PATTERN RECOGNITION IN ULTRASONIC IMAGERY USING THE HOUGH TRANSFORM

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Abstract

In non destructive testing of materials, the ultrasonic imagery is a field in full rise. Indeed , more than one convivial representation of the results , the operations of detection , localization and sizing of the defects can be carried out automatically by the analysis of synthesized images. The problem breaks up in general into a phase of preprocessing to only limit the quantity of information to useful and a processing phase in order to characterize the defect.

In our article, we will briefly describe the the ultrasonic images formation said C-SCAN and TOFD, before seeing how a high pass filtering makes it possible to reduce the image c-scan to the only points of the defect edges. This preprocessing reduces considerably calculations for using the Hough transform in patterns recognition of defects in the case of C-SCAN image , and the localization of cracks in the case of the TOFD image.

Keywords : non destructive testing , ultrasonic imagery , edge detection , Hough transform.

1. Introduction

Traditional algorithms of image processing are a very important contribution for the ultrasonic imagery. In a non destructive testing of the materials,the pattern recognition of the defect is very useful information for a fast decision-making. The Hough Transform is a traditional tool for detection of simple forms in an image.But its version first which consists in considering all the pixels of the image is too greedy in memory and computing times.We thus used an approach suggested by Lei Xu [1] which select randomly a sufficient number of pixels of the image on which the treatment will be done. We will still gain memory and time by reducing the image to the only edge of the defect.

2. Image formation

Image formation consists in producing an image from the reflected signals[2]. The ultrasonic data acquisition technique used for detecting flat defect is the C-SCAN methode .It is based on the measure of the time of flight and the maximum amplitude of of the echo reflected by the defect The part to be controlled is swept by an ultrasonic transducer working in echo mode. His displacements step by step are ordered by computer according to two axes x and y on a rectangular surface.On each positon of the transducer , a signal is emitted and his echo memorized in the same way as its co-ordinates.

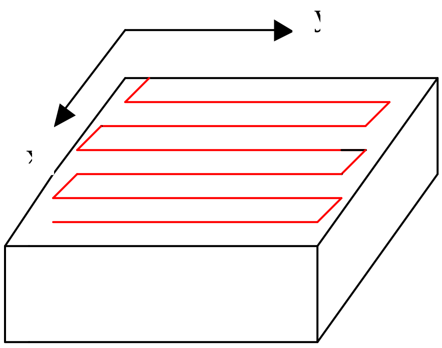

Figure1.Trajectory of the transducer

The matrix containing the respective maxima of the signals echoes is then converted into levels of gray[3] Figure 2 shows the image resultant obtained for a defect of round form.

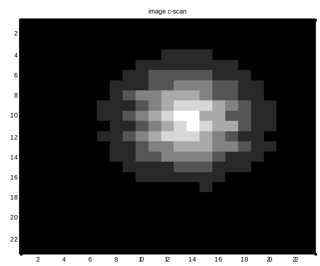

Figure2 C-scan image

For detecting cracks , the ultrasonic acquisition technique is the time of flight diffraction (TOFD) . It is based on the measure of the time of flight of the diffraction echo produced by the extremities of the cracks [4]. We use in this case a symetrical and separate transmetter receiver pair.

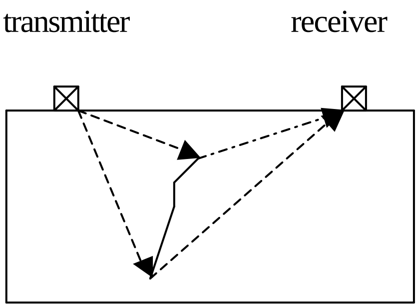

figure 3:crack detection

The interaction between the ultrasonic signal and the extremities of the cracks gives rise to diffraction arcs of parabola in the B-SCAN display which is a representation of the amplitude of the coming back ultrasonic signals according to a section perpendicular to the inspection surface.The image resulting is shown in figure 4.

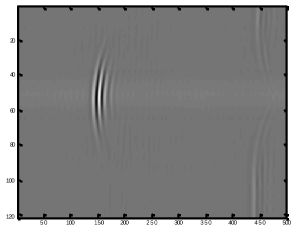

Figure 4. tofd image of an extremity

3. The Hough transform

The Hough transform is a standard technique for detecting curves [4]. It consists of three steps :

1) A pixel in the image is transformed into a parametrized curve.
2) Valid curve's parameters are binned into an accumulator where the number of curves in a bin equals its score
3) A curve with a maximum score is selected from the accumulator to represent a curve in the image.

