Shape of cutting chip monitoring system based on LabVIEW

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ABSTRACT

High efficiency and high automation are essential in the process of metal cutting. How to control the chip will affect processing quality, cutting tool life and productivity greatly. With the development of image processing technology, machine vision has been widely used in real-time monitoring of chip shape. A set of machine vision detection system is developed for realizing image capture, image processing, image pattern matching and image analysis in real time in this paper. Especially, dynamic template is designed to match the complex chip. In this system, LabVIEW is used as system platform, QP 300 picture capture card of Daheng-Image cooperation is used as image capture hardware, LED of CCS cooperation is used as light source. The actual operation shows that this system can identify typical C shape chip and spiral shape chip. Meanwhile, other functions are developed, such as parameter optimization and network transmission.

Key words: LabVIEW, chip shape, image recognition, dynamic template.

1. INTRODUCTION

In the metal cutting process of modern high accuracy, high efficiency and high automation, how to control the cutting chip has become a more and more important topic. Adverse chip will severely affect process quality, cutting tool life and productivity, even cause system breakdown. With the deeper research on image processing technology, we utilized chip control and chip forecast to optimize cutting parameter. For this reason, we develop a set of online image detection system. According to chip formation, deformation and breakdown, it provides us with better path on the chip condition monitor of cutting process. This detection system based on the platform of LabVIEW, adopts LED light source of CCS and QP300 image capture card of Daheng-Image cooperation, develops modules of the image real-time collection and processing, long- range transmission, as well as the identification and decision[1]. Especially, according to the complex chip shape we design dynamic template to match it. The actual operation shows that this system has characteristics of integrity, real-time and easy to function expand.

2. SYSTEM EXPERIMENT STRUCTURE

2.1. System hardware composition

This system is composed of the following hardware:

(1) CCD camera: Panasonic CCD(WV-330/G).
(2) Image Capture Card : CG-QP300 of Daheng-Image Co., inserted in PC computer's slot to complete the image signal's A/D converter. Because it adopts the PCI bus, the captured image data delivery doesn't take up time of CPU.
(3) Light source selection: LED light source of CCS Co., the LED lighting system has rapid response, can acquire high quality and high contrast image. After used 1000 hours, it would enter the half-life and keep on the usage. In this paper, we select FPR bottom angle light source for its uniform exposure, and it is easy to carry on edge detection and image segmentation. The system on-site working conditions are shown in Fig. 1.
(4) Microscope selection: K-700Z stereomicroscope of Motic Co., equipped with up and bottom light sources. Its technique parameters and characteristics are as follows:
    1) Magnification times: 6-31;
    2) Object lens: standard;

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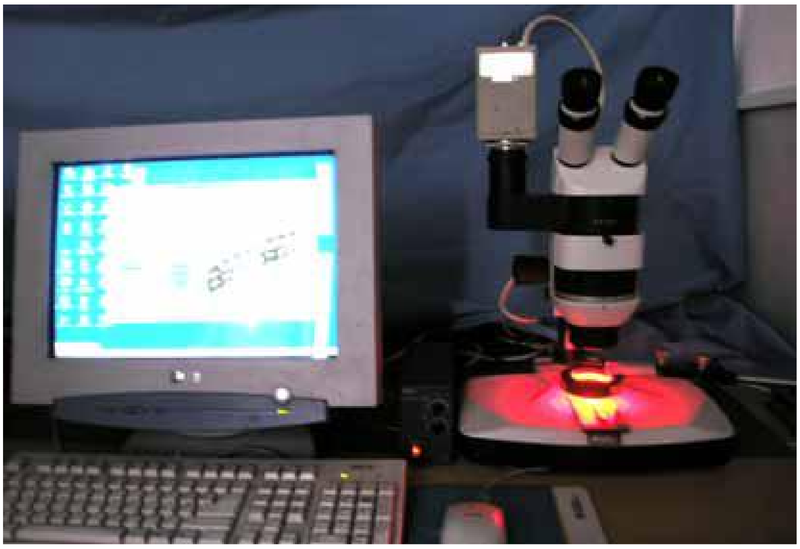


Fig.1.System hardware composition.

3) Operation distance 89mm;
4) Field diameter: 7.4-38.3mm.

