International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 5 Issue 4, May-June 2021 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Damage Assessment System for Aircraft Structural Defects using Wavelet Transform

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ABSTRACT

Defects are often arises on the inner surface of aircraft structures, but most of conventional techniques can determine only the damages and cannot determine the degree of damage. Digital Image Processing and Wavelet Transform are used in this project. Characteristics parameters such as the length of the crack can be exactly detected to measure the faults of aircraft structure. Generally failures of different aircraft components and parts are revealed and examined by the use of non-destructive examination methods. In further detailed explanation and interpretation of failures optical and scanning electron microscopy are used. This paper presents a new approach in automation for crack detection on pavement surface images. The method is based on the continuous wavelet transform. Then, wavelet coefficients maximal values are searched and their propagation through scales is analyzed. Finally, a post-processing gives a binary image which indicates the presence or not of cracks on the pavement surface image.

KEYWORDS: *Digital Image Processing, Wavelet, scanning electron microscopy*

How to cite this paper: V. Akilan | S. Rajkumar "Damage Assessment System for Aircraft Structural Defects using Wavelet Transform" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-5 | Issue-4, June 2021, pp.1525-1527, URL: www.ijtsrd.com/papers/ijtsrd43630.pdf

IJTSRD43630

1. INTRODUCTION

Numerous cases of failures of different aircraft components and parts with abundant data and in-depth analysis of causes, development and manifestation of failures can be found in the literature. The check-up of the integrity of aircraft components is carried out by trained and competent personnel. The regular inspection of particular components is scheduled depending on the number of flying hours, lifetime and priority as specified by strict international regulations.

Failure of an aircraft structural component can have catastrophic consequences, with resultant loss of life and of the aircraft. The investigation of defects and failures in aircraft structures is, thus, of vital importance in preventing further incidents. This review discusses the common failure modes observed in aircraft structures, with examples drawn from case histories. The review will also outline the investigative procedures employed in the examination of failed components.

The wavelet transform has become a useful computational tool for a variety of signal and image processing applications. For example, the wavelet transform is useful for the compression of digital image files; smaller files are important for storing images using less memory and for transmitting images faster and more reliably. The FBI uses wavelet transforms for compressing digitally scanned fingerprint images. NASA's Mars Rovers used wavelet transforms for compressing images acquired by their 18 cameras. The wavelet-based algorithm implemented in software onboard the Mars Rovers is designed to meet the special requirements of deep-space communication. In addition, JPEG2K (the newer JPEG image _le format) is based on wavelet transforms. Wavelet transforms are also useful for `cleaning' signals and images (reducing unwanted noise and blurring). Some algorithms for processing astronomical images, for example, are based on wavelet and wavelet-like transforms.

2. CRACK DETECTION

In general, failures occur when a component or structure is no longer able to withstand the stresses imposed on it during operation. Commonly, failures are associated with stress concentrations, which can occur for several reasons including: Design errors, e.g. the presence of holes, notches, and tight fillet radii; The microstructure of the material may contain voids, inclusions etc.; Corrosive attack of the material, e.g. pitting, can also generate a local stress concentration. From our records and case histories data, an assessment can be made of the frequency of failure modes. This reveals that the incidence of fatigue failure dominates the distribution in aircraft.

3. IMAGE PROCESSING

Modern digital technology has made it possible to manipulate multi-dimensional signals with systems that range from simple digital circuits to advanced parallel computers. The goal of this manipulation can be divided into three categories: Image Processing image in® image out, Image Analysis image in® measurements out, Image

Understanding image in® high-level description out. We will focus on the fundamental concepts of image processing. Space does not permit us to make more than a few introductory remarks about image analysis. Image understanding requires an approach that differs fundamentally from the theme of this book. Further, we will restrict ourselves to two–dimensional (2D) image processing although most of the concepts and techniques that are to be described can be extended easily to three or more dimensions. We begin with certain basic definitions. An image defined in the "real world" is considered to be a function of two real variables, for example, a(x,y) with a as the amplitude (e.g. brightness) of the image at the real coordinate position (x,y). An image may be considered to contain sub-images sometimes referred to as regions–of–interest, ROIs, or simply regions. This concept reflects the fact that images frequently contain collections of objects each of which can be the basis for a region.

3.1. COMMON VALUES

There are standard values for the various parameters encountered in digital image processing. These values can be caused by video standards, by algorithmic requirements, or by the desire to keep digital circuitry simple. Table 1 gives some commonly encountered values. Quite frequently we see cases of $M=N=2K$ where $\{K = 8,9,10\}$. This can be motivated by digital circuitry or by the use of certain algorithms such as the (fast) Fourier transform.

Parameter	Symbol	Typical values
Rows	N	256,512,525,625,1024,1035
Columns	M	256,512,768,1024,1320
Gray	L	2,64,256,1024,4096,16384

Table 1.1: Common values of digital image parameters

The number of distinct gray levels is usually a power of 2, that is, $L=2B$ where B is the number of bits in the binary representation of the brightness levels. When B>1 we speak of a *gray-level image*; when B=1 we speak of a *binary image*. In a binary image there are just two gray levels which can be referred to, for example, as "black" and "white" or "0" and "1".

