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An Optimal Method to Improve the Visual Quality of Medical Images

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Abstract

As the visual quality of X-ray images is a critical reference for the accuracy of the clinical diagnosis, the methods to improve the quality of X-ray images have been investigated. Among many existing methods, using frequency domain filter is a very powerful method to improve the visual quality of images. In this paper, the inherent noises of the input images are suppressed by adding the Laplacian image to the subjected image. The medical X-ray images using the optimal high pass filter has shown improved edges. Further, the optimal high frequency emphasis filter has shown the improved contrast of flat areas by using the result image from the optimal high pass filter. Also the resulting images of the global contrast have improved by the histogram equalization. As a result, the proposed methods have shown enhanced contrast and edges of the images with noise canceling effect.

Keywords: Laplacian Image, High Pass Filter, High Frequency Emphasis Filter

1. Introduction

Even the smallest abnormality should not be overlooked in the correct X-ray diagnosis because the early treatment of this abnormality is critical for the recovery of patients. To identify abnormalities in lung tissue that are roughly spherical with round opacity and a diameter of up to approximately 30 mm[1] which are known as lung nodules[2], the enhanced methods of X-ray images are very important as it improves the visual quality of these images. Numerous enhancement methods have been proposed in this literature, mainly on grayscale transform and frequency domain transform.

Windowing/leveling and the histogram equalization approach are two of the most widely used spatial uniform contrast-based enhancement techniques, which are simple global enhancement approaches and observers can interactively change image contrasts in any grey level range[3].

In this paper, Laplacian filter is used as a suppressed noise method and the existing high pass filter, high frequency emphasis filter, and histogram equalization are used as the enhanced methods. The modified and integral method of these enhanced methods is proposed. The proposed enhancement algorithm shows not only considerable enhanced edges but also enhanced detailed parts.

The remainder of the paper is organized as follows. Section 2 describes the frequency domain filters. Experimental results and conclusions are described in Section 3 and Section 4, respectively.

2. Experimental Section

We have described the detailed process of the frequency domains below[4].

1) In the preprocessing, the size of the input image is computed, and then, the padding parameter is obtained.

2) Each frequency domain filter is processed in sequence.

3) In the postprocessing, the real part of the resultant image is computed, and then, that image is sliced and saved.

Ginsburg[5] has done an experimental showing how the spatial information of an image is distributed in var-

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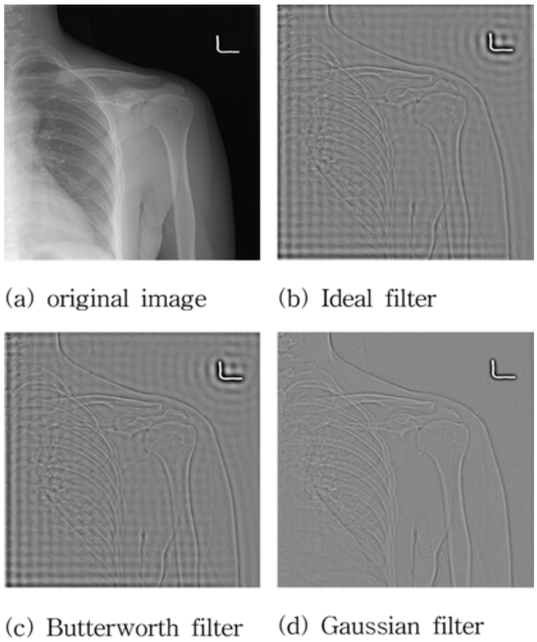

Fig. 1. Four types of highpass filter.

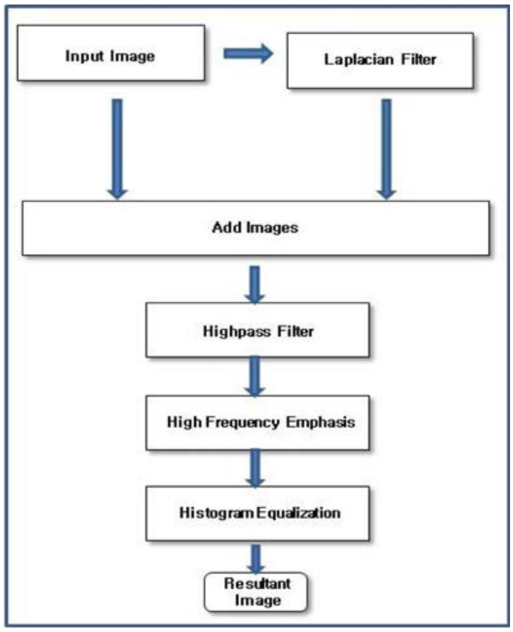

Fig. 2. Block diagram of image enhancement process.

ious frequency bands. Based on the experimental observation, it seems that a cutoff frequency of about 16 cycles per picture width is high enough for the filtered image to show the basic shape of the object presented in the image and is also low enough to exclude all detail structures.

