ISSN: 2664-9640

Machine Vision Enhanced Intelligent IOT Waste Sorting and Disposal System

Yilin Wang, Mu Yang, Di Cheng, Qingqing Zhang, Yunfei Zhao

Henan University of Science and Technology, Luoyang Henan 471023, China

Abstract

Machine vision-enhanced intelligent IOT garbage classification and disposal system is a composite public infrastructure integrating many functions such as intelligent classification, garbage collection, mobile communication, urban management, environmental protection, and information interaction, etc. It functionalizes, platforms, and resources garbage cans, efficiently utilizes urban land and space resources, and is an important grip to promote the construction of green and smart city infrastructure. This project garbage sorting device uses machine learning integrated model stacking method to train the neural network, which greatly improves the recognition accuracy. The hardware and software side sends and receives data through MQTT protocol via cloud server, which helps users to release the shackle of only being able to control the device at home, making it possible for users to monitor the device anytime and anywhere, greatly facilitating the daily use of users and the debugging of development technicians.

Keywords

Smart city; integrated model; neural network.

1. Introduction

Nowadays, China's economy is in the stage of rapid development, the number of people is increasing, the consumption level is improving, people consume a lot of resources, mass production, a lot of consumption, and a lot of garbage, so we should carry out the construction of domestic garbage classification system based on the scientific and reasonable classification of domestic garbage [1]. At present, China mainly relies on manual garbage sorting, people need to judge by themselves what kind of garbage belongs to, and then put it into the corresponding garbage cans, the manual sorting has been effective to a certain extent, but it is not a long-term solution, because it requires a lot of time, manpower and material resources. In order to facilitate and save time, the intelligent garbage sorting device was born, such a device can play a major role in the construction of a resource-saving and environment-friendly society, which is conducive to the further improvement of the quality of China's new urbanization and ecological civilization construction level.

2. The design of system hardware

For the overall design of this garbage sorting and disposal system, starting from the hardware, it mainly consists of machine vision recognition part, new garbage dropping mechanism, infrared distance measuring sensor, LCD screen, ESP8266 module to realize the functions of automatic garbage recognition, dropping, location information and full information to the cloud server. This garbage sorting and disposal system is using STM32F407 MCU as the main control chip to communicate with each other module serially.

ISSN: 2664-9640

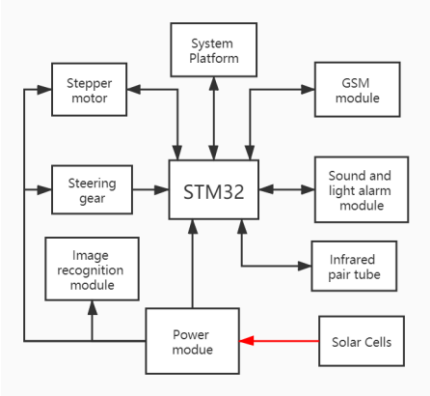

Figure 1 System frame diagram

2.1. Main module circuit introduction

2.1.1Main control part

The STM32F407 microcontroller is used for the main control, and then drives OpenMv and each module for serial communication. STM32F407 is a high-performance microcontroller with integrated new DSP and FPU instructions, and the high speed performance of 168MHz enhances the execution speed and code efficiency of control algorithms, and enables fast product development and digital signal controller applications to a new levels of product development and digital signal controller applications.

2.1.2 Identification Module

Using the low-power, programmable camera openMV4, garbage can be identified through the MicroPython language [2]. Python's advanced data structures make it easier to process complex outputs in the machine vision algorithm, return the identified results and transmit them to the master via the serial port.

2.1.3 Infrared sensor module

The system is designed with full-load alarm function, using infrared tube to judge the height of the garbage contained, when the stacking height exceeds the threshold value will trigger the alarm buzzer to prompt the active replacement of garbage bags to achieve full-load alarm. The principle and structure of infrared induction distance measurement is relatively simple and the distance measurement is long and the power consumption is small.

2.1.4 Display module

LCD color screen has the advantages of low voltage and micro power consumption, high resolution and high contrast, so LCD color screen is chosen to broadcast the propaganda video cycle and display the quantity and the order of putting out, the working status of the garbage can, the full situation and the type of garbage put out on the top.

2.1.5 ESP8266 module

This system uses ESP8266 module as Wi-Fi IoT module, which has the advantages of good ecology, strong compatibility and low price. The module is equipped with PCB on-board antenna, and has 32-bit processor architecture, supports STA, AP, STA+AP three working modes, supports IPv4, TCP/UDP/HTTP/MQTT network protocols. ESP8266 module is used as a hotspot to achieve direct communication between cell phone or computer and the module, and realize wireless control of LAN.

