Research on Image Classification of Recyclable Garbage Based on Transfer Learning

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Abstract

How to make use of domestic waste resources to the maximum, reduce the amount of domestic waste, and improve the quality of living environment via the classification and management of domestic waste is one of issues all countries in the world pay attention to. According to the unified standards established by the country, domestic waste is now broadly divided into four categories, namely recyclable wastes, kitchen wastes, harmful wastes and other wastes. Recyclable waste is garbage suitable for recycling and resource utilization, and mainly includes five categories: waste paper, plastic, glass, metal and cloth. Kitchen waste includes food wastes such as leftovers, bones, vegetable roots and leaves, and peels. Harmful waste are garbage that causes direct or potential harm to human health or the natural environment, including batteries, lamps, medicines, paints, etc. other wastes are garbage with relatively small harm and no value for reuse, such as construction garbage. With the development of deep learning technology, in order to identify and classify domestic waste simply and efficiently, this paper proposes a domestic waste classification and recognition model based on convolutional neural network, this model can automatically extract image features and reduce the complexity of calculation by conducting simple preprocessing on the image,. Experimental results show that convolutional neural network can overcome many shortcomings of traditional image classification algorithms and effectively improve the recognition accuracy of domestic waste.

Keywords

Waste Classification; Image Recognition.

1. Introduction

At present, China is increasing about 1 billion tons of domestic waste every year, if these waste cannot be effectively treated, it will not only cause huge waste of resources, but also pollute the environment, using traditional processes classify garbage, need a lot of manpower, material resources, and time, in addition, traditional garbage classification methods are limited, most garbage cannot be recycled and used, causing a lot of waste. Garbage classification can greatly reduce garbage damage to the environment, and turn garbage into treasures. With the development of deep learning technology, convolutional neural network can enhance image classification algorithms in the precision and speed; also bring new ideas for garbage classification, by combining deep learning and intelligent hardware, it will greatly facilitate people's garbage classification.

2. Application of Convolutional Neural Network in Domestic Waste Classification

As a deep learning branch, convolutional neural networks can divide a full image into many small parts, extract the features in each small parts, and then bring the features of these small parts together, and then complete the image recognition, convolutional neural network include network structure techniques of deep hidden layers, it has the expression ability and feature learning level that traditional control technologies do not have. Many experts and scholars have applied convolutional neural network into domestic waste classification. Huang Huiling conducted research on the color extraction and classification of domestic waste, used the K mean conduct recognition of domestic waste. Wu

Jian conducted research on domestic waste recognition based on computer visual only model simulation, no recognition rate. Wu Bicheng used convolutional neural networks to model domestic waste, however, he did not take into account convolutional neural network deployment in recognition speed of hardware, and he didn't come up with a way to make the hardware work efficiently. In allusion to the above problems, this paper designed and continuously optimized convolutional neural network, designed intelligent dustbin, built cloud servers, and achieve the efficient garbage classification system. The results show that the system is stable, and the neural network is applied to the system and reach high recognition accuracy.

3. System Design

The system realizes functions such as the detection of garbage drop, the transmission of garbage images, and the judgment of garbage type via the combination of software modules, hardware modules, and communication modules. The hardware module integrates functions such as the detection of garbage drop, the image collection of garbage, the sorting and disposal of garbage, and the monitoring of overflow degree. The software module uses the convolutional neural network algorithm to identify and classify the waste image information. The communication module realizes the information transmission in the hardware through the socket communication protocol, and realizes the information exchange between the hardware and the host through the http protocol. Moreover, the system has also designed a small program that can be connected to the server, which can take pictures through mobile phones and upload the photos to the system server; the system server can feed back garbage classification information to the small program, the small program also designs an area management function. The classification status, garbage image information, and overflow status of the intelligent classification dustbin can also be reported to the server in real time, it is convenient for viewing by the small program. The functional structure diagram of this system is shown in Fig.1.

