# EMPLOYMENT OF MODIFIED HOMOMORPHIC FILTERS IN MEDICAL IMAGING

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***Abstract–****The most vivacious area of the image processing is image enhancement. Newer techniques and ideas are being routinely incorporated to this field for the proper enhancement to make the original image suitable for some specific purposes. However, the techniques that are suitable for X-ray image enhancement may not necessarily be suitable for enhancement of the Satellite Telescope Transmitted (STT) images. Many times, Medical images especially X-ray images are required to be sharper than its original version for proper information extraction that is necessary for diagnostic purposes. Homomorphic filters that actually belong to the group of the sharpening filters can be employed for finding fine details in the X-ray images. The Homomorphic filters use the Discrete Fourier Transforms (DFT) as the core transform. Presently, more efficient tools for transformations are being used; such as the Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT), Fast Fourier Transform (FFT) and Fast Wavelet Transform (FWT) in digital image processing. In this paper, along with the conventional DFT technique, DCT, DWT, FFT and FWT are incorporated in the image transformation process that consequently modifies the core process of Homomorphic filters. The performance of the resulting modified Homomorphic filters are compared with that of the original filter. The performance enrichment has become evident from the numerical and the visual comparisons.*

***Keywords–****The Homomorphic Filters, The Satellite Telescope Transmitted (STT) Images, Medical Images, Fourier Transform, Wavelet Transform, Entropy Ratio.*

## 1. Introduction

In 1972, Stockham presented a paper launching Homomorphic filters. The filter used Discrete Fourier Transform (DFT) in its transform block. [1]. In the year 1988, Bringham presented Fast Fourier Transform (FFT) and some of its implementations in his book. This discovery of FFT was a key landmark in the popularization of DFT. He also presented FFT with other bases than 2. [2]. In the year 1989, Jain presented Discrete Cosine Transform (DCT), which opened a new door in signal processing. Wavelets were first shown to be a new powerful transformation and analysis called multi resolution analysis in the year 1987 by Mallat. Discrete Wavelet Transforms (DWT) are computed more efficiently in the year 1989 and named as the Fast Wavelet Transforms (FWT) by Mallat. [3].

## 2. Homomorphic Filters

The Homorphic filters are based on the well-known illumination-reflectance model. This model is designed to develop a frequency domain procedure for improving the appearance of an image by simultaneous gray-level range compression and contrast enhancement.

An image $f(x,y)$ can be expressed as the product of the illumination $i(x,y)$ and the reflectance component $r(x,y)$ as follows:

$$f(x,y) = i(x,y).r(x,y) \qquad (1)$$

This equation cannot be used to operate separately on the frequency components of illumination and reflectance directly because the Fourier transform of the product of the two functions is not separable. So, equation (1) can't be expressed as:

$$\Im\{f(x,y)\} = \Im\{i(x,y)\}.\Im\{r(x,y)\} \qquad (2)$$

But if image $f(x,y)$ can be defined as follows-

$$z(x,y) = \ln f(x,y)$$
$$= \ln i(x,y) + \ln r(x,y)$$

Then

$$\Im\{z(x,y)\} = \Im\{\ln f(x,y)\}$$
$$= \Im\{\ln i(x,y)\} + \Im\{\ln r(x,y)\}$$

Or

$$Z(u,v) = F_i(u,v) + Fr(u,v) \qquad (3)$$

Where, $F_i(u, v)$ and $Fr(u, v)$ in equation (3) are the Fourier transforms of the terms defined earlier $\ln i(x,y)$ and $\ln r(x,y)$ .[4].The function $Z(u,v)$ can be processed by means of a filter function $H(u,v)$ and can be expressed as-

$$S(u,v) = H(u,v).\ Z(u,v)$$
$$= H(u,v).F_i(u,v) + H(u,v).Fr(u,v) \qquad (4)$$

Where $S(u,v)$ is the Fourier transform of the result. In the spatial domain-

$$s(x,y) = \Im^{-1}\{S(u,v)\}$$

$$= \Im^{-1}\{H(u,v).F_i(u,v)\} + \Im^{-1}\{H(u,v)F_r(u,v)\}$$

By letting

$$i'(x,y) = \Im^{-1}\{H(u,v).F_i(u,v)\}$$

and

$$r'(x,y) = \Im^{-1}\{H(u,v)F_r(u,v)\}$$

Finally the equation becomes

$$s(x,y) = i'(x,y) + r'(x,y) \quad (5)$$

$$g(x,y) = e^{s(x,y)}$$

$$= e^{i'(x,y)}.e^{r'(x,y)}$$

$$= i_0(x,y).r_0(x,y) \quad (6)$$

Where, $i_0(x,y) = e^{i'(x,y)}$ and $r_0(x,y) = e^{r'(x,y)}$

are the illumination and the reflectance components of the output images. But as $z(x,y)$ was formed by taking the logarithm of the original image $f(x,y)$, the inverse (exponential) operation yields desired enhanced form of the original image, denoted by the $g(x,y)$. So, the procedure is taking logarithm and exponential sequentially yield the suitable version of the original image.