2.2. Working principle

The intelligent classification system uses the OpenMv4 plus camera to construct a neural network for garbage recognition and to realize the intelligent discrimination, classification and storage of four types of municipal waste. The intelligent garbage cans will control the rotation of the tiller on the equipment to realize the garbage placement through data processing and

ISSN: 2664-9640

analysis after the recognition and classification [3]. When the garbage is put in, the type and quantity of garbage put in will be displayed on the screen. There are four infrared detection tubes inside the device to detect the height of the garbage, when the garbage is detected to exceed the set full load position the module light will change and the LCD screen will show the number of garbage cans will be in full load status, and the ESP8266 module will be used as a hotspot to achieve direct communication between cell phone or computer and the module, and the full load information will be transmitted to the cloud server for alarm, prompting the need to replace the garbage bag, to achieve regular and fixed time [4]. It can collect the separated garbage efficiently and avoid the overflow of garbage accumulation.

3. Introduction of Stacking Algorithm

This project improves the processing algorithm of machine vision convolutional neural networks. A convolutional neural network is a network of visual processing algorithms that can be trained supervised and unsupervised, modeled after the mechanisms of biological visual reception and visual cognition. The underlying network models currently in use are deep convolutional neural networks, which differ from conventional neural networks in that the neurons in each layer of a convolutional neural network are arranged in 3 dimensions: width, height, and depth. Convolutional neural network is a multilayer perceptron neural network combining input layer, convolutional layer, pooling layer, fully connected layer and output layer, each layer is composed of feature mapping (i.e., multiple two-dimensional planes), and the neurons in each plane are multiple and independent. The mapping process from local to global image relies on different convolutional kernels to extract local features of the image and combine the local features into higher-level global features. Multi-layer perception means that the network state is fully connected, i.e., the neurons in each layer are fully connected to all neurons in its next layer, and this state is easy to overfit the data.

If we want to continuously improve the accuracy of intelligent recognition, the only way to control it is to continuously increase the depth of a single network model, but this will lead to the disadvantage that it is difficult to converge when training, so our design takes the situation into account and adopts the method of multi-model fusion to improve the accuracy of recognition and further optimize the efficiency of recognition, so as to obtain high-quality intelligent recognition detection effect.

The process of model fusion is also called integrated learning process, the main design idea of the process is: first generate multiple primary learners by corresponding rules, then use the primary learners to predict the test set, the output value will be used as the input value for the next stage of training, and then the final label will be used as the output value to train the secondary learners, such process will This process will lead to more accurate results. The fusion of multiple models will compensate the deficiencies of a single model to a certain extent, thus achieving better intelligent classification results than training a single model [5].

In this project, the integrated learning approach is based on Stacking, which is a hierarchical model integration framework. The first layer of the model is composed of multiple base learners with the original training set as input, and the second layer of the model is trained by adding the output of the first layer of learners as features to the training set, so that the complete Stacking model is obtained.

ISSN: 2664-9640

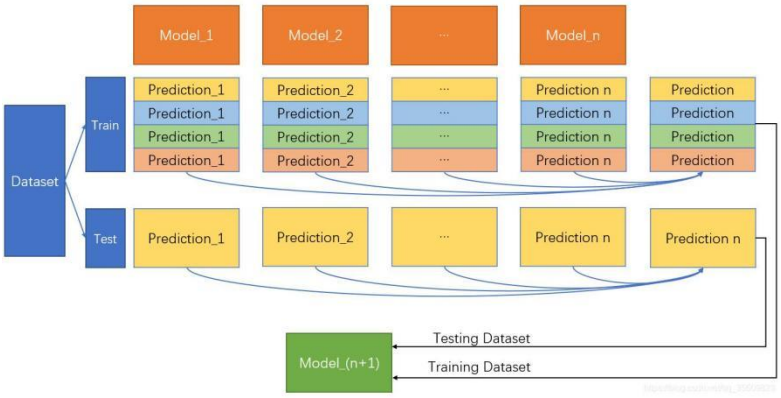

Figure 2 Schematic diagram of the Stacking algorithm

The following is the pseudo code of the algorithm.

Input:Training dataset $D = \{(x_1, y_1),\ (x_1, y_2), \cdots,\ (x_m, y_m)\}$;

Secondary classifier$L_1, L_2, \cdots, L_T$; Meta-learner$L$

Process 1:Learn secondary classifiers $For\ t_{=1,2,\cdots,T}$: $hh_t = L_t(D)\ End$;

Process 2:Construct new dataset for prediction

$For\ t_{=1,2,\cdots,m}$: $X_t' = \{h_1(x_i),\ h_2(x_i), \cdots, h_T(x_i)\}\ D_h = \{x_i, y_i\}$ End

Process 3:Learn meta-classifier

Learning $H(D_h)$;

