Detachable IoT Garbage Sorting Device Based on Machine Vision

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Abstract

China is promoting a garbage sorting system, but people have to spend more time changing their habits, and the garbage bins on the road do not have the function of automatic sorting. Therefore, a detachable IoT waste sorting device based on machine vision is proposed. Through machine vision and a unique mechanical structure design, it can be directly installed on existing trash cans, and is suitable for two and four classifications that meet the Chinese classification standards. Inside the device, it is fixed with an existing trash can with a mechanical electronic lock, and the switch lock operation can be performed through the mechanical key and the Internet of Things applet, which is convenient for the replacement of the device.

Keywords: Garbage classification, detachable,Internet of Things, machine vision

1. Introduction

In recent years, with the accelerated urbanisation of life in China, coupled with the rising living standards of residents, the amount of urban domestic waste generated has maintained a steady growth trend, and in recent years China has become one of the countries with the greatest pressure on urban domestic waste disposal in the world.

According to statistics, China produces hundreds of millions of tonnes of domestic waste every year, and more than 600 cities across the country are piling up 8 billion tonnes of waste, taking up more than 500 million square metres of land. Waste separation and disposal has become a hot social issue, and in order to solve this problem, starting from Shanghai, to 46 cities across the country on a pilot basis, waste separation has been introduced and regulations related to domestic waste separation have been mandatorily implemented.

At present, waste separation in China is mainly carried out manually, i.e. by placing several bins with different categories of labels, and pedestrians are required to make their own judgement before putting them into the bins.

Although manual sorting has been effective in the early stages, it is not a long-term solution. It is not only costly in terms of manpower and resources, but it is also a waste of resources. Smart bins have been proposed and designed for this purpose, but they are still not widely used in public places. The main reasons for this are the high cost, the large size and the low level of intelligence, which does not allow for automatic recognition of the sorting function. In addition, the existing smart bins on the market are capable of sorting recyclable and non-recyclable waste, but are not widely available due to their complex structure and high cost.

2. Overview of Waste Separation Units

The paper discusses a detachable IoT waste sorting device based on machine vision. A convolutional neural network is built through machine learning, and a large amount of waste training data is input into the convolutional neural network for training and classification [1].

In terms of mechanical structure, the paper designs a detachable sorting device that adapts to the majority of bins in the market for both Class II and Class IV bins. A load platform for waste recognition is added above the drop-off opening, which is connected to the acrylic plate using a tiller, and a fixed steel frame is attached underneath the plate to increase the weight of the load. The support structure is made of aluminium alloy to prevent damage to the device.

When sorting waste, the platform can be turned left and right after the recognition device has determined the type of waste to be sorted. The four types of rubbish bin adds a screw bar to the two types of rubbish bin, and the classification of the four types of rubbish is achieved by moving the load-bearing platform on the screw bar through a stepper motor. The whole identification process is simple in structure, short in time to move the device and highly accurate in identification.

After the device has been placed in the bin, the system sends a signal and the electronic lock is activated to attach the device to the bin and is equipped with a mechanical lock on the outside to prevent locking. In addition the unit uses the IoT module SIM7020C for remote upgrades and electronic locking control of the bins, allowing for real-time knowledge of the bin status and updating of the bin training data in the Raspberry Pi during post maintenance [2].

3. Mechanical Structural Design

3.1. Two types of waste separation units

As shown in Fig.1 and Fig.2, the integrated design of the device has two parts. The top plate of the bin can be directly stuck into the middle when retrofitting. The top of the bin is equipped with a hardware box, the sorting structure is designed in the middle drop-off area of the bin, and the upper surface of the lower box is equipped with a camera.

The middle is equipped with an electronically controlled platform for left and right tipping, the tipping board is the same slotted structure that can take the waste. An electronic lock is installed in the upper part of the device, the hardware box can be opened via a remote mini-programmed terminal, and the side is equipped with a mechanical lock at the same time [3].

The model diagram of the two type waste separation unit is shown in Fig.1, and the combination diagram is shown in Fig.2.

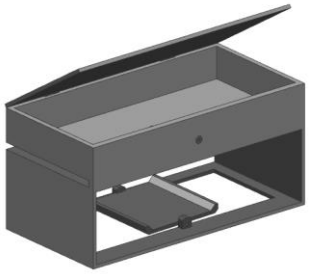

Fig.1 The model diagram of the secondary waste separation unit

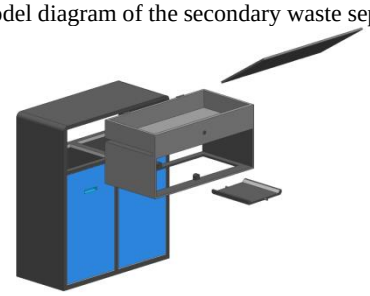

Fig.2 Combination diagram

3.2. Four types of waste separation devices

The sorting structure of the device is installed in the middle input area of the four types of waste bins. The lower surface of the top plate is fitted with a camera, side box is provided with several sorting compartments for collecting different types of waste, side sorting compartments follow the parallel arrangement of common waste bins and therefore have a stronger applicability.

The sorting device can also be dismantled and directly retrofitted to the existing four-type waste classification bin. The sorting compartment is equipped with an electronically controlled platform in the middle of the upper part of the compartment, which can be moved from side to side and tipped downwards, and the tilting and dumping plate is a slotted structure that can receive waste.

Exploded view of the structure of the four types of waste separation units is shown in Fig.3.

