

Design and Implementation of A Surface Barcode Image Acquisition Device Based on Binocular Vision

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Abstract

This project designs a curved barcode image acquisition system based on binocular vision technology, which can acquire high precision, clear and complete curved barcode images for different types of curved barcodes, and the system includes imaging module, binocular convergence control module, image transmission module and complete box structure design, etc. It includes two parts: image acquisition system and image analysis and calculation system. Firstly, the complete image of curved barcode is acquired from different angles by selecting binocular camera, and then the curved barcode is reduced to flat barcode by binocular vision technology, so as to eliminate the distortion of curved barcode and get the accurate barcode quality inspection parameters. It mainly solves the quality inspection of curved commodity barcodes, because the monocular camera will produce serious distortion when image acquisition of curved barcodes, which will adversely affect the detection of barcode size parameters.

Keywords

Binocular vision technology; Curved barcode; Image acquisition.

1. Introduction

At present, the number of members using EAN-13 commodity barcode in China is close to 300,000, covering more than 90% of FMCG products, and almost all commodity retail enterprises are using EAN-13 commodity barcode for circulation and settlement. However, when the commodity barcode cannot be accurately identified due to technical or other reasons in the printing process, it will adversely affect the circulation and sales of goods, and then the interests of related parties will be lost. Therefore, the importance of commodity barcode printing quality is self-evident to the commodity market.

In order to standardize the management of commodity barcode and guarantee the printing quality of commodity barcode to ensure the normal consumption and circulation of commodities in the market, China has formulated and promulgated a series of relevant commodity barcode quality inspection specifications, and the commodity barcode flowing to the market must pass the quality inspection requirements of relevant barcode inspection agencies before it can be registered in the barcode management department and finally circulated in the market. At present, domestic barcode inspection institutions at all levels mainly use special barcode inspection instruments to carry out quality inspection of commodity barcodes, for example, the barcode quality supervision and inspection station in Shaanxi Province uses C42A inspection instrument, which needs to be combined with manual operation to carry out quality inspection of commodity barcodes. However, because some outer packaging is rigid curved packaging materials cannot be sampled, and the commodity barcode printed on the curved surface (referred to as curved barcode) will have errors when scanning and testing with the testing instrument because of its column surface distortion, these factors

lead to such commodities cannot be accurately tested by the existing testing instrument or manually.

2. Current Situation at Home and Abroad

Nowadays, there are mainly UPC (Universal commodity Code) code and EAN (European Article Number) code in the global market, UPC code was established by the United States Uniform Code Council in 1973 and the standardization of this code system was realized in the same year, it is mainly used in North America, and there are five kinds of UPC-(A~E) barcodes, which correspond to universal commodity, medical and health, industrial sector, warehouse wholesale and commodity break code. EAN code is a kind of commodity barcode designated by the International Article Numbering Association, which is widely used in the world and compatible with UPC code at the same time. It has two versions: the standard version (EAN-13 code) and the shortened version (EAN-8 code). China officially joined the EAN code organization in 1991 and started to use EAN-13 code extensively.

The domestic and foreign barcode inspection instruments are all based on laser scanning mechanism, which are composed of photoelectric scanning module, auxiliary length measurement module and calculation processing module, and their inspection process is: the scanning module emits red light to the barcode, and then the light signal is converted into electric signal on the photoelectric conversion module after the barcode symbol is reflected, and finally the electric signal is converted into barcode reflectivity curve to inspect the barcode quality. Since this inspection method has unavoidable complicated characteristics, and the laser scanning mechanism will produce errors when scanning curved barcodes, therefore, with the continuous expansion of the machine vision field, the quality inspection of commodity barcodes through machine vision will become the mainstream direction of future inspection technology. Machine vision inspection technology has more than thirty years of development history, due to its high detection accuracy, speed advantages, currently in the industrial inspection has an extremely wide range of applications. Machine vision inspection principle simply put, is to use the machine instead of manual detection, it uses industrial cameras and image acquisition cards and other equipment to replace the human eye to obtain the image data of the object to be measured, and these data into digital signals transmitted to the processor for image processing. At present, there has been some progress in the technology of quality inspection of commodity barcode through machine vision.

As the research progress of machine vision continues to break through, binocular stereo vision systems have been developed and applied in various fields. The principle of binocular stereo vision is to obtain multiple images from the same three-dimensional scene at different angles by using two cameras imitating human eyes, and then process the acquired two-dimensional images through image algorithms to finally restore the accurate three-dimensional scene information. Due to the accurate measurement of distance and reliability of detection in some extreme environments, binocular stereo vision has a great role in industrial robotics, medical testing, industrial measurement and other fields.