This method is based on a special case of a class of systems known as Homomorphic system. The filter transfer function H (u, v) is known as the Homomorphic filter function which acts on the illumination and the reflectance components of the input image separately. The Illumination component of an image is generally characterized by the slow spatial variations while the reflectance components vary abruptly, particularly at the junctions of the dissimilar objects. These characteristics actually lead to associate the low frequencies of the Fourier transform of the logarithm of an image with illumination and the high frequencies with reflectance. [5].This process of enhancement can be expressed by using the block diagram shown in figure 1. Homomorphic filter helps to have a good control over the illumination and the reflectance. The figure 2 shows the entire cross-section of the Homomorphic filter function. $\gamma_H$, $\gamma_L$ shown in figure 2 are the higher and lower frequency components respectively. A good choice between the higher and the lower frequency provides a dynamic range of the compression and enhancement.[6].

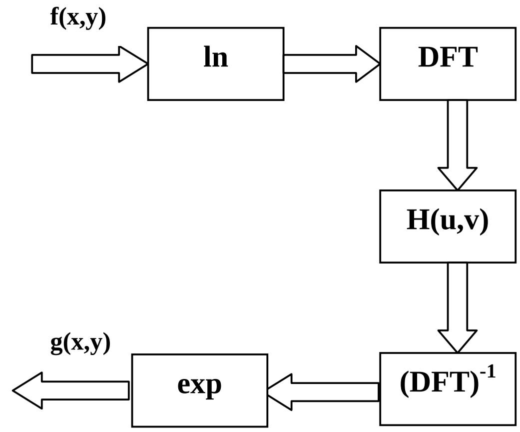



Figure 1: Block diagram of the conventional Homomorphic filtering process.

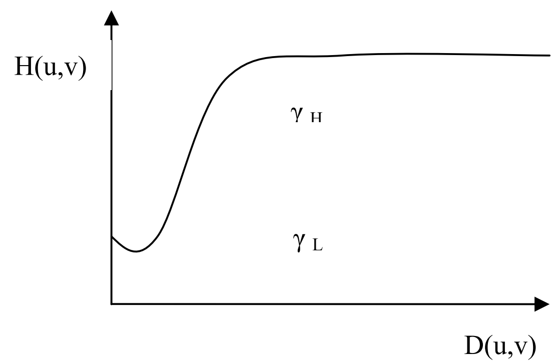



Figure 2: Cross-section of Homomorphic filters function.

The Homomorphic filter is widely used in medical images for sharpening purpose that helps to find detailed information. Detailed information is required for finding the actual area and the original depth of the fractures, displacements. Another requirement of the sharpening version of the X-ray image is that to proper study of the student. The students can find more similarities with the practical problems if they have sharpened version of the original image. It is evident that the sharper version of the X-ray image provides more information that the original one.[7]

## 3. Proposed Modifications

This work contains, some modifications of the Homomorphic filter function (core transform actually) are proposed. The modifications are based on changing the core transform function. This work tried FFT, FFT2, DCT, DCT2 and DWT instead of original DFT transform. A code is developed for these modification purposes. This form filtering sharpens features and flattens lighting variations of the input image. It usually is very effective on images that have large variations in lighting, specially, when a subject appears against strong backlighting. In the code the parameters used to vary the characteristics of the images are boosting up of high frequency values, cut-off frequency of the filter, lower frequency limits, upper frequency limits and the order of the filter. The code can be used for both black and white and color images. An X-ray image is used for the performance evaluation of the proposed modifications. [8].

