Contrast Enhancement of Dark Images using Transformation and Guided Filtering and Bilateral Filtering

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ABSTRACT
Contrast Enhancement involves enhancement of images such that the visibility of images increases. Contrast enhancement of images is used for a variety of applications such as in medical field, image enhances software's. Although there are various techniques implemented for the enhancement of images such as using non-dynamic stochastic resonance [1]. But the technique implemented improves the enhancement of images up to some extent. Here in this paper an efficient technique is implemented for the contrast enhancement using hybrid combination of transformation and filtering techniques. The idea is to use DWT transformation and then applying guided filtering and bilateral filtering. The proposed methodology implemented provides high image quality index and image color enhancement as well as perceptual quality of dark images.

General Terms
Gray Scale, GIF, JPEG, TIFF, RGB model, CMYK model, guided filtering, bilateral filtering, DWT.

1. INTRODUCTION
Image can be termed as array of square pixels which are also known as picture elements. The elements can also be in form of a matrix arranged in style of columns and rows. The images are basically in different types and formats and also contain various colors which are dependent on color space. The images are black and white (grayscale) or colored.

Basically a grey scale image is normally considered to be a black and white image but these images contain many other different shades of grey. Whereas the case with colored images is that they contain multiple shades of different colors. These colors make the image colorful and attractive. Images are made up of various picture elements which have a intensity range. The images are stored in various formats which define the storage properties of images. The different formats enable the images to be in various type thereby performing different functionalities like

-GIF image format is an 8-bit non-destructively compressed bitmap format. The format has several sub-standards like animated GIF etc. It is mostly used for web.

-JPEG —destructively compressed 24 bit bitmap format. Widely used especially for web and Internet. This format is efficient and contains more information per byte.

-TIFF —standard 24 bit publication bitmap format. Compresses non-destructively for an instance.

-PSD –Photoshop format which is capable of keeping all the information in an image and includes all the layers of the image.

There are some color spaces also in which the images exist.

The RGB color model is related with the perception of colors Red, Green and Blue by the receptors in the retinas. The RGB color space generally uses additive color mixing which is used in television and other mediums which projects colors through light. The model is also used in computers and web graphics, But the model is not suitable for print production. There are also secondary colors of RGB.

CMYK model is a 4 color model which is used in printing. This model uses the subtractive color model. Therefore processing of image is carried out by these different color space analysis and other properties.

Images may have low dynamic range of the intensity values which defines the color or contrast of the image due to insufficient light. Thus enhancement by processing of image is required for improved visual perception [1]. Image processing can be explained as a form of signal processing where the input is an image that can be a photograph or video frame which is used for processing. The output obtained from processing of image may be in form of image or a set of characteristics and parameters that generally relates to the image. Image processing techniques treats the image as two dimensional signals and then apply standard signal processing technique to it. Also superfluous edges appear at the image boundaries generated because of discontinuities of the intensity distribution in the image giving improper visual. Image processing techniques deployment resolves such type of enhancement problem in dark or over bright images [2].

Digital image processing is the field of digital signal processing which uses computer algorithms for image processing on digital images. Digital image processing uses wide range of algorithms to input data and also resist build up of noise and signal distortion while processing. Basically images are defined over two dimensions thus digital image processing is modeled as multidimensional system. Digital image processing is also advantageous to analog image processing. With the help of image processing image enhancements are conceded for processing of images giving some specific features of images. The process shows important characteristics of images and the resulted image obtained is more enhanced than the original image and resolves the problems oriented with the image which may be in form of color enhancement.

In image research, image enhancement act as an important technique. It improves quality of image through improving the image features [3]. The basic aim lying behind image enhancement is to enhance the visual appearance of image providing better transform representation of image processing in the form of analysis, detection, segmentation, recognition etc. [4] The problem associated with Image is removed by enhancement which is defined as an input low quality image and the output high quality image required in an application.

Image enhancement examines background information that helps in understanding object behavior without an inspection required from a human. Image enhancement enables the objects that can be extracted from dark background which is not clear may be because of low contrast or if the color of objects and the background is similar.