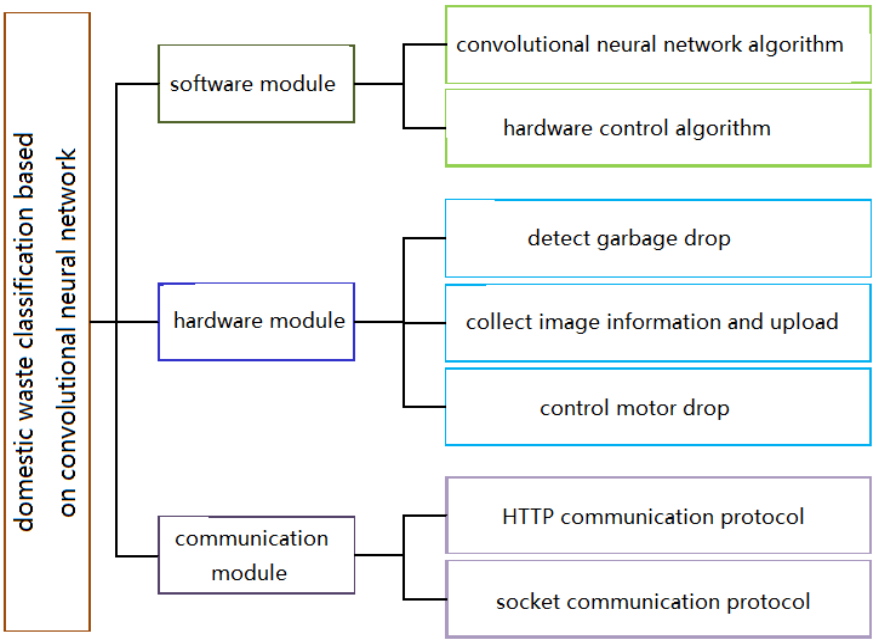

Fig. 1 Functional structure of intelligent domestic waste classification system

4. The Hardware Module Design of the System

The hardware design uses Raspberry Pi as the central control board of the system (collect image information through the camera, it requires Raspberry Pi as the central control board of the system), cooperate with the corresponding expansion board and the corresponding sensor. The system block diagram of concrete hardware design is shown as in Fig. 2.

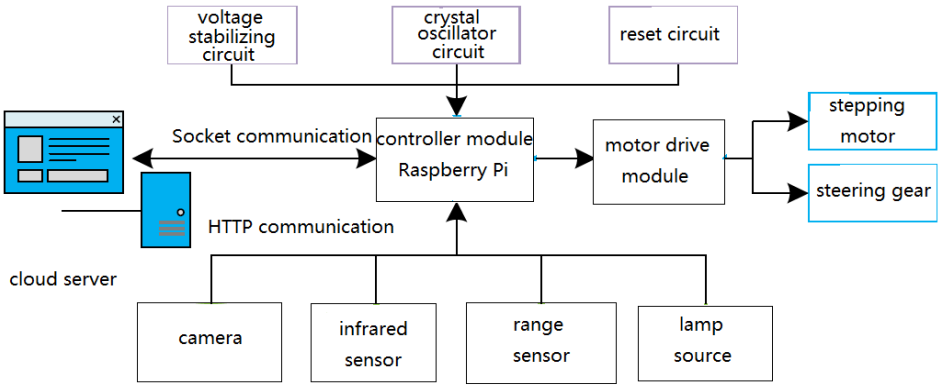

Fig. 2 Block diagram of the hardware design system

4.1 Hardware module design of system

The specific workflows are: the infrared sensor senses the garbage drop action and turns on the light source on the upper part of the dustbin; when the drop is over, the camera collects garbage images and transmits them to the cloud server through the Raspberry Pi development board through the Socket communication protocol; the cloud server uses the built-in convolutional neural network algorithm to identify and classify garbage, and feeds the results back to the Raspberry Pi control board; according to the feedback information, the Raspberry Pi controls the stepper motor and the steering gear to rotate by controlling the motor drive module, so the garbage can be placed in the correct partition, remember the grid area where the garbage is located, record the current overflow degree of garbage types, through the distance sensor, upload the overflow level information to the cloud server through the Raspberry Pi control module, the server can transmit the image information, the overflow degree, and the classification status to the mobile small program in real time. Regional administrators can learn about related information of garbage classification in dustbin in real time.