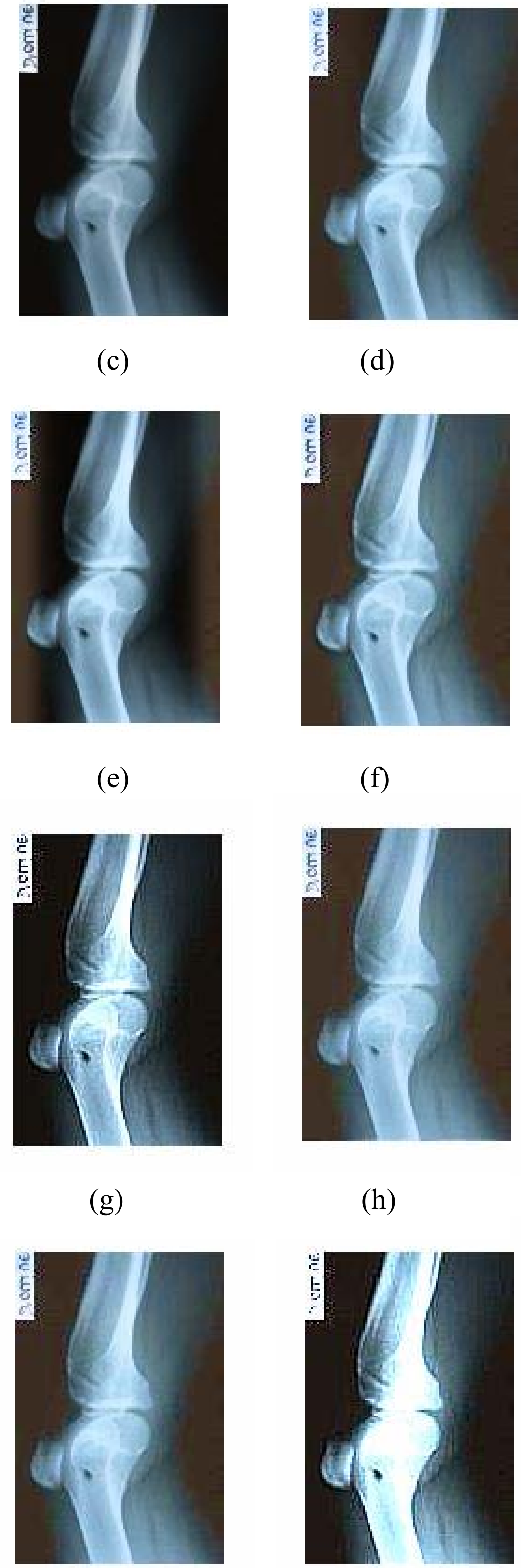
For a Homomorphic filter of order 2, lower frequency limit 0, upper frequency limit 5, boost up of 2 and cut-off of .25 is used for the performances comparison of modified Homomorphic filters with the original one.

## 4. Performance Comparison

The aim of image enhancement is to improve the interpretetability or the perception of information in images for human viewers or to provide the 'better' input for the other automated image processing techniques. But, unfortunately there is no general rule or any mathematical criterion for determining what is 'good' image enhancement when it comes to the human perception. If the image looks good, it is good. It is also true for the converse idea.

This paper launches a new mathematical criterion for the measurement of the degree of the enhancement. Besides the qualitative visual criterion or the subjective criterion of measurement, quantitative objective criterion ER for every transform has been plotted against the cut-off frequency of the respective Homomorphic filter.

(a) (b)



(c) (d)

(e) (f)

(g) (h)

(i) (j)

**Figure 3**: Visual comparison.

For a Homomorphic filter of order 2, lower frequency limit 0, upper frequency limit 5, boost up of 2 and cut-off of .25 is used for the performances comparison of modified Homomorphic filters with the original one. A visual comparion with the preceding specifications are shown in the figure 3.

In the figure 3, (a) Original image (b)DFT transformed Image (c)FFT transformed image (d)FFT2 transformed Image (e)DCT transformed Image (f)DCT2 transformed Image.(g)DWT with single stage filtering (h) DWT with double stage filtering. (i)DWT with triple stage filtering and (j) DWT with quad stage filtering Images have been shown.

From subjective comparison, it is evident that the DWT transformed image with quad stage filtering gives the sharpest version of the original image. Objective criterion is not a must for this case. But if the DCT2 transformed image and the DWT with single stage filtering image is to be taken to have a decision, which one is sharper, it becomes very much confusing for the viewer. The necessity of the objective criterion is started here.

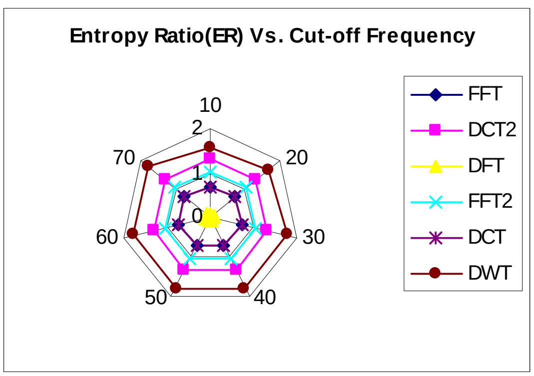



**Figure 4**: Entropy Ratio vs. cut-off frequency comparison.

The DWT transformed images have the highest values of the ER indicating they are the sharpest version of the original image. Now, a decision can be taken about the DCT2 transformed and DWT with single stage filtering image. The DCT2 transformed image has ER of 1.32 whereas the DWT with single stage filtering image has ER of 1.39.So the latter one is sharper.

## 5. Conclusion

In this work, in order to obtain the enhanced performance in the medical image processing, it is intended to modify the conventional transform technique involved in the Homomorphic filtering by using FFT, FFT2, DCT, DCT2 and DWT with the various stages of filtering process. Experimentally, it has been observed that the DWT transformed images performed well than other methods. In measuring the performance of the modified filters, apart from the subjective approach of comparison, a highly quantitative metric –the 'Entropy Ratio (ER)' has been introduced in this paper. However, before applying the proposed tentative approach of the medical image specially X-ray image enhancement in practical purposes, further investigations can be made.

## 6. References

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