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# Wavelet Based Resolution Enhancement with Noise Reduction Method for Panoramic Dental X-ray Images

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**Abstract:** The Panoramic Dental X-ray images are important tool for a thorough dental examination. But they may contain noise and have low resolution. Therefore de-noising and resolution enhancement are very important factors in any subjective evaluation of the quality of images. A wavelet based enhancement technique along with a denoising approach is introduced in this paper. The input image after Median filtering is decomposed into different sub-band images by means of Discrete Wavelet Transform (DWT). Stationary Wavelet Transform (SWT) is also introduced as an intermediate stage. Then the high frequency sub-bands of both DWT and SWT are added together. Then these high frequency sub-bands as well as the input image are interpolated. A new enhanced image is obtained by using inverse DWT (IDWT). A comparison of this technique can be done with different wavelet functions including db9, Bior 3.5 and Haar. Performance evaluation can be done by means of MSE calculation. Also a comparison of the proposed method with two conventional image resolution enhancement techniques in terms of PSNR calculation can be done. The whole work has been done on the MATLAB.

.Keywords**:** Bior3.5, db9, De-noising, Discrete wavelet transform, Enhancement, Haar, IDWT, MSE, PSNR, Stationary wavelet transform.

## I. INTRODUCTION

The first step in disease diagnosis through imaging relies mostly on x-ray images. This is also true in the case of dentistry where x-ray images are most widely used to assist dentists in deciding the pertinent treatment for patients. Panoramic radiography, also called panoramic x-ray is a two-dimensional (2-D) dental x-ray that captures the entire mouth in a single image which includes the teeth, upper and lower jaws, surrounding structures and tissues. The jaw is a curved, horseshoe shaped structure. The panoramic x-ray produces a flat image of the curved structure. It is typically used to provide details of the bones and teeth. The film for a panoramic x-ray is placed inside of the machine that moves around the patient‘s head. The areas of the jaws that are not visualized with intraoral radiographs can be seen with panoramic x-rays [7]. These panoramic x-rays cover a wide area as compared to traditional x-rays and contain objects with a variety of texture and depth such as teeth and tongue. This may leads to low quality of the image. Digital radiographs are obtained either by digitizing the x-ray films or by having the X-radiation that passes through the patient falls directly onto devices (such as a phosphor screen) that convert x-rays in to light, which in turn is captured by a light-sensitive digitizing system [5].

Digital images contain some amount of noise due to the corruption in its acquisition. Medical images are corrupted by a complex type of addition noise depending on the devices which are used to capture or store them. Typically the panoramic x-ray pictures are corrupted by Poisson noise, salt and pepper noise, speckle noise etc [3]. These noises not only produce undesirable visual quality but also lower the visibility of low contrast objects that complicates diagnosis and treatment. Also these radiographs are of low image quality mainly because of low dose usage of x-radiation. The low dose usage is related to its effect to patient’s health. X-ray images usually taken with low radiation dosage are normally presented as dark, low contrast and noisy. The occurrence of noise will severely harm fine details contained within the original image. Due to this low contrast lesions may not be detected in the diagnostic phase. So these problems need to be solved to improve the diagnostic ability. That is noise removal and resolution enhancement are two important tasks in order to obtain better images for analysis by human or machine. This paper incorporates the ideas of image processing for these purposes.

