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Paper Sobel Operated Edge Detection Scheme using Image Processing for Detection of Metal Cracks

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Abstract: This paper is based on detection of surface-breaking cracks in metals. It is an issue in many industries. Earlier in case of detecting cracks and defects, eddy current and ultrasonic techniques were used. Some other methods were also been conducted using eddy currents and microwave methods. In every industry, the detection of defects and classification are based on a digital image and it is the key requirement in quality control system. Conventionally, humans were engaged for detecting defects but it was a time consuming task. But this process is time consuming. So an inspection system based on image processing is needed to be introduced. The main objective of the paper is to design a system based on image processing to detect the defects and cracks in a metal object. By using image processing for crack detection, a better and efficient solution to crack detection can be done.

Keywords: Image De-noising, Edge detection

1. INTRODUCTION

The beginning of digital computer has introduced to the society of a machine that is much more powerful and intelligent than human beings in numerical computation. The question then arises whether the humans capable of processing information received from the environment, has better solution with accuracy or we can say decision making based on data that could be efficient fast and produce better results . This led to the evolution of a new subject called artificial intelligence, which has a large area of common interest and motivation with another subject known as pattern recognition. A major portion of information received by a human to manipulate for the detection task is visual. Similarly, the method of processing and detecting defects from visual information grabbed by digital computer is called digital image processing and scene analysis.

2. COMPONENTS OF IMAGE PROCESSING

In imaging science, image processing is the processing of images using mathematical operations by using one of signal processing or image processing for which the input in an image, such as a picture or video frame; the output which comes may be either an image, frames or a set of parameters related to that image

Basic components of a general purpose image processing system are image sensing, digitizing, processing and displaying.

A. Image Sensor

An image sensor is a device which senses the radiant energy propagating from the image, and transforms it to produce an intensity image. Basically there are Two different technologies are there, viz. photochemical and photo-electronic. Photochemical methods have the advantage of combining image formation and recording on a single entity called photographic film whereas Photo-electronic method on the other hand, separate the recording process from image formation and image-detection. But in the second method, recorded image can be converted more easily to a form which is suitable to computer processing.

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B. Digitizer

A digitizer is required to input the images to a digital computer. It produces digital image which contains discrete intensity values at discrete positions. Most of the image sensors mentioned above either have suitable built-in digitizers or provide signal that can be digitized straightway by an A/D converter. However some sensors are purely analogue devices and their responses must be digitized before being fed to a computer. Equations

C. Crack Detection

In every industry, the detection of defects in metals are important part of many quality control systems and applications. The detection of features and defects based on a high resolution image is the main requirement to overcome this issue. The products which are defective are rejected during the process of inspection because even a small defect may result to a fatal problem in future.

In this paper the detection of cracks in metals is done by image processing. From the grabbed frames or images noise are been removed and edge detection is done. Finally, after getting the edges of the image defects can be detected.

3. PREPROCESSING TECHNIQUES

A. Noise Reduction Using Wiener Filter

The images grabbed during the preprocessing are typically noisy and thus require filtering for noise reduction so that the accuracy of crack detection can be improved and enhanced. Gaussian noise can be explained as a noise having a probability density function (PDF) that is equal to that of the normal distribution. This distribution is called Gaussian distribution. In other words, the values that noise can take on are known as Gaussian-distributed.

Characteristics of Gaussian filter

$H(t) = \dfrac{\exp\left(\dfrac{-t^2}{2\delta^2}\right)}{\sqrt{2\lambda}\delta}$ where, $\delta = \dfrac{\sqrt{\ln(2)}}{2\lambda BT}$, and B is the value of filter's 3 DB bandwidth. The BT product parameter is 'B' times of the input signal's symbol period. For a given BT product, the Gaussian filter function of signal processing toolbox generates a filter that is almost half the bandwidth of the filter generated by the communications Gaussian filter block. Wiener Filter is a type of filter which is used to compute a estimate an unknown signal or data using a related data as an input and filters that known data or signal to produce the output. The wiener filter can be used to filter out the noise from the image to give an estimate of the underlying signal of interest. Using wiener filter for removing noise, we got following results.