4.2 Communication module design of system

4.2.1 Communication interface design of Socket

When the infrared sensor detects that someone throws garbage, the camera collects image information in real time and informs the server through the socket client, the image collection information is sent to the cloud server running the convolutional neural network model. The classification result is generated, and the classification result is sent to the socket customer service terminal through the socket server and completes a socket communication, and then the Raspberry Pi controls the corresponding hardware according to the feedback result and completes the corresponding classification action.

4.2.2 HTTP communication interface design

The first http communication occurred in the hardware platform. The image information captured by the camera needs to be uploaded to the server through the http protocol for recognition, and the recognition results are fed back to the hardware platform in the form of mark; the second http communication occurs in the statistics stage of small program. The cloud server sends garbage images and garbage overflow information to the small program client through the http protocol; so that the small program users can understand the data of the dustbin can in real time. The structure diagram of the communication module is shown in Fig.3.

4.3 Software module design of the system

Convolutional neural network is a feed-forward neural network, which is a deep structured network [7]. Efficient convolutional neural network algorithm can improve the recognition rate of the system. This system uses inception V3 convolutional neural network, one of its characteristics is to decompose a large network into multiple small networks. The decomposition principle is shown in Fig.4. As shown in Fig.4, by decomposing multiple smaller convolutions, the model training speed is

faster. The inception is modified into a network for garbage recognition through the parameter transfer learning method. The convolutional network includes 4 convolution modules and 10 mixing layers. The parameters are shown in Table 1.

