Optimal design of intelligent garbage classification system based on expert system

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Abstract: In order to realize the effective recycling of renewable resources, China has carried out compulsory classification of garbage. However, when people throw away garbage, they are faced with the problem of classification and identification. In order to facilitate users to classify and throw garbage. Expert system is also different from general database system and knowledge base system. What is stored in the expert system is not the answer, but the ability and knowledge of reasoning. In this paper, the optimization design of intelligent garbage classification system based on expert system is studied. The expert system is combined with ANN(artificial neural network), and multi-layer neural network is used to form the expert system. The learning algorithm takes all the neural offset values as the adjustment objects of the learning algorithm, thus improving the mapping ability of the whole network and speeding up the learning speed without increasing the number of neural network layers. The test shows that the system can automatically classify the common garbage in life.

1. Introduction

Under the background of "great cycle", with the rapid development of social economy and the improvement of people's living standards, the consumption of garbage is also increasing rapidly. In order to realize the effective recycling of renewable resources, the Chinese government has forced the classification of domestic garbage, but in life, it is difficult for people to classify and identify domestic garbage. In order to facilitate users to put garbage in classification. With the development of machine vision technology, a solution has been obtained [1]. The concept of deep learning was proposed, and algorithms such as CNN (Convolutional Neural Network) and RNN (recirculating neural network) were promoted and applied. After training, the machine can independently establish recognition logic, greatly improving the accuracy of image recognition [2-3].

The garbage sorting system is a service to replace manual garbage sorting. Combined with the application of AI technology, the signal processing of visual sensors and the application of deployment identification AI technology, it has gradually developed from providing images to perceptual learning, and combined with robot technology to realize automation, efficiency and intelligence of garbage sorting. It is not difficult to predict that with the popularization of AI technology and robotics, garbage sorting technology will further develop.

2. Overview of expert system

In AI research, expert systems have always been a hot topic. It is an intelligent computer programming system that contains a large amount of expert level knowledge and experience in a certain field, and can utilize the knowledge and problem-solving methods of human experts to solve problems in that field [4]. Now it is generally defined that the so-called expert system is a computer system network that uses the knowledge of human experts in a specific field stored in computers to solve practical problems that used to be solved by human experts.

Expert system is also different from general database system and knowledge base system. What is stored in the expert system is not the answer, but the ability and knowledge of reasoning [5]. The development of expert system is suitable for the tasks of diagnosis, interpretation, monitoring, prediction, planning and design, which have no recognized theory and method, inaccurate data or

incomplete information, shortage of human experts or very expensive expertise. In addition, experts in different fields may use different methods and means to solve the same problem, even contradictory. Sometimes the "knowledge" of experts in solving problems may not be good, or even wrong. This brings difficulties to knowledge acquisition itself.

3. System design

3.1. Master design

The intelligent sorting system of domestic waste consists of two parts: the target identification unit and the sorting control unit. The specific goal is to design a set of intelligent sorting robot system to complete the efficient recycling of bottles [6]. The use environment of the system is an intelligent domestic waste sorting workshop, and the target is identified, captured and sorted on the garbage conveyor belt. In order to ensure the rapid grasping of the garbage to be sorted, the position and probability of the object to be sorted are considered to be random, so the mature industrial robot teaching method can not be used to control the robot, and the control design needs to be optimized. At the same time, in order to ensure effective grasping, the gripper needs to be optimized.

According to the requirements of the project and the input conditions of the garbage disposal site, the sorting targets have been set as high-value recycling targets, such as glass bottles and plastic bottles, which are not conducive to natural decomposition and are difficult to be sorted by magnetic attraction and vibration screening. Therefore, an automatic sorting scheme based on general industrial robotic arms and visual inspection methods is designed.

The research of ANN(artificial neural network) has been paid more and more attention in recent years, and it has many successful applications in the fields of pattern recognition, prediction and optimization design. At present, most of the expert systems used in the field of optimization design belong to the traditional symbol-based reasoning system. This kind of complex problem will produce a combined explosion of computation only by traditional means such as serial logic and symbol processing [7-8]. In addition, it is difficult for this kind of expert system to learn new knowledge.