Figure.1- Enhancement of low contrast image

The image enhancement technique also includes and explains Spatial based domain image enhancement and Frequency based domain image enhancement. The Spatial based domain image enhancement is directly operated upon the pixels. The technique is simple in concepts having low complexity and favors real time implementations. But the Spatial based domain image enhancement technique is enable to provide adequate robustness and imperceptibility. Spatial domain methods are generally classified into Point Processing operation and spatial filter operations. Frequency based domain image enhancement analyzes mathematical functions or signals w.r.t. frequency. Frequency based domain image enhancement is operated upon the transform coefficients of images like Fourier transform, discrete wavelet transform etc. by changing the transform coefficients to enhance the image. Frequency based image enhancement contains low computations complexity, gives easy view and manipulation of frequency composition of image and easy application of special transformed domain properties. But drawbacks associated with Frequency based image enhancement are that it is not able to concurrently enhance all parts of image clearly and easy automation of the image enhancement procedure is impossible.

The approaches Spatial based domain image enhancement and Frequency based domain image enhancement differs in the form as they produce multi-scale or multi-resolution representation of image and comparing to contrast enhancement operators it enhances contrast of the image after the segmentation process. Contrast enhancement basically gives image which is better than the original image changing pixel intensities of the image [5].

Image Filtering is considered as fundamental operation of image processing and computer vision. The magnitude of the filtered image at a location is given as a function of the values of the input image provided in neighborhood of the same location. Image filtering consists of Bilateral Filtering an d Guided Filtering. Bilateral filtering smoothes images preserving the edges using nonlinear combination of nearby or close image values. Bilateral filtering method is non-iterative in nature, is local and simple. It merges gray levels or colors based on geometric closeness and photometric similarity both preferring near values to distant values in domain and range. Bilateral filtering displays high dynamic range images which reduces the contrast and also preserves detail. Bilateral filtering is based upon two scale decomposition of the image into base layer which encodes large scale variations and detail layer. Contrast of base layer is reduced which thereby helps in preserving detail. The base layer is obtained with the help of edge preserving filter known as bilateral filter. Bilateral filter is a non linear filter in which the weight of each pixel is calculated using a Gaussian in the spatial domain and multiplied by an influence function in intensity domain resulting in decrement of the weight of pixels having large intensity differences [6]. The bilateral filter calculates the filter output at a pixel as weighted average of nearby pixels. Bilateral filtering is widely used in noise reduction HDR compression, multi scale detail decomposition and image abstraction. It is indiscriminate to the joint bilateral filters which have the weights computation from another guidance image and not the filter input. [7]

Guided image filtering is used for image enhancement to process an image for obtaining more suitable than original image as a result which thereby is used for specific application. Guided image filter is an explicit image filter. It is derived from a local linear model generating the filtering output through consideration of content of a guidance image which may be input image itself or the different image.

2. LITERATURE SURVEY

R. K. Jha [1] et.al. anticipated induced dynamic SR-based contrast enhancement technique. The technique in discrete cosine transform (DCT) domain levels internal noise of dark image. Enhancement from low grade state to enhanced state is attributed to noise induced transition of DCT coefficients that are affected because of presence of internal noise which is due to absence of sufficient illumination and it is modeled through bi-stable system exhibiting dynamic stochastic resonance. By good perceptual quality the image contrast is determined and color information is enhanced with the help of local adaptive processing in their proposed technique. Their proposed mechanism produced enhanced performance in contrast, colorfulness and visual quality when compared with techniques like gamma correction, modified high pass filtering etc. The noisy co-efficient based process used by them is iterative in nature and results in enhancement of image energy through converting transition into another state. Their scheme increased variance of DCT coefficient distribution with the help of DSR mechanism thereby increasing contrast. Their technique is capable of enhancing very dark images by adaptive sub-block selection without loss of information at bright areas and adjusts background illumination, improving contrast, preserving and enhancing color information [1].

