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Image Processing Based Approach to Detect Scratch Defects In Wire-Type Objects

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ABSTRACT

This paper presents an approach for the surface inspection of wire-type objects. The research aims to detect scratch defect of a wire rod. Scratch defect is caused by many reasons such as poor quality of raw material or malfunction of rolling process. The scale inspection system is based on vision technology. Image processing algorithms are applied for detecting scratch defects of wire rod. The detection algorithm is mainly divided into three steps. First, use 9/7 lifts base wavelet transform to have texture analysis. In order to obtain more details, we take the approximation sub-image at resolution level one as source image. Then, we use sobel operator for edge detection method and the detected results are illustrated using real defects from steel wire rods. But the complex backgrounds in images of wire rods inevitably result in false positive and false negative defects. Finally, apply post-processing based on detection results. Compared with the classical methods, the results show that the applied algorithms have a good performance on scratch defect detection of wire rod. Moreover, it has an effective execution time proportional to the number of pixels in the image.

Keywords: Defect detection; Surface inspection; Steelmaking process.

1. INTRODUCTION

The quality control of the final product is fundamental phase in the steel manufacturing cost. Many inspection techniques have been already proposed with the aim of increasing the productivity and improving the final product quality. In the steel production line, wire rod is one of hot rolled steels classified by shape. In general, wire rod is ring shaped coiled steel wire rod surface images with scratch defect and non-defect. It uses 9/7 filter processing. The whole architecture is designed way to speed up and achieve higher hardware utilization. The Discrete Wavelet Transform (DWT) was based on time-scale representation. It provides efficient multi-resolution. The lifting based DWT architecture has the advantage of lower computational complexities transforming signals with extension and regular data flow. The discrete wavelet transform (DWT) is being increasingly used for image coding. This is due to the fact that DWT supports features like progressive image transmission (by quality, by resolution), ease of compressed image manipulation. DWT has traditionally been implemented by convolution. Such an implementation demands both a large number of computations and a large storage features that are not desirable for either high-speed or low-power applications. Edge detection is one of the important operations in image processing and computer vision. It is the process that is used to locate the boundaries of objects or textures depicted in an image [1-5]. To know the positions of these boundaries is a critical task in the process of image enhancement, recognition, restoration and compression. As the data of edge detection is very large, therefore the speed of image processing becomes a difficult problem. The above process is done VERILOG using XILINX-14.1 and to display input and output image MATLAB is used. This paper focuses on software used to detect edges of image employing mainly the MATLAB program for solving this problem [6-8].

2. METHODOLOGY

Discrete Wavelet Transform Decomposition

As the DWT intrinsically constitutes a pair of filtering operations, a unified representation of the polyphase matrix is introduced as follows:

$$P(z) = \prod_{i=1}^{m} \begin{pmatrix} h_e(z) & g_e(z) \\ h_o(z) & g_o(z) \end{pmatrix} \qquad (1)$$

where h(z) and g(z) stand for the transfer functions for the low-pass and high-pass filter banks, respectively, and all suffixes e and o in the literature correspond to even and odd terms, respectively. Thus, the transform is symbolized with the equation:

$$\begin{pmatrix} \lambda(z) & \gamma(z) \end{pmatrix} = \begin{pmatrix} x_e(z) & z^{-1}x_o(z) \end{pmatrix} P(z) \qquad (2)$$

With λ (z) and γ (z) signifying the filtered low-pass and high-pass parts of the input x (z).The lifting scheme factorizes the polyphase representation into a cascade of upper and lower triangular matrices and a scaling matrix which subsequently return a set of linear algebraic equations in the time domain

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bringing forth the possibility of a pipelined processor.

$$P(z) = \begin{pmatrix} 1 & \alpha(1+z^{-1}) \\ 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ \beta(1+z) & 1 \end{pmatrix} \begin{pmatrix} 1 & \gamma(1+z^{-1}) \\ 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ \delta(1+z) & 1 \end{pmatrix} \begin{pmatrix} \zeta & 0 \\ 0 & (1/\zeta) \end{pmatrix}. \quad (3)$$