For this reason, this paper combines expert system with ANN, adopts multi-layer neural network to form expert system, trains ANN with existing examples in actual engineering product design, and uses BP algorithm to learn examples, thus constructing the nonlinear mapping relationship between input and output. At the same time, taking the displacement of all neurons as the adjustment index, the mapping performance of the whole network is improved, the learning speed of the network is improved, and the learning efficiency of the network is improved. Then, taking the expert system as the core, an intelligent garbage classification system is constructed.
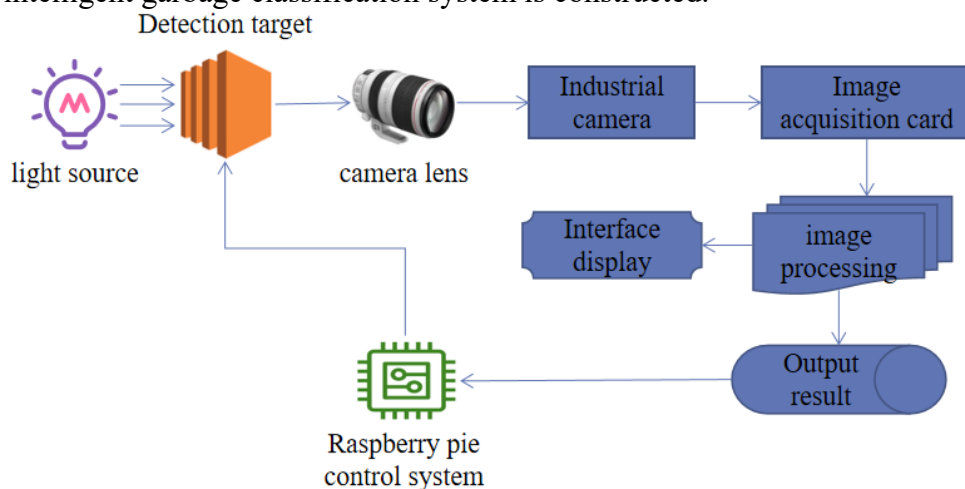

Figure 1 Overall block diagram of garbage intelligent classification system based on expert system

The information acquisition and display part comprises a camera, a display screen, an ultrasonic sensor and a photoelectric transducer, wherein the camera is used for acquiring the information of

garbage images to be identified; The information processing and control part consists of Raspberry Pi and single chip microcomputer; The mechanical structure consists of a motor and a reduction gear set. The sensor enables Raspberry Pi to start collecting garbage images and classify them [9]. Finally, the Raspberry Pi transmits the classification information to the single chip microcomputer through serial communication to control the motor to work and complete the garbage throwing task.

3.2. Control circuit

According to the design requirements of the system, the development board used must include an image receiving end, which can be connected to the camera to obtain the pictures taken by the camera; Comprises an image processing unit, which can process the collected images and identify the collected images; Raspberry Pi 4B+64bit, 1.4 GHz, 4-core, Videocore. IV architecture GPU, camera serial port and other characteristics fully meet the requirements of the system, so 4B+ is selected as the hardware platform of the system. The collected geographic location information and capacity information data are uploaded to the database through the wireless network, and viewed through the developed APP, which is convenient for the staff to manage and process accordingly.

3.3. Visual processing function

It is convenient to extract the target object directly from the multi-valued digital image by setting the threshold to divide the image into pixel groups. Then, the holes are filled to connect the pixel groups of the target object into a whole, so as to prevent the features of the target object from being filtered out. Finally, particle filtering is used to select the range according to the pixel area of the target object to filter out the interference. The obtained binary image and gray image are masked to realize image preprocessing [10].

The garbage images collected by the camera of the garbage identification module need to be detected and identified. In order to achieve better economy, real-time performance and identification accuracy, the SY003HD camera is selected for image acquisition, with a resolution of 1980 *1080 and a frame rate of 60. The USB interface of the camera is connected with Jetson Nano development board to collect garbage images, and the purpose of classification is achieved through YOLOv4 algorithm.

4. Algorithm design

This system identifies different garbage objects and extracts their feature quantities, so that the types of garbage can be judged according to the feature quantities. In this system, a large number of pictures are needed to train image objects to get a training set. That is, a process of taking multiple photos of garbage and then using feature extraction algorithm to extract its features, which is similar to the process of judging the type of garbage by human beings, and comparing objects with reference objects to analyze their credibility.

