Image Enhancement Techniques for Improving the Quality of Colour and Gray scale Medical Images

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Abstract— **Key objective of this paper is to process a medical image so that the result is more suitable than the original image for a medical application. This is achieved by applying range compression, contrast stretching, histogram equalization, noise smoothing algorithms. Digital Medical images are often affected by unwanted noise, blurriness and suffer from lack of contrast and sharpness which sometimes results in false diagnosis. Our paper emphasis on eliminating these problems there by makes the diagnosis easy.**

Keywords— **Image enhancement, Medical imaging, range compression, contrast stretching, histogram equalization, noise smoothing.**

I. INTRODUCTION TO DIGITAL MEDICAL IMAGE

In Digital world, Image is sampled into small unit called pixel. Digital image is represented and manipulated as matrices containing the light intensity or color information at each sampled point (pixel). Color image contains three planes [Red Green Blue]. The combinations of the intensities of RGB represent the color and intensity at each pixel. Therefore a color image can be represented by 3 dimensional matrices. Size = (no of rows X no of columns X 3 colors). [1]

- If 'f' represents an image, 'x' represents number of rows, 'y' represents number of columns and 'z' represents the RGB plane, then f(x, y, z) is used to represent intensity at position (x, y, z).
- If we use 8 bits to represent intensity of each color, then we can represent 2^8 intensities (levels), i.e. from 0 to 255 levels.
- Therefore the value of f(x, y, z) lies in between 0 to 255 (0 to L-1), where L represents number of levels.

Figure 1.1, 1.2 and 1.3 shows the representation of colour image in the matrix form.

110	110	110	110	110	110	110	110	110	110
110	110	110	110	110	110	110	110	110	110
100	98	92	62	62	62	92	98	100	105
100	98	92	62	62	62	92	98	100	105
90	90	90	63	63	63	63	90	20	10
90	80	80	63	63	63	63	80	10	20
90	90	90	63	63	63	63	80	20	10
90	90	92	63	63	63	63	86	10	20
100	98	92	62	62	62	92	98	100	105
100	98	92	62	62	62	92	98	100	105
110	110	110	110	110	110	110	110	110	110
110	110	110	110	110	110	110	110	110	110

Fig 1.1: Intensity of Red at each pixel (plane 1)

10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10
42	42	45	45	50	50	100	140	132	200
140	132	200	140	132	200	140	132	200	140
10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10
42	42	45	45	50	50	100	140	132	200
140	132	200	140	132	200	140	132	200	140
10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10
42	42	45	45	50	50	100	140	132	200
140	132	200	140	132	200	140	132	200	140

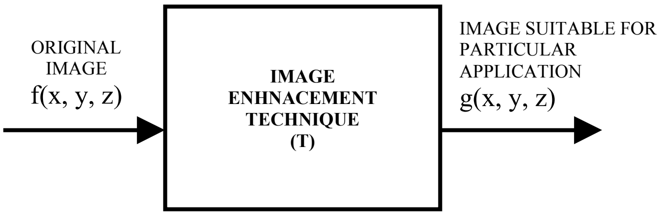
Fig 1.2: Intensity of Green at each pixel (plane 2)

52	52	52	52	30	30	30	30	30	30
52	30	30	30	30	30	30	52	52	52
58	85	95	95	95	95	94	95	95	95
16	20	24	26	28	29	30	32	36	38
16	20	24	26	28	29	30	32	36	38
16	20	24	26	28	29	30	32	36	38
82	82	83	83	84	84	85	85	85	85
16	20	24	26	28	29	30	32	36	38
16	20	24	26	28	29	30	32	36	38
16	20	24	26	28	29	30	32	36	38
61	61	62	62	62	63	63	63	62	63
25	20	29	96	96	96	98	112	100	150

Fig 1.3: Intensity of Blue at each pixel (plane 3)

II. IMAGE ENHANCEMENT TECHNIQUES

Image enhancement techniques are the algorithms which improve the quality of images by removing blurring and noise, increasing contrast and sharpness of digital medical images. There are many image enhancement approaches (theories) like Contrast stretching, Range compression, Histogram equalization and noise smoothing. A certain amount of trial and error usually is required before a particular image enhancement approach is selected. There is no general theory of image enhancement. When an image is processed for visual interpretation, the viewer is the ultimate judge of how well a particular method works. Visual evaluation of image quality is a highly subjective process.



