Development and Design of Intelligent Garbage Classification System Based on Image Recognition

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Abstract: AI is the most popular technology science nowadays, and the branch technology-image recognition technology is an important research field. How can machines recognize and distinguish as accurately as humans is a hot research topic at present. In this paper, an intelligent garbage classification system based on image recognition is designed. Raspberry Pi 3B is used as the main control chip of the system, and CCD camera is used as the camera. The model is based on YOLOv4' s garbage detection in complex environment, and an improved ResNet50 network is constructed to train and identify the types of garbage. The experimental results show that the harmful waste classification accuracy of image recognition can reach 100%, and the recovery garbage recognition accuracy can reach 94%. Practice has proved that this identification method is feasible, which helps people to solve the problem of garbage classification, on the other hand, it can reduce the cost of garbage classification and improve the processing efficiency of garbage classification.

1. Introduction

With the continuous development of China's economy, the people's material living standards are gradually moving towards a well-off society, but its negative impact will directly lead to an increase in the output of domestic garbage in China year by year. In the face of the growing amount of garbage removal in China, it is urgent to deal with the problems such as many kinds of garbage, difficulties in garbage classification and environmental pollution caused by random garbage disposal. In this regard, garbage classification focuses on the practice of storing, putting and transporting garbage according to certain regulations or standards, making it a public resource. However, improper handling of garbage types when dealing with domestic garbage classification will lead to low efficiency in garbage classification and even cause unexpected economic losses and environmental damage.

AI is the most popular technology science nowadays, and the branch technology-image recognition technology is an important research field. How can machines recognize and distinguish as accurately as humans is a hot research topic now [1-2]. In fact, the identification of garbage is, in the final analysis, the image identification technology. With the continuous development of computer science, computer vision technology provides a strong theoretical basis for image identification and classification. In recent years, image recognition and recognition methods based on deep learning have achieved ideal results, which are much better and more robust than traditional methods [3-4]. In this paper, an intelligent garbage classification system based on image recognition is designed. The model is based on YOLOv4' s garbage detection in complex environment, and an improved ResNet50 network is constructed to train and identify the types of garbage.

2. Research method

2.1. Overall structure design of the system

To investigate the current situation of garbage classification in China, different kinds of garbage bins are still placed side by side, and people need to judge what kind of garbage they throw, and then manually put it into the corresponding garbage bins. The whole process of garbage disposal is

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time-consuming and labor-intensive, and some citizens have a weak sense of garbage classification, which is prone to wrong classification or random disposal, which has caused great difficulties for the subsequent sanitation work. After the garbage is put into the dumping port, the material is judged first, and then the size of the garbage is analyzed. If the garbage can't be identified in two rounds of detection, the camera will collect the image and compare it with the image features in the database, so as to greatly reduce the workload of image processing and improve the identification efficiency and accuracy.

Image recognition technology refers to the technology of recognizing, processing, analyzing and understanding images by using computers and mathematical reasoning methods, and finally identifying targets and objects with different modes. Image recognition technology has gradually developed from the initial text recognition stage, such as the recognition of analog images such as letters and symbols, to the digital image processing and recognition stage [5]. Computer image recognition technology also has a similar perception mechanism. The computer efficiently and accurately filters invalid information from a large amount of information, extracts useful information, and stores the characteristic information in the picture. Then the images are classified, recognized and processed through these extracted feature information.

On the basis of image recognition technology, this paper proposes an intelligent garbage classification system based on deep learning, considering that deep learning has achieved good garbage classification effect. The system is composed of Raspberry Pi, camera, conveyor belt, stepping motor and four different kinds of trash cans. According to the established control strategy, the conveyor belt is controlled to transport the garbage to be classified at different distances to the corresponding trash cans, thus realizing the combination of deep learning and garbage classification [6-7]. The relationship and connection mode of each module are shown in Figure 1:

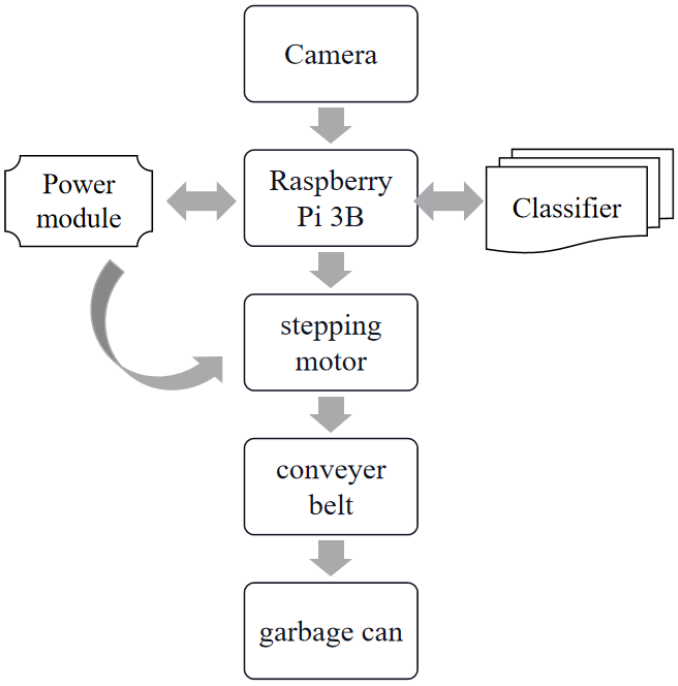

Figure 1 Overall frame diagram of control system

In order to collect, identify and classify garbage images and control the operation of stepping motor, Raspberry Pi 3B is selected as the main control chip of the system. It can input and output a variety of external devices such as pictures, videos, audio, external mouse and keyboard, and its price is economical, but its performance is excellent.

Design and measure the comprehensive performance of CMOS camera and CCD camera commonly used in the market, and finally choose CMOS camera. Compared with CCD camera, CMOS camera has the advantages of low price and low power consumption without changing its original functions.

2.2. Image recognition of intelligent garbage classification

Because there are too many kinds of garbage and the scale of training data is too small. So at present, we can only identify some garbage that is very common in life. Such as batteries, plastic bottles, apples, cartons and cans. In the practical application of image recognition technology, there is still a big difference between computer and human brain. However, due to the increasing demand for recognition, computer learning pattern recognition is allowed to expand the traditional human brain activities. But pattern recognition also has some limitations. When the identified features are highly similar to other types of features, computer image recognition is prone to deviation.

YOLO's first generation algorithm is not as good as SSD algorithm [8-9], but YOLOv4 algorithm is better than SSD algorithm in speed and accuracy. YOLOv4 meets the requirements of rapidity in garbage classification and detection, and also greatly improves the recognition effect of small images. At the same time, the emergence of deep learning classic image detection models such as deep ResNet can also significantly improve the effect of garbage classification. In this paper, an image recognition model of intelligent garbage classification is designed. The model is based on YOLOv4' s garbage detection in complex environment, and an improved ResNet50 network is constructed to train and identify the types of garbage.

In this paper, YOLOv4 image recognition algorithm is selected as the baseline model of the image recognition algorithm in this paper. The AP value of YOLOv4 on MSCOCO data set reaches nearly 43.5%, which is nearly 10 percentage points higher than that of YOLOv4, which is 33.7%. In addition, the fps reaches 65 frames per second, which is much higher than the 45 frames per second of YOLOv4 [10]. The structure of YOLOv4 used in this study is shown in Figure 2:

