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A FLEXIBLE DIGITAL NIGHT VISION ENHANCEMENT SCHEME WITH HOMOMORPHIC FILTERING AND ILLUMINATION SENSING

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***Abstract*— In the era where "DIGITAL" is the new default, there is need to bring out an digital approach for dealing with problems of 'Night vision Enhancement'. A poorly illuminated image puts a contrast constraint to the human eye visibility at night, which is one of the main reasons for increase in accidents at night. Thus, depending on the characteristics of night-vision images, in this paper we propose an image enhancement using python approach to improve the quality of pictures by using CLAHE and filtering as a preprocessing technique. Later on generating an automated parameter adjustment homomorphic filtered image.**

***Keywords*—Histogram equalization, CLAHE, Homomorphic filtering, Gaussian filtering , Localized illumination, General illumination.**

I. INTRODUCTION

Night Crash statistics reveals that poor visibility at night has been a major issue in night driving, as well as in security and surveillance systems ([1], [2], [3]). Gadgets like night-time driving goggles are available for better vision but they are not very popular due to their high-end costs. In [4], Digital Night Vision Enhancement is a processing technique to improve night vision by image processing. These techniques can enhance the images captured by ordinary cameras under low light conditions and can be implemented completely in software. They do not require the use of infrared light and special devices. One of the popular and efficient algorithms for adjusting the contrast of an image is a nonlinear contrast enhancement technique called histogram equalization.

In case of the Digital Night vision enhancement system (NVES), an almost-instantaneous feed of the images of the road ahead or the surveillance area is required to the concerned person. The original image has poor visibility, hence a drastic improvement in the vision is also another demand on the NVES. Due to these requirements, the efficiency of the technique used is of critical importance. The end result must be suitable for the application of object detection and pattern recognition algorithms which would otherwise not have been possible for images captured in the dark. The ground costs involved must be typically affordable to the Organization (for security purpose) and to the end –user for the driving application.

II. RELATED WORK

In [1], describes the basics of histogram equalization, the technique used to improve the contrast of the image, and its types. It made use of global histogram equalization. The pixel values are increased from the maximum value in the image to 255. At each level, the peak signal to noise ratio (PSNR) is evaluated. It is seen that PSNR followed a pattern. Initially it increased, and after a certain value, it started decreasing. Furthermore, the maximum PSNR value wasn't found to be at gray level 255. Thus, the optimum value for maximum value of gray levels was found and this method was termed as incremental histogram equalization. However, the noise in the image is also enhanced which proved to be an drawback. Thus extension of this method would be working on characteristics of noise and noise removal.

In [5], Night Vision Enhancement includes enhancement using 'Selective Retinex Fusion algorithm' in which the brightness component of the image is improved by separating the luminance and reflection component image. As the luminance component contained maximum dynamic range information whereas the reflection component contains the essentials details, the reflection component undergoes enhancement using the Retinex algorithm of s-curve. After this, selective non linear gray mapping was done to give the information about the light source in the image and its effect on the image, related to the distance and luminance. In the end, these two undergo weighted addition to give the final pixel value.

