Low-Light Image Enhancement Using Illumination Mapping

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Abstract - Image Enhancement is one of the important requirements in Digital Image Processing which is important in making an image useful for various applications which can be seen in the areas of Digital photography, Medicine, Geographic Information System, Industrial Inspection, Law Enforcement and many more Digital Image Applications. Image Enhancement is used to improve the quality of poor images. The focus of this paper is an attempt to improve the quality of digital images using illumination Mapping. In this paper, we propose a simple yet effective lowlight image enhancement method. More concretely, the illumination of each pixel is first estimated individually by finding the maximum value in R, G, and B channels. Furthermore the initial illumination map is refined by imposing a structure prior on it, as the final illumination map. Having the well-constructed illumination map, the enhancement can be achieved accordingly. Experiments on a number of challenging low-light images are present to reveal the efficacy of the LIME and show its superiority over several state-of-the-arts in terms of enhancement quality and efficiency.

Key Words: Image Enhancement, Illumination Mapping, LIME.

1. INTRODUCTION

Digital image processing is the technology of applying a number of computer algorithms to process digital images. The outcomes of this process can be either images or a set of representative characteristics in properties of the original images. The applications of digital image processing have been commonly found in robotics intelligent system, medical imaging, remote sensing, photography and forensics. The development of computer has led to developing the science of image processing. At the beginning of the 20th century, it was common to use small colored image, because of the development of computer system and its great ability to store, there was a wide range to use colored image that has a high clarity and big sizes including colored image processing.[1] Digital image processing can be divided generally into three main categories: a. Image Enhancement and Restoration. b. Image Coding and Compression. c. Image Segmentation and Description. Statically analysis plays an important role in various image processing applications in the above groups to know image quality, for example, the processed image results from enhancement, compression and coding needs to be assess its quality, however, this is done by using mathematical analysis. Image enhancement by reducing the noise to a minimal level is one of the most fundamental research topics in image processing. Different types of noise as additive or multiplicative noise are initiated during the process of acquisition to digitization of an image, causing degradation in quality, but there is important element can affect the image illumination that incident on the scene in real world. The level, type, distribution and uniformity of the illumination can be determine the image quality hence, various image processing techniques have been developed to recover the meaningful information under changing lighting conditions [2].

The aspire is to improve the visual appearance of the image, or to provide a "better" transform representation for future automated image processing, such as analysis, detection, segmentation and recognition. Thus, a considerable amount of research has focused on this subject, and numerous enhancement techniques.. Moreover, it helps to analyze background information that is essential to understand object behaviour without requiring expensive human visual inspection. A good number of methods have been developed and they can mainly be divided into two classes: local and global methods. Local methods employ feature-based approaches and the local features can be gained by using edge operators or by computing local statistics such as local mean, standard deviation, etc. They are common contrast enhancement by modifying the features. The common feature-based method is to define the contrast first and enhance image contrast by increasing the contrast ratio [3]. Another method uses local histogram modification to enhance image contrast in a local area, such as (1) local histogram equalization (2) local histogram stretching and (3) nonlinear mapping methods (square, exponential, and logarithmic function). These methods are quite useful in local texture enhancement. However, they may distort original images since the transformation is not a monotonic mapping and the order of gray levels of the original image may be changed significantly.

Global methods are mainly implemented by using histogram modification approaches. One of the most commonly used methods is Histogram Equalization (HE). Jin et al.. have been proposed a novel adaptive enhancement algorithm for integrating a histogram ridge analysis technique and an optimal intensity transform method that aims to minimize the EER of an enhanced image [4]. Gu at al. have been proposed a reduced-reference metric to detect contrast changes using phase congruency and image histograms. By decomposing images into mean intensity, signal strength and signal structure components [5]. Wang at al have been introduced PCQI metric to detect contrast variations of an image pair [6]. For most digital cameras, the pixel value is not directly proportional to the irradiance that falls on the camera [7]. The nonlinear function relating camera sensor irradiance with image pixel value is called the camera response function. Paneeta et al. have been introduced a parameterized LIP (PLIP) model that spans both the linear arithmetic and LIP operations and all scenarios in between within a single unified model [8]. Stark et al. have been introduced a scheme for adaptive image-contrast enhancement based on a generalization of histogram equalization (HE). HE is a useful technique for improving image contrast, but its effect is too severe for many purposes [9]. Huang et al. have been presented color naturalness index (CNI) and color colorful index (CCI) to evaluate natural images based on the human visual system [10]. This paper presents a method of enhancing a low-light image by estimating and refining its illumination map. Images captured in outdoor scenes can be highly degraded due to poor lighting conditions. These images can have low dynamic ranges with high noise levels that affect the overall performance of computer vision algorithms. To make computer vision algorithms robust in low-light conditions, use low-light image enhancement to improve the visibility of an image.

