Design of Vision Servo Sorting Robot System Based on SVM

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Abstract. Aiming at the problems of the traditional industrial waste disposal, such as heavy workload, low efficiency and poor safety, a single visual servo sorting robot based on SVM is designed. These include intelligent identification and classification systems, and wireless communication systems. The robot adopts a rectangular coordinate robot structure. After collecting picture information, the robot interacts with the upper computer. The SVM algorithm is used to identify and classify the waste material to realize autonomous sorting and transportation of waste material. When the system is applied in practice, it can effectively reduce labor input, improve recovery efficiency, and reduce production costs.

1. Introduction
China's factories have not paid enough attention to the classification and secondary utilization of production waste. The classification relies too much on labor, and there are engineering and technical problems such as large workload, low efficiency, and poor safety. This heavy workload cannot sort the reusable parts and items in factory production waste.

Vision Servo Sorting Robot System Based on SVM is designed. Based with the STM32F407 as the core board, the position information of the required items can be obtained through OPENMV, and the information can be sent to the upper computer through wireless communication. After the upper computer obtains the image, it recognizes the parts to be sorted through the SVM algorithm, and sends the action instruction to the single-chip computer after the recognition is completed. The single-chip computer controls the five-axis buffering robotic arm to grab the object[1]. The movable robot can effectively reduce the labor input in the waste sorting of the factory, reduce the labor cost and the possible harm to the human body caused by the waste.

2. Overall design of the sorting robot system
The mechanical structure part of the monocular vision servo sorting robot based on SVM uses a three-axis rectangular coordinate structure[1]. A five-axis buffering robot arm is arranged at the end of the z-axis. The system includes intelligent identification and classification functions and wireless communication functions. The overall flowchart of the system is shown in Figure 1.
2.1. Overall structure design of the sorting robot

The sorting robot is mainly divided into a mechanical module, a camera acquisition module, a sensor module, a control module, a wireless communication module, and an upper computer algorithm module. The specific mechanical design only needs to include the body structure of the trolley, a five-axis buffering robotic arm, a gimbal device and other auxiliary equipment.

The Mecanum wheels used in this system can enable the robot to rotate and perform translation and other operations in the factory without dead angles, while ensuring the stability of the vehicle body and the accuracy of camera acquisition. The camera and the five-axis buffering robot arm are placed on the gimbal to ensure no dead angles of 360 degrees. The control module is mainly composed of the main controller STM32F407, the drive circuit and the information acquisition circuit. The robot communicates with the host computer via Bluetooth, including the transmission of fault information and control instructions.

2.2. Composition of the sorting robot system

The visual target recognition system uses a fixed-focus monocular camera. Through the human-computer interaction interface in the host computer's main control program, various types of parameters of known types of reusable components are input and compared with the images obtained from OPENMV. Furthermore, the intelligent recognition algorithm based on SVM is used for binarization and other processing, and the result is finally obtained.

The sorting robot adopts the upper computer to control the operation mode of the lower computer. The system framework is shown in Figure 2. The host computer is located in the PC of the control center. The controller can view the sorting and identification process through the OpenMV IDE, and can also send instructions to the robot through the host computer. The core part of the sorting robot is the STM32 core controller, which is mainly responsible for data transmission and receiving instructions.

![Figure 1 Overall system flow chart](image1)

![Figure 2 Block diagram of sorting robot system based on STM32](image2)
3. Design of electrical control system of the sorting robot

The overall block diagram of the monocular vision servo sorting robot system based on SVM is shown in Figure 2. The electrical control system is mainly composed of STM32 control system and wireless communication system.

3.1. Control system based on STM32

In the selection of the core drive board of the sorting robot, STM32F407ZGT6 was selected as the microcontroller, which is a 32-bit MCU based on the Cortex-M4 core launched by ST (STMicroelectronics) in 2011[3]. The configuration of this chip is very powerful, the main frequency can be up to 168Mhz, and the resources are very rich, which can well meet the design requirements of the automatic truck system. Using the STM32 F407 chip as the control core of the sorting robot can improve system performance, reduce power consumption and cost.

