Fabric Defect Detection Based on Open Source Computer Vision Library OpenCV

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***Abstract*—A method for fabric defect detection based on OpenCV with rich computer vision and image processing algorithms and functions is presented. Firstly, OpenCV image processing functions implement fabric image preprocessing. We use morphological opening and closing operations to segment image because of their blur defects. Secondly, "seed filling" algorithm is applied to connect broke lines to keep defect edge smoothing. Finally, the edge detection function is to complete accurate positioning defects. Experimental results under Borland C++ Builder 6.0 show that OpenCV based fabric defect detection methods are simple, high code integration, accurate defects positioning, which can be applied to develop real-time fabric defect detection system.**

Keywords-OpenCV; fabric defect; image processing; morphology

I. INTRODUCTION

Fabric defect is one of the most important factors affecting the quality of fabric. The traditional off-line manual detection methods are prone to undetected and error detection. Automatic fabric defect detection technology based on computer vision and kinds of fast algorithms has aroused domestic and foreign researchers' interest, which has become one of the most popular topics [1, 2]. However, high-speed and real-time defect detection system has faced a question of precise defect detection and recognition depending on the optimized image processing results. And the results attained just rely on increasing the amount of data storage and computing capacity as a price. Therefore, enhancing real-time processing speed in defect detection system is the future trend [2]. Most software packages, such as DIPLIB, HALCON, LABVIEW, Microsoft SDK and so on, although they can provide image processing functions, the processing ability, and adaptability are very limited [3].

Open source computer vision library OpenCV [4] funded by the Intel Corporation is a free open source computer vision library, constituted by a series of C / C ++ functions and classes. OpenCV offers many common algorithms to realize image processing and computer vision computing, which can be used to achieve powerful image processing, and develop real-time applications system. It is very suitable for fabric defect detection research.

In this paper, based on the OpenCV data structures and commonly image processing algorithms, a new fabric defect detection is proposed. Under Borland C++ Builder 6.0, fabric images can be processed by computer vision and image processing functions in OpenCV. OpenCV can be used to develop a high efficiency in-line fabric defect detection system, and can quickly and accurately detect the location of detects.

II. OPENCV DATA STRUCTURES AND FUNCTIONS

OpenCV provides a lot of dynamic data structures, such as 2-D and 3-D points structures, lists, queues, sets ,trees, graphs, matrices and other data structures.

A. Matrix data structures

Usually, OpenCV defines matrix data type as the following format.

CV_<bit-depth> (S|U|F) C <nchannels>

While, bit-depth means data length, whose values can be 8,16,32 or 64 bit. S denotes signed integer. U means unsigned integer. F means float. nchannels denotes numbers of channels per element (image pixel). It can be 1, 2, 3 or 4, representing respectively the grayscale, binary, color (RGB), four-channel image (RGB + Alpha).The channels are interleaved. The usual data layout of a color image is b0 g0 r0 b1 g1 r1 ⋯. Although in general IPL image format can store non-interleaved images as well and some of OpenCV can process it, this function can create interleaved images only. For example, CV_8UC1 means an 8-bit unsigned single-channel matrix. CV_32FC2 means a 32-bit float matrix with two channels.

For each channel of a pixel may be integer or float type, usually, OpenCV defines image data types as the below format.

IPL_DEPTH_<bit-depth> (S|U|F).

E.G., IPL_EPTH_8U means an 8-bit unsigned image. IPL_DEPTH_32F means a 32-bit float image.

B. OpenCV functions

Usually, OpenCV functions use the following naming conventions.

cvActionTargetMod(Parameters)

Here, cv exists before each function, meaning a OpenCV function. Action means action of a function. Usually, it is an English verb, such as set, create. Target means the target image region, such as contour, polygon. Mod is an optional, which usually helps explain operating objects, such as the type of operation. Parameters denote the list of parameters. numbers and types of different function parameters are not identical.

III. OPENCV ACCESSING IMAGE ELEMENTS

In OpenCV, the data type of image is usual IplImage. IplImage comes from Intel Image Processing Library, but,

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OpenCV only supports a subset of it. OpenCV has many powerful image processing functions. How to access image pixels, and different accessing methods, decide the processing efficiency. Assuming that you need to access the k-th channel of the pixel at the i row and j column in fabric defect image. The row index i is in the range [0， height-1]. The column index j is in the range [0， width-1]. The channel index k is in the range [0， nchannels-1]. Height is the image height, and width is the width of the image. Then, the image access can be used several ways as follows.

A. Indirect access

The indirect access method is applicable to any type image, but inefficient. For an 8-bit single-channel image, the following statement can be used to access.

CvScalar s = cvGet2D (img, i, j); //get the $I(i, j)$ pixel value

s.val[0] = 120; cvSet2D (img, i, j, s); // set the $I(i, j)$ pixel value

Where, img means an image with structure of IplImage. The following img has the same definition.

For a multi-channel float or byte image, the access statement is shown as follows.

