Micro Image Surface Defect Detection Technology Based on Machine Vision Big Data Analysis

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Abstract. The traditional micro image surface defect detection system had slower running speed and less detection precision, which made the detection system operate inefficient and could not meet the requirements of small image surface defect detection. To this end, the optimization design of the micro image surface defect detection system based on machine vision-based big data analysis was carried out. The system design was optimized with MATLAB 7.0 programming environment; MATLAB technology was used to process small images to visualize calculation results and programming; The filtering of the micro image was detected by the method of spatial domain filtering to complete the detection task of the surface defect of the micro image. The design method was validated and the test data showed that the micro image surface defect detection system ran faster and the detection was more precise. The detection accuracy was 92% and the detection quality was high.

Keywords: Machine vision · Micro image · Surface defect · Big data · Detection technology

1 Introduction

With the continuous expansion of machine vision products, the application in the field of machine vision has become more and more extensive, and the visual performance has been improved as never before. Machine vision is a multi-disciplinary interdisciplinary subject involving image processing, artificial intelligence, pattern recognition, etc. The industries applied include industry, agriculture, military and defense, traffic management, remote sensing image analysis [1, 2]. For example: defect detection and measurement of parts in industry, detection of agricultural product quality, military sonar imaging, identification of vehicles or license plates in traffic management. Machine vision applications are the most common in the industrial industry. Machine vision systems can replace manual inspection, identification and classification of smaller parts, control their production processes, and improve product quality and

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production efficiency. Therefore, it is of great significance to study the micro image surface defect detection technology under machine vision big data analysis.

2 Inspection System Overall Design

2.1 Overall Design of Micro Image Surface Defect Detection System

A complete machine vision based defect detection system captures images through an image acquisition system. The image processing module receives the image and processes the image, converts it into a digital signal, and then performs preprocessing, image enhancement, defect segmentation, feature extraction on the digital image, and finally realizes classification of product defects. The research process is shown in Fig. 1.

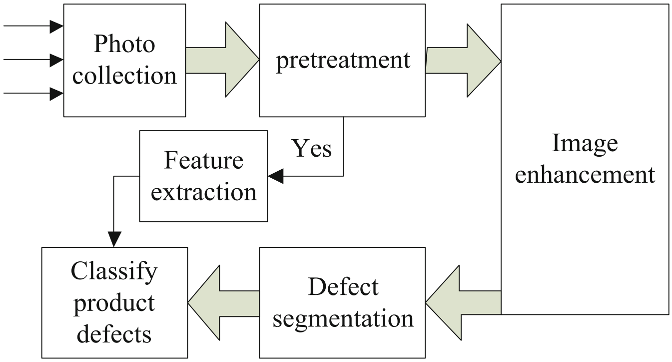

Fig. 1. Overall flow chart of micro image surface defect detection system

The overall design of the micro image surface defect detection system mainly includes two parts: hardware structure design and software algorithm design. According to the function division, the whole system can be divided into four modules: industrial camera, optical lighting system, image processing module and automatic detection result module [3, 4]. Among them, the industrial camera and the optical lighting system belong to the hardware component, and the image processing module and the automatic detection result module belong to the software component.

The object to be measured is placed on the stage, and the image of the part is acquired by the CCD camera through the uniform illumination of the LED light source, the collected image is transmitted to a computer for image processing, and the characteristic parameters are extracted to realize the identification and classificationof the defective image, and finally complete the detection task of the system [5].

2.2 System Hardware Design

Image sensors, also called photosensitive elements, are widely used in digital cameras and other electro-optical devices. Image sensors which are currently used most are CCD and CMOS.

CMOS sensors are semiconductors made from two chemical elements, silicon and germanium, which perform their functions due to positive and negative charge transistors on CMOS. In industrial cameras, CCDs are the most widely used, and CMOS is gradually being applied to HD surveillance cameras. Because CMOS has the characteristics of high integration, low power consumption, fast speed, etc. With the rapid development of CMOS technology, the effect of CMOS is getting closer to the effect of CCD, and there is a tendency to gradually replace CCD [6].

