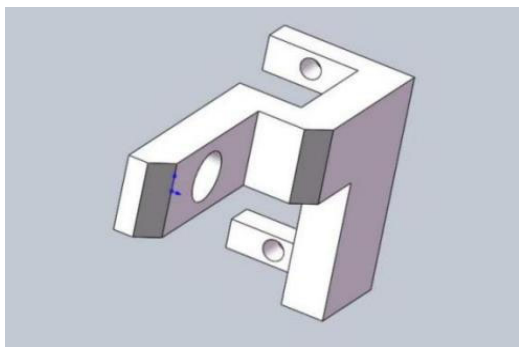


Figure 3. Component 1

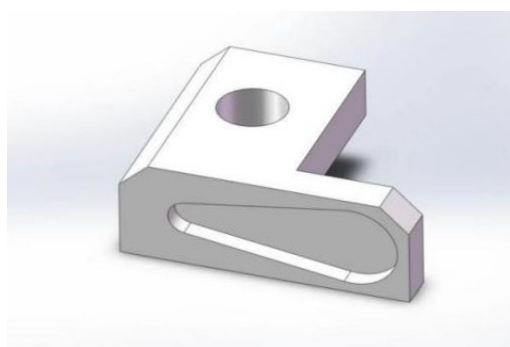


Figure 4. Component 2

Table 1. Hardware list of the automatic uncapping module

classification	Hardware model	Number
steering engine	SG90	1
Ultrasonic wave ranging and measuring module	The HC-SR 04 ultrasonic sensor	1

3.2. Power Supply Module

The photovoltaic module power supply system is mainly composed of solar panels, controllers and storage batteries. Solar panels are placed on the top of the trash can cover. Considering the difference in the distribution of solar energy resources in China, in order to improve the working efficiency of the solar panels, the damped rotating shaft is used as the connection between the solar panels and the trash can, and the tilt Angle of the solar panels can be adjusted to achieve the best local sunshine Angle.

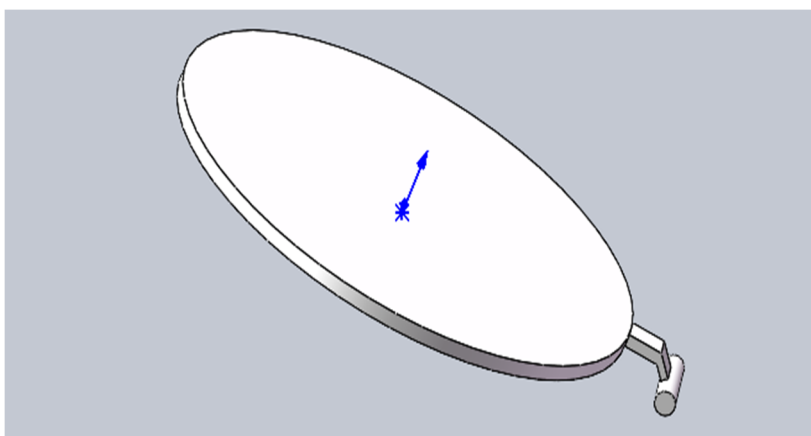


Figure 5. Cover of the trash can

The solar panel used is a 40W single crystal solar panel of 540mm × 540mm. Under the standard test conditions (radiation intensity is 1kW/m², module temperature is 25°C, atmospheric mass AM 1.5), the operating voltage is about 17.5V and the working current is about 2.29A. Using four sections of standard capacity of 3400mAh Panasonic 18650 rechargeable lithium battery. The working performance of the control device element is shown in Table 3.

Table 3. Operating voltage and current of the original control device

element	working current /mA	working voltage /V
esp8266 WIFI The module	80	3.3
Relay module	>5	5
pressure pickup	1.7	2.6~5.5
stepping motor	0.75	12
HD camera	40	5
GPS module	<25	3.3
Oled display screen	15	3.3
Stm32f407	36	3.3
LED tape lights	583	12
Hc-sr501	<0.05	5

3.3. Automatic Garbage Classification Module

The garbage identification device is mainly composed of camera module, single-chip micro-controller module and remote background management system. The camera module is placed in the fan recognition cylinder for obtaining junk images, which is transmitted to the background administrator system through the ATK-ESP8266 WIFI module. The LED light belt on the inner wall complements the light intensity of the camera and controls the relay to effectively reduce the energy consumption of the LED light belt; the background management system recognizes and classifies the images through the neural network model trained by Baidu AI EasyDL platform, and the classification results pass ATK-ESP8266 W

