Article

Research on Design of Intelligent Person Finder Classification Trash Can

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Abstract: ***Background:*** Modern life has inclined a lot of people towards laziness. With the presence of several unreasonable requirements there is a growing realization of this issue in the field of design. The smart home product industry has been promoted by continuous technological iteration and rapid development due to the continuous popularity of the "Lazy Economy". ***Purpose:*** The improvement of people's lives and their consumption levels has led to the increasing attention on issues such as green ecological civilization, sustainable development, and rational resource use. Some cities in China have implemented mandatory garbage sorting policies, enhancing residents' environmental awareness and promoting the sustainable development of modern cities. ***Methods:*** This study will focus on designing environmentally-friendly smart homes with sustainable features and creating a smart trash can to improve the efficiency of home cleaning for residents. Conduct a comprehensive study on different smart homes available in the market and carry out innovative designs. ***Results:*** The product's people-finding function changes the conventional practice of having garbage cans positioned in each area of the house, and ultimately provides a more convenient and intelligent solution for household garbage sorting and environmental protection. ***Conclusion*:** The research on the design of smart person finder classified trash can, mainly solves the following issues: 1. To enable the users to locate the trash can using voice commands or mobile phone application when they are unable to physically move or quickly locate the trash can. 2. Improve the efficiency of garbage segragation, so that the trash can can identify and classify different categories of wastes. 3. Reduce the number of trash bins allocated in the home. 4. Integrate an automated sweeping robot at the bottom of the smart trash can to clean while it is in motion. 5. Cultivate users' good waste segration practices that will relieve the burden of community in waste management, and promote sustainable urban development.

Keywords: Lazy economy; Smart home; Home cleaning; Garbage sorting; Sustainable development

1. Introduction

1.1 Research Background

A new industry known as the "Lazy Economy" has emerged, as a result of people's changing lifestyles. Modern life has inclined many people towards laziness, however, the demands that are often unreasonable are being addressed by the gradual development of innovative designs and systems. The Lazy Economy's continued popularity drives the smart home products industry to continuously create technological innovations and cause rapid development, as shown in Figure 1. The vacuum cleaner is the most widely used smart home product in China, with a usage rate of 40.8%. There is a strong correlation between the internet group and the smart home group, and in 2020, the online channel accounted for 86% of the Chinese vacuum cleaner market. The use of smart home products is becoming more and more widespread, so using smart products

to solve various home cleaning problems is the main choice for residents of this era when facing such problems.

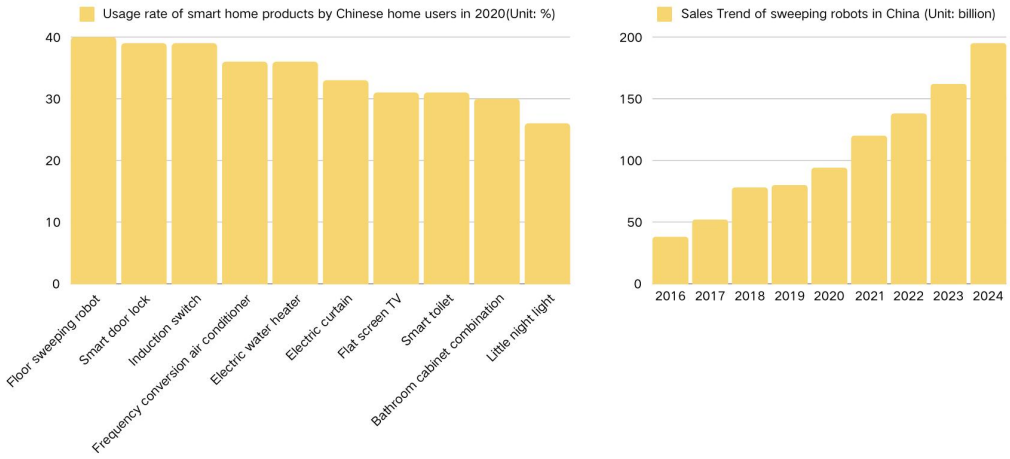

Figure 1: Usage rate of smart home products among Chinese users

Nowadays, as people's lives, material, and consumption levels have improved, there has been a gradually increasing attention on issues such as the construction of green ecological civilization, sustainable development, and the rational use of resources. In 2023, the Ministry of Housing and Urban-Rural Development launched the "Regulations on the Management of Urban Appearance and Environmental Sanitation" and "Measures for the Management of Urban Waste" and other amendments to further refine and improve the legal system of garbage classification. In terms of waste reduction, it is necessary to strengthen the institutional supply, reduce packaging, strengthen the effective connection between the renewable resource recycling system and the waste disposal system, and reduce the pressure on the end treatment facilities. By 2025, residential communities in compulsory classification areas will achieve full coverage of garbage classification, and a system of classification, collection, transportation, and treatment will be basically established. The recycling rate of urban solid waste is projected to exceed 35%, and the utilization rate of resource consumption is expected to reach 60%.

The mandatory garbage sorting policy has strengthened residents' awareness of environmental protection, thus promoting the sustainable development of modern cities. A number of Chinese cities have introduced garbage sorting policies and implemented mandatory garbage sorting measures in urban communities, which require residents to put their garbage into different bins. In order to stimulate the enthusiasm of the masses and the units responsible for domestic garbage removal and transportation, it is necessary to establish smooth supervision and reporting channels. This includes implementing a two-way supervision mechanism that enforces the rule of "no classification, no collection and transportation" and "no classification, no entry, and exit of the community". The aim is to prevent the improper mixing and disposal of domestic garbage. The community is equipped with garbage cans with different colors or signs, the implementation of hazardous garbage, recyclables, kitchen waste, and other garbage four classification standards, in accordance with the red, blue, green, and black four colors, respectively, to identify garbage stations, garbage bin rooms, and other delivery facilities, to help residents correctly put garbage. In recent years, China's garbage classification work has continued to deepen, 297 cities at or above the prefecture level have fully implemented household garbage classification, and the average coverage rate of residential communities has reached 82.5%, and a good atmosphere for everyone to participate in garbage classification is gradually forming. In order to ensure the effective implementation of the garbage sorting policy, some cities supervise and punish the

illegal dumping of garbage, and encourage residents to actively participate in garbage sorting.