Output:Integrated learning classifier$H$

Integrated model stack_model advantage

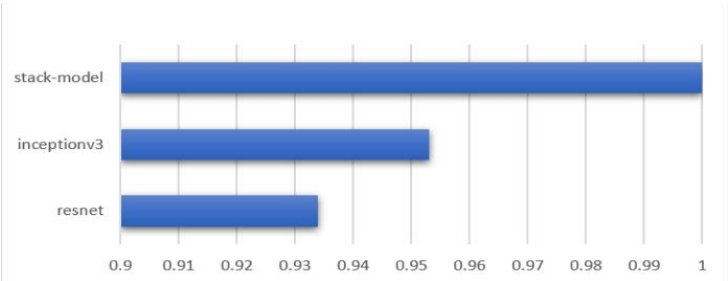

Figure 3 Comparison of accuracy of different models

4. Software programming

4.1. Serial communication function

The microcontroller first detects that the serial port status bit is cleared to zero and a delay of 3 seconds is required to enter the serial port receive interrupt. The role of the delay is to make OpemMv identify the output to reach stability and then proceed to receive the data. When USART_RX_STA&0x8000=0, the interrupt is entered. First get the length of data for this transfer, nest the for loop to send the receive cache to the data register and send it to the serial port. Use the sprintf function to convert the value into a string and call the LCD display function to display the transmitted individual characters. Determine when USART1->SR&0X40=0, this transmission ends and the receive status marker is set to zero and the column start address is set.

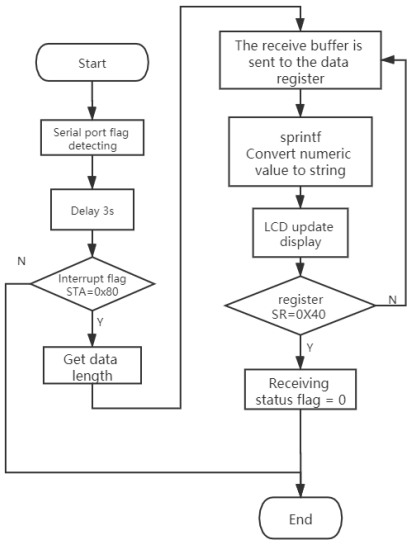

Figure 4 Serial communication flow chart

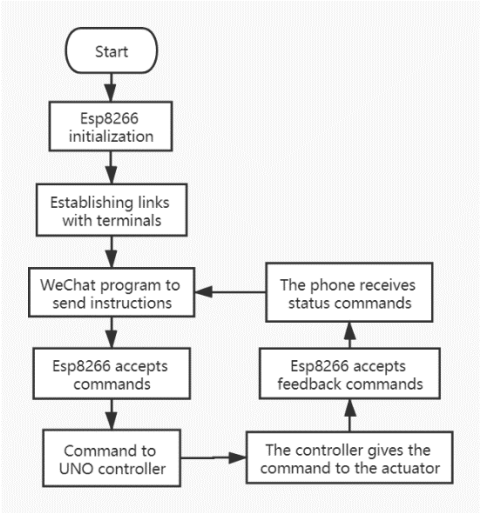

Figure 5 Wi-Fi IoT system control flow chart

4.2. Garbage full alarm program

After each completion of the garbage drop, it is necessary to judge the status of the garbage in the four small buckets. The infrared transmitter tube continuously emits infrared signal of specific frequency, when the detection signal meets the obstacle, the receiver tube receives the reflected infrared light, and after processing by comparator circuit, the output indicator lights up and outputs the digital signal. The microcontroller determines whether the garbage reaches the set overload value by detecting the level, and the detection distance can be adjusted by potentiometer knob.

4.3. Remote communication alarm program

The main board controls the ESP8266 module to connect to the network via WIFI, and the device side uploads data to DevPubTopic via TCP-based MQTT protocol and subscribes to the downlink command DevSubTopic to receive the downlink command. The server is selected from AliCloud ECS server. The upper computer uses WeChat applet. The user side subscribes to the device uplink data DevPubTopic through TCP-based MQTT protocol to get the data of the device and then sends commands to DevSubTopic. the ESP8266 module is used as a hotspot to realize direct communication between cell phones or computers and the module, thus realizing LAN wireless control. When the stacking height exceeds the threshold value, the full

ISSN: 2664-9640

information is transmitted to the cloud server for alarm through ESP8266 [6], prompting the need to replace the garbage bags, realizing the efficient collection of the sorted garbage at regular intervals and avoiding the overflow of garbage hoarding.