This basic Hough transform suffers many difficulties stemming from binning the curves (large accumulators and much processing time).

To reduce these problems , Lei Xu [1] proposed a Randomised Hough Transform (RHT) .

3.1 The Randomised Hough Transform

The RHT randomly selectes n pixels from the image and fits them to a parametrised curve .If the pixels fit within a tolerance they are added to an accumulator with a score .Once a specified number of pixel sets are selected the curve with the best score is selected from the accumulator and its parameters are used to represent a curve in the image .This methode reduce the storage requirements and computational time needed to detect curves in an image.

3.2 *Circle Hough Transform.*

A circle with radius R and center (a,b) can be described with the parametric equations :

x = a + Rcos ?

y = b + Rsin ?

when the angle ? sweeps through the full 360 degree range , the points (x,y) trace the perimeter of a circle. The job of the search program is to find parameter triplets (a,b,R) to describe the circle approximating our defect [5] .

3.3 *parabola Hough Transform..*

The equation of of parabola can be written:

$$y = ax^2 + bx + c$$

if we will consider his top like origin , parameters to be found will be then a and b.

4. Detecting a circular defect.

4.1 *Defect sizing*

Count held of the width of the ultrasonic beam, real dimensions of the defects must be determined by the method known as -6 dB: The values of all the pixels will be compared with the maximum value (position of the transducer in the center of the defect involving a total reflexion of the ultrasonic beam).We will cancel then all the pixels lower than the half of the maximum value, and affect one to the others.

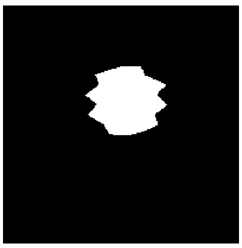

Figure 5 . binary image of the defect

The image obtained represents the real surface of the defect . To quantify it , we just multiply the number of white pixels by the square of the step of the transducer displacement.

4.2 *Edge detection*

For the pattern recognition of the defect , its edge only suffices . We will thus make his detection by a highpass filter. Indeed , the high frequencies in an image, correspond to the fast variations of the levels of gray. Thus we will preserve only the points where the level passes from zero to one (of the black to the white).Spectrum of the binary image is obtained by the Fourier Transform 2D:

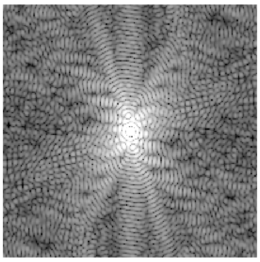

Figure 6 .Spectrum of the binary image

The central zone corresponding to the low frequencies will be put at zero. One will return then to the spacial field by an inverse Fourier transform . We obtain an image which contain only the edge (figure 7).

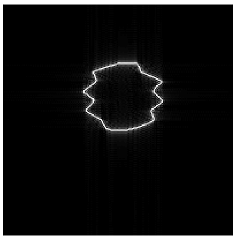

figure 7 : Edge of the defect.

represent a curve in the image .This methode reduce the storage requirements and computational time needed to detect curves in an image.

4.3 Applying the RHT to detect the circular defect

Since the defect is round , we would expect to be able to find circle to match its edges
On the edge of the defect, we carry out a sufficient number of pullings of 3 points being used to determine a circle with each pulling. The Hough space in 2 dimensions is represented on figure 8 at the same time as the points selected randomly.

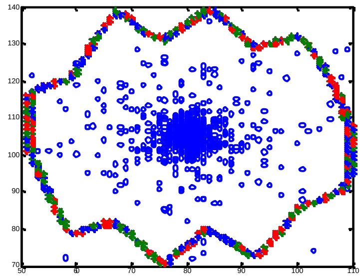

Figure 8 . Hough space 2D

A representation in three dimensions shows better the frequency of appearance of each potential center.