It is important for the cutoff frequency to determine the characteristic of the filter and compare the Gaussian filter with other type of the filters that are the Ideal filter and the Butterworth filter. Fig. 1 shows the each distance of the cutoff frequency and the Gaussian filter is superior to other two high pass filter[6]. Therefore, in this paper, this Gaussian filter is used for the optimal high pass filter.

3. Results and Discussion

We have performed a series of experiments using images in the Standard Digital Image Database, Japan; nodule 154, and non-nodule 93 on chest radiogram to verify the proposed filter. Like a Fig. 2, we have processed the images.

X-ray images do not match the focus in the same way as the optical lens. Therefore, there is a tendency to blur the images. While having the enhancement processes, artifacts are inherent such as the bone-soft tissue boundaries. These artifacts have a detrimental effect on diagnosis. In some cases, they can be pathological evidences in a normal radiograph, or they can hide subtle lesions[7]. In this paper, we have suppressed such noises

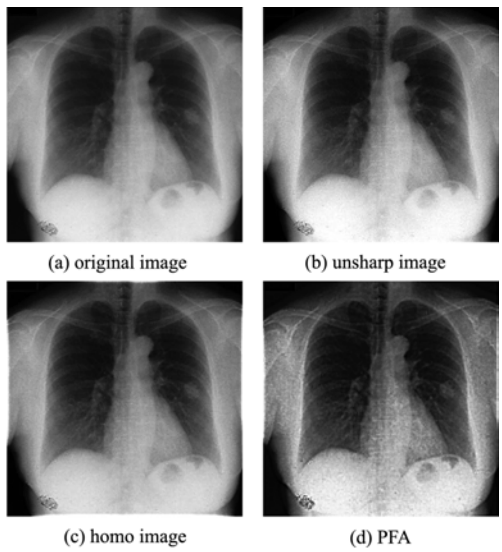

Fig. 3. Simulation result of big nodule.

by adding the Lapacian image to the original. For quality analysis, We have compared and analyzed the Unsharp Masking(UNSHARP) method and the Homomorphic(HOMO) method which enhance the detail of medical images[8].

From Fig. 3 to Fig. 6, the UNSHARP, HOMO and PFA(Proposed Filter Algorithm) are used for improving the input blurred X-ray image.

Among the four images, the resultant image of PFA

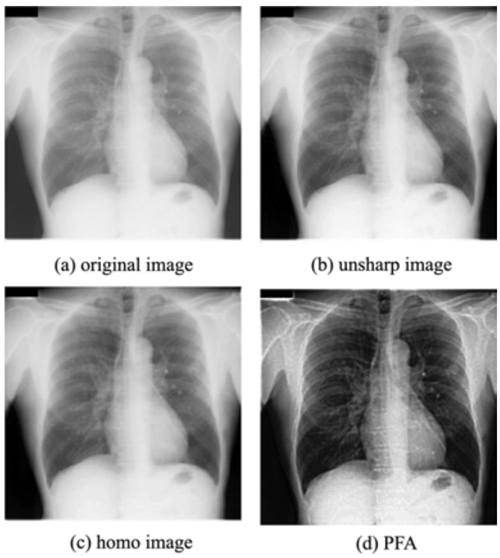

Fig. 4. Simulation result of middle nodule.

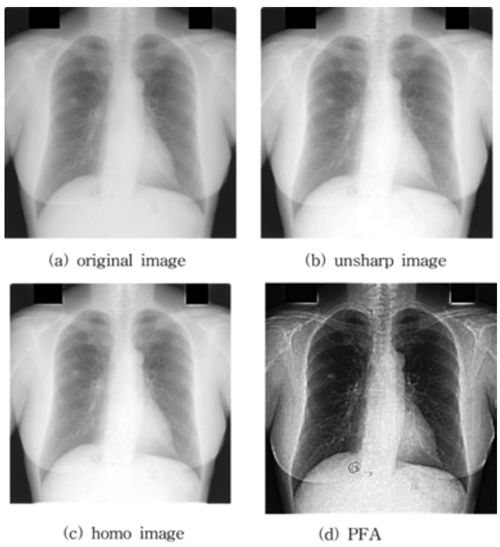

Fig. 5. Simulation result of small nodule.

is superior to the existing resultant images, UNSHARP or HOMO.