3. 3D Reconstruction of Binocular Stereo Vision

The 3D reconstruction of binocular stereo vision is mainly divided into six steps: image acquisition, camera calibration, image pre-processing, extraction of image feature points, stereo matching and 3D reconstruction.

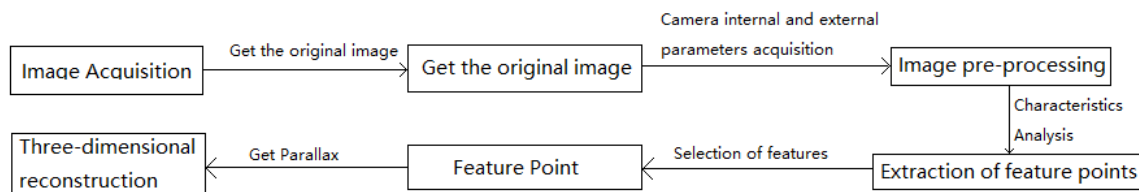


Figure 1. Six steps of binocular stereo vision 3D reconstruction

- (1) Image acquisition: The two-dimensional image data in the scene is acquired by binocular cameras at different locations.
- (2) Camera calibration: According to the internal and external parameters of the camera, some specific experiments or images of known size such as a checkerboard grid are used to obtain the matrix algorithm of digital transformation by comparing the physical object with the 2D data as a way to correct the distortion of the camera.
- (3) Image pre-processing: the obtained image information is processed algorithmically to enhance the image features, generally with noise reduction, smoothing, geometric correction and other processing methods.
- (4) Extraction of feature points: the more obvious feature data in the image information is selected, such as grayscale, corner points and other features.
- (5) Stereo matching: the feature vector is obtained from the extracted features in the image, and the projection points of the same object in the two images are found and matched by the feature vector.
- (6) 3D reconstruction: The projection points of the feature vector obtained from the stereo matching are reconstructed in 3D by using the parallax between the projection points according to the triangulation principle.

4. Design of the Five Modules

4.1. Design of the Imaging Module of the Acquisition System

In the construction of binocular vision imaging module, the geometric structure of binocular vision is crucial. Parameters such as camera baseline distance and optical axis angle in the geometric structure are closely related to the magnitude of the accuracy of the acquired pictures, so the influence of the structural parameters on the measurement accuracy needs to be calculated by mathematical analysis.

In binocular vision system, the main structural parameters are the length between two cameras, i.e., the baseline distance B , the angle between camera optical axis and baseline α_1 and α_2 , and the object distance between the camera and the surface to be measured, and these structural parameters have a mutually constraining relationship, so it is necessary to mathematically analyze and process them with the random sampling points in space to get the error function, and to get a reliable range of structural parameters of binocular imaging for the error function graph to ensure the accuracy of the acquired surface barcode pictures.

Firstly, the error function of the structural parameters of binocular imaging system is obtained by analyzing the structure of binocular imaging system through triangulation method, and the error function is simulated by matlab to determine the optimal structural parameter range with small error, and then the camera and lens to meet the accuracy are selected by studying the size of curved barcode, and the selection of light source is determined through light source comparison experiment, and finally the design of imaging module is completed according to the optimal structural parameter range.

4.2. Binocular Convergence Control Module for Acquisition Systems

After the imaging module was completed, through the experiment of acquiring curved barcodes, the imaging effect of some curved barcode samples with larger curvature and at the edge of the lens when the images were acquired was not satisfactory. After analysis, there are two main reasons for the poor quality of the captured images. The first reason is that the camera focus is at the center of the imaging, while the curvature of some curved barcodes is large, which makes the distance difference from the edge area to the center of the lens larger, resulting in the camera not being able to focus completely on the edge image of the curved barcode. The second reason is the inherent radial distortion of the lens, which leads to the error of the pixel coordinates around the image. Therefore, the binocular convergence control module mainly designs a suitable camera horizontal transmission device to adjust the camera field of view and convergence point, so as to meet the image acquisition of curved bar codes with different curvature sizes and solve the problems arising from the acquisition experiments.

Binocular convergence is mainly realized through the horizontal displacement slide, which is a platform installed on the horizontal slide. By fixing the camera on the platform and making the platform move on the slide, the camera connected to the platform will also produce the same movement with the platform movement, so that the movement of the related camera can be controlled by controlling the movement of the slide, and it can expand the shooting range of the camera when used with the camera to achieve the control of The role of binocular convergence point.

