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A NOVEL APPROACH FOR ENHANCEMENT OF X-RAY MEDICAL IMAGES USING THE POINT PROCESSING OPERATIONS

Govind N Sarage*

Asst. Prof. & Head of the Dept of Computer Science, National Defence Academy Khadakwasla Pune
Email: govind_sarage@yahoo.com

Dr Sagar Jambhorkar

Asst. Prof. Dept of Computer Science, National Defence Academy, Khadakwasla Pune
Email: sjambhorkar@yahoo.com

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ABSTRACT

Enhancement of medical Image is a big challenge and a serious problem. In this paper, the various point processing operations are performed on the chest X-ray image for detecting the breathlessness of 17 yrs old girl. Basically this X -ray medical image is of poor quality. 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. In this paper, the following activities are taken up to draw the results: Study of various point processing techniques and their effect on medical images; Study and implementation of various point processing operations available in the literature and their relative performance comparison with the proposed point processing operation.

Keyword: *X-ray Medical imaging, point processing, image enhancement, RMSE, PSNR*

1. INTRODUCTION

Medical imaging[1] systems, take input signals which arise from various properties of the body of a patient, such as its attenuation of x-rays or reflection of ultrasound. The resulting images can be continuous, i.e. analog, or discrete, i.e. digital; the former can be converted into the latter by digitization. The challenge is to obtain an output image that is an accurate representation of the input signal, and then to analyze it and extract as much diagnostic information from the image as possible.

Image enhancement is the processing of images to improve their appearance to human viewers [1, 3], in terms of better contrast and visibility of features of interest, or to enhance their performance in subsequent computer-aided analysis and diagnosis. Because the objective of image enhancement is dependent on the application context and is often poorly defined, and the criteria are often subjective, image enhancement techniques tend to be ad hoc. Enhancement techniques include point operations[1, 2], where the output pixel value depends only on its corresponding input value, and local or neighborhood operations, where the eventual output pixel value depends on the neighborhood of input pixel values. These latter operations include convolution, which uses appropriate masks or kernels to produce smoothing or sharpening of an image.

Image enhancement techniques [1] 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. One may also derive or compute multiple processed versions of the original image, each presenting a selected feature in an enhanced appearance. Simple image enhancement techniques are developed and applied in an ad hoc manner. Advanced techniques that are optimized with reference to certain specific requirements and objective criteria are also available. Although most enhancement techniques are applied with the aim of generating improved images for use by a human observer, some techniques are used to derive images that are meant for use by a subsequent algorithm for computer processing.

X-ray radiography [3] is the simplest form of medical imaging with the transmission of X-rays through the body which is then collected on a film or an array of detectors. The attenuation or absorption of X-rays is described by the photoelectric and Compton effects providing more attenuation through bones than soft tissues or air. The diagnostic range of X-rays is used between 0.5A and 0.01A. A wavelength which corresponds to the photon energy of

***Corresponding author: Govind N Sarage*,*E-mail: govind_sarage@yahoo.com**

approximately 20Kev to 1.0Mev. In this range, the attenuation is quite reasonable to discriminate bones, soft tissue and air. In addition, the wavelength is short enough for providing excellent resolution of images even with sub mm accuracy. Shorter wavelengths than diagnostic range [3] of X-rays provides much higher photon energy and therefore less attenuation. Increasing photon energy makes the human body transparent for the loss of any contrast in the image. The diagnostic X-rays wavelength [3] range provides higher energy per photons and provides a refractive index of unity for almost all materials in the body. This guarantees that the diffraction will not distort the image and rays will travel in straight lines. X-ray medical imaging uses an external ionized radiation source, an X-ray tube to generate X-ray radiation beam that is transmitted through human body.

2. POINT OPERATIONS

A pixel's grey value is changed without any knowledge of its surrounds. Although point operations are the simplest, they contain some of the most powerful and widely used of all image processing operations. They are especially useful in image pre-processing [5], where an image is required to be modified before the main job is attempted.