Expert system is a formal symbolic description of knowledge, so its knowledge representation is explicit and descriptive, while neural network is implicit. It uses the topological structure of the network to express the relationship between nodes, and the interconnection strength between nodes indicates the strength of the interaction between items. The way for ANN to acquire knowledge is to learn directly from numerical examples or to transform the special cases of knowledge obtained by traditional AI technology into distributed storage of neural networks. Learning is within the system and can become a very active part. For the "fragility" of expert system, that is, knowledge and experience are not comprehensive, there is nothing to be done when encountering unsolved problems. The problem of knowledge updating can be solved by using the self-learning function of neural network to enrich the knowledge base.

The goal of neural network expert system is to realize the automation of knowledge acquisition by using the learning function of neural network, large-scale parallel distributed processing function, continuous-time nonlinear dynamics and global collective action. The neural network expert system $NNES$ can be defined as a quadruple:

$$NNES = (KB, NN, EX, IN) \tag{1}$$

Where KB is knowledge base, NN is ANN, EX is output interpreter and IN is man-machine interface.

$$KB = EB \cup IB \tag{2}$$

Where $EB = R \cup S$ is the external knowledge base, $R = \{r_1, \cdots, r_n\}$ is the rule set and $S = \{s_1, \cdots, s_n\}$ is the template instance set, where the element s_1 is the attribute of the input template, $IB = W \cup L$ is the internal knowledge base, and W, L is the weight set and connection set of the neural network respectively.

$$EX = (NO, EC, fe) \tag{3}$$

Where NO is the neural network output set, $NO \in \{0,1\}$; EC is the expert system action set, $EC \in R$; fe is a function, $fe : NO \rightarrow EC$.

Different from the traditional computer local information processing method, neural network represents specific concepts and knowledge through the interconnection of a large number of neurons and the distribution of weights. In this process, the remaining solutions are excluded, and a specific solution is obtained by comparing the output node with its own signal. Deviation from the learning sample can be allowed in the neural network, that is, the input mode is close to the output mode of the learning sample, and the output will also be close to the output mode of the learning sample, which makes the neural network expert system have associative memory ability.

5. Result analysis

There are two sources of data set used in this experiment: one is to capture network images through Python web crawler code; Second, I took some pictures of garbage, and used OpenCV to enhance the data of the images, expanding the number of data sets by four times. Finally, there are 15000 pictures in the data set, which is divided into training set, test set and verification set according to the ratio of 7:2:1.

In order to verify the recognition performance of the classification model, the collected garbage pictures are input into the trained model in turn, and 50 different garbage pictures are randomly extracted from the data set. The recognition speed of the test model for garbage pictures is shown in Figure 2.
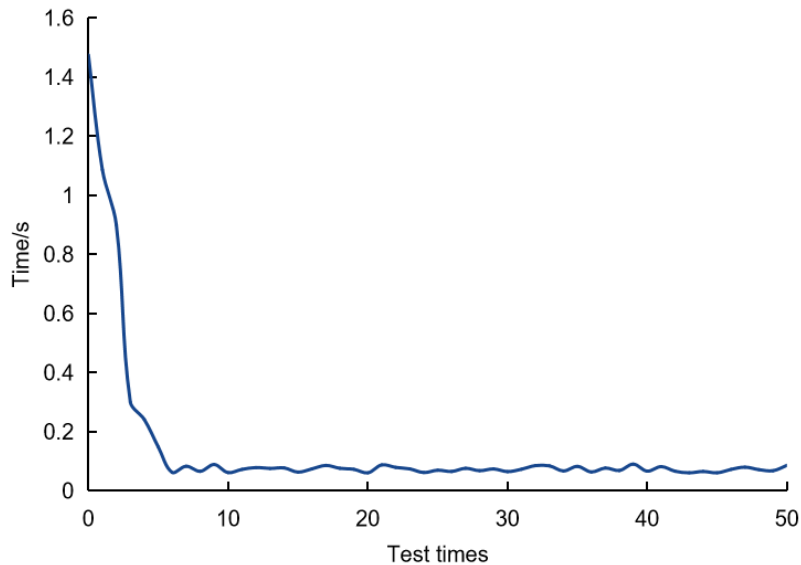