3.1.1. WAVELET TRANSFORM

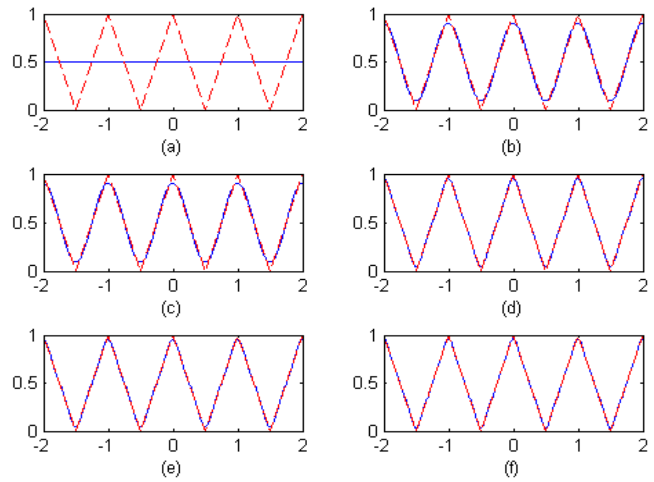


Figure 1.3 A comparative preproduction of original signals. The red line is the original signal. The blue dash line is the approximated signal with (a)K = 0 (b) K = 1 (c) K = 2 (d) K = 3 (e) K = 4 (f) K = 5

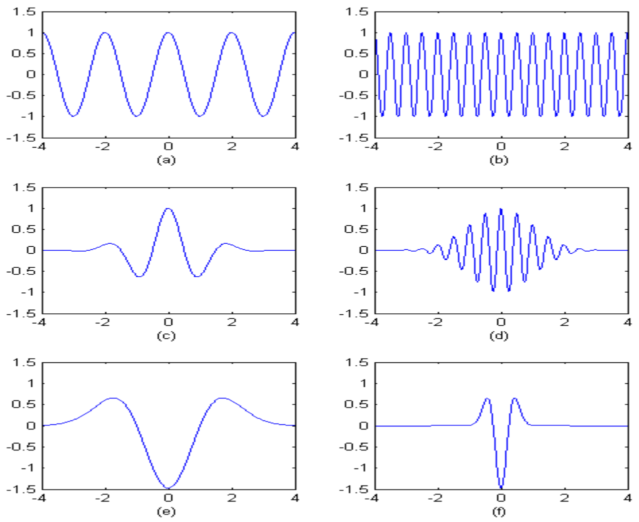
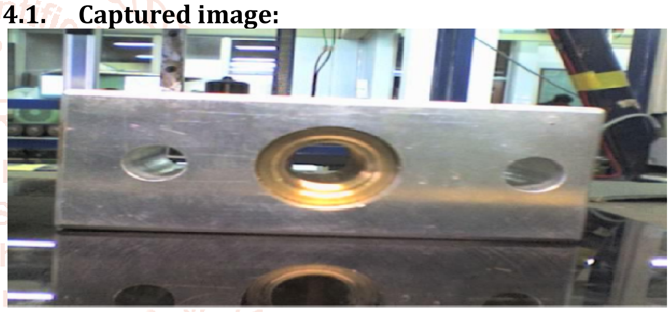


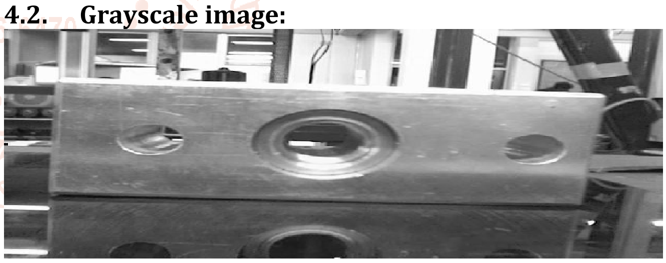
Figure 1.4 Different basis for the transforms. (a) Real part of the basis for Fourier transform, exp(j_t). (b) Basis for different frequency, exp(j4_t). (c) Basis for STFT, using Gaussian window of _ = 1. It is exp(t2=2) exp(j_t). (d) Basis for different frequency, exp(t2=2) exp(j4_t). (e) Mexican-hat mother wavelet function and (f) s = 4

4. PROCESS

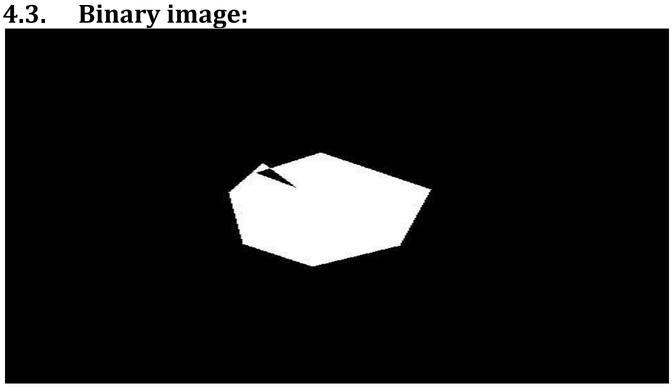
4.1. Captured image:



4.2. Grayscale image:



4.3. Binary image:



5. Conclusion:

We have also tried to comparative discussion of Fourier transform and wavelet transform mentioning the drawback of Fourier transform, besides this we have discussed the advantages of wavelet transform. A new family of filters has been derived from the wavelet theory.

Novel methods based on rotational self-nulling probes and linearly scanned probes were developed. Tests were performed on both in-house manufactured specimens (containing slots machined around holes) and samples provided by leading airplane manufacturers.

By wavelet Analysis results in a non stationary signal and for much clear processing. Very efficient to use this process and get a high clarity and accurate degree of defect. This method is software based, so less time is required and compare to the NDT and other methods.

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