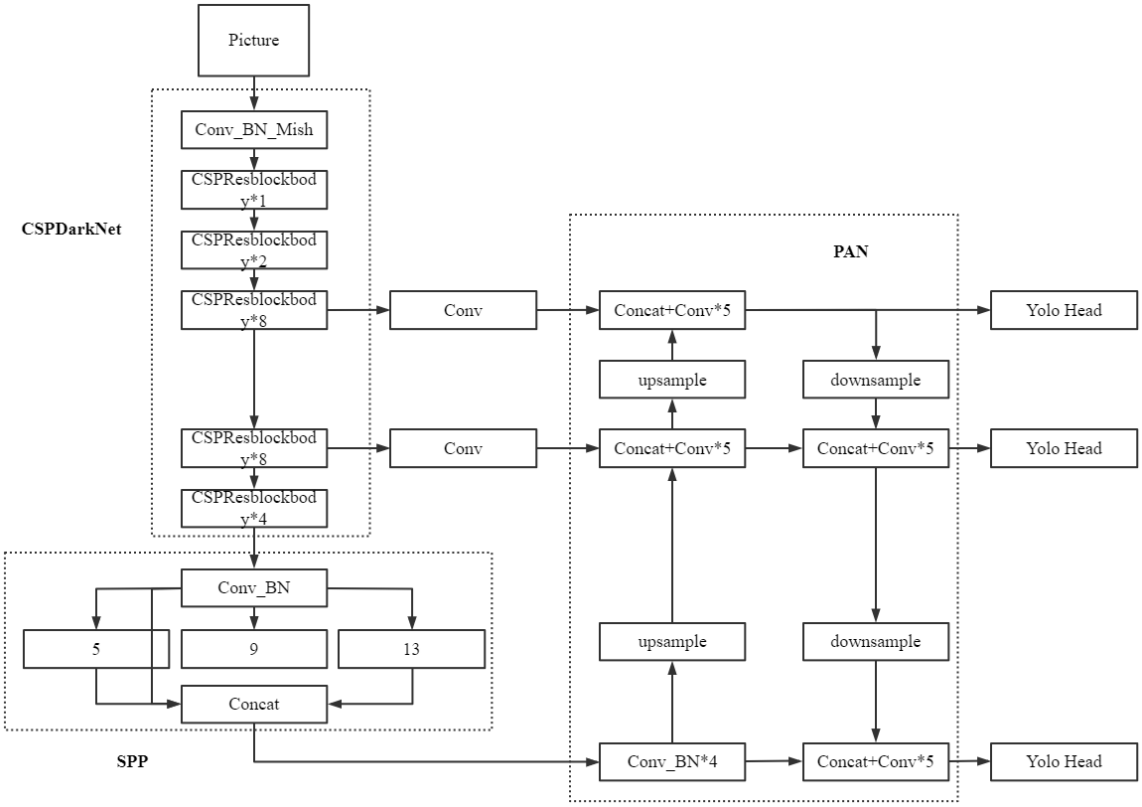

Figure 2 YOLOv4 structure

YOLOv4 not only connects different modules with dense connection structure in DenseNet to share and reuse features, but also uses many methods, such as data enhancement and model fusion, to improve the network performance to a new level. Therefore, on the basis of YOLOv4, this paper improves it, and introduces attention mechanism and variable convolution module to enhance the feature extraction ability of the network. The feature information extracted from the backbone network is fed into the subsequent prediction network, and the subsequent prediction network is the improved YOLOv4 algorithm, which finally predicts the category and location information of the

target object.

According to the task characteristics of garbage classification and identification, garbage can be divided into four categories, and each category of garbage contains many different kinds of garbage, such as cans, crushed cans, mineral water bottles, etc., which itself contains many different kinds of characteristics, so it is difficult to extract some detailed features that appear in the identification process. This paper improves the ResNet-50 network. Based on ResNet-50 network, this paper introduces 1*3 convolution, 3*1 convolution and multi-scale pooling to improve the network's ability of feature extraction.

Because the ResNet-50 network has a weak ability to extract the whole information. In order to integrate the relationship between the whole and local feature information, this paper adds a multi-scale pooled structure to ResNet-50 network to improve the network's ability to extract global information. In order to make full use of global features, different scale pooling modules are introduced. According to the needs of design, the number of multi-scale channels and the size of pooled cores can be changed accordingly. According to the needs of garbage sorting task, this network has designed four channels with different scales, and the size of pooled cores of each channel is 1*1, 2*2, 3*3 and 6*6 respectively.

In the training process of the improved ResNet-50 network, the loss value between the category label of the initial data and the result after the network training can be calculated by the loss function, as shown in Formula (1):

$$l_{CE} = -\sum_{m=1}^{c} t_m \log(y_m) \tag{1}$$

Where: m is the category of garbage. For different times of training, the loss function is calculated as shown in Formula (2):

$$l_{CE} = -\sum_{A=1}^{n}\sum_{m=1}^{c} t_{Am} \log(y_{Am}) \tag{2}$$

Where: A is the garbage sample, t_{Am} is the probability that A belongs to m, and y_{Am} is the model probability prediction that A belongs to m.