CvScalar s = cvGet2D (img, i, j); // get the $I(i, j)$ pixel value. Its values components are s.val[0] // B, s.val[1] // G, s.val[2] // R, respectively.

s.val[0] = 120; s.val[1] = 120; s.val[2] = 120;

cvSet2D (img, i, j, s); // set the $I(i, j)$ pixel value

B. Direct access

Direct access is the most common and efficient method. For a single-channel byte image, the following statement can be used to access the goal pixel.

$I(i, j)$ ~ ((uchar *)(img ->imageData + i* img ->widthStep))[j];

For a multi-channel byte image, the access is shown as follows.

$I(i, j)_B$ ~ ((uchar *)(img ->imageData + i*img ->widthStep))[j*img->nChannels +0]; //B

$I(i, j)_G$ ~ ((uchar *)(img ->imageData + i*img ->widthStep))[j*img->nChannels +1]; //G

$I(i, j)_R$ ~ ((uchar *)(img ->imageData + i*img ->widthStep))[j*img->nChannels +2]; //R

C. Direct access using a pointer

Direct access using a pointer is a simplified and efficient access.

For an 8-bit single-channel image, the following statement can be used to access.

int step = img->widthStep/sizeof(uchar);

uchar* data = (uchar *)img->imageData;

$I(i, j)$ ~ data [i*step+j];

For a multi-channel byte image, the access is shown as follows.

int step = img->widthStep/sizeof(uchar);

int channels = img->nChannels;

uchar* data = (uchar *)img->imageData;

$I(i, j)_B$ ~ data [i*step+j*channels+0]; //B

$I(i, j)_G$ ~ data[i*step+j*channels+1]; //G

$I(i, j)_R$ ~ data[i*step+j*channels+2]; //R

Of course, there is other access, such as direct access using a C++ wrapper [5].

IV. OPENCV BASED FABRIC DEFECT DETECTION

Using image processing methods, fabric defect research can be divided into three categories: statistical methods, spectrum method and model method. Statistical method directly analyze defect image gray value in spatial domain to extract texture features. Texture features of fabric image mainly come from: image dimensions, a first-order statistics, cross-correlation, edge detection, morphological operations, co-occurrence matrix, intrinsic filters, and a variety of local linear transformation [1, 6-8]. Spectral method is to convert the image into the frequency domain for analysis. This method mainly uses the Fourier analysis, Gabor filters, Wigner distribution function and Wavelet analyzing method [9-10]. Fabric texture can often be seen as an image model, and may be defined by a random or deterministic model. These methods are mainly Gauss Markov random field, the Poisson model and cluster models [11, 12]. Because the statistical method is relatively simple, intuitive, and test results are within the acceptable range, this paper based on the use of statistical methods, combined with OpenCV, under the C ++ Builder 6.0 environment, we achieve fabric defect detection.

A. Image preprocessing

High resolution fabric image obtained have abundant texture, which will slow processing speed, and increase identifying difficulty. Conversely, if resolution is too low, the image will be blurred. Images acquired in this paper have a resolution of 300dpi. At the same time, the size of image is considered. The larger image will waste more complex processing and time consumed. Conversely, if the size of image is too small, defects will be undetected. We have 256 × 256 images in experiment. Source images obtained are generally color. For facilitate processing, color image will be usually converted to grayscale. At the same time, because of the noise interfering to the detection accuracy, it is necessary to do denoising for the captured images. For highlighting the defects in the image, we should carry out image enhancement processing algorithm. Using cvCvtColor, Cv-Smooth function in OpenCV and histogram equalization technique, respectively, we can obtain ideal results, shown in Figure 1.

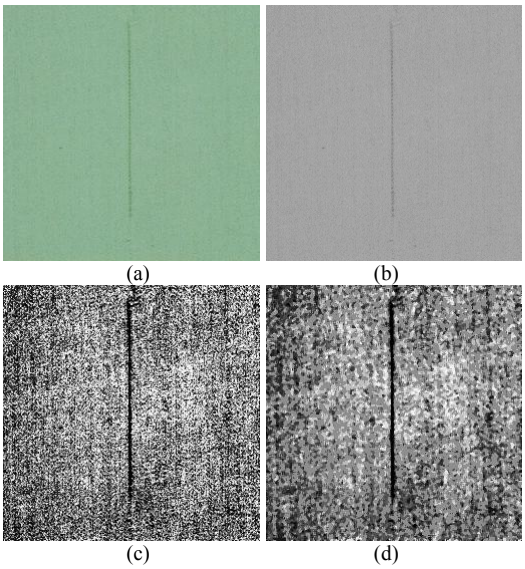


Figure 1. Preprocessing of fabric defect image.(a) Broken end image;(b)Gray image;(c)Image enhancement;(d)Image denoising

B. Thresholding

Fabric defect Image segmentation is a process of removing non-defect information from the defect image, and reducing the amount of data in subsequent processing stage of defect analysis, identification and other advanced processing. The results of thresholding can retain structural characteristics of defects information. For the target of separating defects from background as much as possible, according to the Gaussian model fabric image distribution, we use OpenCV's cvThreshold function to segment defect. The result is shown in Figure 2.

