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Review Article

A Review on Various Defect Detection Techniques

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Abstract

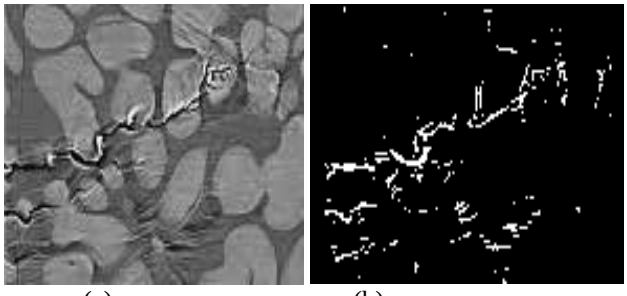
Visual inspection is an important part of quality control in industry. In decades ago, this job has been heavily relied upon manual inspection by human inspectors. Defect detection using manual inspection of an object is not a reliable approach because of fatigue and inattentiveness of an inspector. This manual inspection system has been replaced by automated visual inspection systems. Defect detection is a technique which is used in automated visual inspection system for quality control of the product. In this paper, we are going to review various defect detection methods to detecting the defects from different types of images which are used in automated visual Inspection System and also compare all these methods.

Keywords: *Image Processing, Defect Detection, Gabor filter, Wavelet Transform, Otsu method*

1. Introduction

Image processing is one of the mostly increasing areas in computer science. As technology advances, the analog imaging is switched to the digital system now-a-days. Every day, we capture huge amount of images which are very difficult to maintain manually within a certain period of time. So the concept and application of the digital imaging grows rapidly. Digital image processing is used to extract various features from images. This is done by computers automatically without or with little human intervention. One of the most important operations on digital image is to identify and classify various kinds of defects. Thus to detect the defects from any image some methods are established and placed at three levels. At the lowest level, some techniques are available which deal directly with the raw, possibly noisy pixel values, with de-noising and edge detection being good examples. In the middle, there are algorithms which utilize low level results, such as segmentation and edge linking. At the highest level are those methods which attempt to extract semantic meaning from the information provided by the lower level (G. M. Atiqur Rahaman, *et al* 2009).

Visual inspection constitutes an important part of quality control in industry. This process is time consuming and all the times the inspection doesn't produce the same results. Here the quality is subjective as it varies time to time and with the persons (L. Tomczak *et al* 2007).The quality assurance of product is mainly carried out by manual inspection. However, the reliability of manual inspection is limited by ensuing fatigue and inattentiveness (K. L. Mak *et al* 2005).In the exponential growth of technological era the manual inspection systems has been drastically brought down. The Automated visual inspection systems are utilized in many industrial and commercial applications. There are many visual inspection systems which are used for defect detection of ceramic tiles (G. M. Atiqur Rahaman, *et al* 2009), textured material (Ajay Kumar, *et al* 2002)., textile fabric (K. L. Mak *et al* 2005) and fruits (Hamid Alimohamdi *et al* 2009) etc.There are many techniques that has been employed for detecting the fruit defect (Hamid Alimohamdi *et al* 2009), surface defect (Gui-mei Zhang *et al* 2011) and digital texture image defect (K.N.Sivabalan *et al* 2010) etc.This paper provides the overview of some of these defect detection techniques proposed till now.



(a) (b)

Figure 1 (a) Original image, (b) the image in which defects have been identified (K.N.Sivabalan *et al* 2010)

The overall outline of this paper is mentioned as follows: Section 2 reviews the various techniques of defect detection briefly. Section 3 presents the comparative study

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on different defect techniques. Finally, the conclusion is presented.

2. Various Defect Detection Techniques

In this section, we review different defect detection methods that have been proposed to find out the different type of image defects. These techniques can be described briefly as follows:

In 2006, A. Serdaroglu *et al.* proposed the method based on the use of Independent component analysis method along with wavelet transforms for identifying defects in textile fabric images. In this method, Different sub-bands of the wavelet packet tree scheme of the defect-free sub-windows are obtained and independent components of these sub-bands are calculated as the basis vectors. The true feature vectors corresponding to these basis vectors are computed. In this paper, they presented that applying wavelet analysis prior to ICA increases the defect detection rate compared to the use of wavelet transformation or ICA alone. The idea behind this ICA method is to find the mean value and standard variance for the whole image. These two features are extracted to identify the defects. The original image pixel values are subtracted from the mean value and then will be divided by the standard variance. The intensities which are below certain value will be classified as a defected area.

In 2009, Hamid Alimohamdi *et al.* presented an automated system based on optimal Gabor filter for online defects detection in various fruits. The proposed method works based on analysis of fruit skin as a texture image. This method works as follows: First a bank of Gabor filters is applied on fruit image. Then based on the response of the filters the optimal filter is selected among the filter bank. By thresolding the response of the optimal filter, the skin defects are detected. This method is also well suited for inspection of any other texture materials such as steel rolls, plastic, wood and tile etc.This algorithm is robust, scalable and computationally efficient for detection of fruits defects. This algorithm is also considered the selection of filter parameters especially center frequency and mask size which heavily relates with the texture characteristics. The estimate of parameters is important for improving detection rates and reducing false alarm rates. The parameter used in this algorithm is not works very well on every individual image.