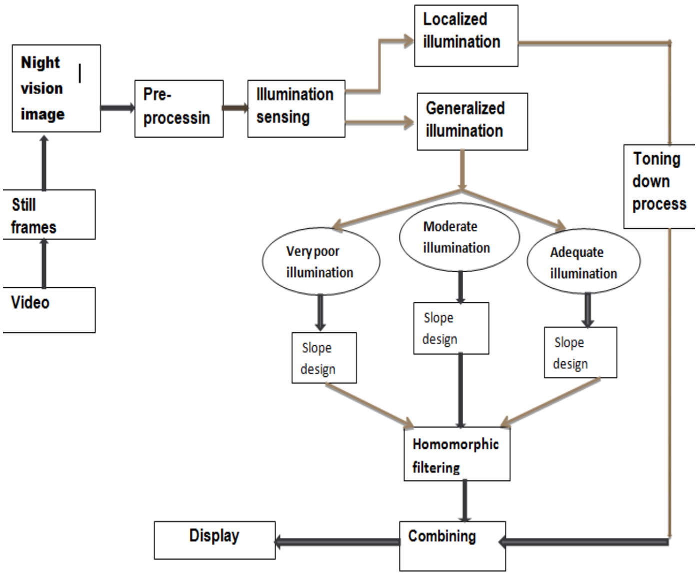
In [11], put forth an image enhancement approach maintaining color fidelity. Firstly, the image is divided into RGB channel and decomposed into reflectance component and illuminance component. Secondly, the non-uniform illuminance component of the image is filtered again to eliminate the uneven illumination. Finally, the reflectance component and the corrected illuminance component are combined and the brightness of the combined image is adjusted.

III. PROPOSED PROBLEM AND METHODOLOGY

In this work, we intend to do the following.

i) Acquire realistic night time images and videos on city highways and roads and study their gray level distribution.
ii) Perform pre-processing using "CLAHE" (Contrast Limited Adaptive Histogram Equalizations and noise removal.
iii) Develop a parameterized Homomorphic Filtering technique with automated parameter selection. Slopes of the Filtering curve will be decided by sensing the brightness level of the acquired, noise removed image.
iv) Extend the well-studied technique on images, to videos of moderate size (640x480) for demonstration purpose.
v) Validate our technique through qualitative performance measures like opinion poll on live videos, and through standard measures like PSNR.

Python is used as the image processing tool because it is open source and emerging software. The entire working of the night vision enhancement can be illustrated using the following block diagram:-



Night vision images: As the project is based upon digital software processing of poorly illuminated images, the night vision images are captured using the mobile camera having good resolution. Thus images or videos are captured using a normal device without the need for sensor or any special devices.

- **Pre-processing**: This field includes removal of noise that occurs while capturing images using Gaussian filtering along with application of 'CLAHE' technique.
  Adaptive histogram equalization first separates the image into small blocks and then applies the conventional histogram equalization technique on each of these blocks. It is a local image processing method. However, this technique can still lead to discontinuities between blocks and noise amplification. An advantage of global histogram equalization over the adaptive approaches is that it is very efficient to compute and can be applied to real-time video without making any major changes in the algorithm.
  Therefore to overcome this, Contrast Limited Adaptive Histogram Equalization (CLAHE) is implemented as CLAHE differs from ordinary adaptive histogram equalization in its contrast limiting. The contrast limiting procedure has to be applied for each neighborhood from which a transformation function is derived. CLAHE was developed to prevent the over amplification of noise that adaptive histogram equalization can give rise to. This is achieved by limiting the contrast enhancement of AHE. The contrast amplification in the vicinity of a given pixel value is given by the slope of the transformation function. This is

proportional to the slope of the neighborhood cumulative distribution function (CDF) and therefore to the value of the histogram at that pixel value. CLAHE limits the amplification by clipping the histogram at a predefined value before computing the CDF. This limits the slope of the CDF and therefore of the transformation function. The value at which the histogram is clipped, the so-called clip limit, depends on the normalization of the histogram and thereby on the size of the neighborhood region.

- **Illumination sensing**: This block contains two types of illuminations which is represented by the images. They are :

  a) Localized illumination: The unwanted source of glare or light due to head lights or street lights which causes the area around the source to be very bright making it difficult for humans to see the region. Hence, the entire picture is divided into blocks size of 64. Each block is then scanned and checked for pixel values beyond certain threshold (sudden high peak values). If such high illumination part exist, it is toned down so as to reduce the glare in the image.

  b) General illumination: The rest of the background illumination or backlight is processed based on the kind of illumination: very poor illumination, poor illumination and adequate illumination.

