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An Evolutionary Approach of Hand X-Ray Image Enhancement Using High Pass and Low Pass Filtering Techniques

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***Abstract*— Medical image enhancement is the processing of medical images to improve their appearance to human viewers, in terms of better contrast and visibility of features of interest, or to enhance their performance in subsequent computer-aided analysis and diagnosis. In this paper, the various low pass and high pass filters specifically high boost filter are applied on the hand x-ray image for improve their performance. These techniques are mathematical techniques that are aimed at realizing improvement in the quality of a given image. The result is another image that demonstrates certain features in a manner that is better in some sense as compared to their appearance in the original image. Basic aim of paper is to improve the image quality of the X-ray image. Various image quality measures have been applied to find the performance of the image enhancement.**

***Keywords*— Medical imaging, low pass, high pass, image enhancement, RMSE, PSNR.**

I. INTRODUCTION

Most of the attributes of digital images[1] and the methods of image processing introduced from outside of medicine. We can single out medical imaging for special consideration because the lives of people often depend on correct acquisition, processing, and interpretation of medical images. It is important that individuals responsible for acquiring and processing medical images understand both the nature of the raw material they work with, and the way the images they produce will be used. Those using medical images for research, rather than purely clinical purposes, also need to understand the way their raw data is acquired to ensure the scientific rigor of their work.

The purpose of medical imaging is to reveal and record the *structural* or *functional* state of the body. Mostly we want to see what is going on inside the body – to check that all is well, or to find out why all is not well. Sometimes we want a record of the current state of the body to be referred to at some future time – to monitor the progress, or absence of progress, of a disease or a treatment. The majority of medical images are intended to reveal aspects of the body that cannot be observed by visual inspection or physical examination of the exterior of the body. Interestingly, most medical imaging methods produce a visible light image that *represents* a physical property of body tissue which *cannot* be observed with visible light – at least not without resorting to surgery, which is mostly expensive and possibly counterproductive. We know from years of development of medical imaging modalities[6] that certain measured physical phenomena correlate with biological properties of interest – either disease or normal structure and function. The correlation between physics and biology is easy to understand in the case of something like X-ray imaging – we expect the transmission of X-rays to reveal the structure and arrangement of bones because the method we use to acquire the image is so similar to our everyday experience of light and shadows. At the opposite end of the spectrum of expectation we find methods such as functional MRI in which we infer altered neural activity by measuring the differential relaxation of an induced nuclear magnetic resonance signal. For fMRI the steps between the investigated biological phenomenon and the observed signal are numerous: increased neural activity – local depletion of oxygen tension – increased blood flow – increased local oxyhaemoglobin concentration – diamagnetic alteration of spin relaxation rate; and all of this changing on a time scale of seconds. The demands on image processing and the potential for artifacts are considerable. A user of the technology who is unaware of it's assumptions and limitations is likely to misinterpret the images produced.

II. FILTERING TECHNIQUES:

Filtering is one of the most common applications of image processing. By filtering we mean the processing of the image in order to remove or reduce a particular unwanted component[1, 5], for example noise, or to enhance or extract a particular set of features, such as edges.

A. Ideal Low-Pass Filtering

The ideal low-pass filter[1, 5] suppresses noise and high-frequency information providing a smoothing effect to the image. A two dimensional low-pass filter function $H(u, v)$ is multiplied with the Fourier transform $G(u, v)$ of the image to provide a smoothed image as:

$$\hat{F}(u, v) = H(u, v)G(u, v), \quad (1)$$

where $\hat{F}(u, v)$ is the Fourier transform of the filtered image $\hat{f}(x, y)$ that can be obtained by taking an inverse Fourier transform. An ideal low-pass filter can be designed by assigning a frequency cut-off value $\omega 0$. The frequency cut-off value can also be expressed as the distance $D0$ from the origin in the Fourier (frequency) domain:

$$H(u, v) = 1 \text{ if } D(u, v) \leq D0 \qquad = 0 \text{ otherwise} \quad (2)$$

where $D(u, v)$ is the distance of a point in the Fourier domain from the origin representing the dc value. An ideal low-pass filter has sharp cut-off characteristics in the Fourier domain causing a rectangular window for the pass band.