4. EDGE DETECTION

In a grayscale image, the edge is a local feature that, within a neighborhood, separates two regions. In this portion each of the gray-level of image is more or less uniform when compared to the other values on the two sides of the edge. So, an ideal edge has a step like cross-section. The processes of edge detection are broadly classified into two categories:

- *Derivative approach:* Edge pixels or edges are detected by taking derivative followed by thresholding (e.g. Robert operator and 4-neighbour operator). They occasionally incorporate noise cleaning scheme (e.g. Prewitt operator and sobel operator). Two-dimensional derivatives are computed by means of what we call edge masks.

- *Pattern fitting approach:* A series of edge approximating functions those are in the form of edge templates over a small neighborhood are analyzed. Parameters along with their properties corresponding to the best fitting function are determined. Based on these information, whether or not an edge is present, is decided. We also call them edge filters.

Both the approaches have advantages and disadvantages. As Faugeras (1993) has rightly pointed out, these properties are self-contradictory in nature and a desired result is always a trade-off between them. Suppose the resultant S(x) of a signal S(x) perturbed by a sinusoidal noise is given by

$$S(x) = s(x) + \eta \sin(\omega x)$$

Taking derivative with respect to x,

$$S'(x) = s'(x) + \eta\omega \cos(\omega x)$$

If η is small then $s(x)$ is close to S(x); while, if ω is large, the noise can predominate the resultant signal especially when the derivative is of interest.

However, following either of the approaches, the complete process of generation of edge map may involve some or all of the steps:

- Noise smoothing
- Edge localization
- Edge enhancement
- Edge linking
- Edge following
- Edge extraction

Many edge detection algorithms incorporate some of these steps without mentioning them explicitly. One of the main reasons of this is that these steps are not always easy to distinguish mutually from one another. In this paper we have used Sobel operator for finding out the edges of image

$$d_1 = \frac{1}{4}[(g_4 + 2g_5 + g_6) - (g_2 + 2g_1 + g_8)]$$

$$d_2 = \frac{1}{4}[(g_8 + 2g_7 + g_6) - (g_2 + 2g_3 + g_4)]$$

The gradient $g'(r, c)$ at pixel (r, c) is obtained by a point operator 0_p applying on $d_i(i = 1, 2)$. Because of the nature of point operator by a point operator, d_1 and d_2 in the above equations can be defined interchangeably without affecting the value of $g'(r, c)$. Note that among these operators, the ordinary operator is not symmetric. Prewitt operator can detect diagonal edges better than that by Sobel operator; while Sobel operator is superior to Prewitt operator in detecting vertical edges. Effect of noise is reduced in case of Prewitt and Sobel operators by inherent averaging of neighboring pixels. Therefore, to achieve the desired result, gradient operators are usually preceded by noise cleaning.

5. SIMULATION AND ANALYSIS

In this paper we have applied Gaussian filter noise in the images for observations and experimental purpose. To improve and enhance the quality of the degraded images restoration and filtering methods are been used. When no knowledge about the degradation process is available the quality of an image may be improved for specific applications by some process called enhancement.

Furthermore, the enhanced and improved quality images are been processed to find the edges using edge detection method. In this paper we have used Sobel operator to find the edges of the image. The results are shown in below figures.

