Assembly system based on computer vision and virtual reality technology

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Abstract. Digital image processing is the key of the vision system, in the virtual instrument system, which is realized by computer software. At home and abroad with the most widely used virtual instrument development platform is Ni's LabVIEW and Lab Windows / CVI, and based on the two software IMAQ Vision is for the two platform provides complete image processing function library or functional modules, such as all kinds of edge detection operator, automatic thresholding, morphological algorithm, filters, FFT, and so, the library contains a large number of the current proof of successful theory algorithm, so users do not need professional programming experience, can rapid development complete good, suitable for the professional image processing and analysis system.

Introduction

Along with the unceasing development of computer technology, PC visualization tends to be more economical and practical. Nowadays, visualization system performs unprecedentedly optimized functions with effective cost thanks to Pentium Pro with MMX, solid OS, PCI local bus, and user-friendly image acquisition software and hardware on account of visual instruments. Before computer image processing system presents, optical photographic and video signal methods took on the job by simulated manipulation. Recently, digital image processing techniques improved remarkably in flexibility, accuracy, adjustment and reproducibility, relying on the fast development of computer technology.

Designs for system hardware and software

Digital image processing is the core of visualization which is accomplished, in the system of virtual instruments, by computer software. At present, LabVIEW and LabWindows/CVI presented by NI are the most acceptable platforms for virtual instruments development in the world. Based on these two sorts of software, IMAQ Vision provides the entire function library and modules for the platforms, including all kinds of edge detectors, automatic thresholding, many morphology algorithms, filters, FFT, etc.. This library contains plenty of certified theoretical algorithms that lay users could recur to develop satisfied systems of image processing and analyzing for their fields with ease, leaving vast programming experiences unnecessary.

Main function of virtual instrument hardware is capturing the measured signal in real world. Generally speaking, the hardware system has two parts, a computer hardware platform and function testing hardware. The computer hardware platform could be any computer types, such as a PC, a portable computer, a workstation, an embedded computer, etc.. This computer takes charge of all

software and hardware of a virtual instrument, in other words, it is a hardware backbone of the virtual instrument. On the other hand, the function testing hardware refers to all kinds of I/O interfaces. According to differences of function testing hardware, the virtual instruments could be classified into four standard architectures as GPIB, VXI, PXI and DAQ.

GPIB(general purpose interface bus)

This is a standard communication protocol between computers and instruments. As the earliest bus, GPIB, restrained by IEEE488, is being equipped by most existing instruments by far. A typical GPIB testing system consists of a computer, a GPIB interface card and several GPIB instruments.

Each GPIB instrument is addressed uniquely and controlled by a computer. If instruments in system are added, cut or replaced, nothing changed but some adjustments for control software in the computer. Nowadays, this idea has been adopted by the interior design for instruments. However, GPIB may not satisfy those applications with high speed requirements, as its data transmission is quite slow as 500KB/s.

VXI(VME bus extension for instrumentation)

VXI system is an extended version of VME bus in the field of instrumentation. It is a consensus criterion of main manufacturers for open instrument bus. A VXI system is made up of 256 units, including a mainframe, multifunctional modules, driver software, system applications, etc.. Any functional modules in the system can be replaced at will to form a new system with Plug& Play.

PXI(PCI extension for instrumentation)

PXI system is a PCI extension for instrumentation. It was a criterion for open modularized instrument bus introduced by NI in 1997. At the same time, PXI brought proven technical codes and norms into PCI. To set up the star triggering bus with accurate timing, as well as the local bus for high-speed communication among neighboring modules, for reaching the requirements of experiments and measures, PXI also takes the multi-board synchronously triggered bus and the reference clock into consideration. In addition, PXI could compatible the mechanical specifications attaching with more requirements for active cooling and environmental testing (in temperature, humidity, vibration and impact).

DAQ(data acquisition)

DAQ system is a data acquisition module based on a standard PC bus (e.g. ISA, PCI, USB, etc.). It took full advantage of computer resources, enhanced the flexibility and expansibility of the testing system obviously. Due to DAQ,a computer-based instrument could be established easily to make the “multi-type machine” and “multi-function machine” come true. With regard to properties, the rapid evolution of A/D conversing and signal conditioning also enforces the acquisition speed of DAQ to reach Gb/s, the accuracy come to the awesome 24 bit, the channels turn to as many as 64. Otherwise, channels like digital I/O and counter/timer could also be combined with no limitation. Those various optional function modules of DAQ with different capabilities, such as oscilloscope, digital multimeter, serial data analyzer, dynamic signal analyzer, random waveform generator, etc., once being attached with a computer combined with corresponding software, leads to a PC with specified functions. This computer-based instrument, due to the inherent intelligence of a PC, is equipped with superior measuring capabilities being comparable to that of a top grade machine. Moreover, it could meet the diversified demands of measures in practice. For most users, this scheme is practical, generally applicable, and cost-effective. No wonder it could satisfy most fields of general science and engineering.