$g\ (x, y, z) = T\{\ f\ (x, y, z)\}$

Fig 2.1: Image Enhancement Technique

Image Enhancement Techniques transforms the original image f(x, y, z) to output image g(x, y, z) which is suitable for medical diagnosis by applying the transformation “T” as shown in Fig 2.1. [2]

Fig 2.2: Original Xray image before image enhancement

Image in fig. 2.2, shows the collapse of D11 and D12 vertebrae with loss of intervening disc space with para vertebral and epidural collection pushing the spinal cord posteriorly. Kyphosis is noted at that level [3]

Fig 2.3: Original 3D Embryo Image before image enhancement

Image in Fig 2.3 shows the Original 3D-ultrasound scanned color image of Embryo used for early detection of treatable childhood ailments [4]. Fig 2.2, 2.3 are dark and low contrast images. Using image enhancement algorithms the image quality can be improved

III. IMAGE ENHANCEMENT USING CONTRAST STRETCHING

A. *Contrast Stretching:*

The difference between the intensity of two adjacent pixels is termed as "Contrast". In high contrast images this difference will be more and in low contrast images this difference will be less. Low-contrast images occur often due to poor or non uniform lighting conditions or due to non linearity or small dynamic range of the imaging sensor. [5] The Contrast stretching transformation is given by

$$g(x, y, z) = \begin{cases} \alpha * f(x, y, z) & 0 <= f(x, y, z) <= a \\ \beta * (f(x, y, z) - a) + g(x, y, z) \text{ at } a & a < f(x, y, z) <= b \\ \gamma * (f(x, y, z) - b) + g(x, y, z) \text{ at } b & b < f(x, y, z) <= L \end{cases}$$

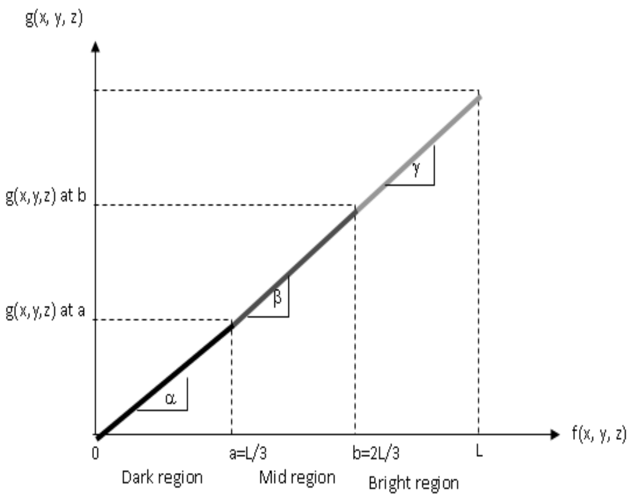


Fig 3.1: Contrast Stretching

The slope of the transformation (□□□□□□ is chosen greater than unity where there is need of contrast stretch.

- For dark region stretch $\alpha > 1$
- For mid region stretch $\beta > 1$
- For bright region stretch $\gamma > 1$
- $a = L/3$
- $b = 2L/3$
- $g(x, y, z)$ at $a = \alpha * a$;
- $g(x, y, z)$ at $b = \beta * (b - a) + g(x, y, z)$ at a

Thus by contrast stretching the details in very dark or bright areas become clearly visible. [6]

B. Result of Contrast Stretching medical image:

Fig 3.2: After Contrast stretching fig 2.2

Contrast stretching works equally good on color image. The formula is applied to all the three RGB planes.