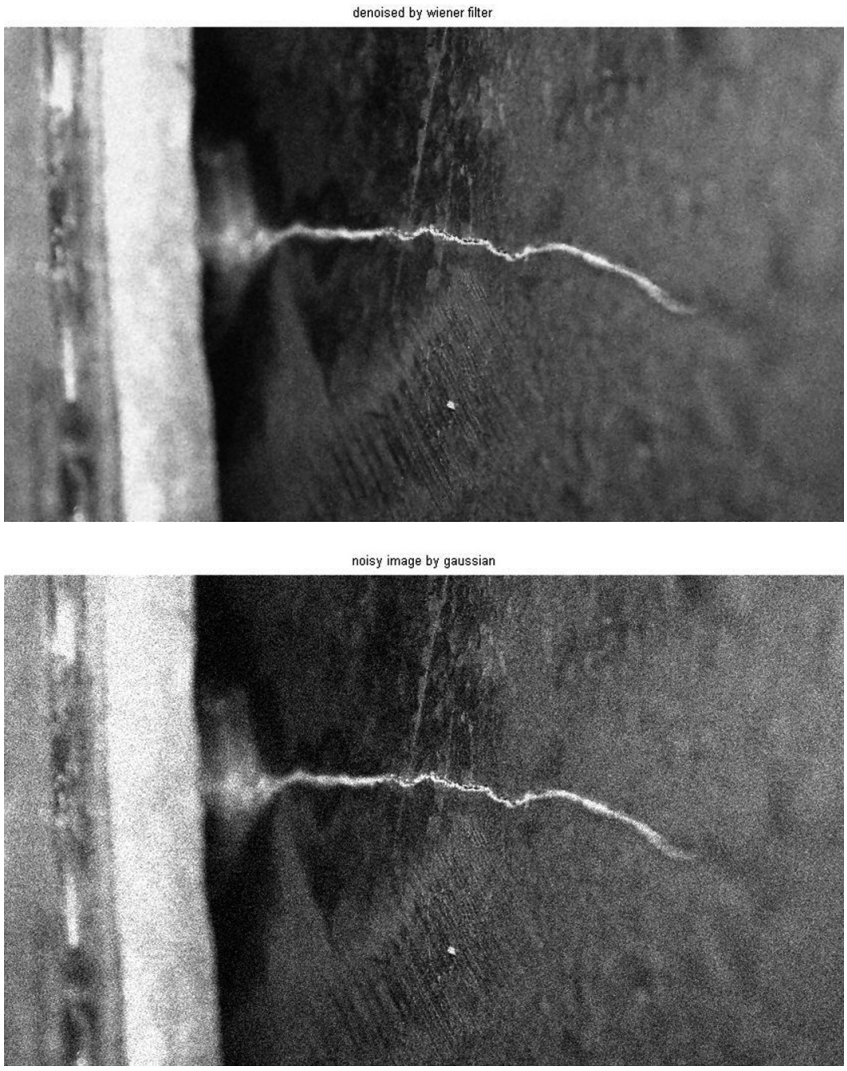
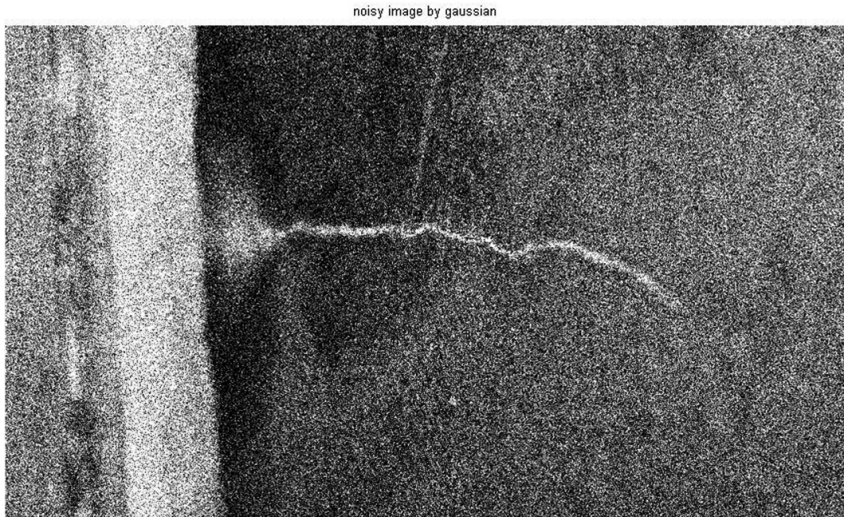


