Interference Information Processing Technology for Defects of Aluminum Honeycomb Structure in Aircraft

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Abstract. In order to get the interference information extraction aircraft aluminum honeycomb structure defect extraction, reliability of testing. This paper uses image processing technology to find a method about image processing composite, with the help of laser shearography detection method detecting detection. The flaw speckle results show that, after Fourier filtering , unpacking of step by step, linear trend processing of the image, gray scale processing method can extract powder composite suited interference information, effectively improve the reliability of detection of the scattered laser displacement suited, provides a new image processing program to help speckle image processing.

1. Introduction

Aircraft aluminum honeycomb structure as a composite structure consisting of skin and honeycomb core, is widely used in the fields of aviation and aerospace. It has the advantages of light weight, high specific strength and stiffness, bearing capacity, impact resistance, good cushioning performance and so on [1, 2]. However the honeycomb composite material is easy to produce fatigue stress and crack in the process of use. Then it caused various defects and damage, reducing the safety, reliability, maintainability of aircraft, affecting the normal operation of the aircraft and reducing the service life. As a kind of inside defects which often occurs, debonding is hidden and dangerous, and difficult to identify by eyes, and the detection process is difficult. These defects will become the source of cracks, causing greater defects. The existence of these defects will change the mechanical state of the whole structure, reduce its strength and shorten its life [3]. Through laser dislocation speckle detection can get defect fringe pattern, found hidden internal defects. Therefore, how to filter the speckle fringe effectively is a very important theoretical and practical significance.Qin proposed a regression algorithm [4], which runs fast and can effectively suppress speckle noise. However, image contrast is not ideal. Qifeng Yu proposed spin filtering method which considers the gray level distribution pattern of different section, choose to filter in the fringe contour line, to remove the noise and does not damage the fringe characteristics at the same time [5, 6]. In this paper, image processing technology is used to find an image composite processing method. The defect is detected by laser dislocation speckle interference, and getting the interference information and improving the reliability of detection.

2. Image processing theory

In the speckle image, speckle is the feature of streak. It is both a carrier of detection information and a multiplicative noise in the image. Therefore, speckle is both signal and noise. Noise of speckle in the image is generally considered the Gauss white noise, the noise size generally greatly, there may be more than a dozen pixel size. For the speckle image processing, it is necessary to find an effective noise reduction method, eliminate the influence of speckle size noise, enhance the visibility and the resolution of stripes, improve the fringe contrast, increase image definition [7]. The commonly methods used to speckle image processing are the following.

2.1. Fourier filter

The Fourier filter is a frequency domain filter, which first converts the image to the frequency domain through the Fourier transform, and then restrain various frequency components selectively. The discrete Fourier transform describes the relationship between the spatial representation of discrete signal and frequency domain. It is one of the most effective tools for signal processing, fast calculation of spectrum analysis, convolution and correlation operation, filtering processing, power spectrum analysis and transfer function modeling plays a key role. The spatial of discrete Fourier transform and frequency-domain analysis methods can solve many image processing problems, so the discrete Fourier transform has wide application in the field of image processing, [8].

Define $f(x,y)$ is a two-dimensional discrete signal ($M \times N$), which is equal interval sampling in spatial. And x, y is discrete real variable. A two-dimensional discrete Fourier transform is defined as

$$F(u,v) = \frac{1}{\sqrt{MN}} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x,y) \exp\left[-i2\pi\left(\frac{xu}{M} + \frac{yv}{N}\right)\right] \begin{pmatrix} u = 1, 2, \cdots, M-1 \\ v = 1, 2, \cdots, N-1 \end{pmatrix} \tag{1}$$

In the formula, u and v are discrete frequency variable.
Two dimensional discrete Fourier inverse transformation is defined as

$$f(x,y) = \frac{1}{\sqrt{MN}} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} F(u,v) \exp\left[i2\pi\left(\frac{xu}{M} + \frac{yv}{N}\right)\right] \begin{pmatrix} x = 1, 2, \cdots, M-1 \\ y = 1, 2, \cdots, N-1 \end{pmatrix} \tag{2}$$