Figure 2: Community garbage classification identification

The "Shanghai Municipal Household Waste Management Regulations" officially implemented on July 1, 2019, marks that Shanghai has taken the lead in entering the "compulsory" era of garbage classification. In 2020, 46 key cities such as Beijing and Shanghai will basically build a garbage classification and treatment system, and in 2025, it will be popularized throughout the country. "Garbage classification" not only marks that China's environmental protection has risen to a new height but also represents that hundreds of billions of market spaces have been opened. In 2019, compared with 2018, the national search volume of "classified trash can" increased by 18 times, of which the search volume from Shanghai increased by 134 times. In terms of sales, in late June, the purchase volume of classified garbage cans from the Shanghai area increased by 105.8 times year-on-year, becoming the hottest commodity in the same period. Alibaba data also shows a surge in demand for trash cans: individual users of Taobao and Tmall alone bought 250 million yuan of classified trash cans in June, with Shanghai accounting for one-fifth of purchases. According to these data, with the impact of the garbage classification policy, the awareness of residents across the country for garbage classification, the increase in sales of garbage cans also indicates that smart garbage cans have good market potential, and smart garbage cans will become indispensable products at home in the future. (Sun, 2020)

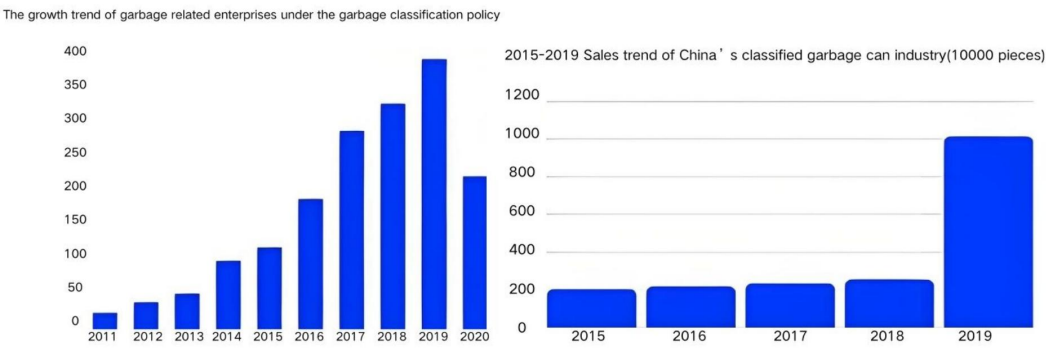

Figure 3: Relevant data on the impact of garbage classification policy on garbage can industry

1.2 Research Purpose

Sustainable design is of great significance to society as a strategic design activity to build and develop sustainable solutions and a design approach that meets the needs of the present without sacrificing the needs of future generations. It focuses on the balance of economic, environmental, moral, and social issues, and pursues the effective use of resources, the protection of the environment, and the healthy development of society. In terms of the sustainable development of urban communities, the Ministry of Housing and Urban-Rural Development said that by the end of 2023, the garbage classification coverage rate of urban residential communities at the prefecture level and above will reach more than 90%, and the garbage classification coverage will be basically achieved by the end of 2025. Local regulations and government rules have been issued in 20 provinces and autonomous regions including Fujian, Hebei, and Shandong, and 173 cities including Shanghai and Guangzhou. Garbage sorting policies in communities encourage people to work together to solve social problems, create a healthy, safe, and comfortable environment, improve people's quality of life, and promote social harmony.

However, this series of mandatory garbage classification policies put a burden on young office workers who are adapting to the "lazy economy", due to the demands in their workplace, they often have no time to focus on things outside the work. In their personal lives, they want simplicity, but in their professional lives, they prioritize aspects such as fitness, beauty, leisure, and other activities. Users pursue relaxation in life outside of work, rely on smart products such as mobile phones for daily activities, and do not want to spend too much time on cleaning, housework, and garbage sorting in their homes. Community household garbage classification may bring some inconveniences to residents. These include: occupying space, requiring more trash cans for classification, difficulties in classifying some garbage, consuming the time of family members, and so on. Adhering to the principles of community garbage classification policy, finding ways to save time and cost, and improving efficiency can also effectively improve the quality of life. Reducing the number of garbage cans at home saves space and guides family members to adopt and abide by the habit of garbage classification through smart products for sustainable cleaning at home, which will eventually achieve a relatively efficient, sustainable, and productive life in a good ecological environment.

1.3 Research Content

According to the analysis of the products on the market and the research of the literature, combined with the urban waste classification policy, the function of smart home design should be summarized, and finally achieve the desired effect. Realization of product identification and classification function design: research how products use object recognition and in-depth analysis and other technologies to identify and classify waste. The product can be guided by image recognition and sensor data analysis to ensure that the waste can be accurately classified and recycled. Sensing and operation function: The product senses the action signal of the human body to dump garbage to automatically open and close the lid of the garbage can, providing a convenient use experience. Monitoring and management inside the product: The use of sensor technology to monitor the capacity inside the trash can, timely remind the user of the filling of the trash can, to avoid garbage overflow or frequent replacement of garbage bags. Product positioning and finding function: Based on the technology of intelligent sweeping robots on the market to scan the home environment and generate a home map to detect the clean area and reduce the collision, the product positioning function is realized. The user interacts with the smart trash can through the mobile app, so that the user can throw garbage in any room of the home without occupying living space.