2.1 ARITHMETIC OPERATIONS

These operations act by applying a simple function

$$y = f(x)$$

to each grey value in the image. Thus f(x) is a function which maps the range 0…255 onto itself.

$$y = \mp c$$

Simple functions include adding or subtract a constant value to each pixel: or multiplying each pixel by a constant:

$$y = Cx$$

In each case we may have to fiddle the output slightly in order to ensure that the results are integers in the 0….255 range. We can do this by first rounding the result (if necessary) to obtain an integer, and then clipping the values by setting:

$$y \leftarrow \begin{cases} 255 & \text{if} \quad y > 255 \\ 0 & \text{if} \quad y < 0 \end{cases}$$

2.2 IMAGE ADDITION AND SUBTRACTION

If an image is contaminated by an uneven background shading pattern, caused by uneven illumination of the scene or variations in detector sensitivity, it can be improved by subtracting the background image from it. If the background image cannot be acquired independently, it can often be synthesized by blurring the original image to such an extent that the features within it are spread out so much as to be no longer identifiable and only the underlying shading remains Subtraction can lead to an underflow, i.e. pixel values less than zero. Again, to avoid clipping, a temporary storage matrix with a greater depth (say, 12 or 16 bits per pixel) or the use of signed floating-point numbers (i.e. numbers which are non-integral and can be positive or negative) is needed to store the differences prior to re-scaling to [0, 255].

Averaging images [1, 5] to increase the signal-to-noise ratio of the resulting image can be implemented in a number of medical imaging systems [3]. It is possible in nuclear medicine imaging, for example, either by adding M sequentially acquired images pixel-by-pixel or by acquiring a final image over a time M times longer than initially planned. Both methods result in an increased dose of radiation to the patient, and therefore should only be used if there is no alternative to acquire an image of diagnostic quality.

Averaging can be performed in X-ray and magnetic resonance imaging (MRI)[3] by reconstructing the image from the average of a number of measurements. Given the finite range of gray values (say, [0, 255]), it is very important to ensure that the addition step does not result in overflow and subsequent clipping of the pixel values. This can be avoided if the pixel values are added into a temporary matrix which is stored with a greater depth (say, 12 or 16 bits per pixel) prior to division and re-scaling to [0, 255].

Figure 1 shows the result of adding or subtracting 128 from each pixel in the image. Notice that addition of 128 results all grey values of 127 or greater will

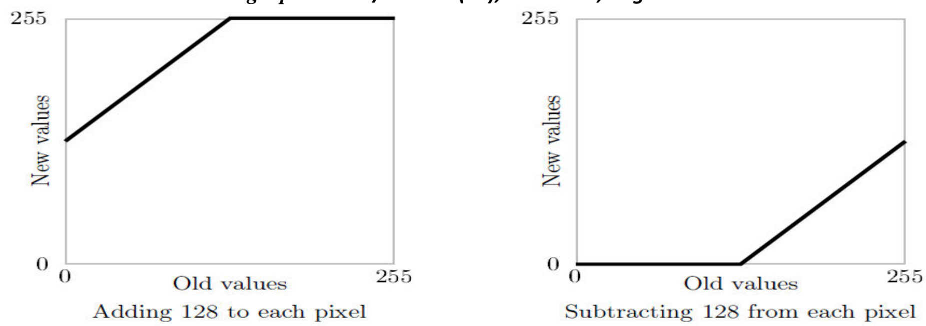


Fig 1: Adding and subtracting a constant

2.3 MULTIPLICATION AND DIVISION

Subtraction [1] of a background image to correct for uneven illumination rests on the assumption that image features are additively superimposed on the scene background. However, in a non-linear system this is not the case, and the intensity associated with a feature is in fact proportional to the background intensity in that part of the image. In such cases, division of the image by a scaled version of its background, rather than subtraction, removes the uneven background. Division of images is a problem if the divisor image contains a pixel value of zero. This is usually avoided by adding a 1 to the entire pixel values of the background image so that they run from 1 to 256, and then re-scaling after division. The division process also removes artifacts that are caused by variations in the pixel-to-pixel sensitivity of the detector and/or by distortions in the optical path. The process is often referred to as "flat-fielding," since it seeks to produce a "flat" or uniform background in an image. It is a standard calibration procedure in everything from pocket digital cameras to giant telescopes. Image division is also used when processing images are collected in different spectral bands; the ratio of the images is an effective way of generating an image at an intermediate spectral band.

Multiplication of images can be used for superposition of texture on to an image, or for masking portions of an image. A potential difficulty with multiplication is that an extreme range of pixel values may be generated. Even with automatic re-scaling a significant loss of precision can result for some values.