2. 2. Software design

2.2 .1. Drive of image capture card and image transmission

(1) Drive of image capture card: adopt Daheng-Image Co. image capture card, compile the drive program according to our demands and make use of the supplied LabVIEW modular of Call Library Function. At first, we use VC++6.0 to generate the captured document of DLL, and then call LabVIEW Block Diagram with the function module of call library, select configure, set contents such as Library Name, Parameter and so on. What need to be paid attention to is that parameter option should guarantee the safety of line distance. At last, we should establish the data passage and buffer areas of the captured image. The concrete institution is shown in Fig. 2.

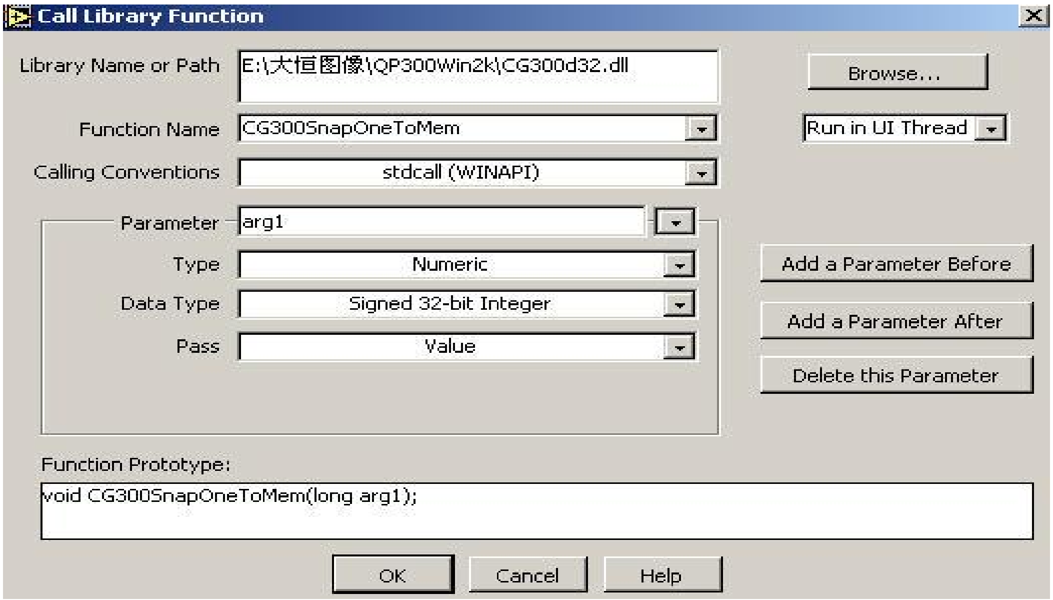


Fig.2.Program setting.

(2) Deliver the captured image to LabVIEW: After complete the drive of capture card, the image must be delivered to LabVIEW. The method we have selected is to deposit the image in specified catalogue, then LabVIEW read the image from this catalogue. Concrete processes is shown in Fig.3.

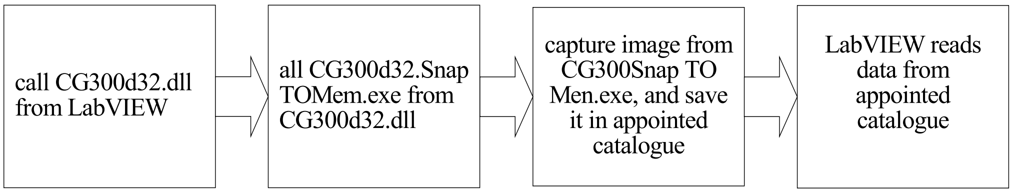


Fig.3. Image deliver process.

2.2 .2. Software workflow chat

The workflow chat of this program is as follows:

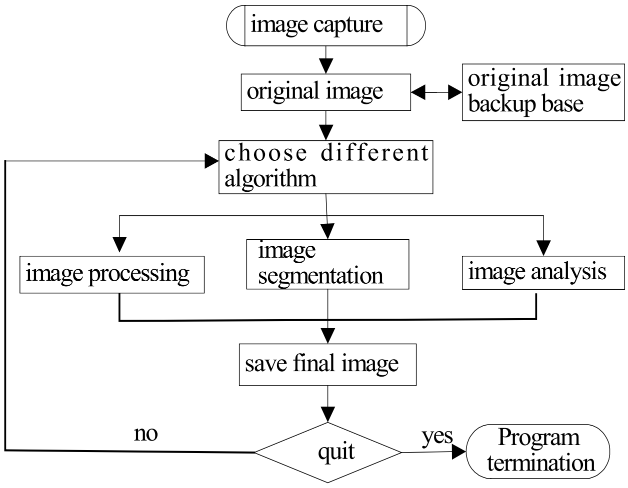


Fig.4. Software workflow chart.