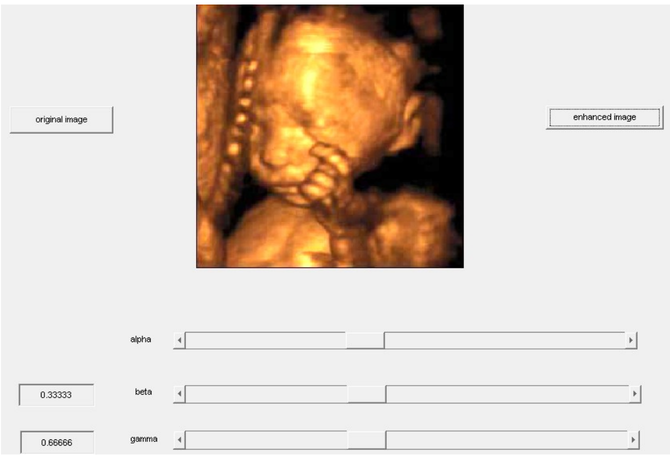


Fig 3.3: After Contrast stretching fig 2.3

IV. IMAGE ENHANCEMENT USING RANGE COMPRESSION

A. Range Compression:

Dynamic Range is the difference or ratio between the brightest intensity and the darkest intensity of an image or scene. Some times the dynamic range of the image data may be very large. The dynamic range can be compressed via the logarithmic transformation [7]

$$g(x, y, z) = c*\log_{10}(1+| f(x, y, z) |)$$

Where, ‘c’ is a scaling constant.

$$c = L / \log10 (1+L)$$

Here we adjust the amount intensity to effectively compress the dynamic range of an image. So the high dynamic range scenes are effectively mapped to the smaller dynamic range of the image. Dynamic range compression avoids the common artifacts, such as halos, loss of local contrast etc. Halo artifacts are the light lines or luminous circles around object edges in an image caused by refraction of light.

B. *Result of Range compressing medical image:*

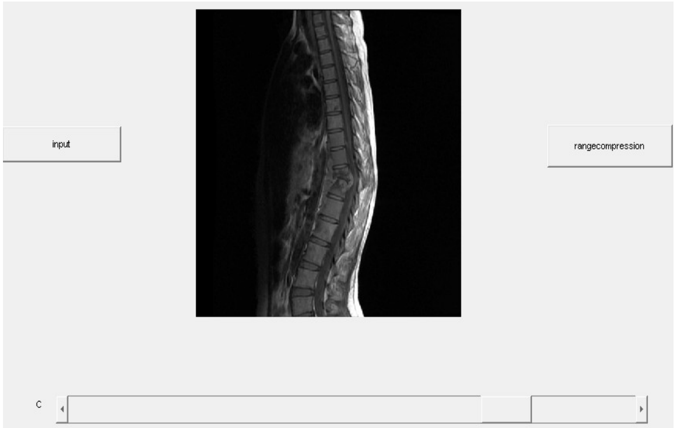


Fig 4.1: After range compressing fig 2.2

Range compression works equally good on color image. The formula is applied to all the three RGB planes.

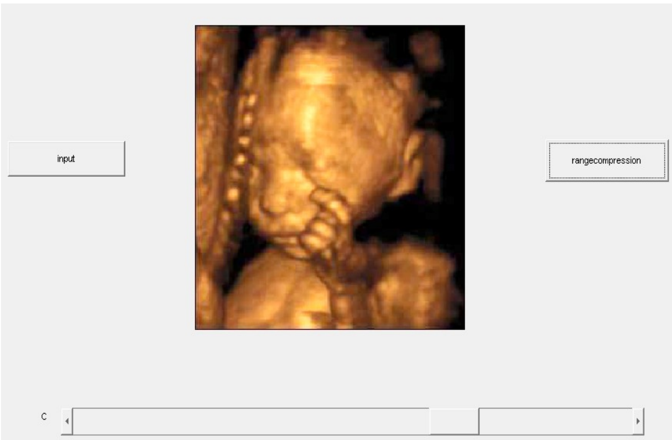


Fig 4.2: After range compressing fig 2.3

V. IMAGE ENHANCEMENT USING HISTOGRAM EQUALIZATION

A. *Histogram and Histogram equalization:*

Histogram is a graph of intensity values on x axis versus total number of pixels in the image taking that intensity value on y axis.

In Fig 5.1 we observe the histogram is not equally distributed. Number of pixels having dark values is more and the Number of pixels having brighter values is less.