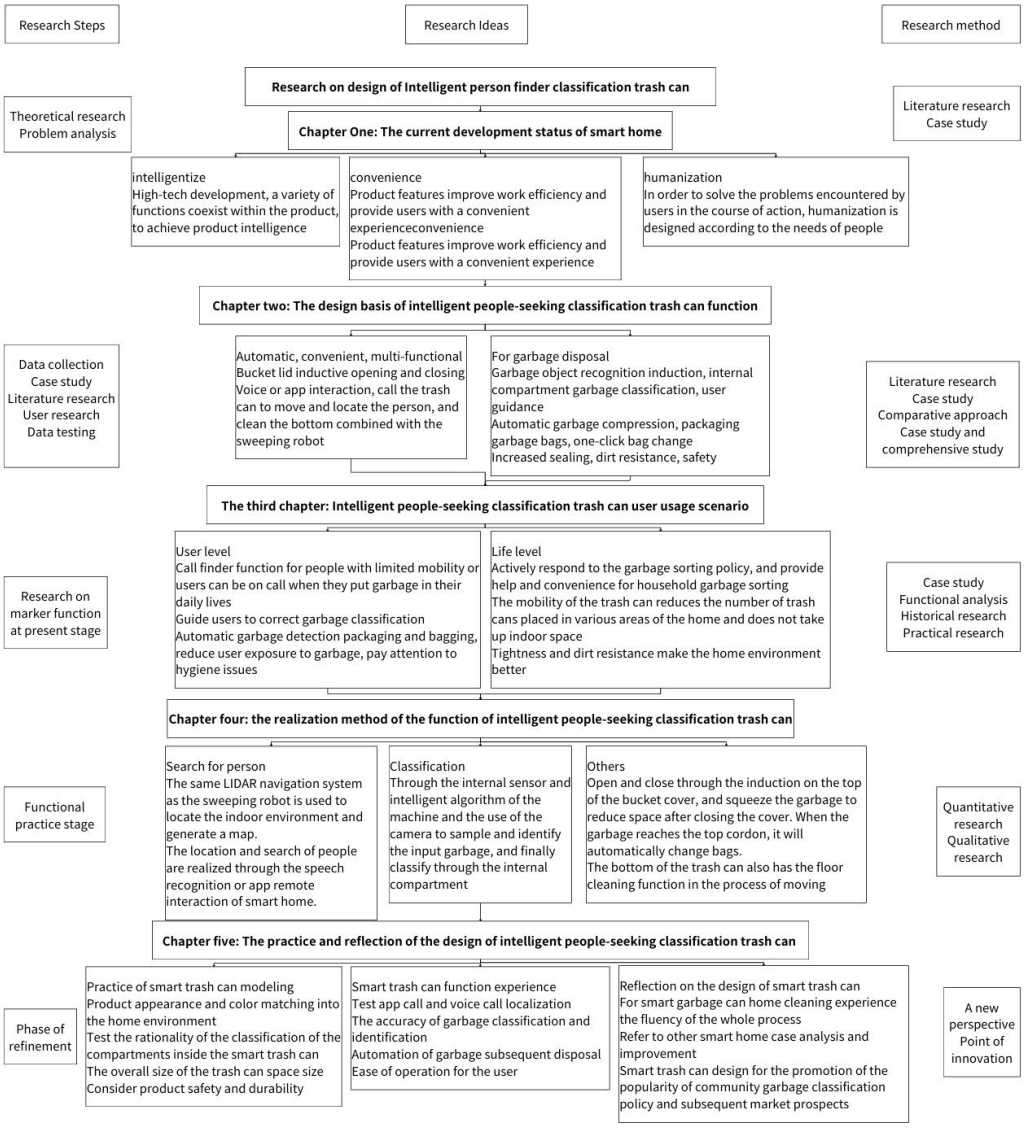

Figure 4: Frame diagram

1.4 Research Methods

This study examined the relevant information of the network and analyzed the competitive products according to the advantages, functions, cost performance, core selling factors, and innovation aspects of the major brands of smart home products at the present stage. Through the understanding of advanced product functions, extract technical functions conducive to the development of new products, and then analyze the pain points and needs of current users according to the investigation, and conceive a smart home focusing on sustainable functions. In order to realize the idea of intelligent people finding classified garbage cans to improve the efficiency of future users' home cleaning, it not only integrates the research status and literature on intelligent garbage cans at home and abroad but also combines specific design practices.

2. Literature Review

Through the literature and journals collected by CNKI, we conducted a comprehensive search and analysis of design research related to smart trash cans in both Chinese and foreign periodicals. Analyze the historical and present research development process of this project, obtaining insights from various aspects of experience. Gain knowledge about the inspiration, appearance, function, and design principles of various research. The timeline shown in Figure 4 indicates a scarcity of

studies related to smart trash cans from 1998 to 2008. However, it does demonstrate the development of prototypes for the advanced features of the functions designed in recent years. These features primarily focus on enhancing the convenience of trash disposal, mobility, and garbage recycling capabilities of smart trash cans. In the past 20 years, there has been a significant focus on the design research and development of smart trash cans. As the social economy has progressed, there has been an increased interest in smart trash cans. The functional goals of smart trash cans have evolved to include intelligence, convenience, diversity, and sustainability. Moreover, the methods and technologies used to achieve these functions have continuously improved. (Gao, 2012) (Jiang, 2015).

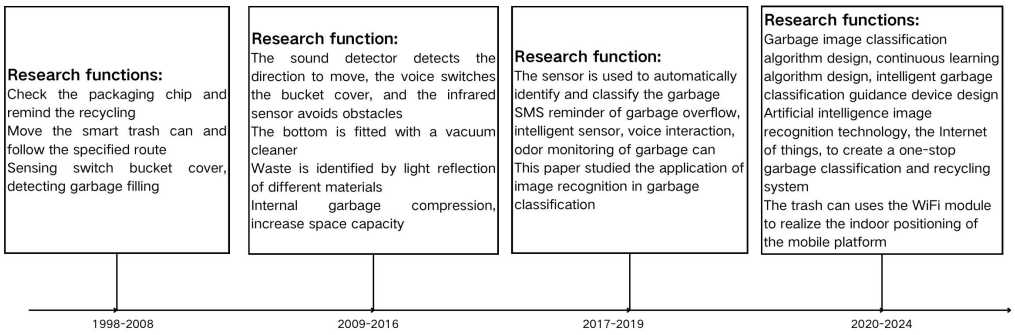

Figure 5: Timeline

The research primarily focuses on urban management, multi-functionality, and garbage disposal in the design of smart trash cans. Through the search of foreign periodicals, doing research and analysis to explore the use of different technical means to achieve the design purpose of smart trash can. In today's era of rapid development in science and technology, the capabilities of smart garbage cans, such as movement, classification, automation, and other functions have become more than just conceptual. Now, you can easily connect to and control the smart garbage can through various technologies such as the Internet of Things (IoT), sensors, garbage can system design, mobile phone apps, and WiFi. Combined with the research technology of journal literature and the advantages of smart homes that have been sold in the market for a long time, it is believed that the new generation of smart trash cans will have breakthroughs. This will not only generate a good market but also contribute positively to the sustainable development of the country.