2.3. Chip image processing

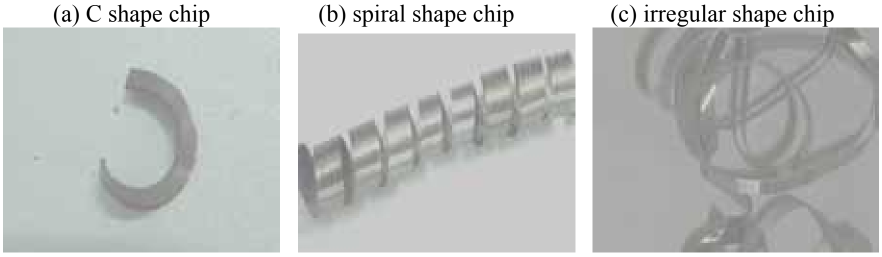
The picture that captured by camera will produce deformation because of being affected by the external environment. Therefore, carrying on image preprocessing is very necessary. The purpose is to recover the real image. Its common methods include smooth, local strengthen.

(1) Smooth: Its purpose is to reduce noise. We select the neighborhood averaging. This is a kind of empty area processing method that the average gray value of a few pixels replaces every pixel gray value. Suppose $f(x, y)$ is function of a $N \times N$ pixels' image, after being smoothed it gets into $g(x, y)$ which is decided by this formula: $g(x, y)= f(m, n)/M$, of which M is the number of pixels, S is point's coordinate integration which lies in neighborhood of (x, y) but not includes it. Attention: neighborhood shouldn't too wide. Otherwise, it will aggravate fuzzy degree of the image. Various chips original image and their smooth results as Fig. 5 shows.

(2)Local strengthen: Using template convolution can easily implement image smooth. But its bad consequence weakens the contrast of image, and produces influence on following recognition. Therefore, in order to resolve this problem, we need calculate or transfer function according to the characteristics of concerned local area. And applying these functions to concerned area to get corresponding strengthen effect. Gray scale histogram transition is the most common method in airspace strengthen. We can use gray scale histogram equalizing or defining to implement small area pixel distribution. If change input image $f(x, y)$ into output image $g(x, y)$, it need to carry out in every pixel position such changes:

$G(x, y)= A(x, y)[f(x, y)- m(x, y)]+ m(x, y)$, among them: The $A(x, y)$ is called local gain function. $m(x, y)$ is the average gray value of the neighborhood around the center pixel(x, y). The result of local strengthen is shown in Fig. 6.

(a) C shape chip (b) spiral shape chip (c) irregular shape chip

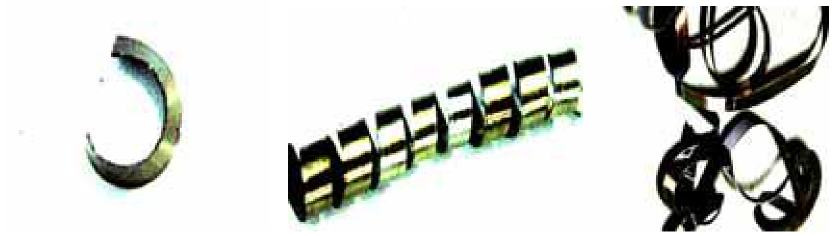


(a) C shape chip (b) spiral shape chip (c) irregular shape chip

Fig.5. Chip image smooth diagram.