The advantage of CCD device is that it has the advantages of high integration, low power consumption, small pixel and low noise, which makes CCD widely used in three fields of camera, signal processing and storage. Compared with CMOS, first of all, CCD can convert light into electric charge and transfer charge storage, and can also take out the stored charge to make the voltage fluctuate. It is the ideal camera original. Secondly, in the case of the same pixel, the size of the photosensitive device is also the same, and the sensitivity of the CCD device is higher than that of CMOS. Thirdly, under the same conditions, the CCD sensor can use a large area, can receive and output a strong photoelectric signal, the acquired image has high definition, less noise, and the seismic effect is also very good [7].

The micro image surface defect detection system designed in this paper uses the BB-500GE industrial digital camera developed by JAJ Company of Denmark to obtain images. It features high resolution, high precision, low noise, etc. It uses Gigabit Ethernet interface processing functions, and is easy to install and use. It is the first choice for indoor and outdoor industrial inspection applications. Compared with foreign products of the same grade, this camera has obvious price advantage and is widely used.

In machine vision systems, the main goal of the illumination system is to select the light source that fits the system and project the light onto the object to be measured, mainly to highlight the contrast between the target and the background. A good lighting system can avoid problems such as flowering, glare, overexposure, etc., and can improve the resolution of the entire system. As it can improve the accuracy and stability of the system and simplify the operation of the software, so the lighting system is the key to obtaining high quality images [8].

After the light source is determined, the correct illumination mode should be selected according to the characteristics of the object to be measured. When used in a specific environment, the choice of light source needs to be considered: the characteristics of the object, the state of motion, the application environment, and the type of camera used. There are four lighting methods, the first one is forward illumination [9, 10]. Forward illumination is to place the light source on the front of the object and the camera. Using the reflection principle of light on the surface of the object to be measured, the scratches, defects and important details of the surface of the object can be well displayed, which is convenient for subsequent experiments and research, forward lighting is the preferred method of illumination for most applications.

The second is backward illumination. Backward illumination is to place the object on the middle of the camera and the light source, which can clearly outline the edge of the object to be measured, and is suitable for observing the shape of the image.

The third is structured light illumination. The structured light illumination is a distortion generated by a line source or a grating projected onto the object to be measured, and the three-dimensional information of the measured object is calculated.

The fourth is stroboscopic illumination. The illumination is to illuminate a high frequency light pulse onto the object, requiring the camera to be synchronized with the light source.

2.3 Software Design

The defect detection process based on machine vision includes preprocessing, segmentation, defect feature extraction and classification of images. As shown in Fig. 2, The collected micro images are processed by the defect detection algorithm, and finally the surface defects of the micro images are detected, thereby achieving the purpose of detecting and controlling the micro image quality. However, the implementation of the defect detection algorithm requires a powerful development environment. The micro image surface defect detection designed in this paper is based on the MATLAB7.0 programming environment.

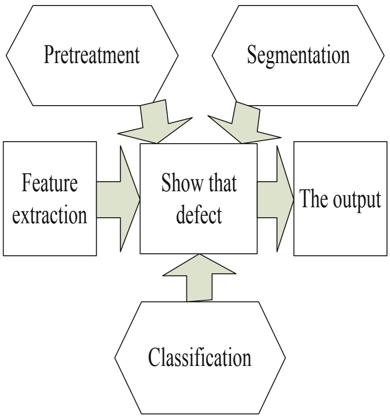

Fig. 2. Machine vision based defect inspection system diagram

MATLAB is a high-tech computing environment released by Mathworks Corporation of the United States. It is a combination of the word matrix & laboratory, meaning a matrix factory. MATLAB has perfect image processing capabilities to enable visualization of calculation results and programming; MATLAB also has a feature-rich toolbox, and can also directly call C, C++, and JAVA to meet the different needs of users. MATLAB's ability to handle matrix operations determines its unique advantages in digital image processing, and MATLAB's analysis toolbox also supports indexed images, grayscale images, image filtering and other functions, which is of great help to the development of this topic. The software part of the surface defect detection system for micro images mainly consists of image preprocessing module, defect segmentation module, defect feature extraction and selection module.