The related algebraic equations are:

$$\begin{aligned} s_i^0 &= x_{2i} && \text{(Splitting)} \\ d_i^0 &= x_{2i+1} \\ d_i^1 &= d_i^0 + \alpha \times (s_i^0 + s_{i+1}^0) && \text{(Predict P1)} \\ s_i^1 &= s_i^0 + \beta \times (d_{i-1}^1 + d_i^1) && \text{(Update U1)} \\ d_i^2 &= d_i^1 + \gamma \times (s_i^1 + s_{i+1}^1) && \text{(Predict P2)} \\ s_i^2 &= s_i^1 + \delta \times (d_{i-1}^2 + d_i^2) && \text{(Update U2)} \\ s_i &= \zeta \times s_i^2 && \text{(Scaling S1)} \\ d_i &= (1/\zeta) \times d_i^2 && \text{(Scaling S2)} \end{aligned} \quad (4)$$

Lifting Scheme

The basic idea behind the lifting scheme is very simple; try to use the correlation in the data to remove redundancy [4, 5]. First split the data into two sets (split phase) i.e., odd samples and even samples as shown in Fig. 2. Because of the assumed smoothness of the data, we predict that the odd samples have a value that is closely related to their neighbouring even samples. We use N even samples to predict the value of a neighbouring odd value (predict phase). With a good prediction method, the chance is high that the original odd sample is in the same range as its prediction. We calculate the difference between the odd sample and its prediction and replace the odd sample with this difference. As long as the signal is highly correlated, the newly calculated odd samples will be on the average smaller than the original one and can be represented with fewer bits. The odd half of the signal is now transformed. To transform the other half, we will have to apply the predict step on the even half as well. Because the even half is merely a sub-sampled version of the original signal, it has lost some properties that we might want to preserve.

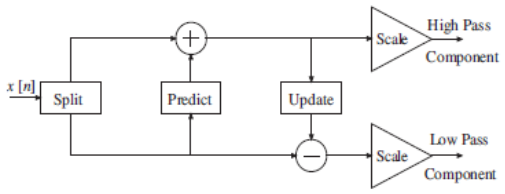

Fig: The lifting scheme: Split, predict, update and scale phases.

In case of images we would like to keep the intensity (mean of the samples) constant throughout different levels. The third step (update phase) updates the even samples using the newly calculated odd samples such that the desired property is preserved. Now the circle is round and we can move to the next level. We apply these three steps repeatedly on the even samples and transform each time half of the even samples, until all samples are transformed.

3. PROPOSED ARCHITECTURE

Initially the Pixel values of any image will be taken with the help of MATLAB, which will be used as the primary inputs to the DWT Block. Basically the registers in the top half will operate in even clock where as the ones in bottom half work in odd clock. The input pixels arrive serially row-wise at one pixel per clock cycle and it will get split into even and odd. So after the manipulation with the lifting coefficients 'a' and 'b' is done, the low pass and high pass coefficients will be given out. Hence for every pair of pixel values, one high pass and one low pass coefficients will be given as output respectively.

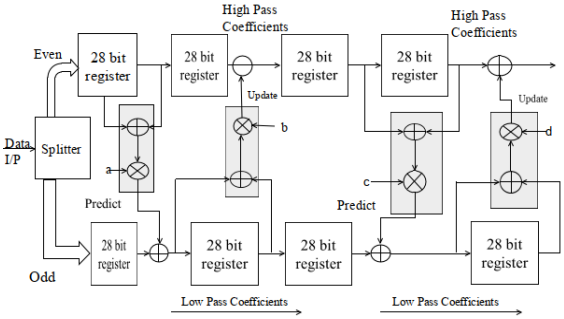

Fig: Computation of Basic (9, 7) DWT Block

The internal operation of the DWT block has been explained above and hence the high pass and low pass coefficients of the taken image were identified and separated. The generated low pass and high pass coefficients are stored in buffers for further calculations.