Also, the multiplicative relationship of the filter model in Eq. 1 leads to a convolution operation in the spatial domain. The rectangular pass-band window in the ideal low-pass filter causes ringing artifacts in the spatial domain. To reduce ringing artifacts the pass band should have a smooth fall-off characteristic. A Butterworth low-pass filter[1, 5] of nth order can be used to provide smoother fall-off characteristics and is defined as:

$$H(u, v) = \frac{1}{1 + [D(u,v)/D_0]2n} \quad (3)$$

As the order n increases, the fall off characteristics of the pass band become sharper. Thus, a first-order Butterworth filter provides the least amount of ringing artifacts in the filtered image. A Gaussian function is also commonly used for low-pass filtering to provide smoother fall-off characteristics of the pass band and is defined by:

$$H(u, v) = e^{-D^2(u,v)/2\sigma^2} \quad (4)$$

Where $D(u, v)$ is the distance from the origin in the frequency domain and σ represents the standard deviation of the Gaussian function that can be set to the cut off distance D_0 in the frequency domain. In this case, the gain of the filter is down to 0.607 of its maximum value at the cut off frequency.

B. Ideal High-Pass Filtering

High-pass filtering[7, 8] is used for image sharpening and extraction of high-frequency information such as edges. The low-frequency information is attenuated or blocked depending on the design of the filter. An ideal high-pass filter has a rectangular window function for the high-frequency pass-band. Since the noise in the image usually carries high-frequency components, high-pass filtering also shows the noise along with edge information. An ideal 2D high-pass filter with a cut-off frequency at a distance $D0$ from the origin in the frequency domain is defined as:

$$H(u, v) = 1 \quad \text{if } D(u, v) \geq D0 \qquad 0 \quad \text{otherwise} \quad (5)$$

As described above for an ideal low-pass filter[1, 5, 8], the sharp cut-off characteristic of the rectangular window function in the frequency domain as defined in Eq. 4 causes the ringing artifacts in the filtered image in the spatial domain. To avoid ringing artifacts filter functions with smoother fall-off characteristics such as Butterworth and Gaussian are used. A Butterworth high-pass filter of n-th order is defined in the frequency domain as:

$$H(u,v) = \frac{1}{1 + [D0/D(u,v)]2n} \quad (6)$$

III. Experimental Result

In this experiment, results are presented for hand X-ray image. This image has been processed and enhanced using the various low pass & high pass filtering techniques such as average(low pass filter) filtering, high boost filtering techniques. The high boost filter used is the novel technique. A contrast enhanced version of the high boost filter are used and analysed. The different parameters for these filters were chosen to maximize the visual quality of the medical images.

The high boost filters as mentioned there result are set into two groups. Group1 is a serial no 1,2,3,and 4 with z values 12,11,10 and 9 resp. and group2 is serial no 5 and 6 with A=5/6 and 3/5 resp. From the visual perception in fig-1 and from the analysed values table1 and fig-2 & fig-3, it is clearly indicates that the high boost filter with z=11 achieve the higher significant outcome as compared to the other high boost filters with any other z value. The other high boost filters with A=5/6 and 3/5 are used for the quality improvement of the medical images. The high boost filter with A = 5/6 having the PSNR value (27.10), RMSE(11.25), AD(0.35), MEAN(150.37) and STD(91.19) whereas the high boost filter with A=3/5 has PSNR(22.52), RMSE(19.05), AD(0.22), MEAN(150.49) and STD(92.98). Hence from the above values as well as from the visual quality, it is clearly proved that the performance of the high boost filter having A=5/6 is not only better than the high boost filter with a=3/5 but also the any other filter as defined in our experiment.

S	Filtering	RMS	PSN	AVG	MEA	STD

No	method	E	R	DIFF	N	
1	high_boost filter_z12	40.19	16.04	-21.06	171.79	89.00
2	high_boost_filter_z11	25.83	19.88	-3.5	154.31	93.21
3	high_boost_filter_z10	32.50	17.89	15.35	135.37	99.50
4	high_boost_filter_z9	54.74	13.36	33.77	116.95	108.7
5	high_boost_filter_56	11.25	27.10	0.35	150.37	91.19
6	high_boost_filter_35	19.05	22.52	0.22	150.49	92.98
7	avg99	16.30	23.88	0.96	149.75	89.69

Table 1. Performance of the filters upon the X-RAY image.