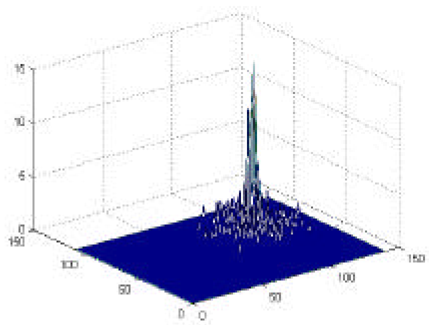

Figure 9. RHT accumulation matrix

The pick of the accumulation matrix corresponds to the location of the center approximating our defect .

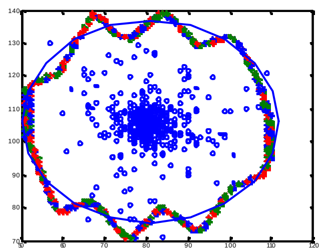

Figure 10. Circle approximating the defect .

5. Detecting cracks

It has been shown that crack defects are characterized by arcs of parabolas in B-SCAN displays obtained according to the TOFD inspection technique [6].Each defect gives rise to a set or family of parabolas with the same main axis

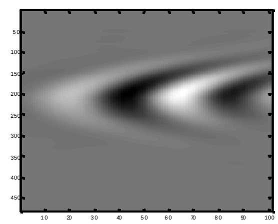

Figure11. parabolas of crack defect in a TOFD image

5.1 *Image preprocessing.*

To limit in this case the numbers of points to which we will apply the randomized Hough transform , we start by cancelling all the pixels whose amplitude is lower than half of the maximum value, and we will ass ign the value one to the remaining pixels.

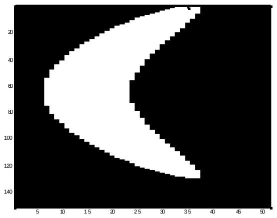

Figure 12. resultant parabola.

The algorithm of the randomized Hough transform will be applied only to the points where the level passes from the black to the white i.e. at the points represented on figure 13.

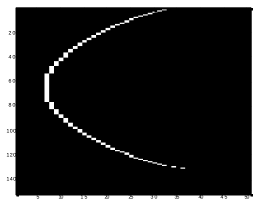

Figure 13.Points resultant from the preprocessing

5.2 *Applying the RHT to detect the parabola*

It is on these spoints that we will make, as for the circle, pullings of three points (sufficient to describe a parabola) randomly.
parameters to be calculated for each triplet of points will be then a and b. Figure 13 shows the space of Hough in 3 dimensions on which the peak indicates the couple of parameters determining the parabola detected.

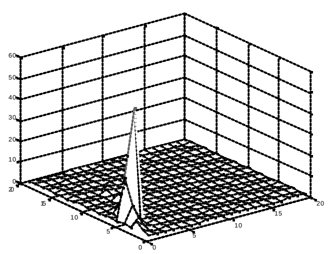

Figure14.Hough space 3D

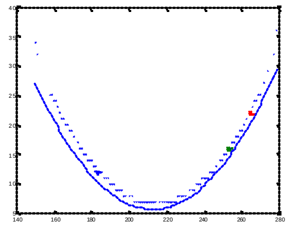

Figure15. Parabola calculated and points of the initial image.

6. Conclusion

We presented two applications of Randomized Hough Transform .The results obtained are very satisfactory being given the considerable reduction of time.The computing will be tested in a forthcoming for detecting these forms in an image containing several defects .

References

[1]Lei Xu ,"A new curve detection methode : Randomized Hough Transform" Pattern Recognition letters, 331-338,1990.

[2]J.Moysan , "Imagerie Numérique ultrasonore pour la detection Automatique de Défauts en contrôle non destructif " ,thèse de l'institut national des sciences appliquées de Lyon ,1992.

[3] A.Rosenfeld ,Digital picture processing ,vol 2, academic pressing ,seconde edition ,New York.,1982.

[4]H.Maitre , "Un panorama de la transformation de Hough ", Traitement du signal , vol.2 , n^o4,pp.305-317,1985.

[5]D.Ioannou , "Circle recognition through a 2D Hough transform and radius histogramming, Image Vision Comput. " 17,15-26 1999.

[6]L.F.C.Lew Yan Voon , " Gradient-based Hough Transform for the Detection and Characterization of Defects during Non-destructive Inspection " Proceeding of Symposium on Electronic Imaging Science and technology ,California , vol 3029 pp 140-146, 1997.