2.2. Frequency domain low pass filtering

Low pass filtering is the low pass filtering of the image in the frequency domain, then the inverse transform is carried out to get the processed image. Fourier transform and cosine transform can get the spectrum distribution of the image, and the image information corresponds to the low frequency component, and the detail and boundary of the image correspond to the high frequency component. The low pass filter can highlight the image information and desalination the details and boundaries of the image. The deformation information of the object corresponds to the low frequency component of the spectrum, while the noise corresponds to the high frequency component of the spectrum. By filtering out the high frequency component, it can suppress or eliminate the noise. Therefore, the low pass filtering technology is widely applied in speckle metrology. Low pass filtering in frequency domain mainly includes ideal low pass filter, Butterworth (Butterworth) low pass filter and exponential low pass filter, etc.

(1) Ideal low pass filter
The ideal low pass filter is defined as

$$H(u,v) = \begin{cases} 1 & (D(u,v) \le D_0) \\ 0 & (D(u,v) > D_0) \end{cases} \tag{3}$$

In the formula, $H(u,v)$ is the transfer function, D_0 is the cut-off frequency, $D(u,v) = \sqrt{u^2 + v^2}$.

(2) Butterworth low pass filtering
The Butterworth low pass filter is defined as

$$H(u,v) = \frac{1}{1 + \left(\sqrt{2} - 1\right)\left[\dfrac{D(u,v)}{D_0}\right]^{2n}} \tag{4}$$

In the formula, D_0 is the cut-off frequency, n is the order of the filter, when $D(u,v) = D_0$, $H(u,v) = \dfrac{1}{\sqrt{2}}$.

(3) Exponential low pass filtering
The exponential low pass filter is defined as

$$H(u,v) = \exp\left[-\frac{D^2(u,v)}{2D_0^2}\right] \tag{5}$$

In the formula, D_0 is the cut-off frequency, when $D(u,v) = D_0$, $\mathrm{H}(u,v) = \frac{1}{\sqrt{2}} = 0.6065$.

2.3. Median filter
Median filtering achieves the purpose of removing noise by finding intermediate values in the neighborhood. It can effectively protect the edges of images, and remove noise at the same time, which has obvious effect on salt and pepper noise.

Set S as a neighborhood set including a pixels (x_0, y_0), and (x_0, y_0) is the pixel in the S , and $f(x,y)$ is the gray value at pixel $((x_0, y_0))$, then the gray value of the median filter at the pixel (x_0, y_0) can be expressed as

$$F(x_0, y_0) = \left[\operatorname*{\textit{sort}}_{(x,y) \in S} f(x,y)\right]_{\frac{m \times n + 1}{2}} \tag{6}$$

In the formula, sort represents the sort; $m \times n$ represents the number of pixels in the set, that is, the size of the filter window. And you can take different values, so that different filter windows can be obtained. The odd number window is usually taken so that it is easier to get the median gray value. The effect of median filtering is closely related to the shape and size of the window. For a two-dimensional image, the shape of a window can be a rectangle, a round or a cross, and the center of the window is generally located on the processed point.

