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An Efficient Technique for Illumination Adjustment Using CLAHE Algorithm

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ABSTRACT : For real time applications in intelligent transportation system processing an image at high speed is essential and must be considered. In this paper we propose an low complexity efficient technique for illumination adjustment based on Retinex theory and CLAHE algorithm. From the experimental results we can conclude that the proposed method achieved comparable good visual quality than the other enhancement methods. This method can process one pixel per clock cycle, for an image with a resolution of QSXGA (2560 × 2048), it requires about 25 ms to process one frame that is suitable for real-time applications. In some low-cost intelligent imaging systems, the processing rate can be slowed down.

I. INTRODUCTION

Nowadays, requirement of cameras gets increased in applications such as intelligent surveillance systems to monitor the public and private sections. In Intelligent Transport Systems, cameras monitor the situation about traffic, vehicle crashes and accidents and they record each and every minute. But poor visibility because of the weather or poor atmospheric light will lead to the Intelligent systems to give poor performance. There are many image processing techniques to overcome this issue such as illumination adjustment, scaling, de noising etc. In ITS pre-processing the image at high speed is necessary. In this paper we focus on image enhancement using CLAHE algorithm technique.

II. RELATED WORK

Dynamic range is the illumination ratio between the darkest and the brightest region in a scene. A captured image in surveillances shows an irrevocable loss of visual information in some places under strong background illumination or in dark environments. This is mainly because the dynamic range of natural scene is far larger than the dynamic range of image captured by the common digital devices. Such overflow will cause a blurred image particularly in the low-luminance regions, and the viewer cannot obtain enough information of the image. To overcome this annoying problem, the existing enhancement methods [5]–[18] for a single image are proposed and can be classified into two categories: spatial-domain processing [2]–[16] and compression-domain processing [15]–[18]. The spatial-domain processing can further be divided into two subgroups: the histogram-based techniques [2]–[14] and the Retinex-based techniques [7]–[16]. To consider the hardware implementation to meet the real-time requirement, the above image enhancement algorithms suffered from some problems. The histogram based techniques are effective contrast enhancement algorithms due to their straightforward and intuitive implementation qualities. However, the histogram-based techniques need to scan the whole image twice to complete the enhancement process, i.e., one for calculating the probability density function and one for obtaining the enhanced image by using the mapping function. They need to store the whole image inside the hardware core that requires a great amount of hardware resource. Longer processing time is needed since it requires reading the whole image data twice from the memory module. The Retinex-based techniques and compression-domain processing techniques usually keep the details of the original image and generate high-quality enhanced images with low noise. However, the algorithms with high time complexity are those that will make the hardware cost high and increase the processing time.
In this paper we propose a illumination adjustment method that follows Retinex theory. From the experimental results we can conclude that we achieved good visual quality compared to the previous techniques.

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III. Retinex Theory

Retinex theory was developed by Land and McCann in the year 1971. It explains about the visual perception. According to the Retinex theory, the intensity of light that reaches the camera or eye depends on the Product of two factors namely illumination and reflectance.

Illumination indicates the ray of light from the source such as sun. Reflectance indicates ratio of total amount of radiation reflected by a surface to the total amount of radiation incident on the surface. Illuminance is defined as the amount of luminous flux per unit area. By the Retinex theory, image observed can be written as,

$$I(U,V) = L(U,V) \times R(U,V)$$

Where I(U,V) indicates the pixel of an observed image that is located in the (U,V) co-ordinate, L(U,V) indicates the illumination and R(U,V) indicates the reflectance of the object.

Illumination is first estimated by using Retinex theory and it is denoted as L[u,v] and is reflectiance that is estimated is represented as R[u,v]. To increase the visual quality of the image estimated illumination L.

IV. Proposed Image enhancement technique

The flow diagram of Proposed Image enhancement method is shown in Figure below. First, an image in RGB colour space is changed into HSV domain. The reason for choosing HSV domain is, it is intuitive to humans. Next, average envelope is found as illumination plane which is denoted as L. By using CLAHE algorithm illumination component L is adjusted to get good visual quality in high and low luminence regions. At last enhanced image that is represented in HSV colour domain is again converted into RGB colour space. The procedure followed in FIEEMD is explained as follows.

Step1 - Estimate the local median and local maximum points of intensity layer of the image. In empirical mode decomposition technique local maximum and local minimum points are calculated. But in FIEEMD technique local median point is calculated instead of local minimum points since it produces smooth illumination output and it results in a increased contrasting reflectance.

Step2 - By connecting all the local maximum and local median points, upper and lower envelopes can be estimated respectively.

Step3 - The first average envelope is calculated by averaging the lower envelope and upper envelope values that is calculated in Step 2 and it is denoted as EA. It results in estimated illumination plane. To get enhanced image, illumination adjustment must be done using CLAHE algorithm.