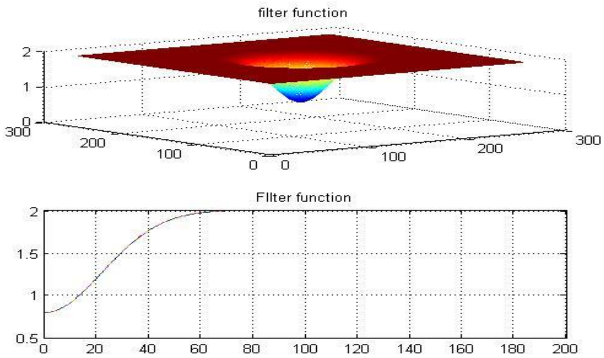
  The slopes for these illuminations is pre- designed by studying the characteristics of many night time images using the homomorphic filter characteristic in different night light condition and stored in a database. Depending on the kind of illumination the image possess it will be processed automatically by selecting the suitable pre-defined slope of homomorphic filter, which is used when there is uneven distribution of illumination.

Homomorphic filtering: Homomorphic filtering is a generalized technique for signal and image processing, involving a nonlinear mapping to a frequency domain in which linear filter techniques are applied, followed by mapping back to the original domain. Homomorphic filter is used for image enhancement as it simultaneously normalizes the brightness across an image and increases contrast and removes multiplicative noise. Illumination and reflectance are not separable, but their approximate locations in the frequency domain may be located. Since illumination and reflectance combine multiplicatively, the components are made additive by taking the logarithm of the image intensity, so that these multiplicative components of the image can be separated linearly in the frequency domain. Illumination variations can be thought of as a multiplicative noise, and can be reduced by filtering in the log domain. Thus the high-pass filter is used to attenuate low frequencies (illumination) and increase high frequencies (reflectance).

The equation of homomorphic filter is given by:

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

Where, constant c is used to control the steepness of the slope, D0 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: The high frequency gain γ_H , the low frequency gain γL and the cut-off frequency D0.



The value of $\gamma_L$has to be less then one whereas the value of $\gamma_H$has to greater than one for enhancing the high frequency components. The slope of the homomorphic filter which provides the illumination content of a image plays an important role to enhance the image.
The images obtained after final processing of localized illumination and general illumination is combined and displayed.

IV. RESULTS & DISCUSSIONS

As mentioned earlier, we have processed the images using global histogram equalization and CLAHE. Fig. 1 shows six night images in the grayscale. We can see that the details of these images are not very visible.

Fig. 2 shows the images after global histogram equalization was performed on the six images. Here, though a few details have better visibility and the contrast is improved, it can be seen that even noise is amplified to a high level. Furthermore, already bright areas (like the light sources, here, headlights), become more bright and destroy the image.

Fig. 3 shows the six images after implementation of CLAHE. Comparing Fig. 3 and Fig. 2, it can be said that CLAHE gives better enhancement of images than histogram equalization

Fig. 1 Unprocessed night images

Fig. 2 Histogram Equalized images

Fig. 3 Contrast Limited Adaptive Histogram Equalized images

Histogram Matching is a technique wherein the transformation of an image takes place so that its histogram matches a specified histogram. In the first case the dusk time image is matched to the morning time image. As there is no much change in illumination, the transformation curve turns out to be approximately linear in all the three cases above. By matching the night time image to the morning time picture of a scene the contrast of the night image is improved. But in figure 4.1, it is seen that the all the details are lost as the bright pixels values are made brighter whereas the figure 4.2 shows that the shadow has been enhanced as well. Though figure 4.3 shows good results by amplifying the dark pixels values the histogram matching technique is discarded due to its inefficiency as stated above.