3. Analysis of experimental results

The design of the algorithm adopts YOLOv4 pre-training model, loads YOLOv4 initialization weights, and uses the learned characteristics of different kinds of garbage to detect garbage, and then puts the detected garbage into ResNet pre-training network to train garbage categories. A total of 1000 photos were collected, including 400 recyclable garbage, 400 kitchen waste, 200 other garbage and 0 photos from harmful waste (harmful waste can be identified by material identification, so no image collection is made here).

In the related research of deep learning, in addition to measuring the training performance of a model with accuracy and Loss values, it is also necessary to quantitatively compare the improved model with the existing classical network to judge the accuracy of the improved model. Fig. 3 shows the results of network comparison on the data set.

Through the results of different networks on the same data set and different data sets, it is found that the model accuracy of AlexNet in the classical convolutional neural network is better than other classical networks, and the highest accuracy can reach 88.2047%. In this paper, the improved ResNet-50 network model is used to by going up one flight of stairs the high accuracy of the original model, and the improved model accuracy can reach 95.0621%.

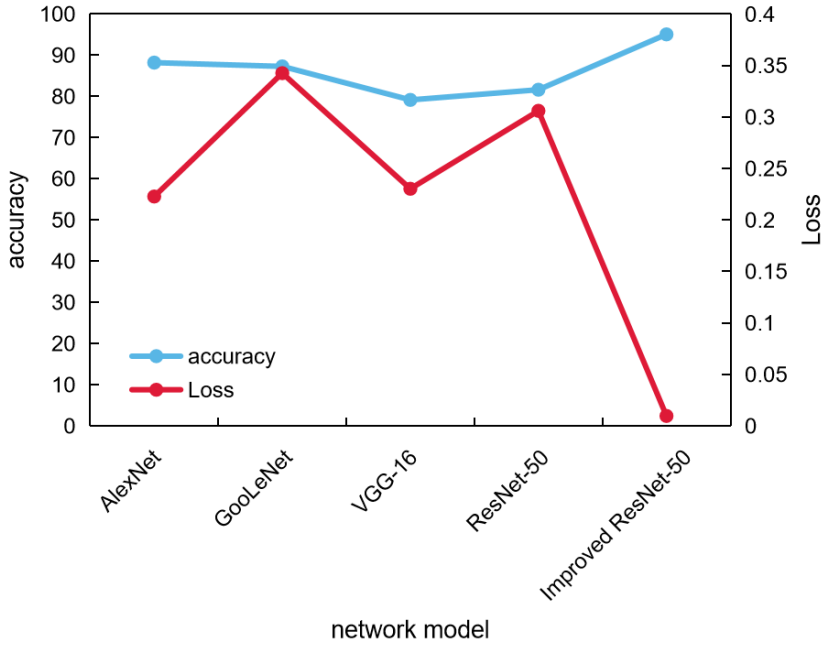

Figure 3 Network comparison result on data set

In the experiment, the battery and cans are classified by inductive sensor. The recognition rate of battery and cans can reach almost 100%, and the recognition speed is very fast. Although image recognition can identify a variety of garbage, it is easily affected by the external environment, which makes the accuracy far less than that of material recognition. The accuracy test results are shown in Table 1:

Table 1 Accuracy test results

Garbage types	Recyclable waste	Kitchen waste	hazardous waste	other waste
Release times	200	200	200	200
Accurate identification times	191	187	200	179
Accuracy/%	94.5	93.5	100	89.5

From the experimental results, it can be concluded that the harmful waste classification accuracy of image recognition can reach 100%, while the accuracy of kitchen waste and other garbage using image recognition is only 93.5% and 89.5%, and the accuracy of recycling garbage recognition can reach 94%.

An intelligent garbage classification system based on image recognition designed in this paper is in line with the development direction of intelligent machinery in the future. Practice has proved that this identification method is feasible, which helps people solve the problems of garbage classification, on the other hand, it can reduce the cost of garbage classification and improve the processing efficiency of garbage classification.

4. Conclusions

This paper designs an intelligent garbage classification system based on image recognition. The model is based on YOLOv4' s garbage detection in complex environment, and an improved ResNet50 network is constructed to train and identify the types of garbage. The experimental results show that the harmful waste classification accuracy rate of image recognition can reach 100%, the accuracy rate of kitchen waste and other garbage using image recognition is only 93.5% and 89.5%, and the accuracy rate of recycling garbage can reach 94%. Practice has proved that this identification method is feasible, which helps people to solve the problem of garbage classification,

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