In 2010, K.N.Sivabalan *et al.* adopted the technique of feature extraction and segmentation to identify the defects in the digital image. The proposed research work was carried out in three different stages: feature extraction, elimination of high frequency components, and identification of defected area. In Feature Extraction, the minimum, maximum and median values are calculated for each row of the image to frame the feature vector. After the extraction of feature vector, the median value is used to eliminate the high frequency components in the digital image. Traditionally the texture components in the image have high frequency spectrum and defect is assumed to be in low frequency spectrum. The extracted image and the median value of each row of the original image are used for identifying the defected area. This proposed defect detection technique which is fast and simple compared to other defect detection algorithms. This Algorithm has the capacity to be used in various types of images. This Algorithm is most suitable for the defects which have low frequency. This algorithm is not suitable for all forms of defects and the efficiency of this algorithm is low.

In 2011, K.N.Sivabalan *et al.* presented technique to identify the defects in various digital images in industries. In this technique Gabor filter and Gaussian filter is used to eliminate the texture elements in the digital image by isolating the defected area. Then a fast searching algorithm is used to identify the defected pixels and to effectively segment it. The proposed technique is suitable for texture and non-texture images. This Algorithm is used to identify the defects in the digital texture image using non texture methods. The Algorithm has proved to be 85% efficient in detecting the defects. However this algorithm is suitable for images which have defects in low intensity levels. This algorithm is not suitable for detecting defects in high intensity levels.

In 2011, Gui-mei *et al.* presented a new segmentation algorithm to detect the surface defect of parts, which applied with morphology and wavelet transform into the Otsu algorithm. The method can effectively extract the defect from the images which contain complex background and noise. In this algorithm, there are two steps: one was segmentation target from the background and the other was segmentation defect from the target. In the first step, the target image was acquired using the morphology method. Then, the monolayer wavelet coefficient was applied to separate the target image. Thirdly, the redundancy information in the image was removed by means of the low frequency-reconstruction. Finally, the one and two dimensional Otsu algorithm was used to segment the defect from part surface. This algorithm has higher segmentation accuracy and better noise resistance than that of the traditional one and two dimensional Otsu.

In 2012, Wei-Chen Li *et al.* proposed a defect detection scheme based on wavelet decomposition techniques to identify various defects in multicrystalline solar wafers containing inhomogeneous grain patterns. The defects found in a solar wafer surface generally involve scattering and blurred edges with respect to clear and sharp edges of crystal grains in the background. This method uses the wavelet coefficients in individual decomposition levels as features and the difference of the coefficient values between two consecutive resolution levels as the weights to distinguish local defects from the crystal grain background, and generates a better discriminant measure for identifying various defects in the multicrystalline solar wafers. This method performs effectively for detecting fingerprint, contaminant, and saw-mark defects in solar wafer surfaces. It can be applied successfully to any types of defects that involve relatively scattering and blurred edges on inhomogeneous solar wafer images. However, asevere micro-crack defect showing thin and sharp edges in the multicrystalline solar wafer cannot be effectively detected by this method.

Table 1 Comparison of Various Defect Detection Techniques

Technique	**Purpose**	**Image Type**	**Calculation Parameter**	**Interpretation**
Independent Component Analysis and wavelet Transform (A. Serdaroglu *et al.2006)*	Identifying defect in textile fabrics	Gray level Digital Image	Mean, Standard variance	It uses defect free sample for more accuracy.
Optimal Gabor Wavelet Filter (Hamid Alimohamdi *et al* 2009)	Detecting skin defects in fruits	Gray level Digital Image	Frequency,	It gives error rate in image.
			Orientation	Execution speed is high.
Feature Extraction and Segmentation (K.N.Sivabalan *et al* 2010)	Detecting defect for various image with varied size	Gray level	Maximum,	No error rate is detected.
		Digital Image	Median,	It is most suitable for defects which have low frequency.
			Minimum	Execution speed is low.
Gabor Wavelet filter and Gaussian filter (K.N.Sivabalan *et al* 2011)	Detecting defect for various digital image	Gray level	Gabor wavelet function, Gaussian filter, median,	This algorithm is suitable for images which have defects in low intensity levels. This algorithm is not suitable for detecting defects in high intensity levels.
		Digital Image	Standard deviation	
Otsu Image Segmentation Algorithm Based on Morphology and Wavelet Transformation (Gui-mei *et al.2011)*	Detecting surface defects of parts	Color Image which contain complex background and noise	Morphology Operation, Wavelet Transform	It has higher segmentation accuracy and better noise resistance than that of the traditional one and two dimensional Otsu.
Wavelet-based defect detection(Wei-Chen Li *et al.2012)*	Identifying various defects in multicrystalline solar wafer images containing inhomogeneous grain patterns	Solar Wafer Image	Wavelet Decomposition	It is successful on any types of defects that involve relatively scattering and blurred edges on inhomogeneous solar wafer images. This method cannot detect the thin and sharp edge of the defects in multicrystalline solar wafer images.

3. Comparative Studies

The comparative study of above mentioned techniques based on the use different parameters is presented in this section. Defect detection techniques use different dataset of information. The type of the images used for the detection process also matters of concern .Table 1 shows the comparison of all these techniques.

Conclusion

From the review of the above papers, it can be concluded that many different defect detection techniques have been employed to find out defects from various types of images. For defect detection accuracy point of view, some technique like Gabor wavelet filter gives high execution speed along with error rate and some techniques like Feature Extraction and segmentation, Otsu method based on morphology and wavelet transform technique gives low execution speed with high segmentation accuracy. These all techniques can detect defects like crack, pinhole, and fingerprint etc. but doesn't gives good result of detecting micro-crack defect which shows thin and sharp edges of the defect.

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