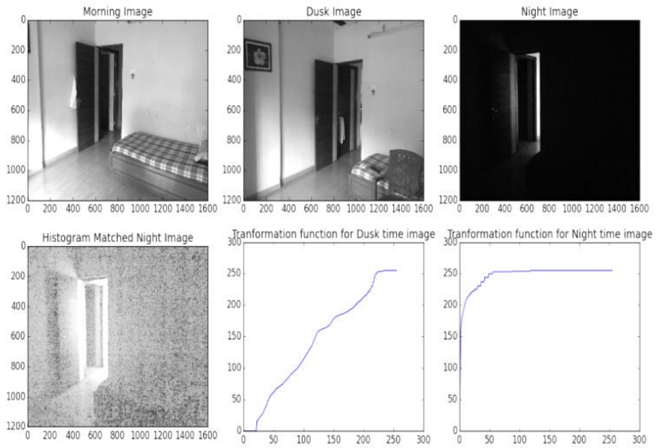


Fig :4.1 Histogram Matching

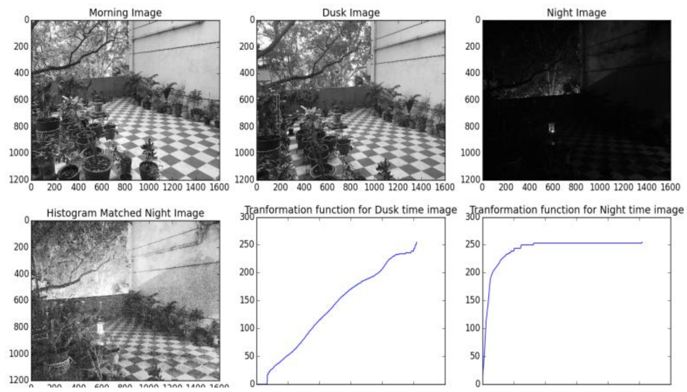


Fig :4.2 Histogram Matching

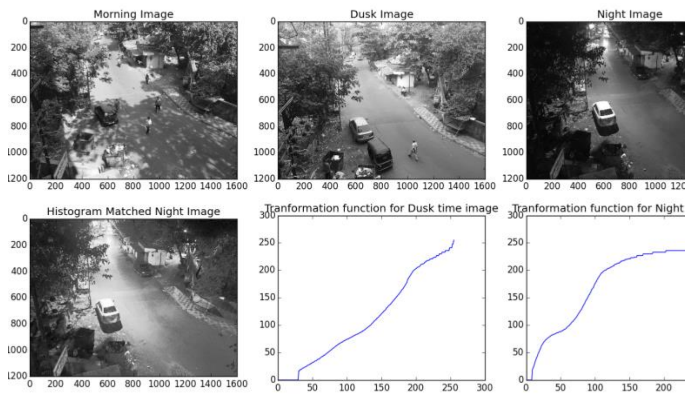


Fig :4.3 Histogram Matching

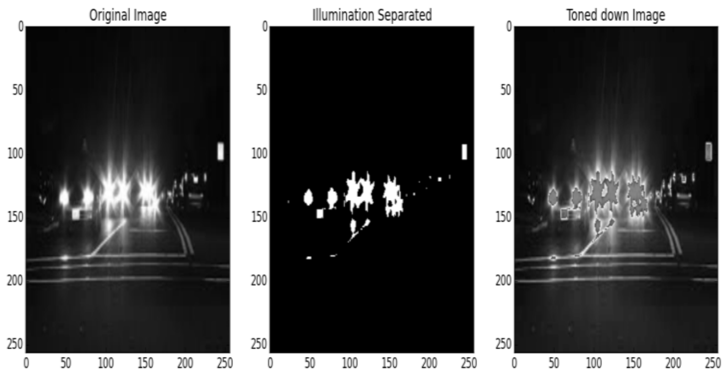


Fig :5 Illumination Separation

Figure 5 shows the localized illumination where the illumination is successfully separated from the image by subtracting the toned downed image from the original image. The third image in figure 5 shows toned down illuminated image whereas the second picture shows the separated illumination.