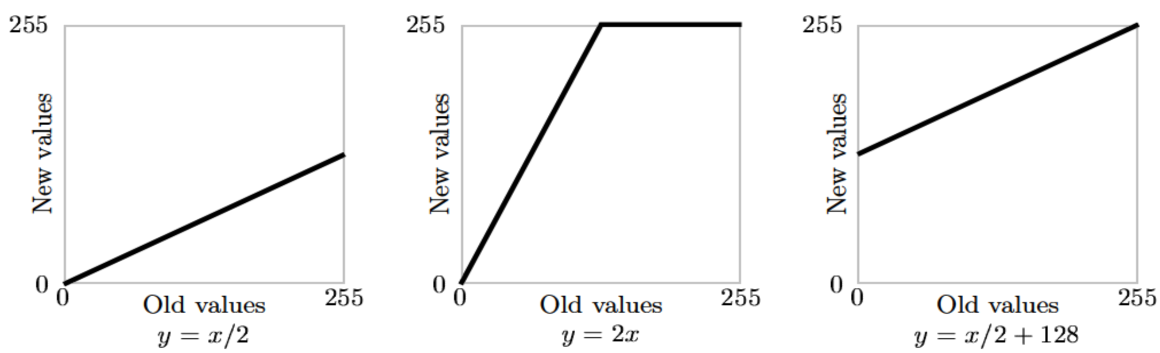


Figure 2: Using multiplication and division

2.4 COMPLEMENTS

The complement [1, 3] of a grayscale image is its photographic negative. If an image matrix m is of type double and so its grey values are in the range 0.0 to 1.0.

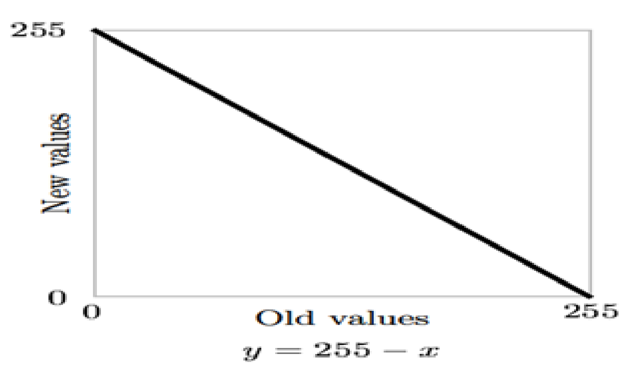


Figure 3: Image complementation

Interesting special effects can be obtained by complementing only part of the image; for example by taking the complement of pixels of grey value 128 or less, and leaving other pixels untouched. Or we could take the complement of pixels which are 128 or greater, and leave other pixels untouched.

Figure 4 shows these functions. The effect of these functions is called solarization.

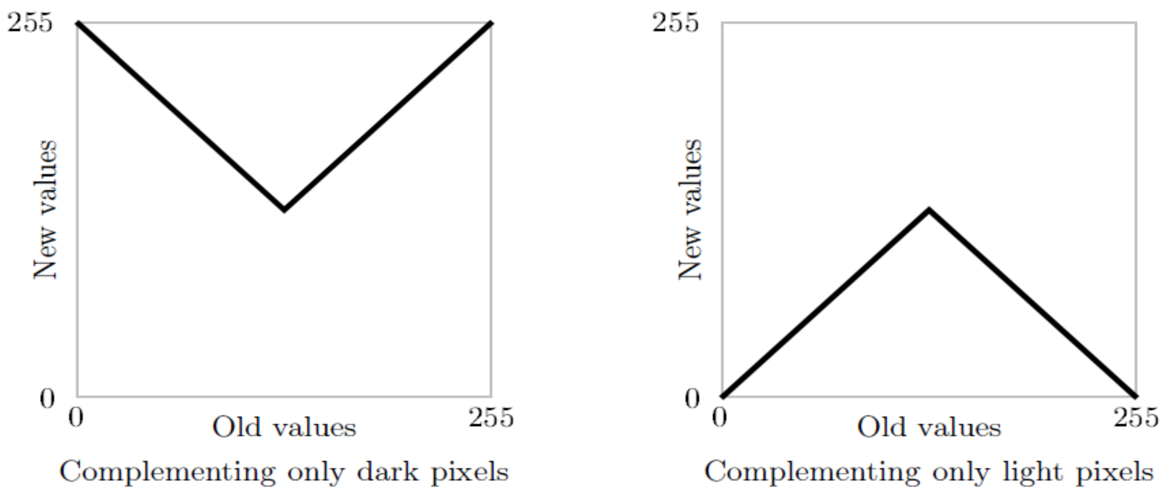


Figure 4: Part complementation

3. EXPERIMENTAL RESULT

The proposed algorithms have been implemented using MATLAB. The performance of various image enhancement approaches using point processing operations are analyzed and discussed. The measurement of image quality for X-ray medical image is difficult to measure. There is no common point processing operations and methods for the image enhancement of the medical image. The statistical measurement could be used to measure enhancement of the X-ray medical image. The Mean Square Error (MSE),Root Mean Square Error (RMSE)an d Peak Signal-to-Noise Ratio (PSNR) are used to evaluate the enhancement performance measure and image quality merics .

