Smart image recognition system based on machine vision

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Abstract. This paper proposes an efficient and accurate method of two-dimensional code recognition for industrial actual projects, and develops a high-speed and batch two-dimensional code recognition system based on machine vision. Firstly, according to the position of the QR code in the target subspace, a method to locate the region of interest of each QR code by using geometric relationship and batch processing QR code is proposed. On this basis, Gaussian noise is added to simulate the possible noise in production practice, and the anti-noise ability of the system is evaluated. Finally, the relationship between system recognition rate and QR code movement speed is analyzed and the experimental results are compared. The experimental results show that the system can meet the requirement of real-time online detection.

Keywords: Machine vision; Bar code recognition; Linear array camera; Image processing.

1. introduction

The traditional barcode or two-dimensional code recognition system reads the barcode or two-dimensional code by hand-held code reader. The reading efficiency is often affected by the scanning position or recognition rate. Aiming at these problems, the system selects 5 megapixel industrial camera to photograph product labels, and automatically extracts barcode or QR code from images. Based on C language, a system integrating industrial camera connection, image acquisition, image analysis and processing, and result processing is developed. The system can recognize barcode or QR code information in images.

2. Hardware structure of bar code and two dimensional code recognition system

The system uses PCI motion control card installed in the computer to drive two servo motors to drive the image acquisition system and LED lighting system to achieve real-time movement and accurate photogrammetry. The industrial camera in the image acquisition system is Swiss Baumer camera EXG50 gigabit network camera with a resolution of $2592 \times 1944$, frame rate 13 FPS. The lighting system uses the 24 V red LED dome light source made by Weilong Optoelectronic Technology Co., Ltd. the computer software is based on window7 system and programmed with C language. The development tool is LabWindows of NI company, and the image processing system is based on NI Vision Assistant. The hardware composition of the system is shown in Fig. 1.
The X / Y-axis motion system in the figure drives the image acquisition system and lighting system to move above the detected products. In order to improve the detection efficiency, 12 products are placed in a plate and detected by moving the motion system 12 times. After reaching the top of a product, turn on the dome light source, and the industrial camera starts to take images and transmit the data to the computer through the GigE gigabit network. The computer processing software processes and recognizes the collected images based on some image processing functions of NI Vision Assistant, and recognizes the information in the bar code or two-dimensional code. Finally, the SN of the test product is extracted from this information.

Fig. 1. Bar code and two dimensional code recognition system structure diagram

3. Visual system software design based on NI platform

The software design of the bar code and two-dimensional code recognition system is the core of the whole system. The system is developed based on C language. The development tool is LabWindows CVI, which is responsible for programming framework and computer software operation interface design. The hardware of the motion system adopts NI-PCI motion control card, Using Ni-Motion development package to develop motion control program.. Industrial camera connection and image acquisition the secondary development of industrial camera is carried out by using Ni-Vision development package, including connecting the camera, setting exposure parameters, collecting images and transmitting them to the computer. Through the image processing function provided by NI Vision Assistant, the image is preprocessed first, and then the barcode and QR code are recognized to obtain SN information from the characters read. The characters read by barcode are SN information, but the characters read by QR code contain multiple information, Read a fixed segment of characters as SN information. Finally, the SN information is displayed on the program interface.

The detection process is shown in Fig. 2.
Fig. 2. Bar code and two-dimensional code recognition system processing flow chart

The system software design is divided into four modules, including product management module, motion control module, LED lighting module, industrial phase image acquisition module and image processing module. Among them, the systems are closely linked and work together to complete the label image acquisition and barcode and two-dimensional code recognition functions. System function module, as shown in Fig. 3.

3.1. Product management module
This system can recognize many kinds of bar code and two-dimensional code, and is suitable for many kinds of products. This module can manage products and configure parameters. By saving ini configuration file, all kinds of product parameters can be distinguished and managed. On the interface of the software, controls are provided to select the product type. When testing, the corresponding product is selected. The software loads the corresponding ini configuration file, reads the parameters, and then tests the product. Different product types have different parameters such as detection location, camera system exposure time, bar code or two-dimensional code type, detection result processing and evaluation. Through the management of ini configuration file, the system can realize the characteristics of flexible detection.

3.2. Motion control module
The motion control system designed in this paper is PCI motion control card of NI, which uses forward and reverse pulse mode to control Panasonic servo driver. The driver is connected to the motor, and the
motor rotates according to the pulse to achieve precise movement in X / Y direction. Based on NI-Motion development library, the computer software is developed with C language. The program functions include origin reset, forward and reverse motion and emergency stop. At the same time, a motion control interface that can be manually debugged is provided in the software design, so that users can manually adjust the motion axis, test and set good camera position parameters in the early stage of system construction.

3.3. LED light source lighting module
The lighting system uses Mightex light source controller to control the 24V dome light source. Mightex communicates with the computer through USB, and the computer software is developed based on the development package provided by Mightex manufacturer. The functions include initializing the light source controller, setting the output current of the light source controller, setting the switch status of the light source controller, etc. In order to optimize the running speed of the system, in the software design of the lighting system, the mode of turning on the LED light source in advance when the motion axis starts to move is adopted to improve the running efficiency.