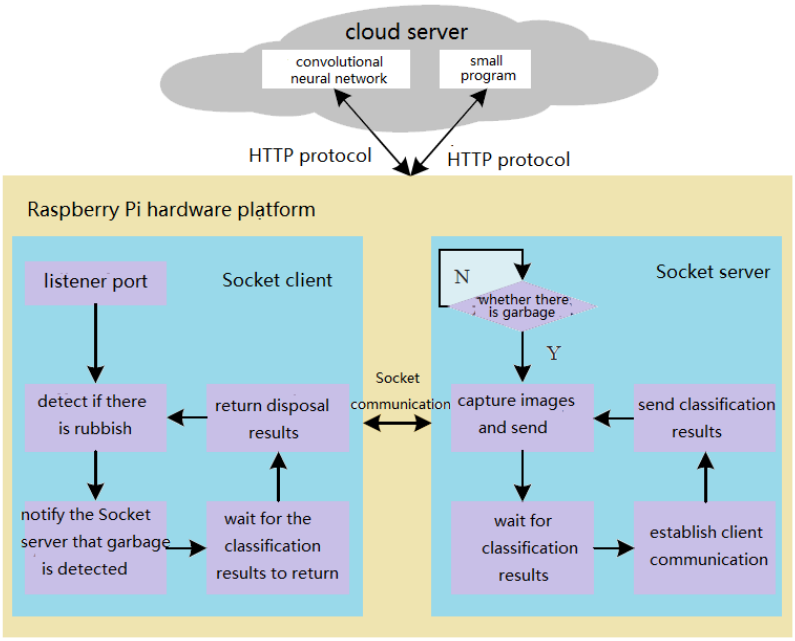

Fig. 3 Structure diagram of communication module

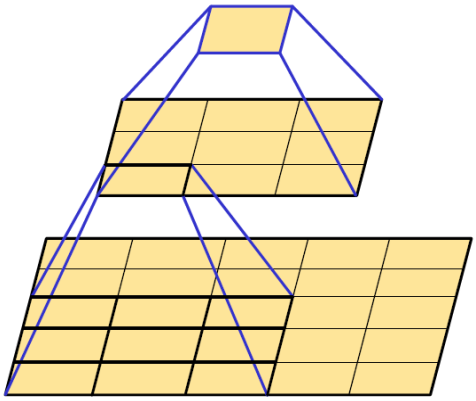

Fig. 4 Decomposition principle

Table 1. Parameters of convolutional network model

network type	step size	input size
conv	3×3/2	299×299×39
conv	3×3/1	149×149×32
conv padde	3×3/2	147×147×32
pool	3×3/2	147×147×64
conv	3×3/2	73×73×64
conv	3×3/2	71×71×80
conv	3×3/2	35×35×192
3×inception	-	35×35×228
5×inception	-	17×17×80
2×inception	-	8×8×1280
pool	8×8	8×8×2048
linar	logits	1×1×2048
softmax	classifier	1×1×m

Among them, m is the type of data set. In this paper, the garbage recognition convolutional network has 47 layers, including input layer, convolution layer, pooling layer, fully connected layer and Softmax output layer. The garbage recognition image model is shown in Fig.5.

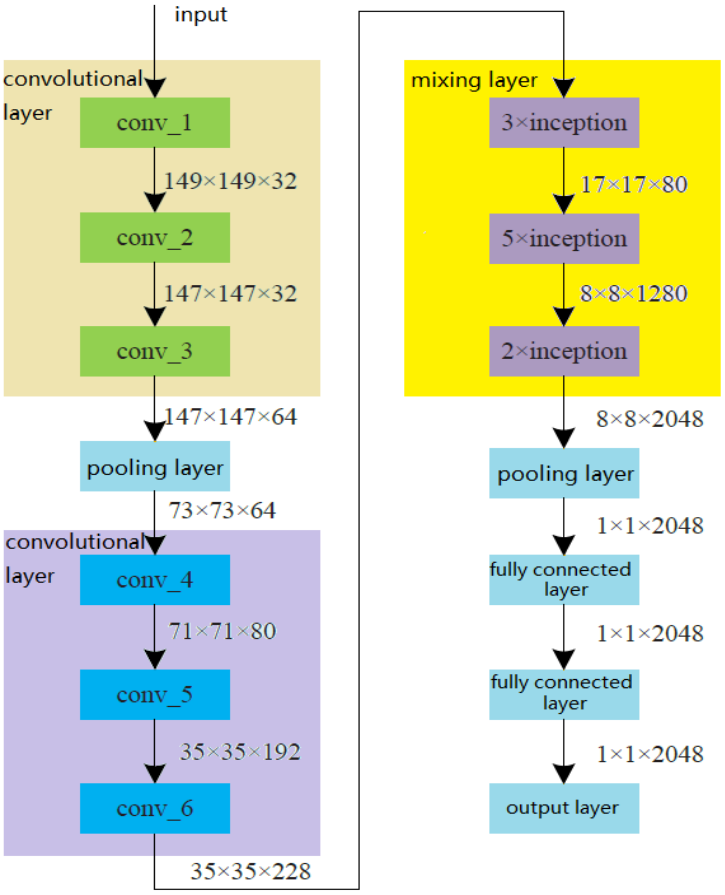

Fig. 5 The garbage recognition image model

After ensuring the recognition rate of the neural network algorithm, we also verified whether the entire system can work continuously, quickly and accurately. By continuous inputting garbage in the system, we observed that when the recognition is accurate, the hardware can accurately put the garbage into the corresponding partition, and accurately upload information to the small program via the cloud server.

5. Conclusion

This paper introduces an intelligent domestic waste classification system based on convolutional neural network, which can achieve high recognition rate of daily garbage. Moreover, the various data of domestic waste classification can be displayed on the small program in real time via the cloud server; it is convenient for mini program users to understand the situation of the regional dustbin, collection type, etc. The system integrates intelligent hardware and suitable communication modules, and has the advantages of low cost, convenient deployment, use, and update.

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