3. Design and manufacture of aluminum honeycomb structure
In this paper, an aluminum honeycomb structure specimen and its internal debonding defect are designed to simulate the real aircraft aluminum honeycomb structure and internal debonding defects. The sample size is 150mm * 250mm, the following specific parameters: thickness of the honeycomb
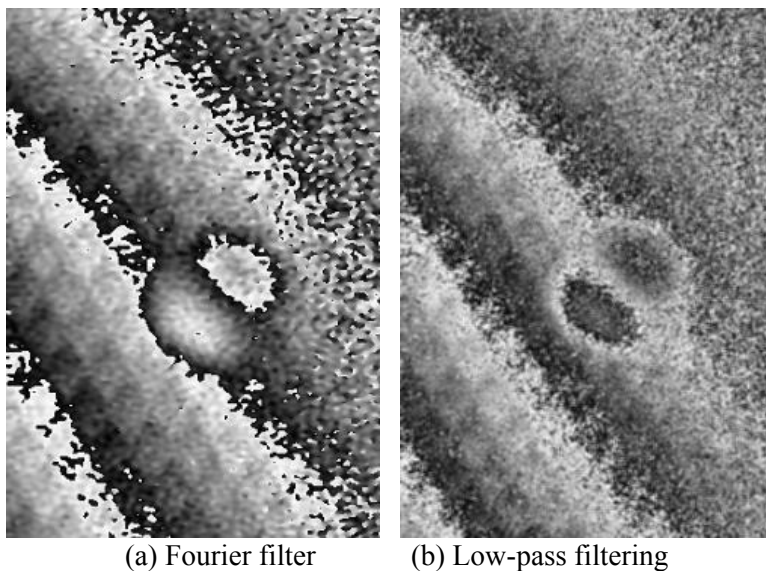
panel's skin were 0.3mm, honeycomb lattice length 4mm and the thickness of honeycomb sandwich foil were 0.04mm. Manufacturing defects in specimen, a layer thin film which the size in accord with the defect size sandwiched between the honeycomb with the skin, then bonding on the part which after the film, making one parts, defect that size is 20mm (0.80inch). The specimen drawings is shown in Figure 1.

Fig. 1 Specimen drawings

4. Test methods and results

Using different image processing methods of the defects observed in picture processing effect. In this paper, the Fourier filter, low-pass filtering, median filtering, unpacking of image processing step, linear trend, gray processing method for image processing, the image processing effect as shown in figure 2
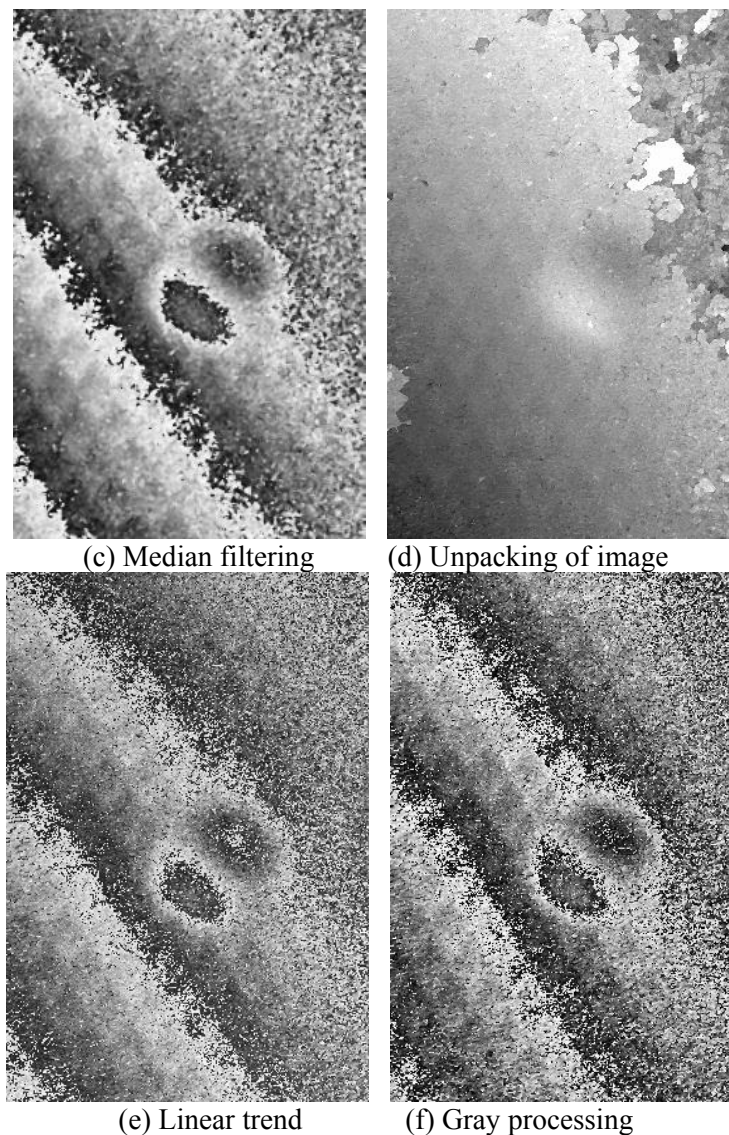