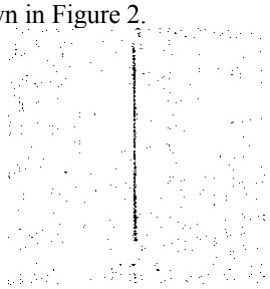


Figure 2. Image thresholding

C. Morphological Processing

Mathematical morphology [13] has four kinds of basic operations: expansion, corrosion, opening and closing operation. Expansion causes the goal pixels to increase, but, corrosion can reduce the target pixels. Corrosion has the specific role to eliminate boundary pixels in goal field, which causes image border to shrink into internal field. Opening can achieve corrode firstly, then expand. On the contrary, the first expansion, then, corrosion, will realize closing. Because of noise interference, when we segment the defect images, some isolated points excluding defects will produced, which will affect the detection accuracy. Morphological structure can be improved to eliminate noise interference. In binary image, opening enables to smooth the target image contour, and remove the burred and isolated points. At the same time, opening can sharpen image border. Closing can fill in the minor groove, bridge the holes and cracks. Two kinds of operations can be combined to use, to obtain the best result. According to the characteristics of defects image, we use the opening. Firstly, we corrode away fabric standard latitude and longitude structure (repeating unit), or the background pixels. Secondly, using expansion to expand, then target information can be restored. Morphological processing results are shown in Figure 3 (a) and (b).

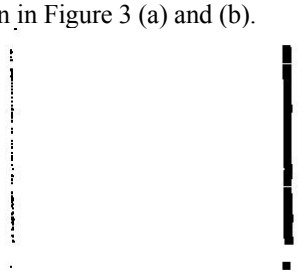


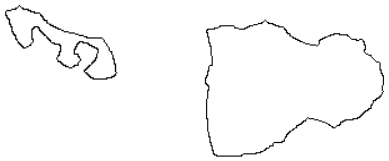
Figure 3. Morphological processing. (a)Closing; (b)Opening

After morphological processing, some fabric image areas exist disjunction. In order to make them continuous, it should connect the broken line. We adopt expand the scope of observation methods to solve the question, which is achieved by using "seed filling" algorithm [14].

The principle of algorithm is based on the basic connection domains, such as 8-connected domains, expanding the search target. When the search processing reaches a crosspoint, a seed is planted. That is to say, whether connect the point or not. According to the priority of the seeds, algorithm chooses the smallest priority of the first seeds to grow until meet another crosspoint. Then, a new seed will be planted. The seed growth processing can form a continuous chain segment, and all pixels in defects image is only one accessing.

Figure 4 is a artificial map to test the algorithm. Figure 5 shows the results of different connections available depending on the seed filling.

Figure 4. Artificial route map for "seed filling" algorithm.



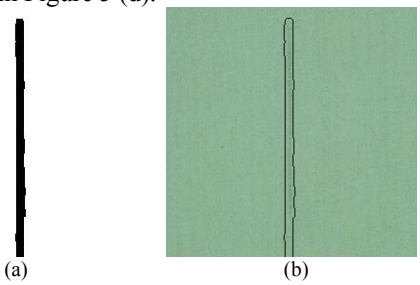
(c) (d)

Figure 5. The results on different searching strategies.

The result of broken lines connection is shown in Figure 6 (a).

D. Defect Location

Through previous several steps, we can obtain defect image. But, in order to clearly identify the location and shape of defect in source image, the positioning of defects must also be carried out. CvCanny function can be used in edge detection, combined with the results of broken connection. We can accurately locate the defects in source image. The result is shown in Figure 5 (d).



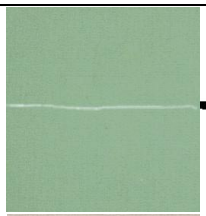
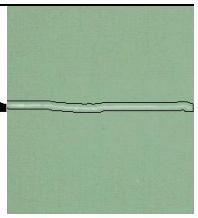
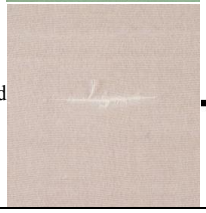
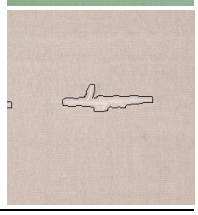
(a) (b)

Figure 6. Defect location. (a)Broken line connection; (b)Defect location

V. EXPERIMENTAL RESULTS

In order to test the usefulness of the algorithm, more defect images are used to test the algorithm, and the results are shown in Table 1. When we detect the damaged defects, there is a point with blot. But, the algorithm can also detect it, which shows that the method is feasible.

TABLE I. DETECTION RESULTS OF FABRIC DEFECT

Defect type	Source image	Morphological processing and broken connection	Defect location
Broken pick			
Damaged defect			

VI. CONCLUSION

Computer vision technology has gradually been applied to fabric defect detection in textile industry. OpenCV provides a lot of image processing functions, which can reduce the preparation of the code. With OpenCV and C++ Builder 6.0, using digital image processing technology, through the fabric defect detection theory, we implement defect image preprocessing, segmentation, morphological processing, broken connections defect positioning of fabric defect detection system. This system with a high degree of integration, high testing speed, has greater application value.

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