The Contrast Limited Adaptive Histogram Equalization (CLAHE) is an improved version of adaptive histogram equalization. Originally it was developed for medical imaging and has proven to be successful for enhancement of low contrast images such as portal films. The contrast limited adaptive histogram equalization algorithm partitions the images into contextual regions and applies the histogram equalization to each one. This evens out the distribution of used gray values and thus makes hidden features of the image more visible. The full gray spectrum is used to express the image.

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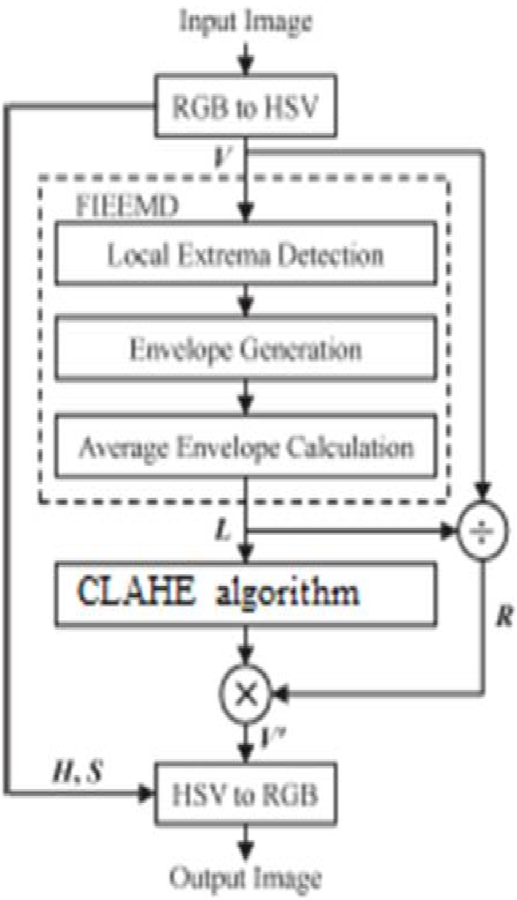

Fig.1 Flow diagram

The only difference between regular AHE and CLAHE is that there is one extra step to clip the histogram before the computation of its CDF as the mapping function is performed. Hence CLAHE is implemented in the same function tiled AHE in ahe.cpp. The program "ahe" takes an additional optional parameter which specifies the level at which to clip the histogram.

Steps followed in CLAHE algorithm

1. Calculate a grid size based on the maximum dimension of the image. The minimum grid size is 32 pixels square.
2. If a window size is not specified chose the grid size as the default window size.
3. Identify grid points on the image, starting from top-left corner. Each grid point is separated by grid size pixels.
4. For each grid point calculate the **histogram** of the region around it, having area equal to window size and centered at the grid point.
5. If a clipping level is specified clip the histogram computed above to that level and then use the new histogram to calculate the CDF.

V. SIMULATION RESULTS

Simulated results of the images using CLAHE algorithm at various stages are shown below. It can be noted that the details in the input image are not very clear as shown in Fig .2

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Fig.2 – Input Image.

The RGB format of the input image is converted into HSV and is shown in Fig.3. The reason for converting RGB to HSV is that it is more intuitive to human beings.

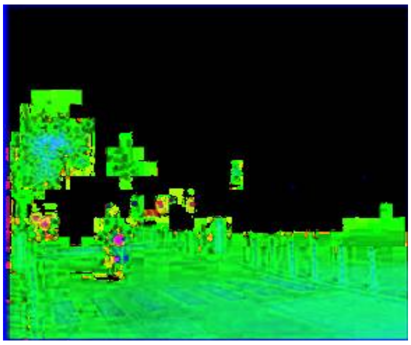

Fig. 3 – HSV Image

The below Fig.4 shows the output of FIEEMD, which is used to estimate the illumination of an image.

Fig.4 – Local Median Filter

To adjust the illumination, CLAHE algorithm is applied and its output is shown below in the Fig.5

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Fig. 5 – Illumination Adjustment

The overall output of the algorithm using Retinex theory is shown below. From the figure, it can be clearly seen that Haze removal is achieved using CLAHE algorithm. This results in better quality images.

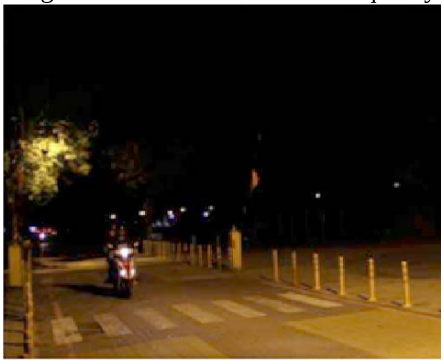

Fig.6 – Enhanced Output Image

VI. RESULTS AND CONCLUSIONS

Our method can efficiently enhance the details of the image to obtain the comparable results as compared with other methods, particularly in the low- and high-luminance regions. The design meets the requirement of real-time image/video applications and is suitable to be employed in end-user camera equipment. In the future the illumination adjustment may be used to get the enhanced image in video. The experimental results demonstrate that our design requires the least computation load and achieves comparable performance in objective metrics and subjective image quality as compared with other image enhancement methods.

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