R. Chouhan [2] et.al. observed that in discrete wavelet transform (DWT) domain contrast enhancement of dark and low contrast images is possible through dynamic stochastic resonance (DSR). In their given mechanism the internal noise of an image is utilized for contrast enhancement. They basically treated degradation as noise which is generated due to inadequate illumination and resulted in producing a noise induced transition of image from low contrast state to high contrast state. They suggested stochastic resonance is capable of inducing approximation and details which helps in obtaining increase in variance and mean of coefficient distribution. They adopted an algorithm which is iterative in nature for obtaining target value of performance metrics for

eg. relative contrast enhancement factor, perceptual quality measures and color enhancement factor at least count of iteration. They explained the technique for enhancing dark images with the help of noise induced resonance in DWT domain using used dark image domain for bi- stabling double well for state of a wavelet coefficient model as motion of particle in double well. They were able to achieve iterative scaling of internal noise which is caused by insufficient illumination by tuning of approximation and detailed coefficient with the help of parameter dependent equation and selecting the parameters by increasing signal to noise ratio of traditional SR system [2].

R. Chouhan [8] et.al. remarked a dynamic stochastic resonance technique in DWT domain for enhancing the images that are dark, grayscale and colored perception for improvement of performance of input signal through addition of external noise. Intrinsic noise of image for contrast enhancement is used in their technique which is capable of enhancing the image without spot artifacts, blocking and ringing. the algorithm is optimized and made adaptive for measurement of performance as distribution separation measure and aim to background enhancement that generally have basis upon standard deviation and entropy. Their technique produced better results in terms of complexity, color preservation etc. giving fine enhancement of extremely dark images. For grayscale and colored dark images their scheme give better visual perception and contrast quality [8].

A. Goyal [9] et.al. studied aspects of guided image filtering for image enhancement. They explained those principle objectives that lie behind Image enhancement process is to process an image for obtaining more suitable image than original image for specific application. The digital image enhancement technique provided a large amount of choices for the improvement of the visual quality of images. They remarked that guided image filter acts as an explicit image filter which is capable of generating the filtering output through consideration of the content [9],

Aiming He [10] et.al. explaine that the guided filter is capable of generating filtering output with the content of a guidance image in the form of input image itself or some another different image**.** They remarked that guided filter acts as an edge preserving smoothing operator similar to bilateral filter but with enhanced manners near the edges. They studied that the guided filter has some sort of theoretical connection with matting Laplacian matrix which makes it more conceptual as smoothing operator and utilize the structures in the guidance image more precisely. The guided filter consists of fast and non approximate linear-time algorithm which has non dependent computational complexity on filtering kernel size. They demonstrated the guided filter in various computer vision and computer graphics applications is efficient and effective which includes noise reduction, detail enhancement, HDR compression, image feathering, haze removal, joint up-sampling etc [10].

Fredo Durand [11] et.al. presented display of high dynamic range images. Their scheme reduces the contrast and preserves the details. The proposed methodology is based upon a two scale decomposition of image into the base layer, programming large scale variations and detail layer. This makes the base layer contrast reduction only resulting in preservation of details. They explained that the base layer is obtained with the help of edge-preserving filter known as bilateral filter. The filter is a non-linear filter in which the weight of each pixel computation is done by a Gaussian in the spatial domain multiplied with influence function in the intensity domain which results in decrement of the weight of pixels that have large intensity differences. They expressed bilateral filtering in frame of robust statistics showing its relation with anisotropic diffusion. They gave an acceleration in bilateral filtering with a piecewise linear approximation present in intensity domain and appropriate sub-sampling resulting in speed up of two orders of magnitude [11].

C. Tomasi [12] et.al. remarked that bilateral filtering is capable of smoothening images and is capable of preserving the edges through nonlinear combination of close by image values. They explained that this method is non-iterative in nature and is local and simple. Concept lying behind bilateral filtering is that the gray levels or colors which have basis on geometric closeness and photometric similarity generally prefers near values to distant values both in domain and the range. A bilateral filter can put into effect the perceptual metric underlying the CIE-Lab color space smoothing colors and preserving edges in a way which are in accordance with the human perception. They concluded bilateral filtering produces no phantom colors on or besides the edges in color images as compares to standard filtering and is capable of reducing phantom colors where they come into view in the original image [12].

3. PROPOSED METHODOLOGY

The proposed methodology implemented here for the contrasts enhancement of dark images works in the following phases:

1. Take an input dark image.
2. Apply DWT transformation on input image.
3. Apply Guided filtering on the resultant image.
4. Finally apply bilateral filtering to get the enhancement image.