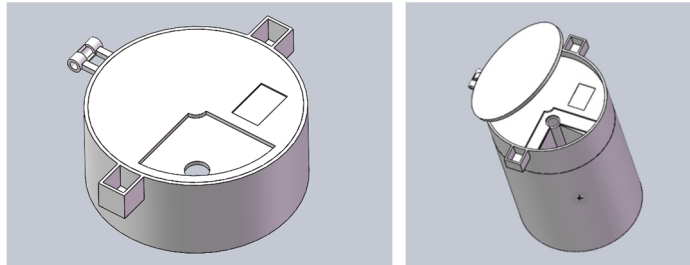


Figure 6. Automatic classification of partial mechanical structures

When the pedestrian walks into the pre set threshold range, the pyroelectric sensor responds and sends a signal to the MCU. After the MCU receives the signal, triggering the stepper motor operation, and makes the upper bucket cover of the automatic classification part rotate and open to the side. When the pedestrian is away, the pyroelectric sensor and the stepping motor close the upper bucket lid of the response control automatic classification module.

3.4. Capacity Detection Module

The capacity detection function is used to detect the height of the garbage in the trash can. When the height of the garbage reaches a certain degree, the warning light on the trash can will be lit to remind users not to throw garbage, and also remind the cleaning personnel to clean the garbage in the bucket or replace the garbage bag in time. Capacity detection uses ultrasonic ranging to measure the distance between the bucket cover and the garbage. By embedding the ultrasonic module on the lid of the trash can, the ultrasonic signal can be transmitted vertically into the bucket. When the measurement distance is less than the set value, it means that the garbage is full and the garbage bag needs to be replaced.

When the garbage contained in the trash can reaches 80%, the SU receives the sensor signal and feeds back to the background management system to inform the managers to clean up in

time; when the trash can is full and no management processing, it can temporarily stop operation and display relevant prompt information on the display screen to prompt pedestrians to use other nearby trash can.

3.5. UV Disinfection Module

Ultraviolet sterilization lamp through ultraviolet irradiation, destroy the DNA structure of microorganisms, so that the bacteria immediately die or can not reproduce, so as to achieve the purpose of sterilization.

Specific implementation plan: the control circuit connects the rotating motor; the rotating motor and the rotating disk are directly connected with the ultraviolet lamp holder. When the rotating motor is electric, the rotating motor drives the rotation and rotation, so that the ultraviolet lamp holder can rotate 360, and the ultraviolet can be installed on the upper fixed plate to disinfect the garbage below.

3.6. Display The Touch Function

It is mainly realized by LCD LCD touch screen. As the interface of human-computer interaction, it mainly designs the functions of opening and closing trash can cover and query of garbage type. The displayed picture is 800 * 480ppi pixel and is stored in BMP format. When the image in BMP format is stored in data, the image is scanned from left to right and from top to bottom. Screen touch for capacitive touch, when the user touch the screen, the system for its coordinates and stored in a defined structure variable, when detected the user let go, read touch the coordinate value, when the coordinate value set the coordinates of the button position within the range, then realize the corresponding functions, such as page jump, play audio, etc.

4. SYSTEM STRUCTURE

4.1. Positioning

This design adopts ATGM332D Beidou and GPS dual-mode positioning module, which has the advantages of low cost and small size. Through the output data of the module can obtain the basic information of Beijing time, longitude, latitude, altitude, speed and heading, and also obtain the current positioning quality and positioning mode, the number of connected GPS satellites and the number of Beidou system satellites. Figure 5 shows the connection diagram of the positioning module and the SCM pin. When the location is made in an outdoor public place, it takes about 1min to obtain the location data of the trash can, obtain the current latitude and longitude information according to the data frame returned by analysis and upload the latitude and longitude information to the server through the communication module; mark the current location information on the map using the reverse address resolution of the Tencent map.

4.2. Cloud Server-side Design

Collect the data information of the hardware trash can, be responsible for storing the data, and play the role of the data transfer station.