Table 1: Design research review

Research Direction	Reference	Trait
Future city, smart city waste management	"Smart Trash Bin Model Design and Future for Smart City" (Huh, 2021) "an intelligent trash can system based on both NB-IoT and edge computing for smart cities" (Jia, 2020) "Smart bin: Waste segregation system using deep learning-Internet of Things for sustainable smart cities" (Mohammed Aarif, 2022)	① Using sensor, image processing or spectral techniques, respectively, for waste disposal ② This paper proposes an intelligent garbage can monitoring system based on edge computing and narrowband Internet of Things (NB-IoT) to realize intelligent waste management in smart cities. ③Smart waste management system for smart cities, which uses deep learning and IoT to separate waste classification into biodegradable and non-biodegradable.

multifunction	"IoT(Internet of Things)-based Smart Trash Can" (Kim, 2020) "Smart Trash Can Robot System with Integration of Internet of Things and Mobile Applications" (Chang, 2019)	① The smart trash can has the functions of garbage compression, automatic lid opening, garbage amount display, and garbage can monitoring.②The user calls the car trash can indoors through the mobile app, and realizes automatic obstacle avoidance navigation through deep learning intelligent path planning.
Garbage disposal	"Design of Intelligent Sorting Trash Can System Based on Mobile Net Model" (Wu, 2022) "Design of Intelligent Sorting Trash Dustbin Based on STM32" (Zhou, 2020) "The Design and Implementation of the Smart Trash Can based on the Internet of Things" (Wang, 2020)	① The system combines image recognition and speech recognition for dual mode recognition and garbage recognition. ② The mechanical structure of the smart trash can uses an STM32F103ZET6 chip, speech recognition, ultrasonic, and other modules to identify the types of garbage, garbage compression storage, and automatic sealing. ③ The use of sensors, infrared ranging, motor, and ultrasonic to achieve automatic garbage classification and garbage overflow detection.

3.1 Design Principle of Intelligent Person Finder Classification Trash Can

In today's ever-changing smart home market, product functionalities are getting more advanced, aiming to fully meet the diversified needs of users. In view of this trend, this design thoroughly examines the limitations in the current social household waste delivery process and draws the advantages of a variety of smart home products. Creatively envisages a smart garbage can that integrates cleanliness, convenience, and multiple functionality. The design principle of the intelligent person finder classification garbage can is mainly based on the functions of modern smart homes. It aims to achieve the automation of the garbage can mobility and person detection as well as the intelligence of garbage sorting ability. The design combines multiple technologies, including positioning technology, sensor recognition technology, image recognition technology, voice interaction, etc., to provide users with a new home cleaning experience (Sun, 2017). Although the existing smart home products on the market, may not have a perfect or fully equipped smart trash can that can detect people and accurately sort waste, this does not prevent us from integrating and improving the existing technology to bring this design concept to reality. The design of our intelligent people-finding classified garbage can is inspired by the innovative application of the combination of the intelligent garbage can and intelligent sweeping robot. Modern intelligent sweeping robots not only have the ability to scan the home environment, plan the cleaning path, and generate a home map, but also users can view the cleaning area or customize the cleaning route through their mobile phones. Take Cobos as an example, its high-end flagship product uses the latest AIVI artificial intelligence and visual recognition system, giving the machine deep learning capabilities. In the initial cleaning, the robot can record the location and spatial structure of each room in the home, and formulate the cleaning route accordingly. Additionally, this data can be utilized to enable the smart trash can to locate individuals within the home (Di, 2016). In the traditional home, the setting of multiple garbage cans in each room occupies valuable space, and there are also cases in daily use in which the garbage can not be found immediately or the user is inconvenient to move to get to it. To completely change this situation, in this design, we ingeniously transform this function of the intelligent sweeping robot and integrate it into the intelligent garbage can. The user simply needs to provide instructions using the mobile phone application. The smart trash can will

then utilize the household map recorded by the sweeping robot to accurately position itself and quickly move to the user's side enabling the intelligent person-finding function. This innovative design improves the convenience of home life, not only that, if the intelligent sweeping robot has the functions of vacuuming, washing, obstacle avoidance, voice interaction, and so on, it can replace many products to complete the home cleaning work alone, showing the infinite possibilities of collaboration and integration between smart home products.

Figure 6: ECOVACS robot vacuum cleaner

The intelligent person finder classification trash can is designed to solve the problem of garbage segregation. It features multiple compartments inside the product, each compartment corresponds to different garbage categories. By identifying and pushing the garbage into the corresponding compartment, the trash was effectively classified and sorted. There are many ways to classify garbage in garbage bins. Through sensor recognition technology, it utilizes infrared sensors and weight sensors to accurately identify the physical characteristics of garbage to provide data support for subsequent garbage classification. Image recognition technology, combined with deep learning algorithms, the camera can accurately identify the types of garbage images. These intelligent classification methods not only improve the accuracy of garbage classification but also greatly reduce the workload burden of users.

In the design concept of the intelligent person finder classification trash can, it is necessary to combine the technical characteristics of the current modern intelligent trash can in addition to the core function of intelligent classification. Taking the design of the Townew smart trash can as an example, it not only has the induction switch bucket cover function commonly available in smart trash cans but also has achieved a significant breakthrough in user experience. The core function of the design of the smart garbage can is to "free hands and simplify operation". With a single click, users can activate the built-in automatic packaging system, which can quickly and firmly seal the garbage bags in the bucket. This effectively solves the problem of manual packaging and the difficulty of achieving complete sealing with traditional garbage cans. After the packaging is completed, the system will automatically lay a new garbage bag to ensure that the bag is evenly laid, and there is no need for users to find bags, bagging, and other complicated operations, which greatly improves the convenience of users' daily lives. It is worth mentioning that Townew intelligent garbage can also has an intelligent adaptive overload packaging function, when the amount of garbage exceeds the mouth of the bucket, the built-in program will sense the location and height of the garbage, and automatically adjust the length of the garbage bag, to ensure that efficient packaging can be realized even in the case of overload, and further enhance its practicality (Miao, 2021). In the details of the design, Townew smart trash can adopts the suspension bucket cover design, compared with the fully sealed bucket cover, this design enables the odor to be slowly released, avoiding the unpleasant smell when opening the cover, and bringing the user a more comfortable experience. Through innovative design concepts and advanced technology applications, the smart trash can not only realizes intelligent classification but also achieves the ultimate user experience, bringing users a more convenient, clean, and comfortable living environment.