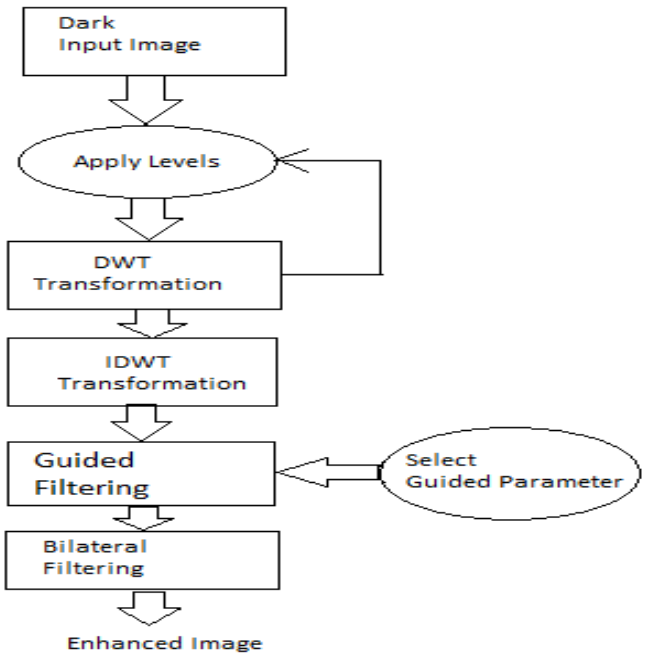

Figure 2. Flow Chart of the methodology

DWT Transformation

Discrete Wavelet transformation is a technique of applies filtering of image on the basis of level of images. DWT transformation first applies transformation using Harr Wavelet on first level where it first divides the image into four regions i.e. Horizontal, Vertical, diagonal and Coefficient. These

regions contains HH, HL, LH and LL region of the image. The low pixel intensity region is then further divides into four regions and likewise image transforms.

Figure 3. DWT Transformation

Guided Filtering

Guided Filtering technique is based on the linear transformation invariant of filtering of the process which consist of an image 'I' and a guide parameter 'P' which result in an output image 'Q'. The output of the filtering output image is given on the basis of weighted average.

$$q_i = \sum_j W_{ij}(I) p_j$$

Where 'i' and 'j' are the pixel indexes. The Filter Kernel Wij is a function of the guidance image I and independent of p. This filter is linear with respect to *p*.

Bilateral Filtering

A bilateral filter is a non-linear, edge-preserving and noise-reducing smoothing filter for images. Here bilateral filtering is based on the average intensity pixels of the neighboring intensity pixels. The weighted average can be identified using Gaussian distribution. The Euclidean distance is used to find the neighboring pixel. The bilateral filtering parameters can be found using:

$$I^{filtered}(x) = \frac{1}{Wp} \sum_{xi \in \varphi} I(xi) fr(||I(xi) - I(x)||) gs(||xi - x||)$$

Where the normalization term

$$W_p = \sum_{xi \in \varphi} fr(||I(xi) - I(x)||) gs(||xi - x||)$$

And it ensures that the filter preserves image energy and

- I^{filtered} is the filtered image;
- I is the original input image to be filtered;
- x are the coordinates of the current pixel to be filtered;
- Ω is the window centered in x;
- f_r is the range kernel for smoothing differences in intensities. This function can be a Gaussian function;
- g_s is the spatial kernel for smoothing differences in coordinates. This function can be a Gaussian function;

4. RESULT ANALYSIS

The result analysis can be done on the basis of following parameters;

1. **Color Enhancement Factor (CEF):** The overall effect of colored image pixels in the enhanced image and original image. Its value is greater than 1 for better CEF.
2. **Perceptual Quality Measure (PQM):** It is the ratio of Contrast measure of the enhancement image to the measure of original image. Its value should be greater than 10 for better enhancement.
3. **Contrast Enhancement Factor (F):** It is computed as the ratio of Quality index Post enhancement (Qa) and Pre enhancement (Qb). For better relative Contrast Enhancement Factor it should be greater than 1.

The table shown below is the analysis of CLAHE technique for different dark images.