(a) Fourier filter   (b) Low-pass filtering

(c) Median filtering   (d) Unpacking of image

(e) Linear trend   (f) Gray processing

Fig. 2 Image processing effect

From the figure 3, we can know that the image definition which by Fourier filtering is better than the low pass image filtering, median filtering, and the effects on the image speckle stripe can be eliminated by unpacking of

Image processing step, through image linear trend processing or gray processing can filter out larger granular noise, this paper puts forward the following three methods were used to carry out comprehensive treatment to observe the effect of image processing image.

Method one: ①the Fourier filtering, ②unpacking of step by step, ③the linear trend, ④the gray image processing composite processing method;

Methods two: ①low pass filter, ②unpacking of step by step, ③ the linear trend ④the gray image processing composite processing method;

Method three: ①the median filtering, ② unpacking of step by step, ③the linear trend, ④the gray image processing composite processing method;

The image processing method of different combination of observation of the effect of image processing. The image processing step of number representing the speckle image, as shown in figure 3, figure 4, figure 5.
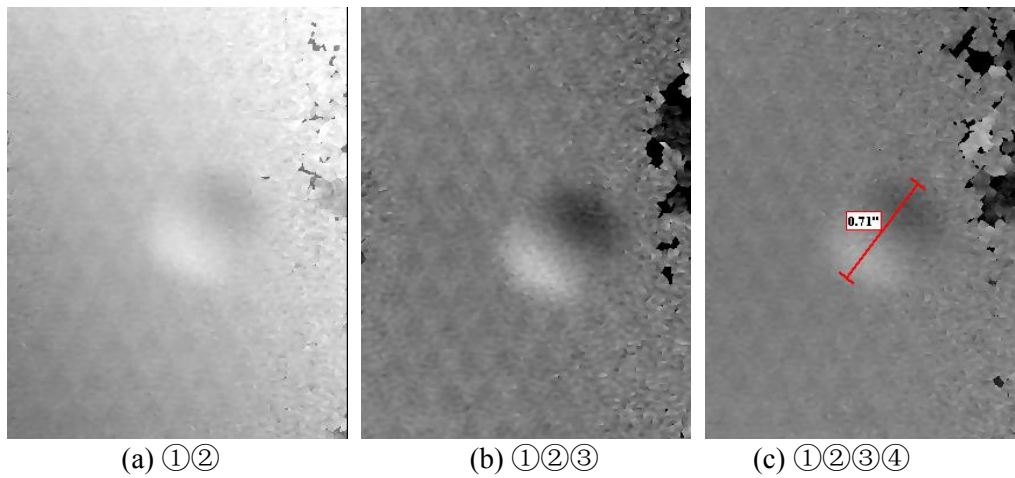
(a) ①②   (b) ①②③   (c) ①②③④