Fig. 3(a), 4(a), 5(a), and 6(a) show the original images with big, middle, small nodules, and non-nodule, repectively. The enhanced PFA images are shown in Fig. 3(d), 4(d), 5(d), and 6(d), repectively. The original images in Fig. 3, 4, 5, and 6 present undesirable properties like low SNR(Signal to Noise Ratio) and low contrast ratios. Therefore, these images have so poor image quality that nodules can not be seen. While simulating the PFA. Big nodule and middle nodule not only

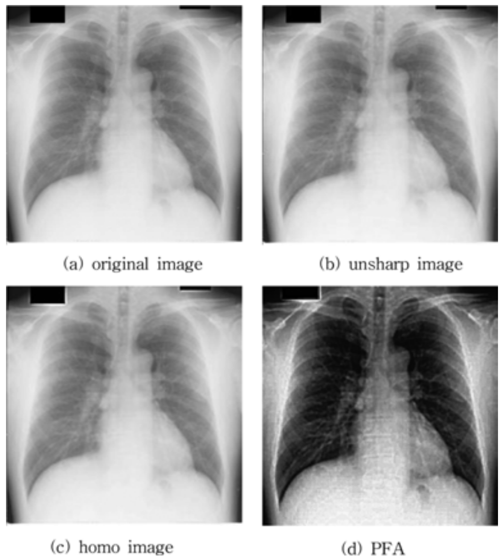

Fig. 6. Simulation result of non-nodule.

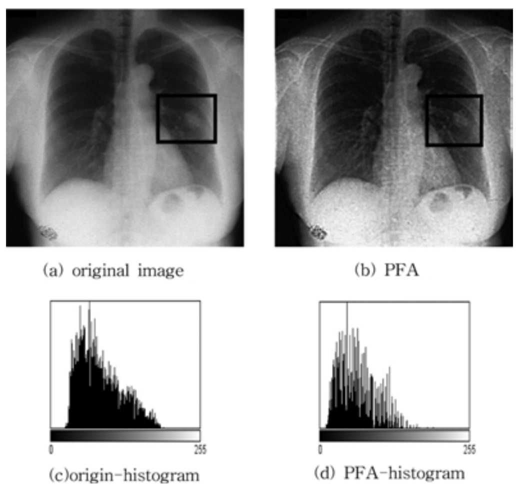

Fig. 7. Position and histogram of big nodule.

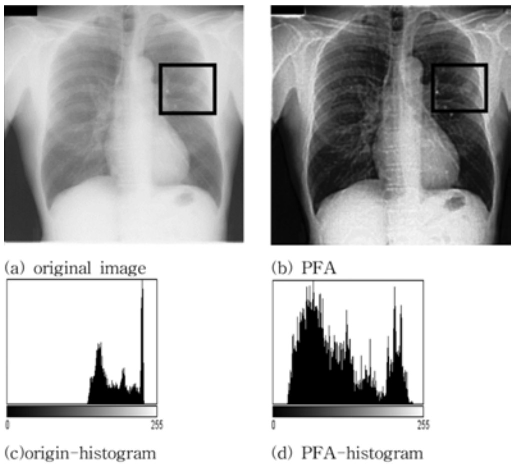

Fig. 8. Position and histogram of middle nodule.

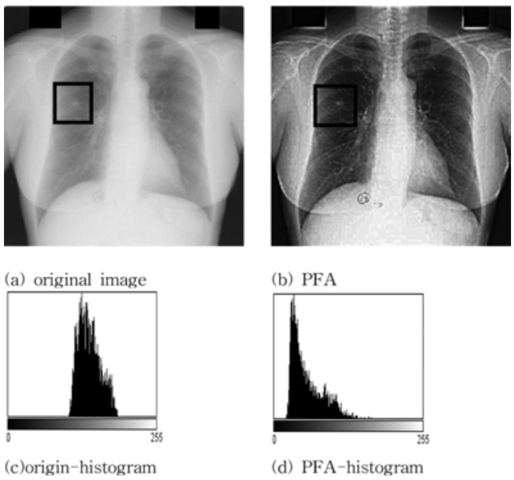

Fig. 9. Position and histogram of small nodule.

can be seen clearly in Fig. 3(d), 4(d), but also small nodule in Fig. 5(d) and the detail feature in Fig. 6(d) can be observed.

Fig. 7, 8, and 9 are the positions for the each nodule and the comparisons of contrast ratios for the each nodule. While seeing the each histogram, we have shown the enhanced contrast ratios for the PFA images.

4. Conclusion

In this paper, we have used the input image which is the padded X-ray CR(Chest Radiogram) images based on the cutoff frequency. Firstly, The Laplacian filter has been used for surppressing the artifacts which are inherent in the X-ray CR images. Secondly, the optimal high pass filter and the high frequency emphasis filter have been used for the enhanced edge and the detailed sharpness. For quality analysis, we have compared the PFA with the existing filters. As a result, the proposed optimal filter has shown the subjective enhanced quality and the enhanced histogram of the each nodule.

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