(1) Create products. Select http protocol to transmit data and provide the following functions: store the data points reported by the device, provide API interface to realize device management, provide data push to the application; log in to register China Mobile Internet of Things platform, enter the platform to select the multi-protocol access option of the console to create the product; and add product parameters

(2) Add the equipment. Each product corresponds to multiple devices, through which data flow is set to receive various data from the collection bin. This paper takes an intelligent garbage equipment as an example to illustrate, other garbage equipment setting is the same.

(3) Add the data template. To collect data from the smart garbage collection side, add a data flow template to the creation device. The intelligent garbage monitoring system mainly collects the information of temperature, garbage capacity, temperature alarm times, full overflow alarm times, fault alarm times, position longitude and latitude, and sterilization and disinfection times.

5. ECONOMIC BENEFIT ANALYSIS

The team through field investigation field visits a university community, from garbage classification operating enterprises, community rc departments to obtain related classification data, related data as shown in the following table, according to the due to obtain data, we will be the regional data average processing, get the university living garbage theory component data see the table below:

Table 4. Survey Data of Garbage Classification of a university (2023-2024):

Project	Volume (ton)	Proportion	The proportion of theoretical quality
Kitchen garbage	174.48	48.45%	44.91%
Other garbage	76.89	21.35%	22.73%
Hazardous waste	3.96	1.10%	1.30%
Recyclable	Broke	33.24	9.23%
	Waste plastics	40.84	11.34%
	Old metal	2.95	0.82%
	Waste fabric	15.16	4.21%
	Cullet	12.60	3.50%
Total	360.12	100%	100%

On the one hand, the above treatment method is consistent with the actual situation of garbage classification, and on the other hand, it can also reduce the complexity of the subsequent economic analysis process.

5.1. Cost-benefit Estimation of Garbage Classification and recycling

According to the implementation mode and method of Beijing, the cost of the implementation of smart trash can in the whole university is estimated, and the economic benefits obtained by classification and recovery are analyzed. The cost mainly includes the equipment cost required for the configuration of the garbage sorting box, the processing cost after the garbage sorting, and the personnel cost involved in the operation and management, etc. Due to the little change before and after the classification, the transportation cost is not considered temporarily.

5.1.1 Estimation of Waste Classification Cost

(1) Estimation of the equipment configuration cost

According to the school standard supply and demand configuration of 65 smart garbage cans. According to the cost of the dustbin, the total cost of the dustbin reaches 30,000 yuan. The depreciation life of the garbage sorting box is calculated according to 10 years, then the annual depreciation cost is 10,000 yuan, the depreciation cost and operation management fee of the comprehensive garbage sorting box, and the annual equipment allocation cost is 50,000 yuan, which is recorded as C1.

(2) Estimate of restaurant-kitchen-waste classification and treatment cost

The university costs 200 yuan per ton of kitchen waste. The university produces 174.48 tons of kitchen waste every year, which costs about 35,000 yuan. Based on the investment and

operation costs in the process of kitchen-waste disposal, the annual cost of kitchen-waste classification is 50,000 yuan, which is recorded as C2.

(3) Cost estimation of hazardous waste and other garbage classification and treatment

The cost of waste incineration is 10 yuan / t, and the amount of waste for incineration is about 80t per year, so the annual incineration cost is 800 yuan. Comprehensive incineration treatment cost and equipment depreciation cost, the annual classification and treatment cost of hazardous waste and other garbage is 8,000 yuan, which is recorded as C3.

5.2. Estimation of Garbage Classification Income

The income obtained after garbage classification mainly includes two parts, one is the recycling of recyclable garbage, the other is the reuse of kitchen waste.

5.2.1 Estimation of Income Obtained From Recyclable Waste Classification

According to statistics, the annual recycling amount of garbage reaches 105 tons. The income of recyclable waste is calculated according to the value of about 1000 yuan / t, and the annual income is 105,000 yuan, which is recorded as I1.

5.2.2 Estimation of Income Obtained From Restaurant-kitchen-waste Classification

After the collection of kitchen waste, high temperature aerobic composting technology is adopted to make green organic fertilizer. The yield rate is about 60%. The market price of organic fertilizer is 300 yuan / t, then the income of kitchen waste classification and recycling is 180 yuan / t. According to the above calculation, if the annual production of kitchen waste is 174.48t, then the annual income is 31,406 yuan, about 32,000 yuan, which is recorded as I2.

