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MEDICAL IMAGE ENHANCEMENT USING RECURRENT NEURAL NETWORKS BASED TV HOMOMORPHIC FILTER: A Survey

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Abstract— Image enhancement is a fundamental requirement in digital image processing since it allows an image to be used in a variety of applications, such as digital photography, medicine, geographic information systems, industrial inspection, law enforcement, and many other digital image applications. Image enhancement is a technique for improving the quality of low-resolution images.

The homomorphic filtering approach is one of the most common methods for digital image improvement, especially when the input image has inadequate lighting. Many diverse imaging applications, such as biometric, medical, and robotic vision, have exploited this filtering technique. Homomorphic filtering reduces the relevance of low frequency components by applying a high-pass type filter in the frequency domain. However, there are various variations of mathematical equations used to present this filter in the literature.

Keywords*-Liver Cancer, digital image processing, digital image enhancement, homomorphic filtering, Image Enhancement Techniques, Application of Enhancement technique.*

I. INTRODUCTION

Digital image technology is a subset of digital signal technology that deals with manipulating digital images with the use of computers. Analog image processing is inferior to digital picture processing. It is expected that with the help of ethnic eyes, the visuals will be deciphered without difficulty. It is made up of a number of steps. Image Acquisition, Image Enhancement, Image Restoration, Color Image Processing, Wavelets & Multi-Resolution Processing, Compression, Morphological Processing, Segmentation, Representation & Description, and Object Recognition are some of the techniques used in image processing. The process of image enhancement is crucial. It is used to improve the quality of digital photos. It's used to draw attention to specific aspects of an image.

Images are sometimes taken in low-light situations. The same uniform region will appear brighter in some regions and darker in others under this situation. This unfavourable circumstance will result in a slew of serious issues in computer vision-based systems. The pixels could be misclassified, resulting in incorrect segmentation results and, as a result, inaccurate system evaluation or analysis. As a result, processing these types of photos before feeding them into the system is critical.

Homomorphic filtering is a popular method for enhancing or restoring images that have been degraded by uneven illumination. The illumination-reflectance model is used in the operation of this approach. The image is characterised by two basic components in this model. The amount of source illumination incident on the scene being observed is the first component (x,y). The reflectance component of the scene's objects is the second component (x,y). After that, the image f(x,y) is defined as [1]-[3]:

$$f(x,y) = i(x,y)r(x,y)$$

The intensity of i(x,y) changes slower than r in this model (x,y). As a result, i(x,y) is thought to have more low frequency components than r. (x,y). The homomorphic filtering approach takes advantage of this fact to diminish the relevance of i(x,y) by lowering the image's low frequency components. This is accomplished by running the filtering process in the frequency domain. To process a picture in the frequency domain, it must first be translated from the spatial to the frequency domain. This can be accomplished through the use of transformation functions such as the Fourier transform. Prior to the transformation, the logarithm function was employed to convert the multiplication operation of r(x,y) with i(x,y) in (1) to an addition operation.

In general, homomorphic filtering can be implemented in the following five steps:

Step 1: To decouple the i(x,y) and r(x,y) components, take a natural logarithm of both sides.

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

Step 2: Use the Fourier transform to transform the image into frequency domain:

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

or

$$Z(u, v) = F_i(u, v) + F_r(u, v)$$

where $F_i(u,v)$ and $F_r(u,v)$ are the Fourier transforms of $\ln i(x,y)$ and $\ln r(x,y)$ respectively.

Step 3: High pass the $Z(u,v)$ by means of a filter function $H(u,v)$ in frequency domain, and get a filtered version $S(u,v)$ as the following:

$$S(u, v) = H(u, v), Z(u, v) = H(u, v) Fi(u, v) + H(u, v) Fr(u, v)$$

Step 4: Take an inverse Fourier transform to get the filtered image in the spatial domain:

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

Step 5: The filtered enhanced image $g(x,y)$ can be obtained by using the following equitation

$$g(x, y) = \exp\{s(x, y)\}$$

However, in literatures, there are several variations of equations that have been used to present $H(u,v)$ in last equation. Therefore, this paper will survey some of them.