Figure 1: Above image contains Noise intensity of 0.01



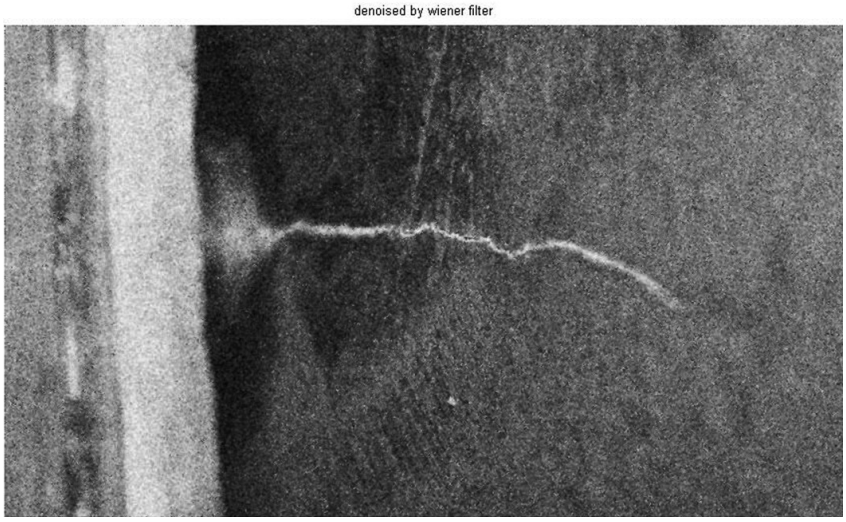


Figure 2: Above image contains Noise intensity of 0.1

The figures shown above are the defected images containing cracks having noise intensity of 0.01dB and 0.1 dB intensities. The results we got after removing the noise using wiener filter with various noise intensities are shown in the figures and we come to know that wiener filter is showing good results in filtering noises.

After filtering the images, the edges of the images are found using edge detection methods i.e. Sobel operator. The results are shown below in Figure 4.

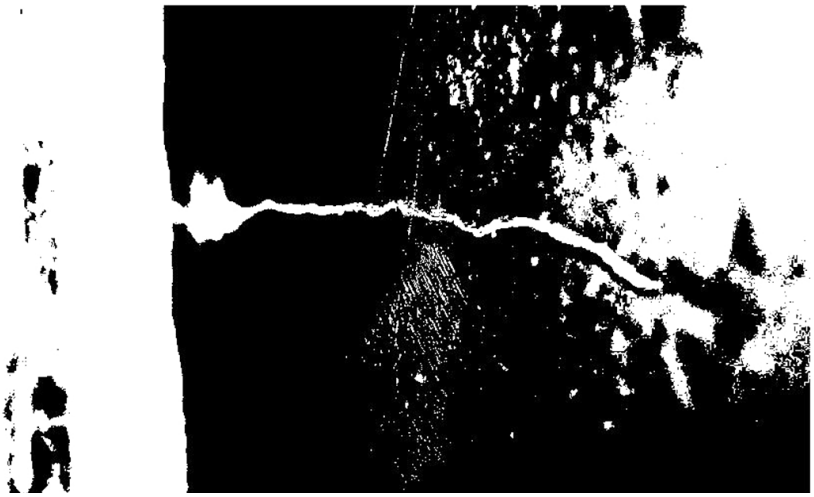


Figure 3: It shows the black white image used for finding edges

Above two figures showing the results for edge detection of image after using Sobel operator. Figure 3 showing the black white image that is used for subtracting it from a black image of same dimensions as that of the black white image taken as reference. A black image is called false because there is absence of all colors i.e. (RGB) in it. Figure 4 showing the edges of image after applying sobel operator to it. Figure 5 below shows the histogram values of the images before and filtering it.

6. CONCLUSION AND FUTURE WORKS

Based on the above results and analysis we come to know that wiener filter shows a good result in removing noise from the images. Pixel values and brightness is shown in the histograms of the images so that it will be useful to find the edge detection and segmentation. In future the segmentation and image thresholding will be processed and defects will be detected.