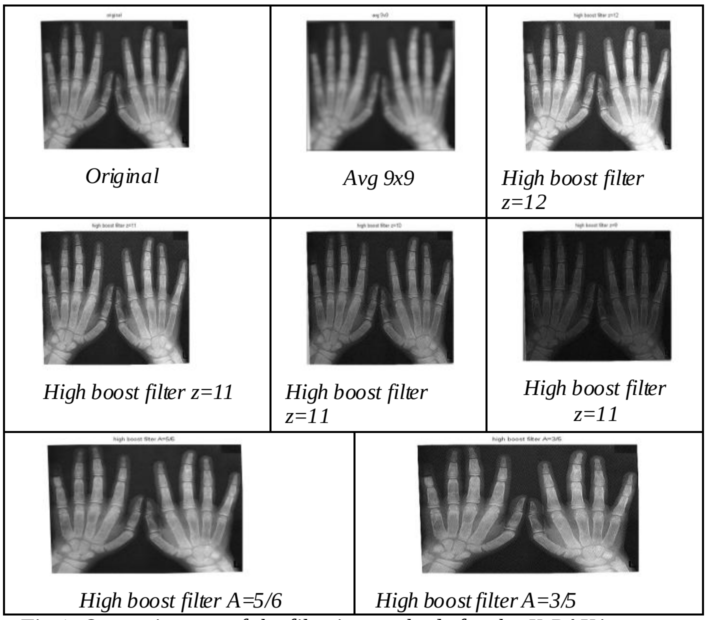

Fig 1. Output images of the filtering methods for the X-RAY image.

IV. CONCLUSION

This research has been devoted to the image enhancement techniques based upon the low pass and high pass filtering that can be applied to enhance noisy hand x-ray medical image. The trade-off between noise elimination and detail preservation was analyzed using the MSE, RMSE, PSNR, AD, MEAN and STD and visual criteria. Thus a comparison between the qualities and performance of various filtering techniques were deduced using these criteria. Effectiveness of each filter is dependent on the type of image, the error criterion used, the nature and amount of contaminating noise. It was seen that the high boost filtering with z=11 and A=5/6 performed well for the image enhancement; this can be clearly seen with its considerable improvement in PSNR and producing visually more pleasing images.

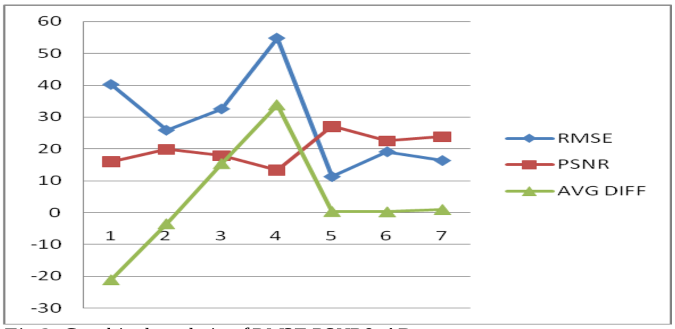

Fig 2. Graphical analysis of RMSE,PSNR& AD

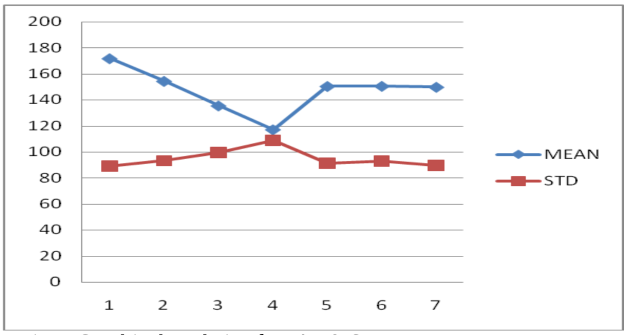

Fig 3. Graphical analysis of MEAN & STD

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