Table 1. Analysis of CLAHE

Image	Time	MSE	PSNR	F	PQM	CEF
image 1	1.56	1.57E+03	16.1854	1.4785	8.2644	1.8947
image 2	1.7784	570.4275	20.5688	1.9375	8.7834	1.9917
image 3	1.5912	1.44E+03	16.5401	1.7631	9.0127	1.7836
image 4	1.1856	9.74E+02	18.2439	1.2456	8.2368	1.1849

The table shown below is the analysis of Existing technique [2] for different dark images.

Table 2. Analysis of Stochastic Resonance [1]

Image	Time	MSE	PSNR	F	PQM	CEF
image 1	0.39	4.81E+02	21.3061	3.2574	9.9375	2.486
image 2	1.8252	1.78E+04	5.6231	2.486	10.0275	3.2858
image 3	0.468	4.14E+03	11.9652	3.4906	9.1859	4.3957
image 4	0.5304	9.71E+03	8.2593	5.2957	10	3.586

The table shown below is the analysis of proposed technique for different dark images.

Table 3. Analysis of Proposed Methodology

Image	Time	MSE	PSNR	F	PQM	CEF
image 1	0.5304	1.50E+03	16.3557	3.6294	10.1937	2.8164
image 2	0.9204	1.81E+04	5.5454	2.6712	10.2835	3.5173
image 3	0.5304	1.27E+04	7.1037	3.7193	10.0184	4.6182
image 4	0.5834	1.26E+03	18.4753	5.4821	10.2237	3.9163

The figure shown below shows the Color Enhancement factor of the proposed methodology.

Figure 4. Color Enhancement factor of Proposed Methodology

The figure shown below shows the Perceptual Quality Measure of the proposed methodology

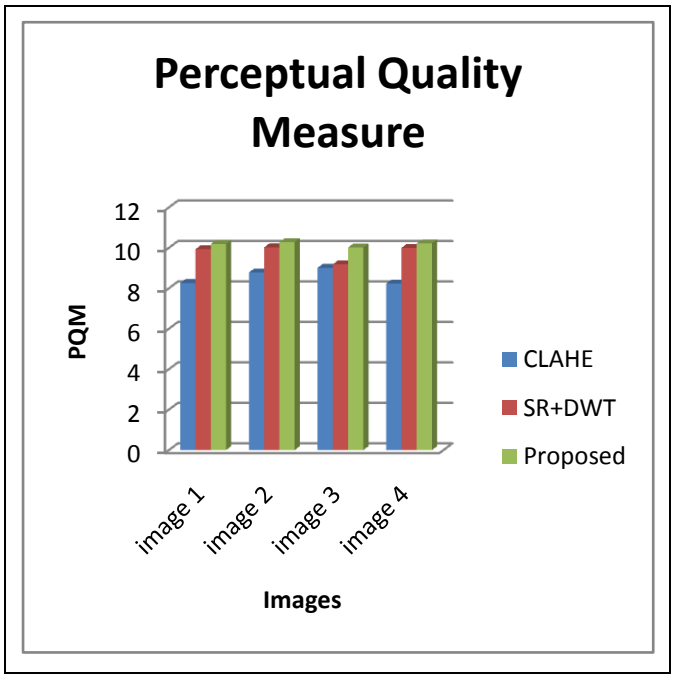

Figure 5. Perceptual Quality Measure of Proposed Methodology

5. CONCLUSION AND FUTURE WORK

The proposed methodology implemented here for the contrast enhancement of dark images using combinatorial method filtering and transformation provides better image quality as compared to the other existing techniques of contrast enhancement. The result analysis shows the performance of the proposed methodology. The proposed methodology performs better as compared to the existing techniques.

The result is compared on the basis of various factors such as Color Enhancement Factor and Perceptual Quality Measure and Contrast Enhancement Factor. Although these factor should contains values greater than 1, 10 and 1 respectively. Here contrast enhancement using Contrast Limited Adaptive Histogram Equalization technique and contrast enhancement using stochastic resonance and proposed methodology is implemented and compared on the basis of above factors.

Although the technique implemented here provides high contrast enhancement factor as compared to the work discussed in [1], but further enhancement can be done in the proposed methodology for all types of dark images as well as HDR images.

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