In the sorting robot, two timer pins are used as two PWM signal outputs to control the motor. One timer pin outputs PWM signals to control the steering servo. In addition, the timer pins can be used as sensor input pins. Used to capture time signals.

3.2. Wireless communication system

During the operation of the system, the lower computer (automatic truck) sends real-time operating data to the upper computer, and can accept the instructions from the upper computer. When the robot needs human intervention during the sorting process, it can send control instructions to the lower computer through the upper computer.

HC-06 is selected as the Bluetooth module on the robot. The module uses the CSR BC4 + 8M FLASH scheme and a built-in RF antenna. With low power consumption, low cost, powerful features[3].

4. Design of visual recognition system for sorting robot

The visual recognition system of the sorting robot is divided into the visual servo control system and the part algorithm design based on SVM.

4.1. Visual servo system

The system includes image acquisition and display, image digital processing, servo mechanical control of linear switching between three threads. Image information is collected at regular intervals, and the collected signal is judged to be digitized according to the template in the database.

4.2. Part algorithm design based on SVM

In the relatively stable environment inside the factory, the camera is in a relatively static state to capture the waste picture, and the robot can offset the influence of the unstable external light by relighting the bright light on the recognition platform.

Classification, that is, through the NTH power of polynomial kernel function, will collect the training samples mapped to high-dimensional feature space, and then use the SVM algorithm in the sample in the feature space to find the characteristics of various samples and internal sample of database is the optimal separating hyperplane, it can represent the characteristics of the sample support vector set, in order to form a discriminant function. In the process of waste identification, the collected three-channel RGB image is converted into a single-channel gray image. Grayscale image pixel values are 0–255. If the intensity of background light changes, the pixel of the grayscale image will fluctuate greatly, so the binarization operation is carried out again [4]. Collected waste paper the coordinates of each point on the image of the area, the coordinates of the area into different objects and object selection, draw the object edge line, generated by the edge line inscribed rectangle, the rectangle find diagonal point after discretization, reusing the mapping relationship between matrix and the image coordinate and world coordinate mapping relationship [5]. By calibrating the camera system in advance, the size profile of the target fertilizer was measured. Finally, the difference algorithm is used
to collect the difference operation between the frame and the background frame. If the pixel value after the calculation exceeds the threshold value, the target object exists, and then the feature of the difference image is enhanced to achieve the target location. In order to ensure the accuracy, the closed operation was performed again to connect the large white area in the background difference result, eliminate the white noise in the small area, and enhance the image features. Formula (1) represents the current image frame, \( f_{mk}(x, y) \) Represents the background image frame. Figure 3 is the flowchart of the background difference algorithm to locate the target.

\[
E_k (x, y) = \left| f_k (x, y) - f_{mk} (x, y) \right|
\]

Figure 3 Image recognition flow chart

5. Conclusion
By controlling the sorting process, the industrial waste sorting robot has successfully distinguished 26 different shapes and types of waste, with the maximum absolute error of measurement <3 mm.

The size of the sample dataset used for training is shown in table 1. The experimental results show that the accuracy of the results trained by the SVM model is 99%, and the harmonic average of the accuracy rate and recall rate is close to 1, which can well solve the classification problem of screws, nuts, gloves and copper wire. At present, there are still many places in the market that need waste sorting, so the monocular visual servo sorting robot can be extended to sort all kinds of workpiece or materials, and can identify different sorting objects by processing the identifiable images [6].

| Name     | Total number of identifications | Effective entification number | Harmonic average |
|----------|---------------------------------|------------------------------|------------------|
| screw    | 100                             | 99                           | 0.99             |
| spike    | 100                             | 100                          | 1                |
| gloves   | 100                             | 99                           | 0.99             |
| copper   | 100                             | 99                           | 0.99             |
| wire     |                                 |                              |                  |

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