3.4. Image acquisition module of industrial camera
After using gigabit network cable to connect GigE industrial camera, the IP address of the industrial camera is configured. After that, NI-DriverMax software is used to connect and configure the parameters of the industrial camera. Ni-Vision is used to control the acquisition and transmission of images. The longer the exposure time is, the higher the brightness is. The working process of industrial camera includes image connection, image acquisition and image transmission.

3.5. Image processing module
In the captured product label image, due to the slight deviation of the fixed position of the product, the PatternMatching tool in NI Vision Assistant is used to identify the position of the product label in the image, and then determine the position of the barcode or two-dimensional code in the image. In order to reduce the complexity of image processing, Shorten the time of image processing, and set the region of interest (ROI) for barcode or QR code. The parameter ROI of this function is the predefined ROI variable in the library, and the coordinates, height and width of the upper left vertex of the incoming rectangular area.

When developing computer software, the function in NI Vision Assistant library is used to identify the bar code information in the area. The function returns the barcode detection information of the structure pointer package of BarcodeInfo*, and extracts the result character from the structure pointer, that is, the SN of the detected product. When reading the two-dimensional code, the two-dimensional code information in the function recognition area of NI Vision Assistant library is used, and the function return value DataMatrixReport* is the structure pointer, which contains the two-dimensional code detection information, from which the result characters are extracted. Due to product differences, the characters in the two-dimensional code detection information include product type, origin, SN and other information, and the fixed character segment in the result character is the SN information of the product.

The main NI Vision Assistant library functions used are as follows:
1) PatternMatch * imaqMatchPattern: template matching, used for label location. 
2) ContourID imaqAddRectContour: set the region of interest.
3) BarcodeInfo * imaqReadBarcode: read barcode information.
4) DataMatrixReport * imaqReadRataMatrixBarcode: read
4. Image measurement results and performance analysis

4.1. QR code recognition results
Barcode recognition is carried out in the region of interest, and the detected barcode type is Code128. After setting the type and detection information, image processing and analysis are carried out according to the gray difference in the region, and the character information in the barcode is read. As shown in Fig. 4.

4.2. QR code recognition results
Similar to bar code, two-dimensional code recognition is carried out in the region of interest. The type of detection QR code is DataMatrix. Set the type, detection parameters, size range of QR code, and read the character information in the QR code. Read the two-dimensional code character information, take a fixed character segment is the required SN information. As shown in Fig. 5.

4.3. Test results and performance analysis
There are bar code or two-dimensional code map and corresponding SN characters on the product label. Because the reading speed of bar code or two-dimensional code is fast, and the process of computer processing and recognizing bar code or two-dimensional code is more accurate than character recognition. In order to improve the detection efficiency, 12 products were detected and the results were displayed. The image processing time of a single product is less than 90 ms, and the recognition speed can meet the design requirements.
Test 12 groups of bar code and two-dimensional code recognition effect, as shown in Table 1.

Table 1. Bar code and two-dimensional code measurement results

| SERIAL NUMBER | BAR CODE       | TEST RESULTS / SN | QR CODE       | TEST RESULTS / SN |
|---------------|----------------|-------------------|---------------|-------------------|
| 1             | XWROXDG        |                   | DW111700990   |                   |
| 2             | XWROXUS        |                   | DW111700988   |                   |
| 3             | XWROIYJX       |                   | DW111700985   |                   |
| 4             | XWR0Z6Q        |                   | DW28170001    |                   |
| 5             | XWS0CEM        |                   | DW28170005    |                   |
| 6             | XWS0CQM        |                   | DW28170004    |                   |
| 7             | XWS0CR0        |                   | DW29170004    |                   |
| 8             | XWS0CRE        |                   | DW29170001    |                   |
| 9             | XWS0CWZ        |                   | DW29170013    |                   |
| 10            | XWS0D22        |                   | DW29170004    |                   |
| 11            | XWS0D18        |                   | DW29170004    |                   |
| 12            | XWS0DCU        |                   | DW27170021    |                   |

The recognition rate of bar code and two-dimensional code recognition system is closely related to the image quality, and the stability of lighting system is particularly important. The stability of the external light also has an impact on the recognition rate. Considering this problem, the light blocking structure is added in the design to ensure the stability of the brightness.

In order to improve the efficiency of program execution, multi thread control method is used in software development, including motion control thread and image acquisition and processing thread. Global variables are used as flag bits between threads. In this way, image processing can be carried out when the program controls the motion of industrial camera, which improves the efficiency of program execution and ensures the running speed of the system.

5. Summary

The system is based on Ni platform, using Ni Motion motion control card and Baumer industrial camera, using Ni Vision Assistant image development library, and developing computer software based on C language platform LabWindows. After many tests, the best lighting effect is set, Ensure bar code and two-dimensional code recognition rate. The program framework adopts multithreading mode to improve the running efficiency. The system uses automatic scanning recognition instead of manual scanning and inputs the characters in barcode and QR code, which improves the recognition efficiency of barcode and QR code. Through the analysis of the measurement results, the bar code and two-dimensional code recognition principle and image algorithm in this paper are actually available. The system is also helpful to improve the efficiency of production management system.

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