Figure 7: Townew sweeping robot

Table 1: Design technique research

Product function	Search for people	Garbage sorting
Implementation mode	(1) Voice recognition user commands, sound source localization, motor drive trash can movement (Gao, 2012). (2) Intelligent mobile robot using lidar and improved reciprocating and A* algorithm to improve efficiency (Ge, 2022). (3) The mobile robot uses odometry to locate, WiFi fingerprint information to eliminate errors, and combines lidar information to build an environment map (Qin, 2022).	① This product is based on Jetson nanoimage recognition technology for garbage classification (Shen, 2023). (2) Classify garbage through a metal detection module (Chen, 2015). ③ Based on the intelligent classification recycling box of STM32F7 and OpenMV, the camera will identify and classify the garbage (Zhang, 2024). (4) Analyzing the type of the item through the beam irradiation and the chip of the input material (Liu, 2016).
Key technology	① The Philips UDA1341TS special voice processing chip is designed, and the diffusion photoelectric switch is used for obstacle avoidance. (2) The MCU module of the system takes an STM32 chip as the core, lidar builds the map, and ultrasonic sensor assists obstacle avoidance. ③ The construction of a mobile robot map, the Hokuyo UST-20LX laser sensor is selected, and the SLAM algorithm combining WiFi and lidar is established.	① The YOLOv4 image recognition technology based on Jetson Nano is implemented for preprocessing, and the garbage is located and classified through deep learning model training. (2) high-frequency oscillating metal sensor, when the non-ferrous metal target is close to the sensor, the oscillation frequency increases. ③ The smart trash can is a development board with an STM32F767 microprocessor as the core. (4) Raman spectroscopy analysis technology uses light beams to illuminate garbage to determine the type of material

4.1 The Key Technology and Problem Analysis of Intelligent Person Finder Classification Trash Can

To address the issue arising from the implementation of the garbage classification policy in the community, in the pursuit of an efficient and convenient modern society, the Intelligent person finder classification trash can is designed with its unique function of calling person finder and garbage classification. This approach significantly reduces the time and cost associated with cleaning tasks and improves the overall efficiency of life. One of the key technologies of the intelligent person locating and sorting garbage cans is person locating and navigation technology. To enable the "one-click call" function of the trash can, it must be ensured that the trash bin can be accurately and quickly moved to the user's location. This can be achieved by using both interactive positioning and sound source positioning, which are the two methods often used in today's smart home applications for locating objects.

4.1.1 Voice Interactive Search Function

The home environment finder positioning system utilizes the technology of intelligent sweeping robots, specifically, laser scanning to strategically plan the path. The technology calculates the distance between the robot and an obstacle in front of it by measuring the time difference between the laser's transmission and reception. Specifically, our laser navigation requires multi-point ranging, using the RPLiDAR A1 LiDAR can perform multiple 360-degree continuous scans per second, collect nearly 8,000 point cloud data per turn, store it in memory, and then send it to the host computer for processing to obtain positioning information about the space environment. Although LiDAR has advantages such as high accuracy, no network dependence, and fast scanning when identifying large obstacles, it is merely a tool for information gathering. The generation of a topographic map and the understanding of terrain by machine can not be separated from the aid of an algorithm. In this process, Simultaneous Localization and Mapping (SLAM) technology plays a key role, which enables the robot to build a map of the surrounding environment in real-time and conduct real-time positioning according to its own movement. Thus enabling autonomous navigation and positioning (Zhao, 2022). In addition to SLAM and LiDAR, the system also requires other sensors and algorithms to work together. Real-time data management algorithms, sensing and mapping algorithms, navigation and motion algorithms work together to ensure that robots can accurately perceive, map, and understand the surrounding terrain to provide efficient people-finding and location services.

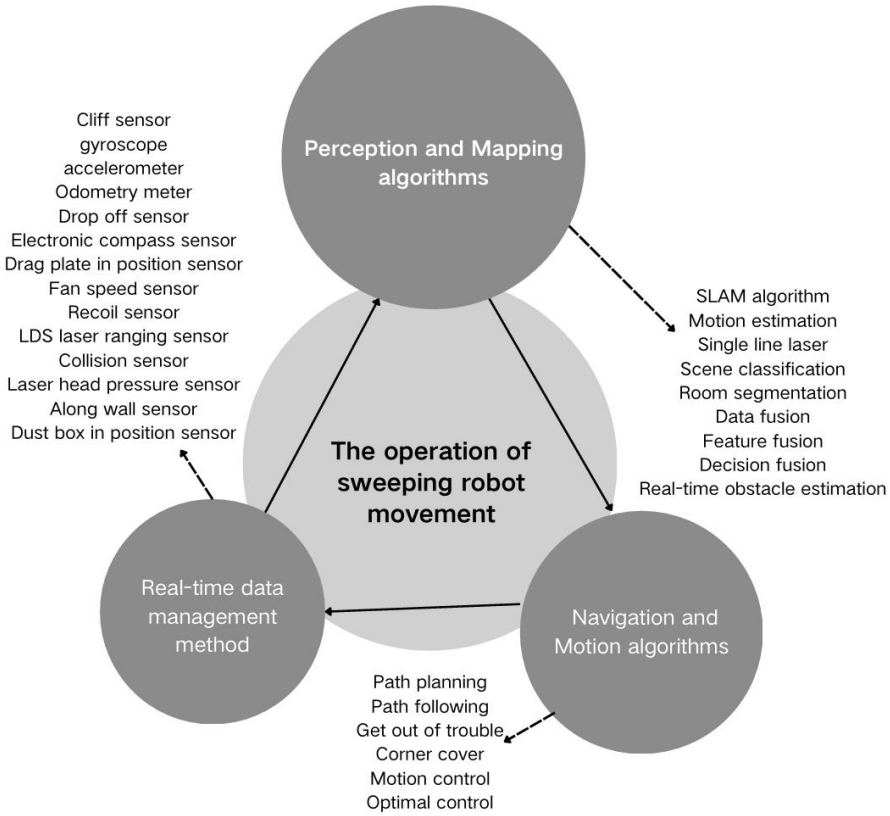

Figure 8: Operation of the robot vacuum cleaner

As technology advances, service robots are looking for more convenient and user-friendly ways to interact with each other instead of complex keyboards and remote-controlled buttons. Among them, speech recognition technology has become a crucial breakthrough, with its high degree of intelligence in recent years to achieve rapid development. In order to achieve natural interaction with robots, we can use voice cloud platforms, such as well-known domestic iFlytek, Baidu, and cloud sound platforms.