Fig.1: Input Image

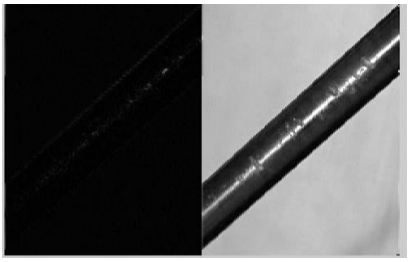

Fig.2: DWT output

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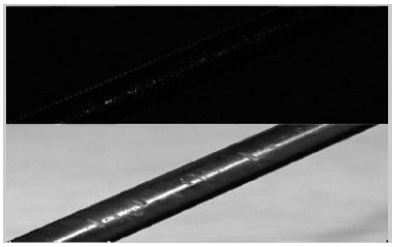
Fig.3: Transposed DWT Output

Edge Detection

In case of Sobel Edge Detection, there are two masks, one mask identifies the horizontal edges and the other mask identifies the vertical edges. Each of the masks has the effect of calculating the gradient in both vertical and horizontal direction. Initially after START the image is read i.e. its pixel values are read. Then that image is convolved with the filter. After the horizontal and vertical mask of the operator are convolved with the original image. Let the horizontal and vertical convolution be Gx and Gy respectively. Then one threshold value is set as say T. Calculate gradient G. It is calculated as
{Square root [(Gx^2) + (Gy^2)]}
Then consider first pixel say M. For M if G is greater than T then consider the next neighbouring pixel and continue the procedure. When G is less than T mark that pixel as it locates the edge. The mask values for Gx and Gy of SOBEL OPERATOR are:

Gx=

-1	0	1
-2	0	2
-1	0	1

Gy=

1	2	1
0	0	0
-1	-2	-1

Equation (1) shows convolution of input image with horizontal mask whereas Equation (2) shows convolution of image with vertical mask

Gx= {f(x+1,y-1)+2f(x+1,y+1)}-{f(x-1,y-1)+2f(x-1,y)+f(x-1,y-1)}.... (1)

Gy= {f(x-1, y-1) + 2f(x, y-1) + f(x+1, y-1)}-{f(x-1, y+1) + 2f(x, y+1) + f(x+1, y+1)}.... (2)

These masks can then be combined together to find the absolute magnitude of the gradient at each point. Therefore the gradient magnitude is given by:

|G| = √ ([Gx]^2+[Gy]^2) …… (3)

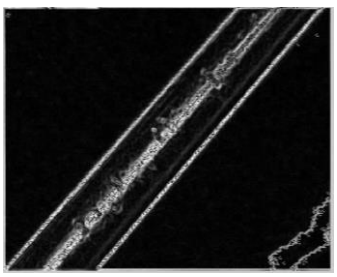
Fig.4: Edge Detection Output

4. CONCLUSION

In this paper, an image processing algorithm is proposed to detect scratch defects in wire rod objects. The 9/7 DWT is used to decompose the image into higher and lower components. The main feature of the lifting based DWT scheme is to break up the high pass and low pass filters into a sequence of upper and lower matrices and convert the filter implementation into banded matrix multiplications. Then the sobel operator is used to detect any edges present in the rod. The Sobel operator is used for edge detection. In the edge function, the Sobel method uses the derivative approximation to find edges of the image. So, it returns edges at those points where the gradient of the considered image is maximum. The horizontal and vertical gradient matrices are used for the Sobel method whose dimensions are 3×3 in the edge detection operations. It has been proven by the results we have obtained, that the edge detection mathematical method by simulation using MATLAB software is very good method for the analysing the image. After reading the pixels of an image the algorithm is applied in VERILOG. The advantages of this proposed system is: Detects any scratches with various size and orientation. The algorithm works in noisy environment.

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