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The process of recovering the signal that has been corrupted by noise is called de-noising. For noise removal better choice is to use a nonlinear spatial filter. This paper introduces an order statistic filter for this purpose that removes noise without significantly reducing the sharpness of the image. Enhancement of an image improves its appearance by increasing dominance of some features or by decreasing uncertainty between different regions of the image. Enhancement of the de-noised image is performed in the wavelet domain, where the DWT [2] and SWT [2] decompose the low resolution image into four frequency sub-bands. The various sub-bands are Low Low (LL), Low High (LH), High Low (HL) and High High (HH). The SWT is used to preserve the high frequency content in the image [3]. SWT is similar to DWT But no down-sampling is used in SWT. Thus these four sub-bands will have the same size as the input image. The sub-bands of dwt are then interpolated by a factor of 2. The interpolated high frequency sub-bands and the SWT high frequency sub-bands are added together to produce the estimated sub-bands LH, HL and HH. The new estimated high frequency sub-bands can be interpolated further by a factor of $\alpha/2$ for higher enlargement. Instead of LL sub-band the input image itself is used. Finally inverse wavelet transform is carried out to produce the high resolution image [4]. Thus this work mainly put forward an enhancement technique which creates sharper de-noised image. A comparison of proposed resolution enhancement technique can be done using different wavelet functions including db9, Bior 3.5 and Haar. Performance evaluation is done by means of Mean Square Error (MSE) calculation. Also a comparison of the proposed method has been done with two conventional image resolution enhancement techniques, which include bicubic interpolation [1] and wavelet zero padding [6].

The remaining paper is organized as follows. In section 2 proposed methodologies is presented. Experimental results and discussions are given in section 3. Finally the concluding remarks are given in section 4.

## II. PROPOSED METHODOLOGY

A noisy, low resolution (LR) digital panoramic dental x-ray image is the input image for processing and is basically a colour image. So colour image to gray scale conversion is done before median filtering. The noise present in the image result in minute grey scale variations within the image. To remove these kinds of noises better choice is to use a median filter. Median filter is an order statistic filter [1]. This is basically a nonlinear spatial filter. The response of such a filter is based on ordering (ranking) the pixels contained in the image area enclosed by the filter, and then replacing the value of the central pixel with the value determined by the ranking result. That is it replaces the value of a pixel by the median of the gray levels in the neighborhood of that pixel [1]. It can remove noise without significantly reducing the sharpness of an image. A 3x3 median filter is used over here. As a result of this a de-noised and LR digital panoramic dental x-ray image is obtained.

The resolution of an image is its clear perception to the viewer. The resolution enhancement of image mainly deals with the process of conversion from lower resolution (LR) to a higher resolution (HR). HR means that the density of pixel per unit area in the image is high, and hence an HR image can offer more details. This paper put forward a wavelet approach for resolution enhancement of digital panoramic dental x-ray images. Here a single level DWT (with Haar, Bior3.5, db9 as wavelet function) is employed to decompose an input image into different sub-band images [4]. The high frequency components of the input image are contained in the three high frequency sub-bands (LH, HL, and HH) of the input image. Bicubic interpolation with enlargement factor of 2 is applied to high frequency sub-bands of the image. Down sampling each of the DWT sub-bands gives rise to information loss in the respective sub-bands. SWT [4] is introduced to minimize this loss. The interpolated high frequency sub-bands and the SWT high frequency sub-bands have the same size. They are added with each other to obtain estimated sub-bands. These new high frequency sub-bands are further interpolated or higher enlargement. In the wavelet domain, the low resolution image is obtained by low pass filtering of the high resolution image. In other words, low frequency sub-band is the low resolution of the original image. Therefore, instead of using low frequency sub-band, which contains less information than the original high resolution image, we use the input image for the interpolation of low frequency sub-band image. Finally IDWT [4] is applied to obtain the de-noised and HR digital dental image. The block diagram for the proposed methodology is shown in Fig.1.Improving the visual quality of dental digital x-ray image can be subjective. Therefore it is necessary to establish quantitative measures to compare the effects of image enhancement algorithms on image quality. So we calculate the mean squared error (MSE) of the enhanced image. It is defined as the square of the difference between the input image I (i, j) and output image O (i, j) and is given by the following equation.

$$MSE = \frac{1}{mn} \sum_{i=0}^{m-1} . \sum_{j=0}^{n-1} [I(i, j) - O(i, j)]^2 \qquad (1)$$

where m and n are the number of pixels of two images respectively.