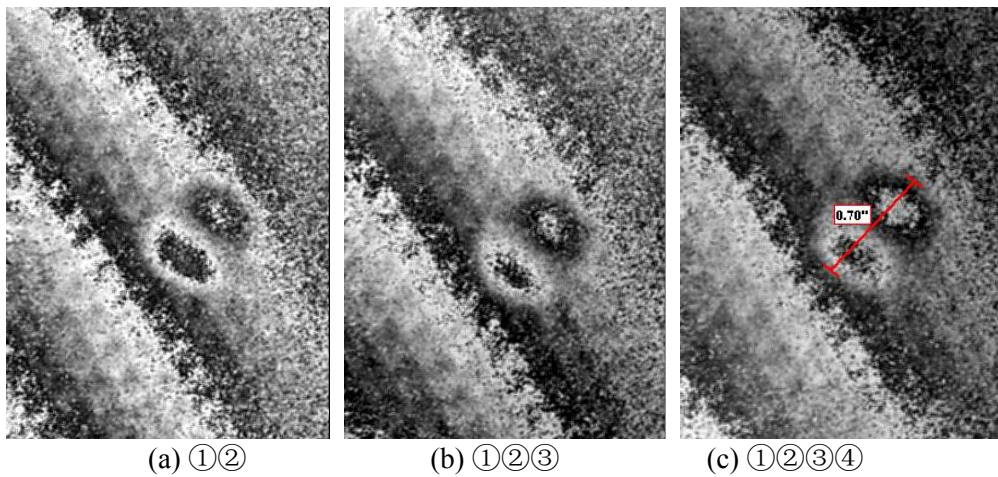**Fig. 3** Method one processing effect diagram

(a) ①②   (b) ①②③   (c) ①②③④

Fig. 4 Method two processing effect diagram

(a) ①②   (b) ①②③   (c) ①②③④
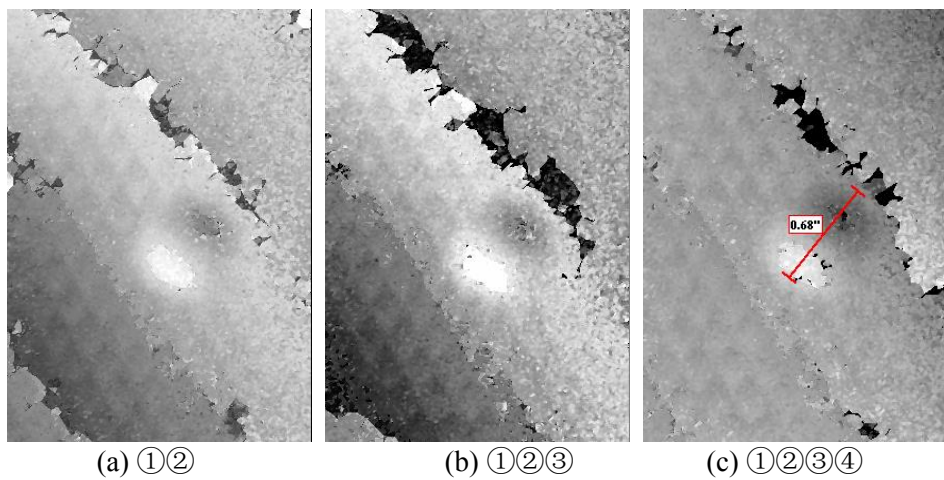
Fig. 5 3Method three processing effect diagram

From figure 3, figure 4, figure 5, we know that after method one processing, the speckle image become more and more clear, contrast enhancement, and better effect after treatment; after method

two processing, the speckle image become more and more blurred, the speckle image failed to filter, the treatment effect is getting worse; after method three processing, the speckle image and the noise can be filtered out roughly. But poor contrast, prone to leak. The size of defect using three different image processing methods are roughly the same.

5. Conclusion

(1) Different image processing methods are suited for processing different image noise. After the composite image processing method, we can get the speckle that have high image definition.

(2) Treatment by method one, the obtained speckle image is superior to the speckle image processed by method two and three.

(3) Treatment by method two, high definition ad contrast, recognition can meet the requirements, can extract the useful information of the speckle image, improve the detection reliability.

Acknowledgments

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