The captured image is often plagued by noise due to interference from the light source, camera and environment [11, 12]. During the detection process, noise and defects are very confusing, reducing system performance, affecting the results of the experiment, and also having a serious impact on subsequent feature extraction processes [13, 14]. Therefore, the acquired image is filtered before image processing. Commonly used filtering methods include median filtering and averaging filtering.

Defect detection technology mainly studies the detection and classification of defects on the gear surface. Image segmentation technology divides defects from images and lays the foundation for subsequent classification of defects. Common methods for image segmentation include region-based detection methods and edge-based detection methods.

Describing the characteristics of the target area in the image can be started from the following aspects: gray statistical features, geometric features, algebraic features, intuitive features, topological features and transform domain features, As shown in Fig. 3. Feature extraction is to extract the attributes and parameters that can describe the characteristics of the target from the target, identify different defects, and extract the different parameter characteristics, which feature to use depends on the problem.

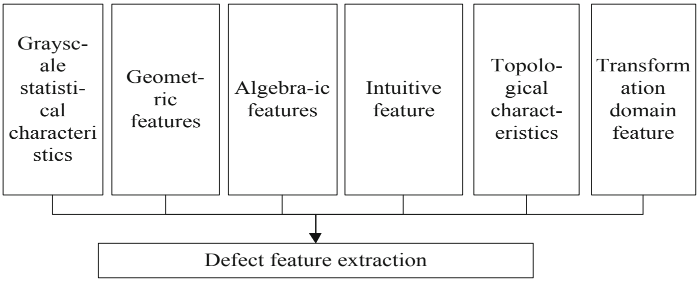

Fig. 3. Defect feature extraction map

The defect classification is mainly to realize the automatic extraction and classification of the defects extracted from the image according to its own characteristics, which is mainly realized based on the processing of image processing and feature extraction. Commonly used defect feature recognition methods include artificial neural network pattern recognition method and fuzzy pattern recognition method. Which defect identification method to choose depends on the specific characteristics of the application and the defect.

3 Key Technology for Detection

The result of scanning an image according to a rectangular scan grid is that a one-dimensional integer matrix corresponding to the image is generated. The position of each element (pixel) in the matrix is determined by the order of scanning, and the gray value of each pixel is determined by the sample, an integer representation of the gray value of each pixel is obtained after quantized. Therefore, the result of image acquisition is to digitize a continuous image of nature and finally obtain a digital image. It generally has two common representations: the first is an array representation of grayscale images, as follows:

Let continuous images $f(x, y)$ be sampled at equal intervals and arranged in $M \times N$ array (generally square matrix $N \times N$) as shown below,

$$f(x,y) = \begin{pmatrix} f(0,0) \cdots f(0,N-1) \\ f(1,0) \cdots f(1,N-1) \\ f(N-1,0) \cdots f(N-1,N-1) \end{pmatrix} \quad (1)$$

The second is binary image representation. In digital image processing, in order to reduce the amount of calculation, the grayscale image is often converted into binary image processing. The so-called binary image is only two gray levels of black and white, that is, the pixel gray level is 1 or 0.

The micro image stitching is to use the overlapping part information between the collected local images, and align and splicing each other to realize the full scene generation global image. The acquisition of tiny images is a process of collecting sequence images. The adjacent images will have overlapping parts. The overlapping partial image information is used to splicing all the local images to form a complete image, which gives a visually intuitive effect. The quality of the image surface is clearly visible, which involves the registration and splicing of the image.