Mean Squared Error (MSE) & Root Mean Square Error (RMSE):

The MSE measures the average pixel by pixel difference between the original image f (i, j) and the modified image F (i, j).

$$MSE = \sum \frac{(f(i,j) - F(i,j))^2}{MN}$$

$$\text{RMSE} = \sum \frac{(f(i,j) - F(i,j))^2}{MN}$$

Peak Signal to Noise Ratio (PSNR)

PSNR is usually expressed in terms of the logarithmic decibel scale. The PSNR is most commonly used as a measure of quality of reconstruction of lossy compression codecs (e.g., for image compression). The signal in this case is the original data, and the noise is the error introduced by compression. When comparing compression codecs it is used as an approximation to human perception of reconstruction quality, therefore in some cases one reconstruction may appear to be closer to the original than another, even though it has a lower PSNR (a higher PSNR would normally indicate that the reconstruction is of higher quality). One has to be extremely careful with the range of validity of this metric; it is only conclusively valid when it is used to compare results from the same codec (or codec type) and same content. It is most easily defined via the root mean squared error (RMSE) as:

$$\text{PSNR} = 20 \, log_{10} \frac{255}{RMSE}$$

These all measure the difference between the original and the modified enhanced image. The popularity of MSE, RMSE and PSNR may be attributed to their relation to the squared error. This is due to the fact that many image enhancement algorithms attempt to minimize the squared error, thus, these metrics give a good indication as to what extent this goal was achieved. It can also be said that the calculation of MSE, RMSE and PSNR is a relatively straightforward and simple process.

The enhanced X-ray image obtained by various point processing operations are shown in figure 1. If the value of MSE and RMSE is low and the values of PSNR are high then the enhancement approach is better. The fig 6 shows the performance analysis of the proposed approaches with the regard to X-ray medical image for indicating the breathlessness of the 17 yrs old girl. It was observed from the figure-5, figure-6 and table-1 that the proposed complement > 128 and multiplication by 2 method found suitable and enhanced the X-ray image better than the other point processing methods as stated.

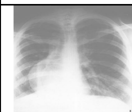
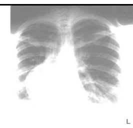
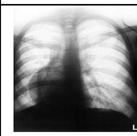
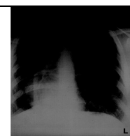
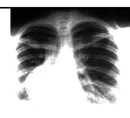
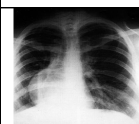
SR NO	POINT OPERATION	IMAGE	SR NO	POINT OPERATION	IMAGE
1	Original image		6	Div by 2 + 128	
2	Add 128		7	Complement	
3	Sub 128		8	Complement < 128	
4	Mul by 2		9	Complement > 128	
5	Div by 2				

Fig 5: Output images of the point processing operation.

Sr.no	Point operation	MSE	RMSE	PSNR
1	Add 128	6308	79.42	10.13
2	Sub 128	5943	77.09	10.39
3	Mul by 2	1830	42.78	15.50
4	Div by 2	3866	62.18	12.25
5	Div by 2 +128	4254	65.22	11.84
6	Complement	22362	149.53	4.63
7	Complement <128	16699	129.22	5.90
8	Complement >128	80.73	8.98	29.06

Table 1: Experimental results and statistical measurements

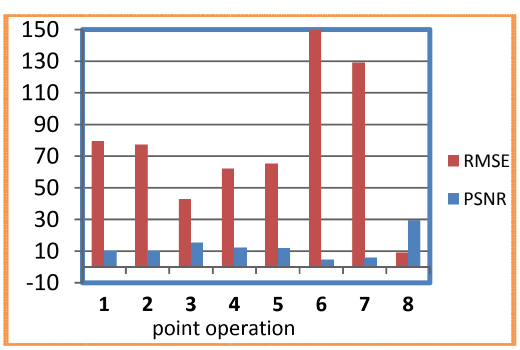


Fig 6: Performance analysis

4. CONCLUSION

The performance of X-ray image enhancement using point processing operations using quantitative performance measures such as MSE, RMSE, PSNR as well as in term of visual quality of the images. Many of the point operations methods are fail to enhance the chest X-ray image, since the information about the variance of the noise may not be identified by the methods. Performance of all algorithms of point operation methods are tested with X-ray image of chest for indicating the breathlessness of the 17 yrs old girl. The computational result showed that the complement>128 and multiplication point processing operation algorithms performed better than the other point processing operations.

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