5.3. Economic Benefit Analysis of Garbage Classification

Garbage classification cost includes equipment allocation cost (C1), kitchen garbage classification cost (C2) and (C3), the total annual cost is 108,000 yuan; garbage classification income includes recyclable garbage classification (I1) and (I2), the total annual income is 137,000 yuan. The final annual economic benefit is calculated according to formula (1), and the result is 29,000 yuan.

$$B = I - C = I_1 + I_2 - C_1 - C_2 - C_3 \quad (1)$$

B is the annual economic benefit, ten thousand yuan; I is the annual total income, ten thousand yuan; C is the annual total cost, ten thousand yuan.

The university produces 360.12 tons of waste per year, and is effectively classified that it can get 29.1% of recyclable waste, 48.45% of restaurant waste, 22.45% of hazardous waste and other waste. After deducting the total cost required in the classification, it can get 29,000 yuan per year, with the main contributor to the benefits of recyclable waste.

5.4. Income From Garbage Classification

5.4.1 Direct economic benefits

(1) Garbage classification and recycling, and make full use of resources

The classification of household garbage can not only take different treatment measures for different garbage, but also the valuable resources can be found in the classification process, so as to recycle the available resources in the garbage to the greatest extent, so as to complete the transformation from garbage to available products.

(2) Improve the living environment and promote people's health

The large amount of waste output makes the environmental and health problems increasingly prominent. Whether the garbage disposal method is reasonable or not is related to the

government's investment in environmental governance. Through garbage classification to reduce garbage stacking, reduce the pollution to the environment, is more conducive to people's health.

(3) Save land resources and improve economic benefits

Implement garbage classification, collect valuable waste, turn waste into treasure, and promote the recycling of resources. At the same time, corresponding laws and regulations will be formulated to enable people to buy waste processors, form a new fashion of consumption, and promote economic growth. From the perspective of comprehensive benefits, carrying out garbage classification and publicity and education is helpful to improving the quality of the people. Garbage classification reflects the level of civilization of a country and reflects the country's concern for people's life. Through the implementation of garbage classification, the implementation of garbage classification into practice, not only reflects people's great importance to environmental construction, but also reflects the quality of people.

5.4.2 Indirect Economic Benefits

While implementing garbage classification, it will not only produce direct economic benefits, but also relieve the pressure of future resources. First, the implementation of garbage classification policy will bring new investment opportunities and guide the capital to pay attention to garbage classification investment. Second, make full use of kitchen waste to produce organic fertilizer and improve the soil structure. Third, carry out garbage classification and recycling, establish a garbage classification and recycling system, rationally use valuable garbage, such as waste paper, and reduce the demand for international resources.

6. INNOVATION POINT

Compared with the traditional trash cans, the main innovations of this work are as follows:

(1) Management and cleaning work can be carried out intuitively and more easily:

Combined with Wechat small program, cloud server and other Internet technologies, relying on data collection and analysis to rationally allocate resources, through a Wechat small program timely feedback capacity and other information so that cleaning personnel timely manage garbage equipment and clean up garbage.

(2) Energy saving and environmental protection with solar panels:

The solar panel with damped rotating shaft, which can adjust the tilt Angle of the solar panel to reach the best local sunshine Angle and improve the power generation efficiency. At the same time, the battery is placed in the hollow shaft of the trash can bracket to ensure the normal and continuous work of the trash can when the sunshine is insufficient.

(3) Use the single-chip microcomputer as the system master control to realize the automatic cover opening function

The external mechanical device and the internal program can automatically open and close the garbage can, and the internal fan trash can is connected with the bracket with a hinge page. After identification, the camera can automatically classify and return through the fan area. When recycling the garbage, the support handle can be pulled to remove the garbage can.

7. CONCLUSION

This smart trash can has automatic open cover, automatic garbage sorting, Capacity detection and other functions, Use solar panels to supply power, energy saving and environmental protection, Cleaning personnel can query the capacity and location of the corresponding trash can according to the wechat small program, It can be used for garbage sorting and recycling, Make full use of the resources, Improving the living environment, Promoting the people's health,

Save land, Improve the economic efficiency, Meanwhile, take a university as an example, Some economic benefits can be obtained by using this trash bin, To relieve the future resource pressure, Therefore, in view of the actual situation of garbage classification in residential areas, office buildings and other occasions, This design can provide effective classification, convenience to use and manpower saving, It has certain promotion and application value.

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