II. HOMOMORPHIC FILTER EQUATIONS

In [1]- [5], the usual filter for homomorphic filtering was introduced. This filter has a circularly symmetric curve form in the frequency domain, with (u,v)=(0,0) coordinates as its centre. This filter is based on the Difference of Gaussian (DoG) filter, which is a modification of the Gaussian highpass filter. The DoG filter's transfer function is as follows:

$$H(u,v) = (\gamma_H - \gamma_L)\left[1 - \exp\left\{-c\left(\frac{D(u,v)}{D_0}\right)^2\right\}\right] + \gamma_L$$

f

Where constant c has been introduced to control the steepness of the slope, D_0 is the cut-off frequency, $D(u,v)$ is the distance between coordinates (u,v) and the centre of frequency at (0,0). For this filter, three important parameters are needed to be set by the user. They are the high frequency gain γ_H, the low frequency gain γ_L, and the cut-off frequency D_0. If γ_H is set greater than 1, and γ_L is set lower than 1, the filter function tends to decrease the contribution made by the illumination (which occupies mostly the low frequency components) and amplify the contribution made by the reflectance (which occupies most of the high frequency components). At the end, the net result will be a simultaneous dynamic range compression and contrast enhancement. The value of the low frequency gain should be set such as γ_L=0.5, to halve the spectral energy of the illumination, and the value of high frequency gain is set such as γ_H=2 to double the spectral energy of the reflectance components [1]. In [6], the value of *c* is suggested to be equal to 0.5. In practice, all these three parameter values are often determined empirically and there is no clear way to choose the exact suitable values for these parameters.

Work in [7] evaluated the properties of homomorphic filter by comparing it with some other advanced image enhancement method. Two equations have been used for homomorphic filtering process in that paper. They are defined by the following equations:

$$H(u,v) = (\gamma_H - \gamma_L)\left[1 - \exp\left\{-a\left(u^2 + v^2\right)\right\}\right] + \gamma_L$$

$$H(u,v) = (\gamma_H - \gamma_L)\left[1 - \frac{1}{1 + \left[(u^2 + v^2)/a\right]^n}\right] + \gamma_L$$

The last equation is the Gaussian high-pass filter, and (10) is the modified Butterworth high-pass filter. In (10), the term $[(u^2+v^2)/a]$ determines the transition point and Butterworth power coefficient *n* determines the steepness of the transition slope. Empirically, when applying the homomorphic filtering process onto different types of image, the author found that a maximal amplification value $(\square_H - \square_L)\square 1.5$ is too much for many images. Furthermore, the author also found that the modified high-pass Butterworth equation is better than Gaussian high-pass filter for the use in homomorphic filtering process because it allows an independent setting of the transition point from the transition slope.

Another homomorphic filter equation has been used in [2]. The transfer function of this filter is defined as

$$H(u,v) = \frac{1}{1 + \exp\{-a(D(u,v) - D_0)\}} + A$$

In this equation, the high frequency gain and the low frequency gain are given as:

$$\gamma_H = 1 + A \qquad \text{and} \qquad \gamma_L = \frac{1}{1 + \exp\{aD_0\}} + A$$

The suggested values for this transfer function are a=1, D_0=128, and A=10.

A simple modification to the standard homomorphic filter has been proposed in [8]. This modification has significantly improves the performance of face recognition. This filter is using the Butterworth equation:

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

The suggested value of D_0 is 0.25 and *n* is 1. The work in [8] split the original image into several sub-images. It then filters each sub image individually. The enhanced image is found by combining these filtering results. For the face images, the enhancement result $g_R(x,y)$ is defined

$$g_R(x,y) = 0.5[g_V(x,y) + 0.75.g_H(x,y)]$$

Where $g_V(x,y)$ is the filtered result from image that has been split vertically, and $g_H(x,y)$ is the filtered result from image that has been split horizontally. The constant 0.75 in (14) has been chosen based on several experimental results.