EFFECT OF HOMOMORPHIC FILTER PARAMETERS

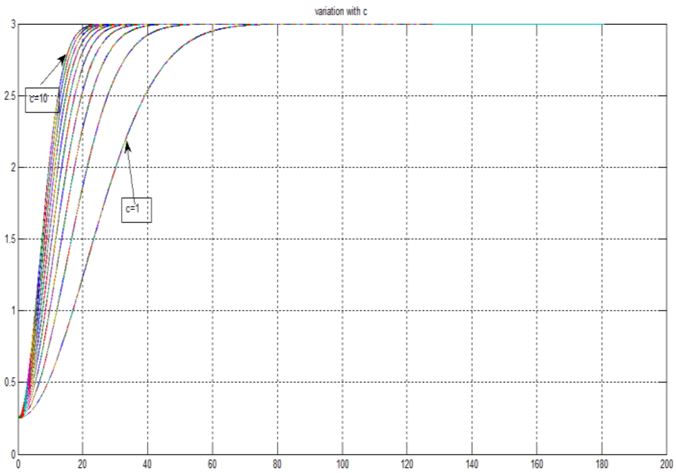


Fig.6.1 Effect of variation of constant c in homomorphic filter curve

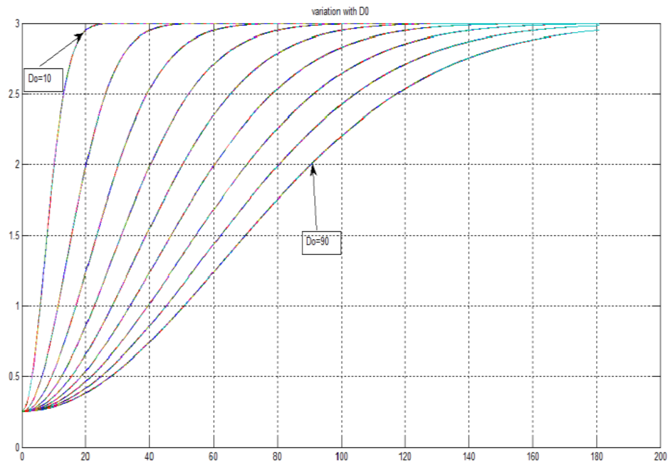


Fig.6.2 Effect of variation of Cut-off in homomorphic filter curve

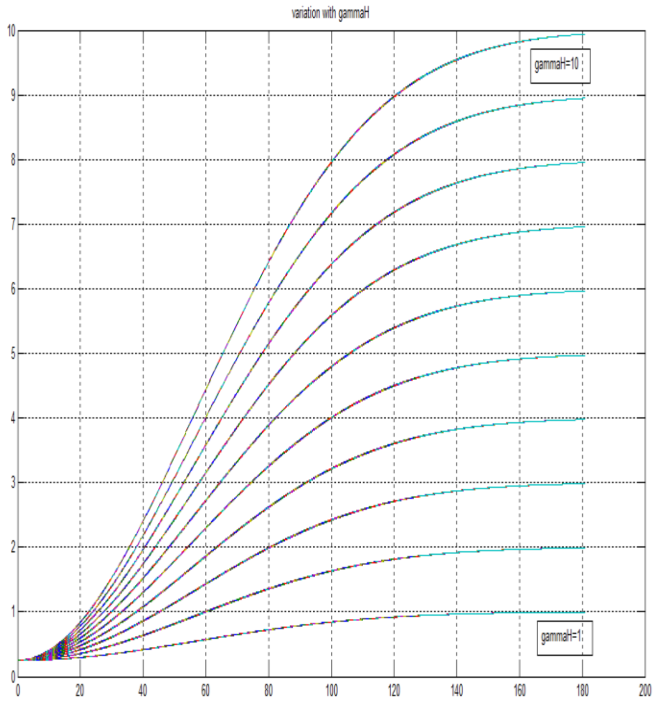


Fig.6.3 Effect of variation of gammaH in homomorphic filter curve

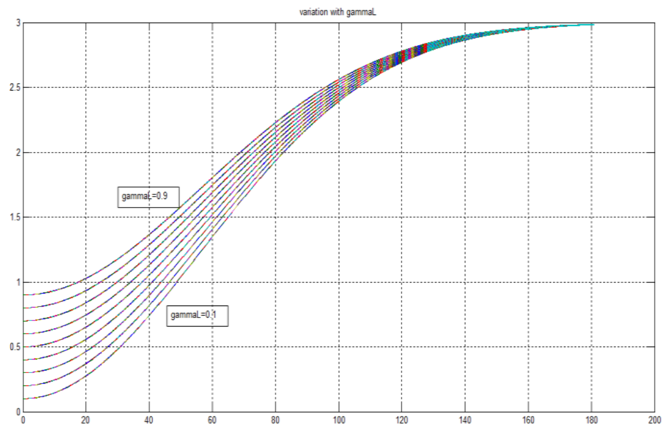


Fig.6.4 Effect of variation of gamma L in homomorphic filter curve

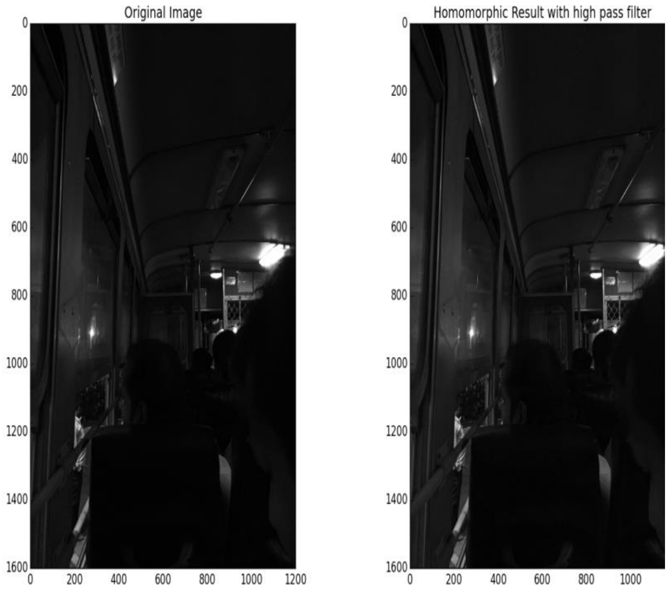


Fig:7 Homomorphic result using high pass filter.

The figure 6 contains the parameters that effect the homomorphic filter curve. It is seen in fig 6.1 that as the value of c increases by small amount the steepness of the slope also increases. This causes the value of the filter function to increase with increase in c value. The variation in cut-off value affects the flatness of the slope as well as the slope steepnessThus the effect of cut-off is negligible for the dark image. Flatness decreases with increase in Do value as seen in figure 6.2.The gammaH variations also affects the slope causing it to increase with reduction in its value. GammaL changes affect the slope of the curve causing it to be more steep in small increment in its value. Thus as homomorphic filter effectiveness for night images depends on the slope which provides illumination, variations in the gamma L and c have major effect on the overall night vision image. Figure 7 shows the homomorphic results using high pass filter.

V. CONCLUSION & FUTURE WORK

In this paper, we propose a flexible digital night vision enhancement approach with homomorphic filtering and illumination sensing.

Histogram Matching technique output quality varies from one image to another and thus this technique cannot be used. The uneven illumination of the original image can be equalized and details are preserved by compressing the dynamic range of the bright area in the night-vision image using homomorphic filtering. While contrast of the dark area is enhanced in the proposed technique.

The illumination separations results lead to patchy effect which needs to be improved by using smoothening filter.

Collaborations of illumination separation and application of homomorphic filtering along with forming a database the for various illuminations lies to be the future work of this project.

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