Figure 2 Model test results

The garbage classification model is deployed to Raspberry Pi 4B, and the corresponding running environment is established. Firstly, the garbage identification speed of the model is tested. In the same way, 50 different types of garbage pictures are input into the model running on the Raspberry Pi in turn, and its identification speed is shown in Figure 3.
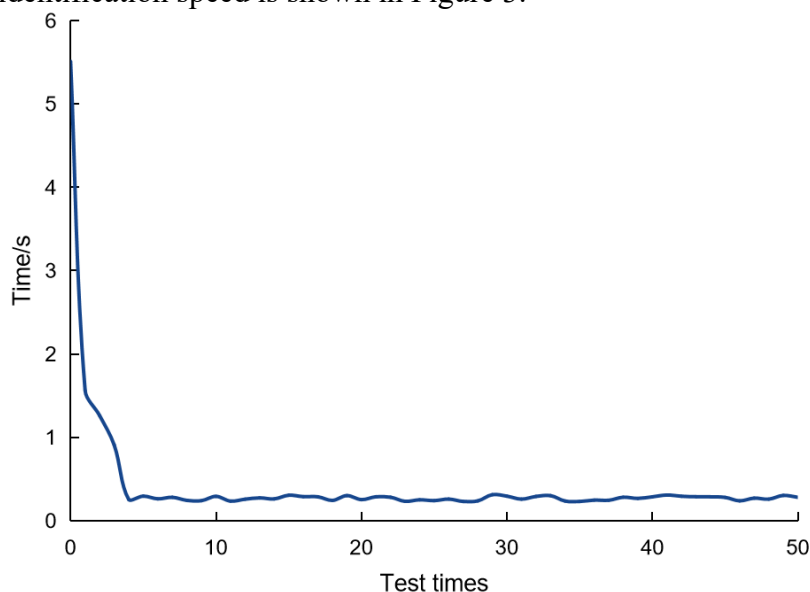

Figure 3 Running model test of Raspberry Pi

Because it can be accelerated by GPU on personal computer, the recognition process is slow compared with personal computer. Finally, the feasibility of the device is verified by testing batteries and beverage bottles. It can be seen that the system can accurately identify the types of garbage, the mechanical structure of the system can run normally and correctly, the driving device can act efficiently, and the performance of the system is very good, which can complete the garbage classification work well.

6. Conclusions

Expert system is the most active and valued topic in the field of AI application at present. Expert system is an intelligent computer program system, which includes knowledge and experience of a certain expert level in a specific field, and it can apply people's professional knowledge and problem solving methods to this field. Then, the expert system is used to realize the intelligent classification of daily life garbage. The system can accurately identify the types of garbage, the mechanical structure of the system can run normally and correctly, the driving device can act effectively, the system works well and can complete the garbage sorting work well.

References

[1] Kang Z, Yang J, Li G, et al. An Automatic Garbage Classification System Based on Deep Learning[J]. IEEE Access, 2020, (99):1-1.

[2] Li J. Integrated design of household garbage classification, compression and packaging equipment[J]. Academic Journal of Manufacturing Engineering, 2017, 15(4):75-80.

[3] Li X, Bi F, Han Z, et al. Garbage source classification performance, impact factor, and

management strategy in rural areas of China: A case study in Hangzhou[J]. Waste Management, 2019, 89(8):313-321.

[4] Shi C, Xia R, Wang L. A Novel Multi-Branch Channel Expansion Network for Garbage Image Classification[J]. IEEE Access, 2020, (99):1-1.

[5] Ma Hanxu, Liu Zhongfu, Liu Ziyang, et al. Design of an intelligent garbage classification and treatment system powered by solar energy [J]. Automation and Instrumentation, 2020, 35 (8): 6.

[6] Qin Guosen, Luo Wei, Jiang Jiansheng, et al. Shenzhen Yantian District Domestic Waste Classification Full Chain Intelligent Management System [J]. Environmental Health Engineering, 2022, 30 (6): 3.

[7] Kangzhuang, Yang Jie, Guo Haoqi. Design of a garbage automatic classification system based on machine vision [J]. Journal of Zhejiang University: Engineering Edition, 2020, 54 (7): 10.

[8] Shen Lei, Li Minglin. Optimization Design and Strength Analysis of the Lifting Mechanism of a Mobile Split Garbage Compression Station [J]. Mechanical Manufacturing and Automation, 2018, 47 (1): 5.

[9] Ma Xinling, Guo Zhaoyang, Le Qizhong, et al. Intelligent classification trash bin with a combination of multiple recognition methods [J]. Machinery and Electronics, 2020 (012): 038.

[10] Wan Lixia, Long Wei, Zhao Xiongfeng, etc. Optimization design of a multi-dimensional optical system for five categories of white blood cells [J]. China Laser, 2015 (7): 7.