The author in [6] has proposed illumination normalization method by using homomorphic filtering in two steps. On the first step, the author processed face images by using a modified homomorphic filter based on DoG filter to eliminate the effect of uneven illumination. In the second state, the author has applied histogram equalization method to enhance the contrast of the image. In this paper, the process of parameter's selection is as the following:

- Selection of high frequency gain, γ_H :

1. Apply homomorphic filtering to input face images using $H(u,v)$ as filter function, set $\gamma_H = 2$ and vary γ_L from 0 to 1.
2. Execute histogram equalization process.
3. Perform face recognition using Eigenfaces method.
4. Compare the recognition rate from different γ_L.

Selection of low frequency gain, γ_L:

1. Apply homomorphic filtering to input face images using $H(u,v)$ as filter function, set $\gamma_L = 0.02$ and vary γ_H from 1 to 3.
2. Execute histogram equalization process.
3. Perform face recognition using Eigenfaces method.
4. Compare the recognition rate from different γ_L.

III. RELATED WORK

According to KIM (1997) [9], the degree of intensity over sight might change depending on the histogram equalisation, which is related to the pulling down virtue of the histogram equalisation. To overcome the disadvantage of histogram equalisation, KIM (1997) proposed histogram equalisation mentioned in imitation of so many preserving bi-histogram equalisation. The whitening of the suggested technique is based on preserving the mangy depth of a picture while increasing the contrast. The method first destroys an enter image of two sub-images based entirely on the low of the entrance image. One of the sub-images is the set of specimens that are less than or equal to the low, while the other is the use of specimens that are larger than the mean. A block-overlapped histogram equalisation dictation was mentioned by Tae et al. (1998) because boosting the contrast of an imagegraph sequence requires the use of numerous applications. The traditional histogram-based contrast access method is constrained within real-time applications due to high computational or tank age requirements, and it also exhibits exorcism degradation caused by possible break over infrequently dispersed pixel intensities, which can result in a terrible loss of vital information. Yueet et al. (2005) [10] proposed a non-linear picture improvement method primarily based on Gabor filters, which allows for selective increase based on the ethnic visual system's contrast sensitivity function. The attached method's imagegraph increment is especially fantastic for digital functions in order to improve the discover visual function of the photos suited for a variety of factors, including interpolation.

Saibabu et al. (2006) [11] proposed an image graph rising technique for digital photographs taken under extremely non-uniform lighting conditions. After editing the method to make it more flexible in accordance with the image characteristics, the immediate technique comprises ternary problems, namely adaptive depth enhancement, distinction improvement, and colouring restoration. The adaptability of the switch function, which is based on the low about each pixel's regional, makes the algorithm more flexible or easier to regulate. Nyamlkhagva et al, (2008) [12] developed a novel method called Brightness Preserving Weight Clustering Histogram Equalization, which may retain the brightness of the original image while also beautifying the discovery over the unique image. The method assigns each nonzero bit on the unique image's histogram to an analysis cluster or computes the weight of each cluster. Three criteria are used to limit the number of clusters (cluster weight, weight ratio, and widths of twins neighbour clusters) in order to drown pairs of close clusters. The even divisions, i.e. the end result image histogram, are obtained by the clusters. Finally, variation capabilities for each cluster's sub-histogram are determined, or the sub-ripe histogram's phases are mapped using analogous transform functions in imitation of the final picture. Because of image distinction affluence, Fan et al. (2010) [13] developed the latter method, which is especially suitable for multiple-peak images. The dedicated technique has been used to recover the twins hazards associated with the HE algorithm, in which the input image is initially convolved using a Gaussian filter with the biggest parameters. The original histogram was then divided into a number of sections using the picture histogram's value values. Others of the components are outperformed by the partial approach over simplicity or flexibility. The result reveals that the suggested approach has outstanding overall performance in terms of image enrichment within the region. Because of its simplicity, this can be achieved with minimal hardware or consumer electronics. Md, Foisal et al. (2010) [14] suggested a method for increasing scientific image graphs based on a non-linear ascending method with logarithmic dramatically change coefficient histogram equalisation. The fact that the interaction between stimulus and appreciation is logarithmic causes logarithmic changes in histogram matching. A device for evaluating the overall performance contrast excuse with observance on the proposed raise approach has been aged as an excuse for improvement based on the seriously alteration. This method improves the visible quality of images to the point that dark shadows fit after a limited potential range of imaging for X-ray images. Kwok et al. (2010) [15] developed an approach for improving regional regions by histogram equalisation. The image has been forward cloven among sectors and made independently stronger by histogram equalisation, intermediate images have been aggravated recursively by way of construction usage on that strategy, or a work image has been arrived at by a weighted-sum amount on the basis of a depth gradient measure in the fond approach.