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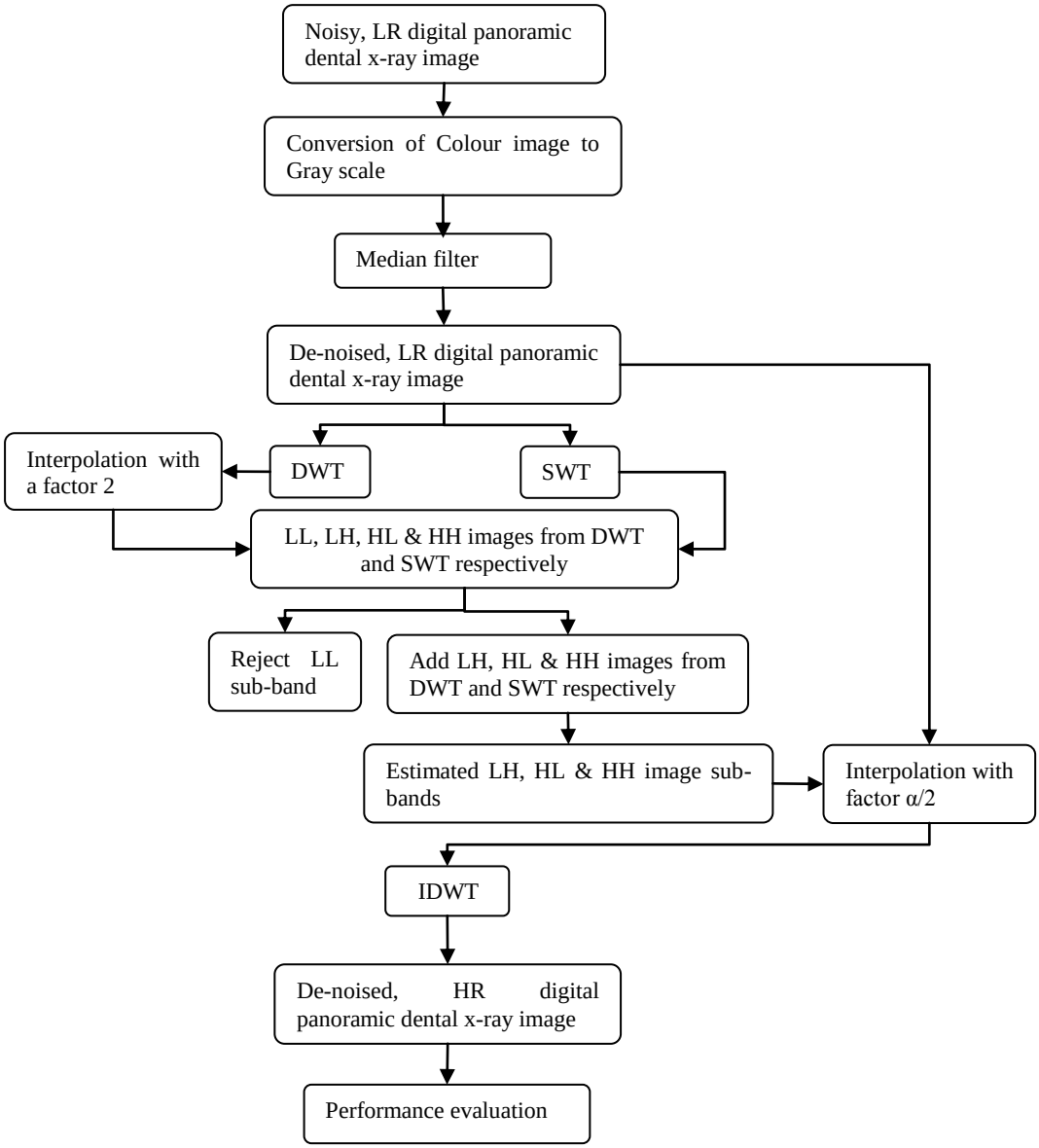


Fig.1 The Block diagram for the proposed method.