Experiment and analysis

Median filter

Image information acquisition process is often subject to all kinds of noise sources. These noise sources in the image are always presented in the form of some isolated pixels, which can be understood as the pixel's gray level is space-related, meaning there is a remarkable difference between noise sources pixels' gray level and their neighboring pixels. If this kind of interference is not filtered, it will bring a vital consequence to later image's regional segmentation, analysis and judgment. Compared with the conventional linear filters (e.g. low-pass filter), the nonlinear filters are able to solve some problem of image processing better, among which the most useful one is called rank-order filter which could be applied once adjusted in IMAQ Vision. Median filter is one sort of rank-order filter which could not only suppress noises, filter pulse interference and the noises of image scanning, but also overcome the problem of image details blurred caused by linear filter, preserving the image margin information. The intention of the median filter is to take a portable matrix template, proceeding as follows:

①Set the size of the filter template, e.g. 5 ×5 template

②Roam templatein the drawing, and coincide the template center with a certain pixel location in the drawing

③Read the correspondent grey level value of each pixel under the template

④String these gray level values in a row from small to large

⑤Find out the median value in the row

⑥Assign this median value to the corresponding pixel in the center of the template

From the above process, the main function of the median filter is to change the pixel's value whose grey level is greatly different from the surrounding pixels into a similar value with the one of surrounding ones and in this way to eliminate the alone noise sources.

The above method of median filter can be only applied in grey image while the IMAQ Vision can expand it in dealing with color images, the specific method as follows:

Extract the red, green and blue color palette respectively from the original 32-bit color image. The R, G, B of a color image in IMAQ Vision is represented as a 32-bit integer, the second 8-bit is the value of R, the third 8-bit is the value of G and the fourth 8-bit is the value of B.

②Apply the median filter method in the red, green and blue tones template (8-bit) respectively. Compared with the low-pass linear filter, a median filter owns the advantage that it will not make the boundaries fuzzy when it attenuates the random noises, which ensured the accurate grain size characteristics.

③The treated red, green and blue color palette based on the corresponding bit operation will replace the original color image template to generate a new32-bit color image and removed the noise ones.

Binarization processing of the color images

It can ensure the system's threshold algorithm results with a higher precision and still gain a good binary image after treatment in the case of poor light conditions when using the RGC threshold algorithm while not the general grey threshold algorithm. It may achieve a better treating effect with the traditional gray threshold algorithm only if there is a rather big grey level difference between the target object and the background of the original image. Therefore, there must be an excellent lighting environment with a high standard. Experimental results show that this method is simple and effective and laid a very good foundation for the follow-up process but it also needs to spend time on the tri-color artificial threshold adjustment.

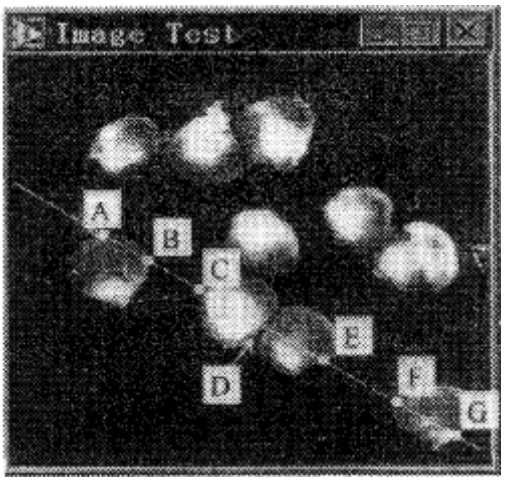


Figure 1 original image

Hole filling process

It may appear holes inside the binary image target area after the treatment ofthreshold algorithm.It may be the consequence of the unobvious difference between the light conditions, background and target in the value of pixels and may also because the value of threshold algorithm has not been taken reasonably. Its solution should be as the closed algorithm of mathematical morphology. After treatment, the holes inside the target area (grain) are managed to be filled well.

Regional segmentation

Using only threshold processing is difficult to obtain accurate regional segmentation results. Figure 3 is a histogram of the image in Figure 2 along the line L of gradation. There are big gray jumps among A、B、C、E、F、G from the figures while the point D has a relatively small amplitude jump. Obviously, it will cause a picture distortion by taking the threshold value based on the point D, and further could not get an accurate grain characteristic. However, if take the grey value of A、B、C、E、F 、G which is lower than D as the testing threshold value, it may get a more accurate grain boundary but can not detect the boundary Information where point D exists. Thus, when the threshold process can not meet the requirements, it is necessary to have an image segmentation by using morphology algorithm.

Image segmentation is a process dividing the digital image into disjoint (non-overlapping) regions and is the basis of pattern recognition. Regional segmentation is a method of image segmentation, namely each pixel is classified into various objects or areas. Once an object has been separated, it is possible to measure and classify them.

It laid the foundation for the correct region segmentation through the above a series system processing- filtering, binarization and filling holes etc.. The principle of region segmentation is "open" algorithm. Firstly, determine the connectivity guidelines 8 communication (the result of 8 communication is more closer to people’s feeling). Then take the structural element as 7 × 7 matrix template and the median location of the matrix is set as the origin of structural elements.

After four timesconsecutive corrosion, the grains are completely separated, as shown in figure 3(b). In this case, the CPC contains 31 images objects.