Local sectors with higher contrast dominate the rest, resulting in the expected global contrast improvement. The intermediate images are generally averaged using a weight-sum approach, resulting in a larger picture.

After doing the composition survey, I was struck by how easily the problem of transform-based image increase introduces some artefacts like as:-

a. They cannot at the same time improve all parts of the image very well and it is difficult to automate the image improvement procedure.

b. The main hassle regarding transfer-based image improvement is that, afterward enhancement the image detail are ruined.

IV. IMAGE ENHANCEMENT TECHNIQUES

A. Spatial Domain Techniques

The image pixels are immediately taken into account by domain approaches. The pixel values are changed in order to achieve the required improvement. Logarithmic transforms, government dictation transforms, and histogram equalisation are examples of spatial domain approaches that are based on pixel manipulation. Spatial methods are particularly beneficial for changing the seasoned stage values of individual pixels and, as a result, the overall image's normal distinction. However, he frequently decorates the entire image in an indiscriminate manner, which frequently yields unfavourable outcomes. It is no longer possible to properly adorn edges or other required information in accordance with the rules. Histogram equalisation techniques are wonderful for deep images. The twins' categories can be used to classify the strategies.

Spatial filter operations or the Point Processing function (Intensity transformation function). This article provides an overview of some of the most well-known techniques. The simplest spatial domain action is point processing (intensity transformation function), therefore actions are limited to a single pixel. Pixel values in the processed picture graph are based on pixel values in the original image[16].

Inverse logarithmic transformations translate a vast range of grey level values into a limited range of grey level values, expanding dark pixels' values while compressing brilliant pixels' values. When the grey level values of a picture have an extremely vast range and a very tiny range, the log and inverse log operations are particularly useful [20].

Existing ways of differentiation elevate techniques to be divided into two groups: direct and indirect methods. Direct procedures define a difference metering and attempt in accordance with enhancement. Indirect solutions for the ignoble hand improve distinction by utilising underutilised regions or a powerful measure rather than specifying a specific difference term. In this case, the approaches for increasing bill contrast can be divided into two categories: Histogram Equalization (HE) and Tone Mapping. Histogram Equalization is one of the most common methods for contrast enhancement. It tries to alternate the spatial histogram of an image in order to fit an equal distribution carefully. The main purpose of this method is to imitate a uniform distributed histogram by leveraging the input image's excrescent thickness feature. The advantages of the HE include the elimination of such sufferings as weight morbid appropriate because local element fit according to its global remedy about the image small scale vital points that are commonly related, such as the little packing containers over the histogram. The drawback is that it is not a good quality for partial applications such as consumer electronic items, which preserve brightness as the fundamental in imitation to avoid traumatic effects [17]. The equalisation result is usually an unfavourable breach in visual statistics, both in terms of attribute and depth scale. Certain grey level zones can be segmented from the rest of the image using these techniques. When distinct aspects of an image are stored in different grey levels, this technique is useful. Plane a little Slicing is a type of Piecewise transformation that emphasises the contribution of individual bits used for pixel grey levels to the overall image appearance and determines the adequacy of the amount of bits used to quantize each pixel in image compression. Spatial Filter Operations, also known as neighbourhood operations, are applied to a pixel and its immediate neighbours. Linear and nonlinear spatial filters are divided into two categories based on the type of operations done on the pixels. Convoluting a mask with an image, or running a weighted mask over the entire image, is a linear spatial filter technique. Window, template, and kernel are all terms used to describe a mask. The augmented image is not linearly related to pixels in the original image's neighbourhood with non linear spatial filters. The max filter is used to find the image's brightest point. It is a 100th percentile filter that reduces salt noise, whereas the Min filter locates the image's darkest point. It removes pepper noise and is a 0th percentile filter. The median filter is a statistical filter that is used to find the pixels' median value. It eliminates the sound of salt and pepper. This filter reduces blur while rounding corners.