These platforms place core services such as computing, identification, and storage in the cloud, and provide interfaces to users only through APIs or SDKs, greatly improving the ease of use and identification efficiency. The system uses a speech recognition module for speech detection and uses a microphone array to capture and recognize sound source signals (Wang, 2021). At the same time, the inertial navigation system (Xue, 2016) and mobile robot technology are combined to provide accurate position information for the movement of the robot, so that the robot can independently detect the location of the sound source. After successfully identifying and locating the sound source, we adopted Arduino (Liu, 2021), an open-source platform and hardware development board, to control the robot's movement. Arduino has quickly gained the favor of developers because of its open source and easy-to-use characteristics and is widely used in diverse fields such as smart homes and medical services.

So when the user emits a sound signal, it is first accurately captured by the microphone installed on the module. The microphone recognizes the sound signal after receiving it, and the microphone array located in the head of the machine passively detects this sound signal, ensuring that the source of the sound is accurately captured. The system analyzes and processes the received sound signal, and identifies the specific location of the sound source target through inertial navigation technology. Then, the voice recognition module transmits the recognition result to the Arduino core control module. After receiving the information, the voice recognition module quickly reacts and accurately controls the direction of the machine to ensure that it accurately approaches the sound source. The integrated laser synchronous positioning and mapping (SLAM) technology mentioned above, makes the machine in the process of autonomous search, not only accurately find the target, but also flexibly avoid various obstacles to ensure the smooth completion of the task, and further ensure the safety and accuracy of the machine in the process of moving.

4.1.2 Mobile Phone Call Searching

On the basis of using LiDAR and SLAM algorithms to build maps and avoid obstacles, the function of locating people indoors can also be achieved by using mobile phone mobile-client interaction. Indoor positioning technology can be implemented in many forms. So far, several common positioning technologies mainly include WiFi positioning technology, radio frequency identification (RFID) positioning technology, Bluetooth positioning technology, Infrared positioning technology, ultra-wideband (UWB) positioning technology, etc. (Yang,2016).

With the rapid development of Internet technology, people are increasingly dependent on mobile phones and WiFi. The wide coverage of WiFi and the wireless network card configuration of mobile phones, computers, and other electronic devices greatly enhance the practicality and convenience of WiFi. In this context, WiFi-based indoor positioning technology has become a high-profile solution due to its low cost and easy deployment. The technology combines the mobile phone client and WiFi positioning technology to realize efficient indoor positioning services. Specifically, we used the received signal strength indication (RSSI) approach based on Wi-Fi signal strength. By deploying multiple ESP8266 Wi-Fi receivers, the signal strength data of the user's mobile device is collected for RSSI-based indoor positioning. At the heart of this approach lies the use of the fingerprint concept, in which signal strength information from the receiver is collected at various reference points and stored in a cloud server to form a so-called "finger map." When a user is located at a specific reference point, the user's position relative to the reference point can be accurately determined by comparing the fingerprint data obtained in real time between RSSI and the cloud. This positioning mechanism not only improves the positioning accuracy but also provides users with a more intelligent service experience. The smart trash can can accurately move from the standby position to the user's location according to the positioning results to achieve the "call" function. In addition, we combine other external sensor technologies such as

LiDAR scanning to further improve positioning accuracy. These sensors can provide more environmental information to help correct possible errors during WiFi positioning (Hu, 2021). Through this multi-sensor fusion method, the algorithm accuracy of the whole SLAM system has been significantly improved. With its unique advantages, indoor positioning technology based on WiFi provides users with a more convenient and intelligent service experience. In the future, with the continuous progress of technology and the continuous expansion of application scenarios, technology is expected to play an important role in more fields.

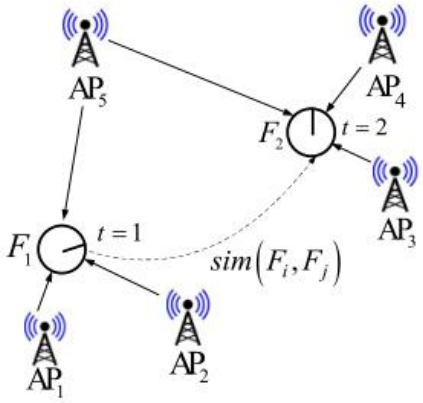

Figure 9: WiFi fingerprint data collection

Due to the rapid pace of modern life, many people find it difficult to find time to clean their home environment as a result of their demanding work schedules. In this case, smart home devices equipped with cleaning functions serve as helpful assistants, capable of performing cleaning tasks in the home environment. The intelligent person finder classification trash can greatly reduces the demand for placing multiple trash cans in different rooms at home with its unique function of person finder. This smart trash can uses advanced indoor positioning technology, such as sound source positioning and WiFi positioning, to accurately determine the location of the user. Once the positioning is successful, the trash can move to the user's location autonomously through the automatic obstacle avoidance and navigation function, which brings great convenience to the user.

4.2 Garbage Classification Function

The main goal of the classification function of the intelligent search classification garbage can is to achieve the intelligent classification of domestic garbage, comply with the community garbage classification policy, improve the efficiency of garbage classification, reduce human participation, and save time cost. The classification function mainly uses sensor technology and image recognition technology. A variety of sensors can be built into the smart trash can, and these sensors can be connected to the cloud service platform through the Internet of Things technology to realize the real-time transmission and processing of data. In combination with the training of a deep learning model, the smart trash is capable of capturing the image information of the garbage using the built-in camera. It then utilizes the image recognition algorithm to automatically classify the garbage. This method can greatly improve the accuracy and efficiency of garbage classification. The application of image recognition technology in realizing automatic garbage classification involves several key steps. Firstly, the image information is collected through sensors or cameras and converted into a data format that can be parsed by the computer. Subsequently, image preprocessing is performed aiming to enhance the key features in the image (Sun, 2024) for subsequent feature extraction. In the feature extraction stage, the system will extract representative features from the preprocessed image, which can reflect the unique properties of different

garbage types. Next, designing an efficient and accurate classifier is the key step, which relies on the preset recognition rules to recognize the extracted features and improve the recognition of the features, so as to ensure that the final classification results are accurate and reliable.