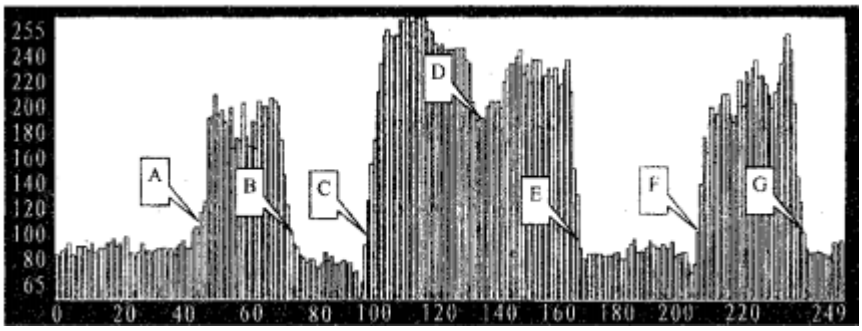
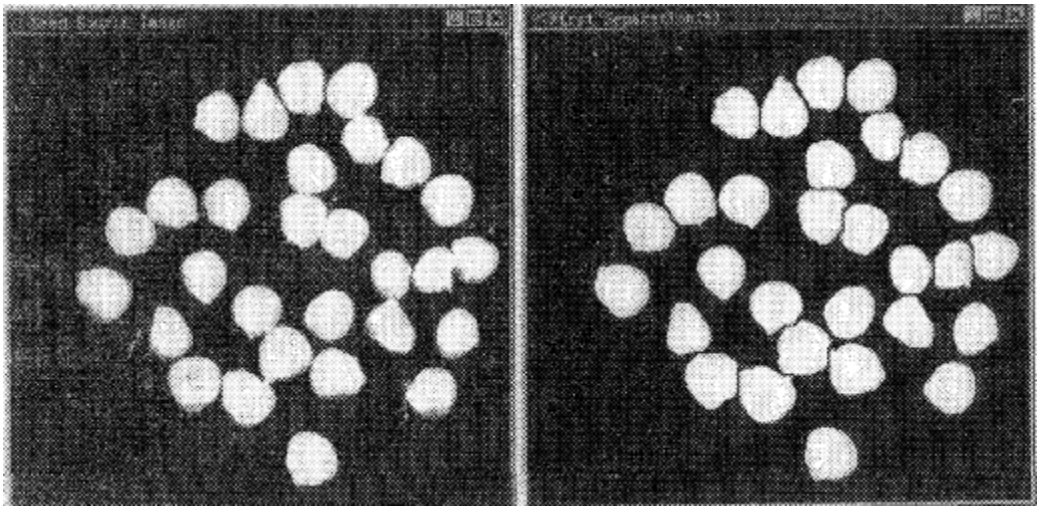


Fig. 2 The grey histogram of original image

IMAQ Vision first performed edge detectionbefore the etching process and obtain a complete target edge, and thenthe image is expanded to the edge of the grain after etching. In this way, it both ensures the full image segmentation, while maintaining the original object edges from any damage.



(a) (b)

Fig. 3 edge detection

Filter treatment

In practice, there will be a large number ofmicro-sized debriswith the field grains, as shown in the A and B of fig.3(a), (b). And there might be spots in the background. If they are not removed in image processing, they will be mistaken as grains and hence as statistical samples. The treatment is a filtering process according to the size of the target objects, and its basic idea is the corrosion algorithm of Mathematical Morphology. After several times etching of IMAQ Vision, it returns the grains which fails to be etched to the shape before corrosion as the same to ensure its edge information.

After filtered minor impurities, identify the grain color(Fig. 4) and count features, including each grain’s area, perimeter, major axis, minor axis, centroid coordinates and other data etc.. Then treatment process ends.

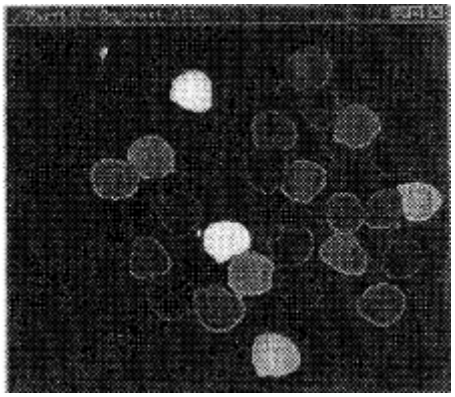


Fig. 4 The final result of image processing

Conclusion

With the development of computer technology especially the PCI bus technology, MMX technology and network technology, the real-time image acquisition vision systems based onvirtual instrumentare increasingly widely applied in test, measurement and control field. That currently Pentium MMX / PII / PII PC and workstation are configured multiple PCI expansion slots and AGP video card, the new operating system such as Windows 95/98 achieves to support "plug and play" function, and the image color board developers are constantly developing and improving driver software and modular vision software to provide a more robust API and a more excellent application development system platform for users, makes the virtual instruments visual system is flexible to use and powerful in functions with PC bus scheme applied and also makes the system owns a splendid expansiveness, maintainability and cost performance, as a result, it is becoming more and more widely accepted by users.

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