First of all, the design of the electronically controlled slide table, including the control motor of the slide table, the transmission method and limit device. After the analysis of the sliding table control motor principle, the design used Keil software to write the motor driver software, and downloaded to the STM32 microcontroller, with the stepper motor driver, power supply to control the stepper motor. The control of the upper computer to the lower computer is completed through serial communication, i.e., the upper computer sends control commands to the electric slide table for manipulation, which meets the control requirements of binocular convergence.

4.3. Image Transmission Module for Acquisition Systems

The main purpose of the image transmission module design is to combine two camera signals in the hardware interface and software image information into one way to meet the requirements of acquiring surface barcode images.

In the design of the image transmission module, the hardware switch core board is used to merge the two camera network interfaces into one network interface, and then the built-in library file of the camera is developed by Visual Studio software to complete the real-time output of the two signals into one.

4.4. Overall Box Structure Design of the Acquisition System

In the overall structure design of the acquisition device, the control layer, acquisition layer and sample layer are mainly designed. The three-dimensional structure is divided into two layers: the bottom layer is the sample layer, which is used to place the barcode samples; the top layer is the acquisition layer, which places the camera, light source and the right eye camera slide.

In the acquisition layer, two industrial cameras are used for image acquisition at the top left and top right of the curved barcode, and the acquisition space is fully closed to avoid the interference of ambient light. The size of the acquisition window can show the maximum size of the EAN-13 barcode, and at the same time, if the window is too large, the existence of irrelevant information around the barcode will be captured, which will have a negative impact on the subsequent image pre-processing and extraction of feature points, therefore, the window size is set to 100.00mm×80.00mm.

In the sample layer, the curved barcode sample is fixed under the acquisition window according to the designed fixture. Since the substrate of the curved barcode is a column, it is easy to roll if it is not fixed, so a suitable fixture must be designed to fix it when the barcode image is acquired, and after the experiment, the fixture is made by the spring connection pad to meet the structural design, and the sample is fixed between the pad and the window plate by the spring pad when the barcode image is acquired. The design of the fixture can allow the maximum sample size of 150mm, which can satisfy the acquisition of most curved barcode in daily life.

After completing the design of the acquisition layer and the sample layer using the 3D software structure design drawing, the whole structure of the acquisition device is completed by the acrylic sheet.

4.5. Software Development

After the acquisition device including imaging module, binocular convergence control module, image transmission module and overall structure design is completed, the final curved barcode image acquisition system is completed by software development with Visual Studio platform.

When the camera interface is connected, the camera is connected through buttons such as refresh camera and open camera, and the real-time screen is displayed in the right acquisition frame, which is the screen of the left and right eye cameras respectively, where the three buttons under the right eye camera are the buttons to control the movement of the slide table, which are moving to the left, stopping and moving to the right. The bottom left of the interface mainly displays the relevant parameters of the camera acquisition for easy adjustment.

Finally, the image of curved goods barcode is captured by the acquisition device and transmitted to the computer, and the quality inspection of 30 curved barcodes with different curvature is carried out with the image processing algorithm, and the result shows that the quality inspection can be completed for 27 of the curved barcodes, which proves the feasibility of the acquisition system. In the comparison test, 100 flat barcodes that have been tested in the barcode quality supervision and inspection station of Shaanxi Province were pasted on the curved packages, so that the testing results were compared with the results of the inspection station, and the results showed that the testing parameters of the two were very close and the judgment results of the testing were consistent, which proved the testing accuracy of this system.

5. Development Prospect

The project designs a curved barcode image acquisition system by binocular vision technology, which can acquire high precision, clear and complete curved barcode images for different types of curved barcodes, and acquire complete images of curved barcodes from different angles by selecting binocular cameras, and then restore curved barcodes to flat barcodes by using binocular vision technology to eliminate distortion of curved barcodes and get accurate barcode Quality inspection parameters. It mainly solves the quality inspection of curved commodity barcodes, because the monocular camera will produce serious distortion in the image acquisition of curved barcodes, which will adversely affect the detection of barcode size parameters. It brings great convenience to the life of merchants, improves the working efficiency, and has positive significance to the circulation and sale of goods.

It plays a key role in solving the quality detection of curved commodity barcodes and improving the accuracy and efficiency of scanning codes in shopping malls and other places. Since the launch of the curved barcode image capture system, major shopping malls have fully used the curved barcode image capture device, and in the era of economic globalization, the implementation of the use of curved barcode image capture device must be superior to the

traditional monocular machine vision system, the prospect of curved barcode image capture device must be considerable.

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