For the hardware design, we refer to the existing literature research and choose a trash can structure that conforms to the current design. With a diameter of 35cm and a height of 40cm, the bin is divided into four separate areas through an innovative cross-shaped structure, which is used to store recyclable materials, kitchen waste, hazardous waste, and other waste. In order to achieve the automatic classification and delivery of garbage, we installed a rotatable garbage separation structure directly above the cross structure. The rotating action of this garbage separation structure is controlled by two carefully chosen servos. The main servo is located between the cross structure and the lower part of the garbage separation structure and is responsible for driving the whole separation structure to rotate above the different garbage areas. The auxiliary servo is connected to the upper half of the separation structure through the sector structure, and when the auxiliary servo rotates, it can accurately send the garbage into the corresponding sorting bucket. In the choice of servo, we fully considered the rotation angle, accuracy, torque, and other key factors, and finally selected LD · 27MG model metal digital servo. This actuator has excellent performance and can be precisely controlled by PWM pulse signals to provide torque up to 20kg and achieve a large angle of 270° rotation. Its high rotation precision and fast response ability ensure the accuracy and efficiency of garbage classification (Chen, 2023).

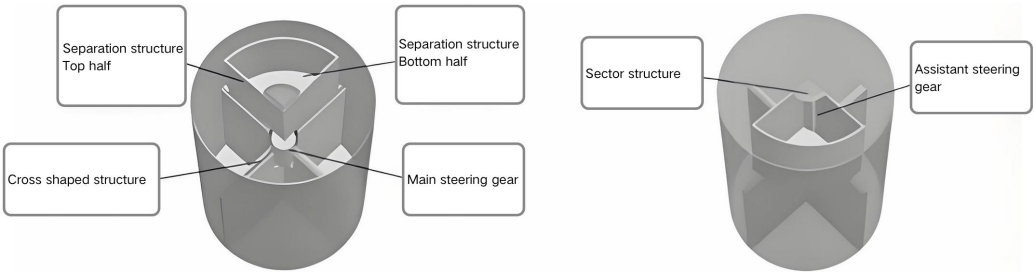

Figure 10: Inner structure of garbage can

In the intelligent garbage classification system, we first use visual devices such as cameras to collect images of garbage. In order to improve image recognition, we use the enhanced image technology and then extract key features to realize the leap from image classification to actual object classification, so as to achieve the goal of accurate garbage classification. The key part of image processing is YOLOv4 (Wang, 2020) image recognition technology based on the Jetson Nano platform. With this technique, images first go through a preprocessing step and then are fed into a deep-learning model for object detection and classification. Through continuous model training and optimization, we were able to improve the recognition accuracy of the system for various types of garbage. In the whole system, the STM32 microcontroller plays the role of the core controller, it is responsible for coordinating the work of each module, including the function of the acquisition circuit, key, and other external equipment. At the same time, we also study the Python-based Raspberry PI motherboard to control the camera and steering gear using computing power. The camera is responsible for capturing the image, while the servo executes the corresponding garbage classification action based on the result of image recognition, that is, the comparison with the known data in the database. Through image recognition and classification, we build an efficient and intelligent garbage classification system, which not only improves the accuracy of garbage classification but also provides users with a convenient operating experience.

5. Design and Implementation of Intelligent Person Finder Classification Trash Can

5.1 Appearance Concept of Trash Can

With the continuous progress of the social economy, people's quality of life is steadily improving, and the pursuit of comfort in indoor spaces is becoming increasingly significant. In modern interior design, the use of color has become particularly critical. It can not only beautify and decorate the indoor environment, but also profoundly affect people's psychological feelings, and bring a more comfortable and pleasant experience to the occupants. In interior design, the combination of black, white and gray tones can produce unique psychological effects. When the main tone is white or gray, and the appropriate embellishment of black, it can give the space a stable and heavy sense, effectively balance the visual focus, and avoid the overall color being too light or thin. In addition, with the popularity of smart homes, the color design of products also needs to be coordinated with the indoor environment. The right color combination can make the product better integrated into a variety of interior styles. For example, in industrial product design, too soft light powder or light green may make people question its durability, so choosing a representative color that matches the ambient tone for color design can enhance the overall coordination and beauty of the product.

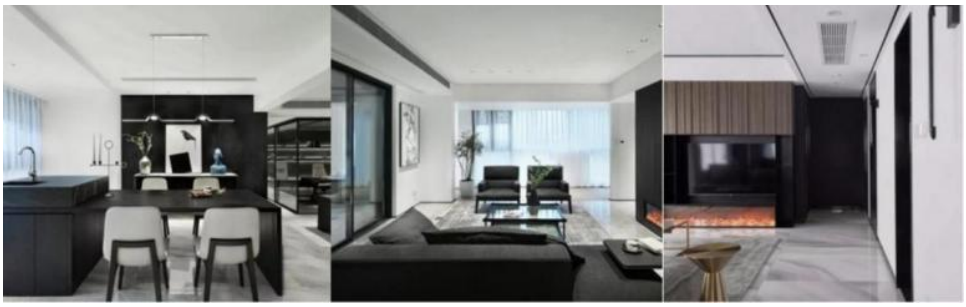

Figure 11：Black, white and gray interior design

In color matching, the intelligent finder classification trash can selects a colorless system based on "black, white and gray", which ensures the harmonious unity of the overall effect. At the same time, it is embellished with a small number of color elements to form a sharp contrast, making the trash can more visually fashionable and high-end. As a neutral color, black, white and gray can easily match a variety of home and decoration styles to avoid conflicts with other home elements. In actual use, the product's black, white and gray color matching makes elements such as the interface, buttons and indicators more eye-catching, with high contrast, which helps users quickly identify and accurately operate the functional area of the product, improving the product's ease of use and user experience.