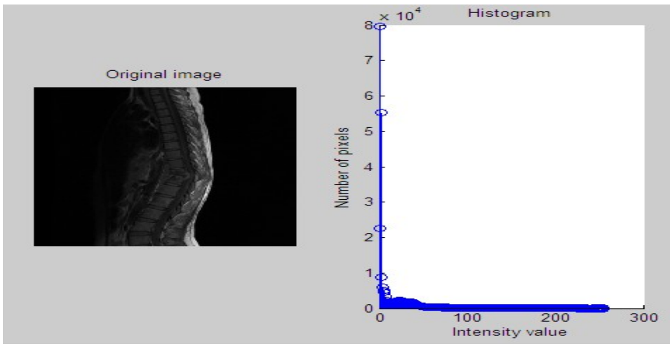


Fig 5.1: Histogram of fig 2.2

So this histogram is not equalized or equally distributed over all intensity values. Histogram equalization is used for enhancing the contrasts in an intensity image. This works for images where almost all of the different intensity levels are represented.

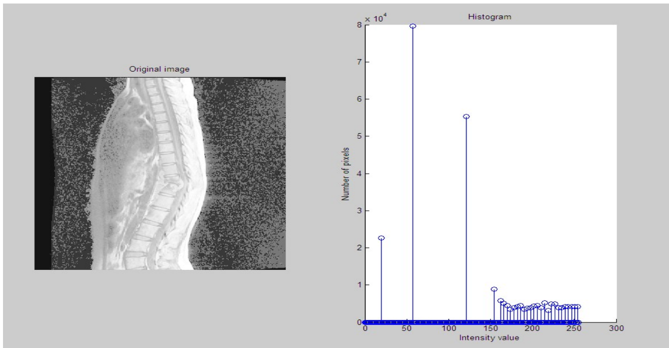


Fig 5.2: Histogram equalization of fig 2.2

B. *Gamma Corrections:*

If an image is low contrast and dark image, we try to improve its contrast and brightness. The widespread histogram equalization method cannot correctly improve all parts of the image. When the original image is irregularly illuminated, some details on resulting image will remain too bright or too dark. So we go for gamma correction which performs nonlinear brightness adjustment [8]. For darker pixels brightness is increased and bright pixels remain bright almost same as before. Thus more details are clearly visible. If gamma=1 the mapping is linear. When gamma = 0.5, number of pixels having high/brighter intensity level are more. So the image will be brighter having high contrast. When gamma = 1.5, number of pixels having low/dark intensity level are more. So the image will be dark having low contrast. Thus by varying the gamma value the contrast of image is varied. [9]

```
for i=1:rows
    for j=1:colms
        J(i,j)=c*(I(i,j))^gamma;
    end
end
```

Where, I=original image and J= gamma corrected image
c= constant

The following plots show the resulting image and its histogram after three different gamma correction settings with c=1. Best result is observed with gamma = 0.5.