The small image surface defect visual inspection system in this paper uses CCD camera as the sensor. In the process of collecting and transmitting, the small image is affected by various noise pollution and other factors, which degrades the image quality and affects the reliability of the detection result. Therefore, it is necessary to perform accurate filtering processing. After these processes, the quality of the output image is improved to a considerable extent, and the edges of the image are more intuitive, which not only improves the visual effect of the image, but also facilitates the computer to analyze, process and recognize the image.

The spatial domain filtering method is implemented in the image space by means of a template for neighborhood operation. A template is a one-dimensional array, and the value of each element in the template determines the functionality of the template. The template operation implements a neighborhood operation, that is, the result of a certain pixel point is not only related to the gray level of the pixel, but also related to the gray level of the neighboring pixel point. The description of the template operation in mathematical operations is a convolution (or cross-correlation) operation. Template operation is an operation method often used in digital image processing. Image filtering, sharpening and refinement, and edge detection are all used in template operations. The filtering is divided into two types: linear and nonlinear. The simplest linear filter is a local mean filter. The algorithm is that the gray value of each pixel $f(k,l)$ is replaced by the mean, $h(i,j)$ of the gray values of the points in the local neighborhood indicated by its template. The mean calculation formula is as follows:

$$h(i,j) = \frac{1}{M}\sum_{k,j \in N} f(k,l) \tag{2}$$

$$h = \frac{|i,j|^2}{2} \tag{3}$$

Where M is the total number of pixels contained in the neighborhood N; $f(k,l)$ is the gray value at the position (k,l) in the neighborhood N.

4 Experimental Results and Analysis

In order to ensure the effectiveness of the micro image surface defect detection system proposed in this paper, experimental demonstration is carried out. In the experiment, the image of 1–5 in the micro picture feature library was selected as the verification sample of the model. The experimental data is shown in Table 1 and Table 2.

Table 1. Error verification table and error results

	M1	M2	M3	M4	Desired output	error
1	1.03	1.10	−0.97	0.19	1	−0.62
2	1.04	1.18	0.03	0.01	1	−0.06
3	1.02	1.17	−0.17	0.12	1	−0.13
4	1.06	1.42	0.27	0.03	1	−0.01
5	1.03	1.21	−0.41	0.21	1	−0.07

Table 2. Verification sample situation statistics

The total number of samples			
Number of qualified 4		Unqualified number 1	
Qualified	Unqualified	Qualified	Unqualified
3	1	0	1

It can be seen that if the relative error range of the qualified product is set to 12%, and all the others are unqualified (including the unrecognized all the records are unqualified), then, among the five tiny bearing pictures in the sample, one of the total of four qualified was judged as unqualified; All with one originally failed are judged as unqualified. The statistical table is shown in Table 2. The correct recognition rate of the model is 92%, which fully demonstrates that the micro image surface defect detection system under machine vision big data analysis has high accuracy, reliability and safety.

On this basis, the detection error is taken as the test index, and the comparison results are shown in Fig. 4.

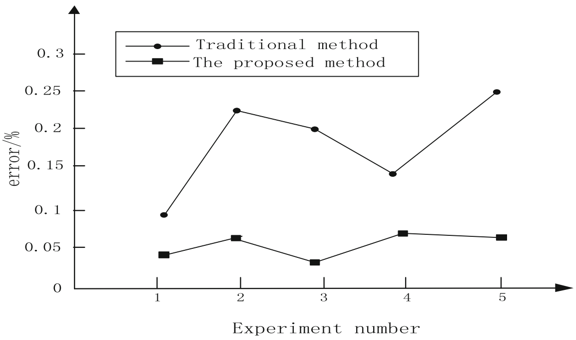

Fig. 4. Comparison of error of different methods

As shown in the figure, the detection error of the traditional method fluctuates greatly, about 0.2, while the detection error of the proposed method is about 0.05, which has obvious advantages and high practical application.

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