## III. EXPERIMENTAL RESULTS AND DISCUSSIONS

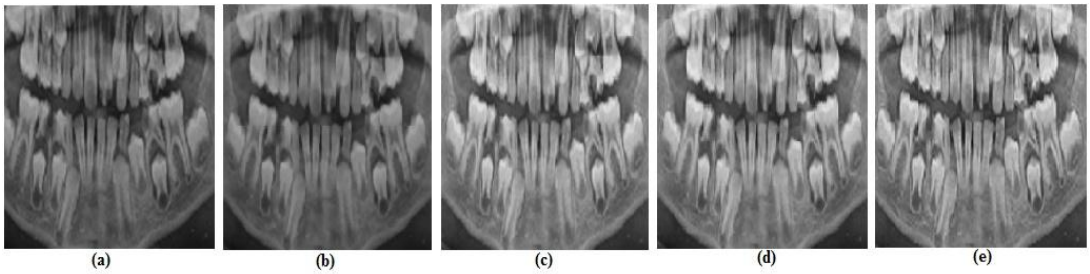


Fig.2 (a) Noisy, LR Panoramic Dental X-ray image. (b) Median filtered Panoramic Dental X-ray image. (c) De-noised, HR Panoramic Dental X-ray image using the proposed technique with Db9 as wavelet function. (d) De-noised, HR Panoramic Dental X-ray image using the proposed technique with Haar as wavelet function. (e) De-noised, HR Panoramic Dental X-ray image using the proposed technique with Bior3.5 as wavelet function.

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Fig. 2 shows the experimental results obtained by applying the proposed method. In Fig. 2, Noisy and LR panoramic dental x-ray image is shown in (a), which is the input image for processing. De-noised and LR image obtained after median filtering is shown in (b), the HR image using the proposed technique with db9 as wavelet function is shown in (c), with Bior 3.5 as wavelet function is shown in (d) and with Haar as wavelet function is shown in (d).

To show the effectiveness of the proposed method using different wavelet functions, a comparison of the MSE performance is given in Table I. These results indicate that the proposed technique with Bior3.5 as wavelet function has higher performance as compared to Haar and Db9 as wavelet functions.

TABLE I : COMPARISON OF MSE VALUES FOR DIFFERENT WAVELET FUNCTIONS

| **Wavelet Function** | **MSE** |
|---|---|
| Db9 | 0.0403 |
| Haar | 0.0366 |
| Bior3.5 | 0.0357 |

A comparison of the proposed technique in terms of peak signal to noise ratio (PSNR) calculation has been done with two conventional image resolution enhancement techniques, such as bicubic interpolation and wavelet zero padding (WZP) . Table II gives the comparison. It is clear that the proposed technique over performs those conventional techniques.

TABLE II : COMPARISON OF PSNR VALUES

| **Techniques** | **PSNR** |
|---|---|
| Bicubic Interpolation | 23.89 |
| WZP | 24.37 |
| Proposed method | 25.29 |

## IV. CONCLUSION

This work has proposed a de-noising and resolution enhancement technique for digital panoramic dental radiography images using wavelet decomposition and reconstruction. Noise present in image is removed by windowing the noisy image with a median filter before performing the enhancement process. A comparison of proposed resolution enhancement technique is done with different wavelet functions including db9, Bior 3.5 and Haar. It is clear that better performance is achieved using the proposed technique with Bior3.5 as the wavelet function. Quantitative assessment of the image quality is performed by means of Mean Square Error (MSE) calculation. The proposed method has been compared in terms of PSNR evaluation, which shows the superiority of the method. Thus enhancement will improve the accuracy of dental x-ray image and will be helpful to dentist for analysing the symptoms of the patients. This work can be further extended to find a novel enhancement method that still improves the quantitative measures with different noise reduction techniques. Also this work can be extended to other medical images as well.

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