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Fast Defect Detection Algorithm on the Variety Surface with Random Forest using GPUs

Bae- guen Kwon[1] and Dong-joong Kang[1]

[1] Department of Mechanical Engineering, Pusan National University, Pusan, 609-735, Korea
(Tel : +82-51-510-2163; E-mail: {vis, djkang}@pusan.ac.kr)

Abstract: This paper proposes a defect detection method that can find the surface irregularity of the variety surface. The human like, the Variance of Variance (VOV) method can calculate the characteristic pattern of surface with mathematization. Also defect with unusual pattern appear using the VOV method. The object surface usually has smooth or textured plane, including defects with intensive irregularity. Conventional variance detection algorithms are not adequate for detecting various defect types of multiple scales and intensity variations. The purpose of this paper is to propose a method that can find defections of different scales in a single framework. This method can detect defects of different sizes by changing the window's size, which is combined with GPU computing for real time processing of inspection. The local VOV value does not affect other calculation result that can good for parallel processing. GPU has the high performance with parallel processing and it solved the typical processing speed problem of VOV method. For robust detection, we combined result of single VOV detection using machine learning process. From the results of the experiments that used in real images, it is verified that the method can be applied to detect the defects of images for irregular and textured intensity under uneven illumination.

Keywords: VOV(Variance of Variance) Detection, GPU Computing, , Random Forest, Inspection System

1. INTRODUCTION

Today inspection system has also become bigger and more important for quality control. The vision inspection system is one of the most important systems in Factory Automation system and has lots of positive characteristics. During the inspection process, one does not need to contact the surface. Also, the inspection process is not influenced by electronic and magnetic environment. The surface temperature also has no influence on the inspection process. Accordingly, the vision inspection system is used in many ways in the factories. Moreover, recently, most of the hardware – camera, frame grabber, processor, and memory – have been developed, which has also helped in guiding the development of the vision system that we currently have today.

2. DEFECT DETECTION ALGORITHM

2.1 VOV(Variance of Variance) Detection

This paper uses the VOV detection method. The algorithm consists of two parts. At first, image is divided into small parts, and these parts called a 'patch'. And we obtained line variances and patch-VOV values.

The variance means plane's pattern. If the plane has flat character, the variance becomes small, but on texture plane has the much bigger variance. This character also is used on line problems. Texture line has the bigger variance then flat lines. In human eyes, we can find defect with unusual pattern. Also defect has unusual variance with other background plane.

$$\sigma_i^2(k) = (m-1)^{-1} \sum_{j=1}^{m} (x_{ij}^{(k)} - \bar{x}_i^{(k)})^2 \qquad (1)$$

In k^{th} patch, i^{th} row's variation is expressed as Equation (1). $x_{ij}^{(k)}$ is the pixel value of i^{th} row and j^{th} column at k^{th} patch. $\bar{x}_i^{(k)}$ is also the mean of the pixel values in the i^{th} row.

$$\sigma_r^{VOV}(k) = (m-1)^{-1} \sum_{l=1}^{m} (\sigma_{rl}^2(k) - \bar{\sigma}_r^2(k))^2 \qquad (2)$$

In the front, we get the row and column variance vectors. Then, the variances of these vectors are calculated by Equation (2) and it is called VOV of patch or single VOV value. If the patch has a uniform pattern, the elements of the variance vector will get similar values. Hence, we can get similar VOVs from non-defect vectors. However, if the patch gets some defects, its row and column variance vector has special variance, and that variance increases the VOV significantly.

2.2 Random Forest with VOV value

If use just single VOV detection, it is easy to lost character of defects and whole system has low reliability. The VOV detection has variety character with window size changing. The bigger window has the more robust detect reliability and weaker at noise. Also we cannot use large window detection on complicated pattern. Hence, for robust at variety plane, combination of classifiers is the essential. We use the Random Forest for combination. It is fast and robust method to combine the classifiers.

2.3 GPU Computing

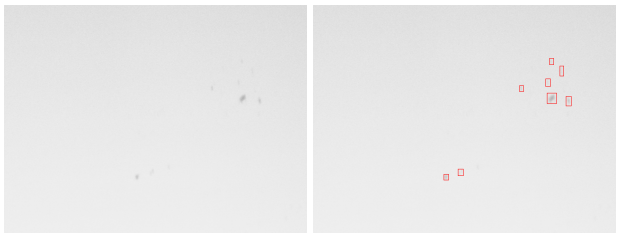
The VOV method can derive the character of plane well and random forest make it has better performance.

However, we cannot use in real-time problem, because the complexity of variance. In variance equation, we have to need the square and divide equation. The VOV detection has too much time to detect defects. Also, random forest has many VOV values.

Today, the performance of Hard-Ware was developed and we can use high-performance CPUs with fast processing speed. However, for effectiveness problems, cluck of singe core of CPU is not increasing continually. Hence, the Multi-core CPU was developed and it becomes the future of the CPU's history. However, the multi-core system does not have multiple performances with the number of cores and parallel computing became the new issue of future computing. On the other hands, GPU has the many-core system with hundreds or thousands cores. GPU has the more powerful performance with parallel computing and it became the new way for high-speed and huge computing. The VOV detection is one of good algorithm for parallel computing. The variance equation does not affect other variance equation and each single algorithm is all independent. So we can use GPU computing with VOV detection.

3. Experimental Result

The images of the side-protector from two UXGA Progressive Scan Cameras (0.0383mm/pixel) with 150 x 200 mm^2 hand-made white plane LED light were obtained. 640 x 480 pixels grayscale law image and the Multi VOV detection that was mixed with single VOV detectors were used. We used 13 features (2 features about plane's texture and 11 features about window size) for learning process. The number of tree is 100 and maximum dimension of node is 10. We used 5000 clean and 1000 defect points. The pixel resolution of the grayscale image was 40pixels/mm. A 2.8GHz Quad-Core Processor and 4Gbyte DDR3 Memory were used for CPU calculation and NVidia GTX-465 used for GPU calculation to obtain results.



(a) (b)

Fig. 1 The results of the VOV Detection using GPUs
(a) Original Image, (b) Result Image

Fig 1 (a) is the image of yellow car surface and (b) is the result of calculation. It takes each 2.375sec and 0.241sec to calculate with CPU and GPU.

4. CONCLUSION

The detect defects based on probabilistic VOV method was proposed. It was found that this method detects defects well and independence with defect size. It also does not need to know the state of the surface. Additionally, this method is also robust at the texture surface and can change colors without changing parameters. However, this method has a critical problem in which it takes too much time to process. For real-time processing, we use the GPU computing to solve this problem and we can compose faster detection method. Moreover, it is not a perfect kind of inspection system. When the plane was mixed with two or more materials, the method did not detect any defects. Therefore, more steps are needed to segment the image from the side-protect holder. Hence, a lot of work is needed.

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