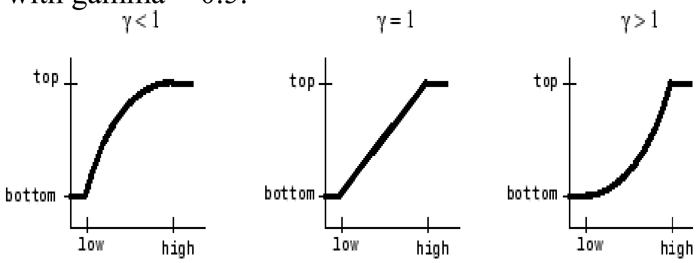


Fig 5.3: Gamma Corrections

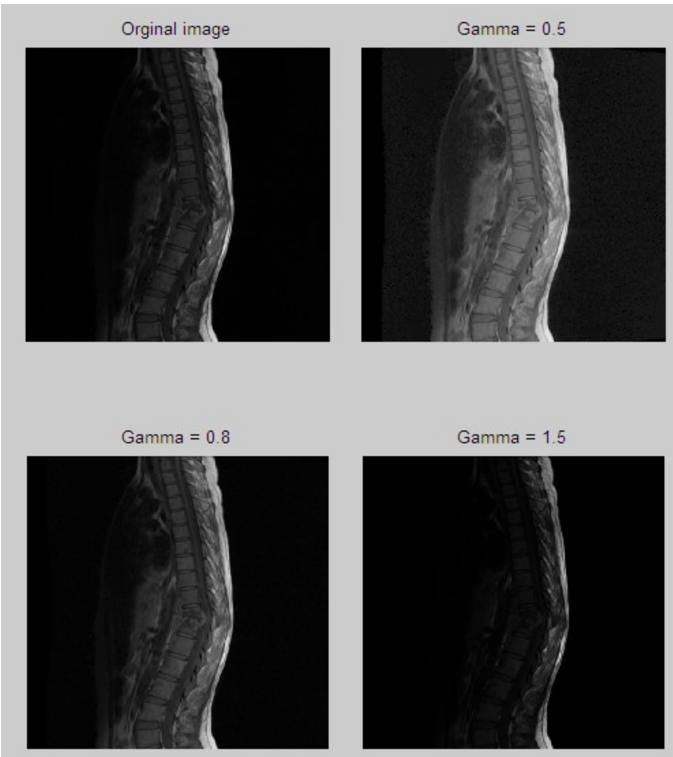


Fig 5.4: Gamma correction and histogram equalization

VI. IMAGE ENHANCEMENT USING NOISE SMOOTHING

Noise artifacts are a part of every medical image obtained with any technology which can significantly hinder the diagnostic quality. Noise can be removed using median filter. The main idea of the median filter is to run through the image pixel intensity values, replacing each pixel value with the median of neighboring pixel values. The pattern of neighbors is called the "window", which slides, over the entire image signal. For 2D image this window is of a box pattern.

The median filters smooth the transient changes in signal intensity (noise). They are very effective in removing impulsive noises from the image by preserving the edge information. [10]

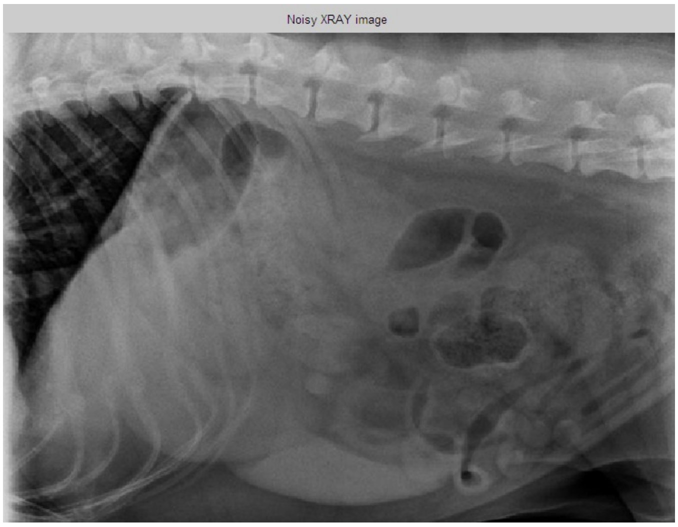


Fig 6.1: Noisy X- Ray of the Abdomen [11]

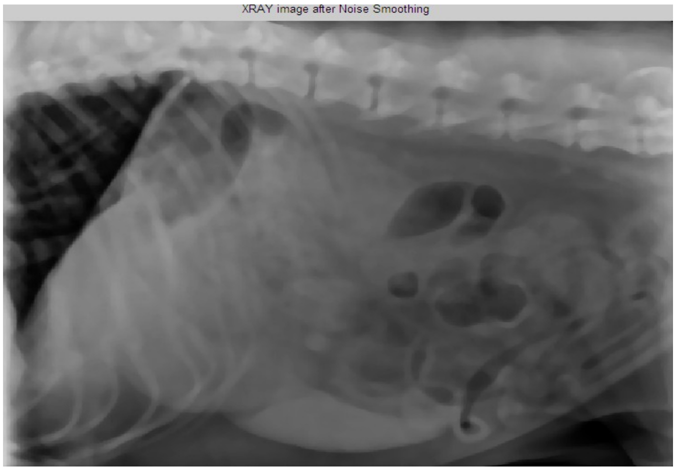


Fig 6.2: Image enhancement using noise smoothing

The result shows that the image in fig 6.2 is free from noise after noise smoothing by using median filter and suitable for diagnosis.

VII. CONCLUSION

In this paper we have presented how different image enhancement techniques like range compression, contrast stretching, histogram equalization with gamma correction and noise smoothing can be used to enhance the quality of medical images. Simulation results show that the techniques produce visually good results which make the diagnosis easy.

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