2.4. Image comprehension and match recognition

The image comprehension is to make a description and explain the image characteristic, which includes two main processes: image segmentation and image classification[2]. First, based on the gray scale histogram we choose proper



(a) C shape chip (b) spiral shape chip (c) irregular shape chip

Fig.6. Image local strengthen diagram.

threshold to carry out edge extraction. Generally, the gray value between two peaks value is suitable, in this way, the object and background can be divided. Their characteristic parameter to be extracted to carry on the characteristic template's match after complete image segmentation. The common characteristic parameter has area, shape, the constant rectangular quantity and distance etc.. Mathematics expression of the area A: $A= k\times N$, k is the area of every pixel, N is the general number of pixels. The shape factor S can be represented by $S= L\times L/ A$, L means object's circumference. In order to reduce the amount of template matched calculation. On one hand, we can utilize the known experience to decrease required matched position. On the other hand, we can make use of closed matched position and similar long region template to reduce recalculation. During experiment process, gathering the chip sample, defining chip's edge by gradient method of technology, thus getting chip's quantity, casting shadow area and girth, finally getting shape factor G. Shape factor G is the ratio of the equivalent casts shadow area S and actual measured casting shadow area A: $G=S/A$.

(1) To definite the shape factor G, first, according to tested chip's girth L and actual measured casting shadow area A, get each chip's equivalent diameter by this formula:

$$D=4A/L \tag{1}$$

(2) Calculating casting shadow area S with the equivalent of the equivalent diameter (cutting chips) again:

$$S=\pi D^2/4=4\pi A^2/L^2 \tag{2}$$

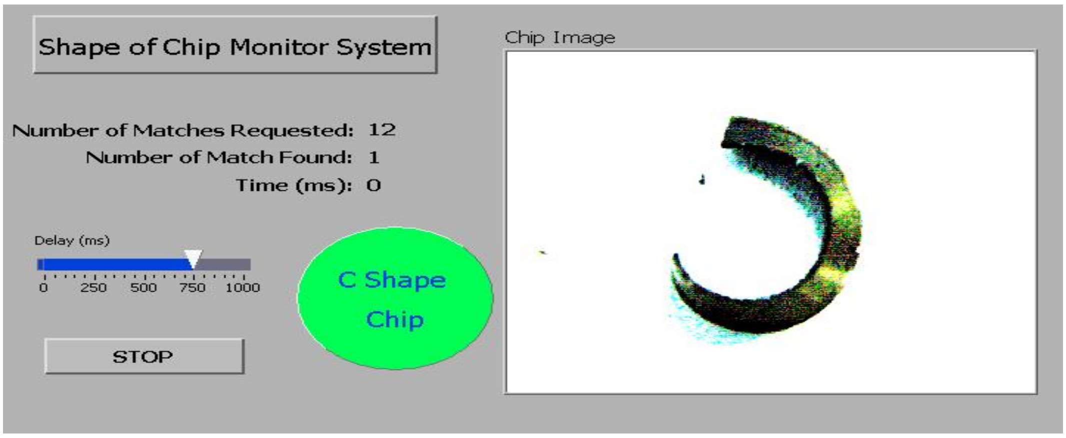
(3)According to the definition of the shape factor G, apply the former formula into formula (1), and get

$$G=4\pi A/L^2 \tag{3}$$

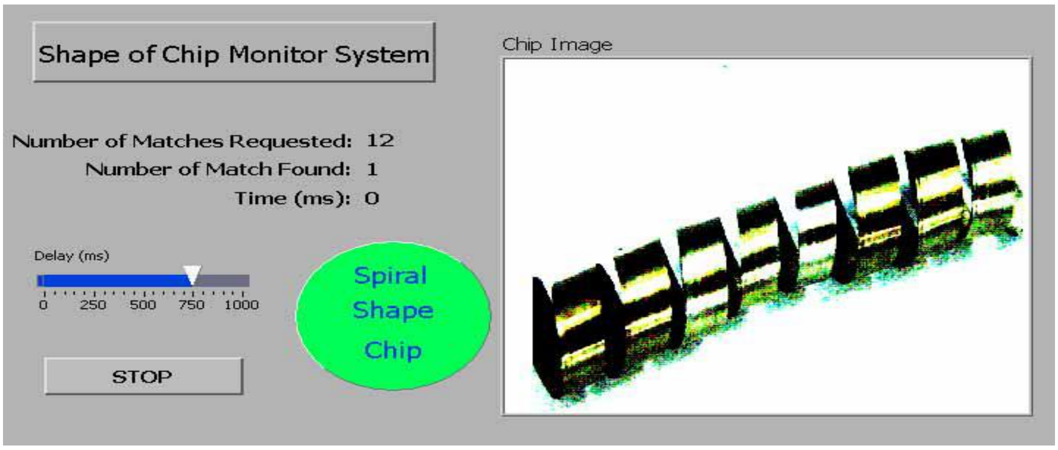
(4)The more the shape factor approaches 1,the more the cutting chip approaches globe body, the factor size is inverse relation with diameter square, so we specify standard that when $G< 1$, the cutting chip is irregular shape chip; $G=1$,is C shape chip; $G>1$, is spiral roll shape chip.