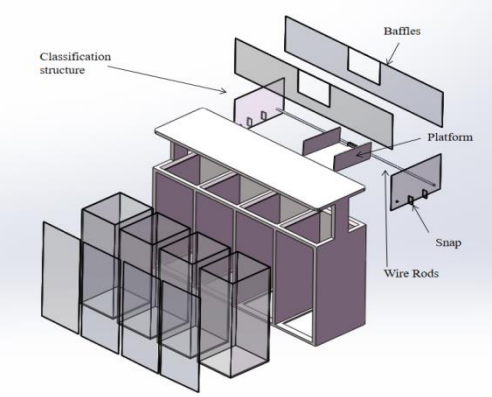

Fig.3 Exploded view of the structure of the four types of waste separation units

The sorting compartment is equipped with an electronically controlled platform in the middle of the upper part of the compartment, which can be moved left and right and turned downwards for dumping. The platform can be turned down 90 degrees, which is shown in Fig.4.

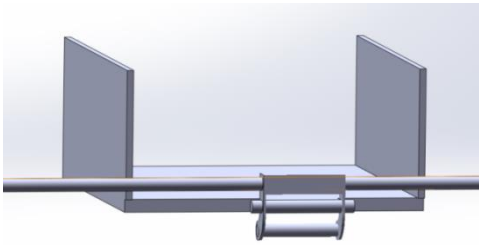

Fig.4 Platform can be turned down 90 degrees

4. Hardware Design

4.1. Master control STM32F103C8T6

The STM32F103C8T6 is chosen as the core processor of the hardware control system. The main functions of the STM32F103C8T6 are: data connection of the Internet of Things, control of the rotating platform servo, system power detection and switching of the mechanical electronic lock.

Its peripheral configuration is powerful, supporting SP interface, I2C interface, USART interface and other communication interfaces, as well as ADC, timer and other peripherals, and reserved for redundant I/O ports, to facilitate the later expansion of the device and maintenance. The master control STM32F103C8T6 is shown in Fig.5.

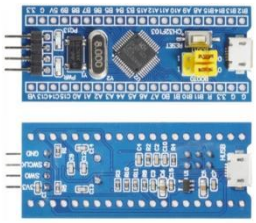

Fig.5 Master control STM32F103C8T6

4.2. Raspberry Pi 4B

The camera sensor pixel is 1080p with 130 degree wide angle, which makes the shooting range perfectly cover the drop-off opening; in addition, it also has a flash function, which is enough to work properly in both day and night.

The camera is mounted directly above the bin drop-off point and takes interval photos to capture images of the rubbish on the platform and transmits the data to the Raspberry Pi.

The Raspberry Pi processes the original images, converting them into grey-scale, binary and RGB images, and matches them with a training set of rubbish that has been pre-input into a convolutional neural network to find common features based on contour recognition, colour recognition and other recognition methods [1].

The data is then transferred to the STM32 to identify the category of waste to be placed. The data is then transferred to the STM32 control board to perform the corresponding operations. The Raspberry Pi 4B is shown in Fig.6.

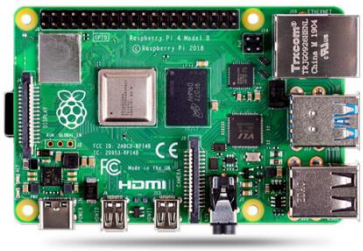

Fig.6 Raspberry Pi 4B

4.3. Electronic lock

The electronic lock is installed in the upper middle of the device, the locking method is magnetic induction. The starting current is 0.9A, the stable current is 0.15A, and the working voltage is DC 12V. The power on is locked

while the power off is unlocked, and the power is connected to the microcontroller.

According to the instructions of the microcontroller for on and off, it plays the function of automatic switch lock. The electronic lock is shown in Fig.7.

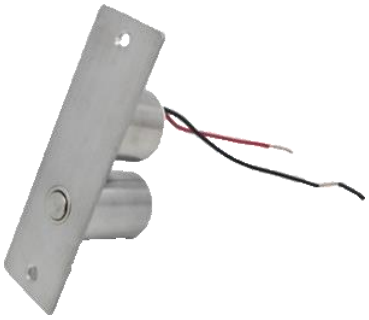

Fig.7 Electronic lock

4.4. IoT module SIM7020C

The module uses the License band and can be deployed in three ways (in-band, protected-band or independent carrier) to coexist with existing networks. It can be deployed directly on GSM, UMTS or LTE networks to reduce deployment costs and enable smooth upgrades. 20db increase in signal gain compared to GPRS Capable of supporting tens of thousands of connections in a single sector, supporting low latency sensitivity, low equipment cost, low equipment power consumption and optimised network architecture [2]. the IoT module SIM7020C is shown in Fig.8.

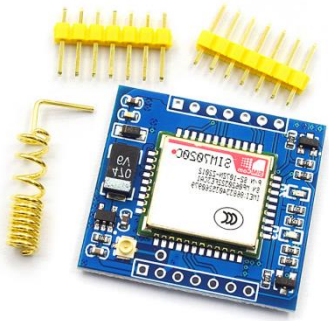

Fig.8 IoT module SIM7020C

5. Conclusion

This paper addresses the problems of difficult waste classification and high replacement cost of similar waste bins in the market, and designs a detachable IoT waste classification device based on machine vision. Through the combination of detachable design and machine vision recognition, it has a wide range of application and high practicability compared with existing intelligent waste sorting bins.

The proposed structure improves the recycling rate of recyclable waste, reduces the loss of material resources and has a certain value of use.

Overall, the innovation of this system lies in the design of Class II and Class IV detachable devices, the combination of machine vision and the Internet of Things, which reduces the cost of waste bin intelligence and improves the maximum benefit of the waste separation.

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