5. Physical test results and analysis

The base layer of stacking usually includes different learning algorithms, so the stacking ensemble is often heterogeneous, and the base layer used in our improved algorithm is the Resnet50, Inception V3 network structure.

```
resnet50:
15/15 [==============================] - 10s 656ms/step - loss: 4.5979e-04 - acc: 1.0000 - val_loss: 0.0393 - val_acc: 0.934
Found 75 images belonging to 6 classes.
test acc: 0.934


inceptionv3:

# 15/15 [==============================] - 26s 2s/step - loss: 0.0644 - acc: 0.9916 - val_loss: 0.1640 - val_acc: 0.9541
# Found 75 images belonging to 6 classes.
# test acc: 0.953125


stack_model:
63/63 [==============================] - 26s 413ms/step - loss: 0.0248 - acc: 0.9980 - val_loss: 0.0202 - val_acc: 1.0000
test acc: 1.0
```

Figure 6 Run results graph

It is clear from the graph of the run results that

The accuracy of the first Resnet model is 93.4%

The accuracy of the second inceptionv3 model is 95.3%.

The accuracy of the third integrated model is increased to 100% after stacking.

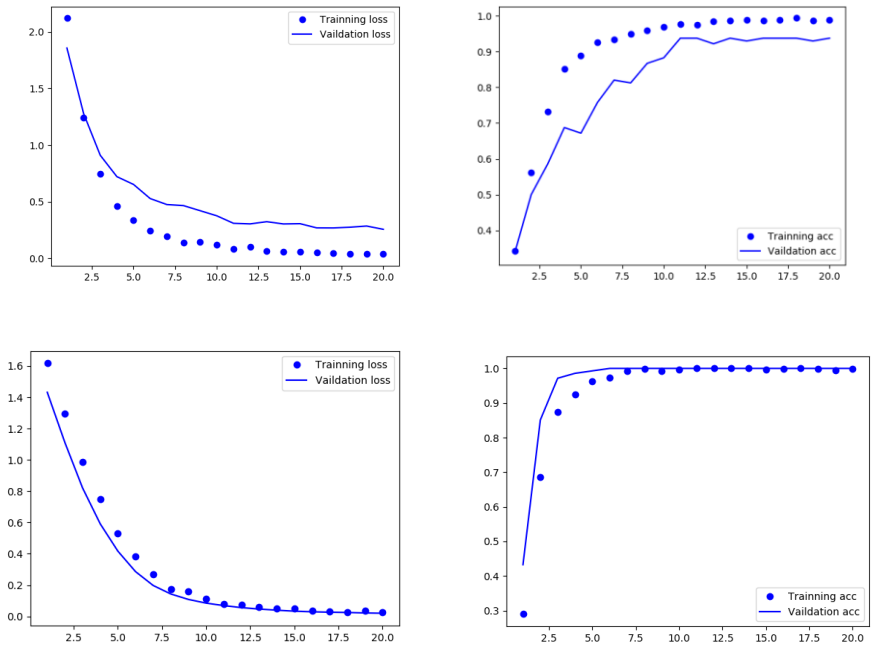

Figure 7Accuracy curve simulation comparison chart

From the above figure can be seen inceptionv3, Resnet model simulation out of the curve test accuracy and training accuracy difference is large, after the integration of the model stacking method for fusion, the accuracy has been greatly improved. Intelligent recognition of automatic placement speed. By its recognition accuracy is high, low latency ability can be completed in a few seconds to automatically identify the garbage put.

ISSN: 2664-9640

6. Conclusion

This paper introduces a machine vision enhanced intelligent IOT garbage sorting and disposal system, which effectively uses the advantages of the era of big data and is designed with the requirements of the ecological civilization of the times, taking into account various aspects such as intelligent sorting, garbage collection, and information interaction at the technical level. The system carries out innovative design of garbage dropping structure, which can facilitate garbage dropping as well as effectively improve the space utilization rate. It also improves the machine vision network processing algorithm in intelligent recognition, and through multiple big data entry and extraction, it continuously makes the recognition accuracy rate improve step by step, maximizing the problem of intelligent garbage recognition and classification.

Acknowledgements

National College Student Research and Training Program (SRTP) (s202010464039)，College Student Research and Training Program (SRTP) of Henan University of Science and Technology (2020076).

Resources

[1] Zhou J, et al. Practical guide to garbage classification[J]. Xinhua Monthly,2019(5).
[2] Dong M. Target Mark recognition algorithm based on machine learning and image processing [J]. Computer and Digital Engineering, 2016(12):2488-2492.
[3] Zhang Yong, Hao Weidong, Zhu Bo Xuanuan. Embedded welding robot based control system design [J]. Combined machine tools and automated processing technology,2017, 000(001): 89-91, 94.
[4] Zheng JH. Research on intelligent design and application of garbage cans [J]. Enterprise Technology Development (Academic Edition), 2019(1):72-73,76.
[5] Liu Yuanyuan, Zhao Xiqing. Color Prediction of Steel Surface Based on Stacking [J]. Computer Age,2020(08):65-68.
[6] Yang Xiaolei. Design and application of urban management cloud platform system in the context of smart city [J]. Electronic Technology and Software Engineering,2021(01):184-185.