3. LabVIEW ENVIRONMENTAL SYSTEM REALIZATION

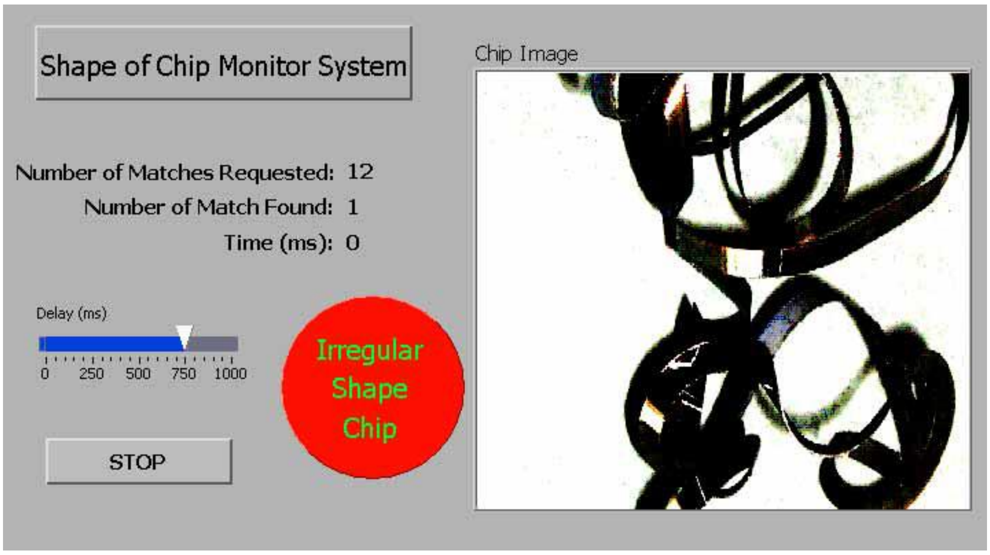
We adopt LabVIEW of USA NI Co. as development environment. LabVIEW is a virtual instrument development platform which based on graph language. It generated application program can independent runs when escape from development platform. Especially, IMAQ Vision Builder module is establishment on interactive pattern and " hypothesis analysis ", can rapid develop image processing and visual software. We make full use of its function: " software is instrument " to invoke its rich specialized control parts and datebase, develop identification software independently to detect the shape of cutting chips. Based on above algorithm and corresponding built SubVI[3], after link the needed SubVI by structure of WIRING tool and sequence etc., we can accomplish image processing and identification preliminary programming. To get deep programming, we must use the modular of IMAQ Vision Builder. It contains a series of MMX optimization function, synthesizes to utilize not even sampling and edge detection and geometry build module method, and allow matched object 0-360 degree of the revolving and a certain scope of dimension scale change. First, establish New Script, enter the pattern of Pattern Matching under Machine Vision tab, establish template. After Creat from ROI template generate *. PNG file. At the same time, choose pattern of permit template rotating when establishing template. And enter Edge Detector, choose Advanced Edge Tool, set Contrast value in 60. to test the value of feature template Caliper, such as area or distance. Then, Generate LabVIEW program again with IMAQ Vision Builder[4]. Finally, join LabVIEW program and debug. Take turning for example, C shape and spiral shape chip are considered as normal, and irregular shape chip is not normal, when it emerging, the program will alarm. System recognition results as Fig.7 shows.



(a) detection result is C shape chip.



(b) detection result is spiral shape chip.



(c) detection result is irregular shape chip.

Fig.7. System recognition results.

4. CONCLUSION

This system puts IMAQ Vision Builder SDK of LabVIEW as well as Motion and Vision module together effectively, accomplishes effective monitoring in TCM(cutting tool state monitoring) system. Even when lighting condition changing (uniform change), poor lens focusing and part image hidden, it can also acquire fairly accurate results. As a result, the cutting chip monitor system's actual operating value can be improved. Meanwhile, software component of this system may also be used in implementing long-range alarm.

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