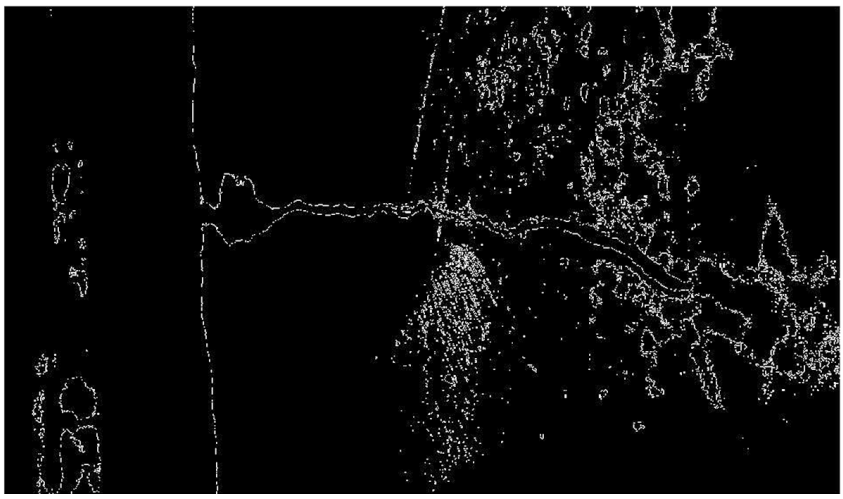


Figure 4: It shows the edges of the image

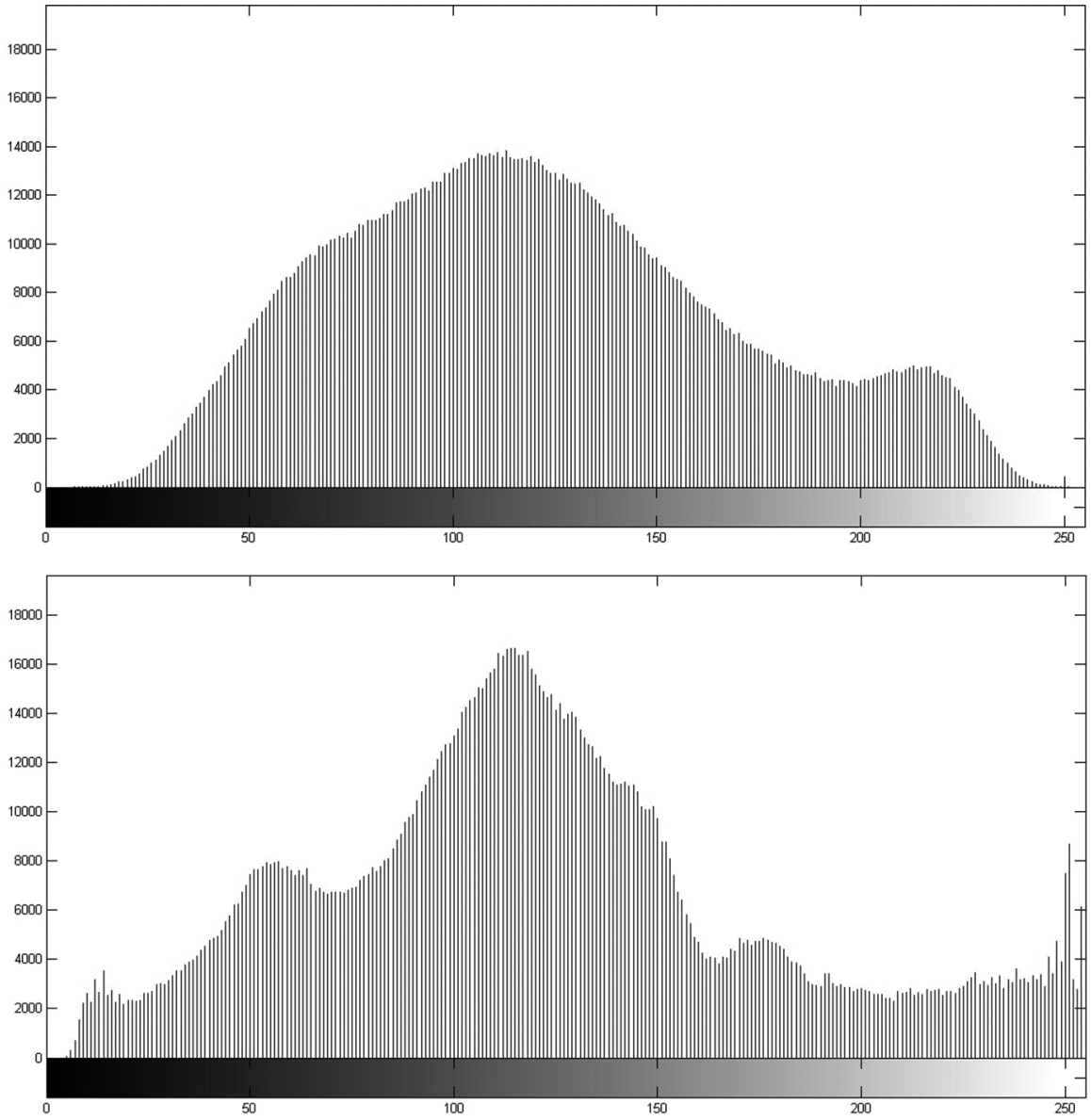


Figure 5: Images above in the figure shows the histogram values of both the images having different noise intensities

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