B. Frequency Domain Techniques

Instead than manipulating the image itself, frequency domain approaches focus on manipulating the orthogonal transform on the image. Frequency area techniques are appropriate since they process the image according to the frequency content. The premise behind frequency domain image enhancement techniques is to compute a 2-D distinct unitary drastically change about the image, as a result of the 2-D DFT, and then manipulate the radically change coefficients using an operator

M, or below work done the reverse transform. The image's orthogonal radical change has two components to it: magnitude and phase. The magnitude is determined by the image's frequency content. In order to fix the image returned according to the spatial domain, the phase is old. Separate cosine transforms, various Fourier transforms, Hartley Transforms, and so on are common orthogonal transforms [24]. The seriously changing area allows for verbalization of the frequency content material on the image, but high frequency content material, such as edges and other delicate data, is easily boosted. Frequency areas that work with the Fourier transform an image dramatically.

The edges of a picture, as well as violent transitions (e.g. noise), contribute significantly to the Fourier transform after high frequency content.

After the fundamental look of the image above clean areas, low frequency things of the Fourier significantly shift.

For better performance, a bilateral filter (non linear filter) is used.

Tomasi and Manduchi presented the bilateral filter for the first time in 1998. The bilateral filter concept was also introduced as SUSAN filters and as a neighbourhood filter in. It's worth noting that the Beltrami flow algorithm is thought to be the theoretical forerunner of the bilateral filter, which generates a range of image-enhancing algorithms from 2 L linear diffusion to 1 L non-linear flows. The bilateral filter calculates the weighted sum of pixels in a small neighbourhood, with weights based on both spatial and intensity distances. Edges are well retained while noise is averaged out in this fashion [21].

Two Gaussian filters are combined to provide bilateral filtering. The first filter operates in the spatial domain, while the second operates in the intensity domain. This filter smooths edges using spatially weighted averaging. In classical low pass filtering, any point's pixel is presumed to be identical to that of surrounding points [18, 23].

V. APPLICATIONS OF IMAGE ENHANCEMENT TECHNIQUES

Image enhancing techniques are beneficial in a variety of sectors. Agriculture, geology, weather forecasting, education, forestry, remote sensing, fingerprint matching, and other fields employ the image enhancement concept. Image enhancement is a common and significant use in remote sensing. For transforming low contrast satellite photos into high contrast satellite images, many image enhancement techniques are applied. In fingerprint matching, image enhancement techniques come in handy. Frequency domain techniques are most commonly employed in remote sensing to improve poor contrast photos. These methods are commonly used to improve fingerprint images [22]. Piecewise linear transformations are divided into three categories: contrast stretching, intensity level slicing, and bit plane slicing. One of the image enhancement techniques is contrast stretching, which includes editing an image to make it look better to human viewers. It's frequently used in post-production to change an image's contrast, dynamic range, or both. The goal of the contrast enhancement procedure is to alter the local contrast in different sections of a picture such that features in dark or bright areas can be seen by humans.

VI. CONCLUSION

Because changing an image in accordance with creates visually ideal images, belief increases algorithms offer a wide range of ways. The specific job, image content, viewer characteristics, and viewing conditions all influence the choice for certain strategies [19]. The stricture over spatial domain view rise strategies has proven to be effective, but it is still one of the most difficult aspects of digital picture technology, with the repercussions highlighted for each way. In this work, the objectives have been carried out in accordance with the rules in order to achieve the dissertation goal, which is to enhance an excellent image increment approach while adhering to the diagram. The approach of using a bilateral filter to de-noise scientific photographs is described here. Its total performance is multiplied when compared to linear filters such as Wiener, mean, and so on. It performs better overall after citing the uproar into the excessive frequency region, but it fails to recover uproar after the pitiful frequency region, resulting in a greater PSNR than the ref approach.

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