After determining the basic color of the intelligent people-seeking classification trash can, we further proceeded with the appearance design of the product. The design not only focuses on intelligence and sustainability but also aims to create a product that will blend into the home environment and be loved by the public. To this end, we have adopted a bionic design approach that has had a profound impact on the design world. With its unique design value, bionic design gives industrial products humanized features and humanistic care, making it more popular in the market. Bionic design covers many methods such as functional bionic, shape bionic, structure bionic, texture bionic, color bionic, image bionic and so on. In order to explore new ideas, we started from the biological prototype, combined with the practical needs of the trash can and the basic tone of black, white and gray, and chose to simplify the biological lines. In particular, we take the shape of the penguin as the inspiration, by simplifying its lines, and combining it with the interior of the large capacity of the trash can, to create a cute

and playful penguin image. Such a design not only complements the basic tone of the product but also brings a pleasant feeling to the user visually, further enhancing the market appeal of the product.

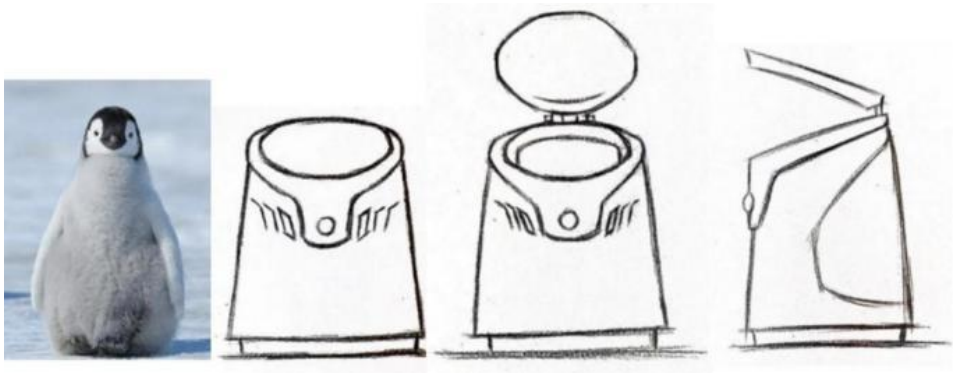

Figure 12：Appearance and product sketch of the penguin

5.2 Product Production

After the appearance of the product is established, Abs resin materials are 3D printed and painted through modeling.

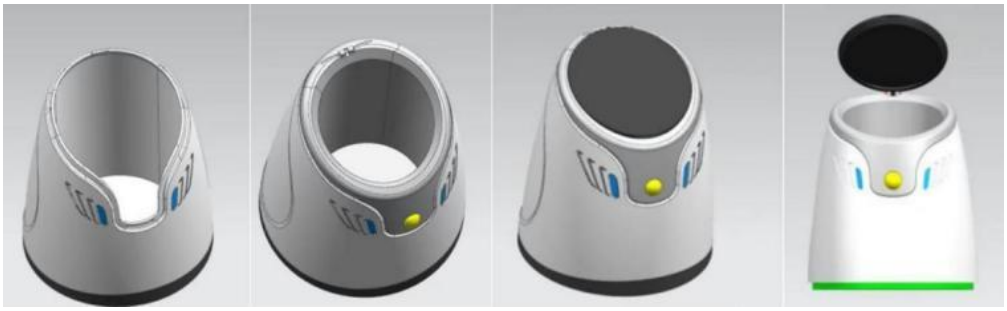

Figure 13: Product modeling

Figure 14: Product production

Figure 15: Product appearance

Figure 16: Product details

6. Conclusion

This smart home product design aims to combine and innovate the existing product functions of smart homes available in the market by addressing the current problems related to urban waste classification. By incorporating new functions into the design, we provide users with innovative and surprising experiences. In the urban environment where land is precious, office workers, while busy at work, also actively respond to the community's garbage classification system and pay attention to the rational use of resources. During the design process, we specifically focused on addressing the needs of residents in economically developed cities such as "Beijing, Shanghai and Guangzhou". These cities are densely populated, living space is limited, a rapid pace of life, and an urgent demand for efficient and convenient smart home products. The intelligent people-seeking classification trash can is designed based on these characteristics, and solves the following problems through innovative functional design: 1. The primary purpose of the person finder function in the trash can is to enable users to locate the trash can quickly and conveniently by using voice commands or mobile phone app interaction when the user's action is inconvenient or cannot find the trash can immediately. 2. The garbage bin utilizes advanced technology to identify and classify the garbage, improves the user's ability to sort their wastes efficiently, and provides guidance for proper waste disposal practices. 3. The smart garbage can improves the efficiency of household waste management and promotes cleanliness. It has features such as an induction switch for the bucket lid, garbage disposal classification, bucket lid deodorization, a warning system for garbage overflow, and automatic packing and bagging. 4. Reduce the number of garbage cans distributed in various areas of the home, maximize the indoor living space, and better comply with the garbage classification policy of urban users. 5. Combine the sweeping robot with the smart trash can which can be put at the bottom, enabling different functions for sweeping and mopping as well as the ability to clean while in motion. 6. Develop effective garbage sorting habits among users, relieve the pressure of garbage disposal in the community, and promote sustainable urban development. These design features free the hands of users, greatly improve the quality of life of residents, effectively save time costs, and promote the clean and sustainable development of the urban environment.

The implementation of urban waste classification management stimulates public awareness and thinking about sustainable development, promoting a deeper understanding of the saying "clear water and green mountains are as valuable as gold hills and silver mountains" which is thought-provoking. In the author's perspective, intelligent product design requires designers to pay more attention to problems in life, use technology to change people's lifestyles, develop better living habits, and spread more civilized life concepts, so that civilization will develop in a more advanced direction. Looking to the future, with the continuous progress of science and technology and the improvement of human environmental awareness, the combination of intelligent products and green design will become a trend. We will continue to explore new technologies and methods to continuously improve the performance and user experience of the smart search garbage can, and promote the sustainable development of the smart home industry. At the same time, we also hope that through the design and research of intelligent people-finding classified garbage cans, the public's concern and thinking about sustainable development, and jointly contribute to the establishment of a better living environment.

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