2. METHODOLOGY

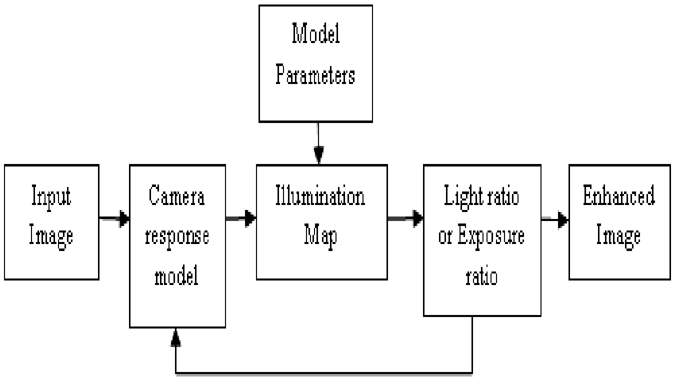

Fig-1. Image Enhancement Architecture

A. Camera Response Model

In the proposed framework, the initial step was to remove the low-light portion from images using a camera response model (CRM) technique, as shown in Fig-1. This model can be divided into two parts: the bright transform function (BTF) and the camera response function (CRF). The parameters for the CRF are determined by the camera, and those for the BTF are determined by the exposure ratio. In general, a camera uses non-linear functions, such as de-mosaicking and white balance to improve the overall visual quality of an image.

Lime:

The basic operation performed on any low light images can be implemented using speed-up solving procedure and exact solving procedure. In speedup solving procedure brightness levels are increased with the highest speed .In exact solving procedure, contrast levels are exactly identified and applied to images. These levels are calculated using histogram equilisation .

Beta Model:

In some pictures, light is reduced. In order to select the light levels in particular image ,beta models is used. In this method, pixel movement capturing is performed using auto correlation properties .In this way the nearest neighborhood light levels are compared and obtained. After obtaining the light levels and by applying this to the original image light level of the image is increased.

Gamma Model:

Gamma model is used to reduce the light intensity in input image. So, for reducing the light intensity feedback factors have been used. This feedback factors are generated by successive reflectance mapping and elimination mapping. By applying feedback factors on input image light intensity is reduced.

Beta-Gamma Model:

In this model both light intensities can be increased or decreased. It can be performed by applying polynomial models on autocorrelation properties as well as reflection properties. This polynomial model decide the light to increase or decrease.

Sigmoid Model:

Sigmoid model is used for selection of above discussed models. It is operated in parallel with the system. For selecting those methods gamma radiance ,atmosphere and temperature coefficients these are the model parameters these are generate internally based on pixel property of images.

B. Illumination Map Estimation

Estimation of Atmospheric Light Also termed as homogeneous light, is an important factor to obtain a dehazed image. For computing the value of this atmospheric light A, the dark map image is screened as expressed and finds the most haze opaque pixel in it. This pixel location is then mapped spatially to RGB image and the corresponding value of the pixel in the normalized image is selected. This technique works satisfactorily for the underwater image. As in this case since we the image is segmented into foreground and background, it compute two values of A, unique to each region and proceed further with dehazing.

A transmission map gives the extent of light reaching the camera in a degraded image. The dark map derived out of red channel prior is used to obtain this transmission map. This is the main clue as to determine the extent and depth of the hazy image and light transmission in an image formation process. A higher value of w results into the complete removal of haze making the image look unrealistic and exhibits color distorted image whereas the lower value of w results into lower intensity image and makes it darker. The value of w ranges between 0 and 1 in a normalized image. In all experiments conducted, w value is chosen as w = 0.7. This parameter characterizes the amount of haze to be retained in the processed image and produces haze free image.

On account of the pixel-based operation, the transmission map generated appears pixelated. If used as it is to recover the scene radiance, the final dehazed image looks pixelated. This transmission map has to be smoothened. The result is obtained with a filter as proposed to smooth the transmission map.

It can be observed that dark channel of hazy image is not dark whereas same dark channel image in case of a clear image is relatively darker. This image of whiteness which is observed in the dark channel image of hazy image is utilized to derive the depth map. Transmission map is inverse of dark channel image. This transmission map corresponds to the amount of light that travels from the object and reaches the camera plane in the presence or absence of haze. More the haze in the propagation path less is the amount of scene information reaching the camera and darker is the transmission map. It is observed that, for clean image the transmission map is brighter.

C. Exposure Ratio:

Enhanced image is applied to light exposure ratio again if the values are reduced then exposure ratio decreases and vice versa. On this situation boundary conditions are applied then average exposure ratio is calculated and is applied to camera model for better enhancement.

3. SIMULATION RESULTS

The input taken is a low light image and by the application of the proposed method, the enhanced image obtained is of good quality. From Fig-2 images which are captured at low light are enhanced to produce the images with low distortion and color.

Image1

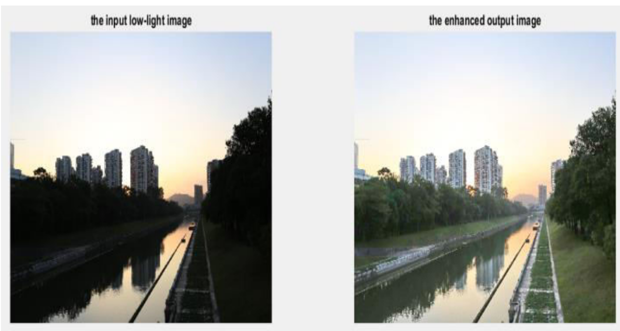

Image 2

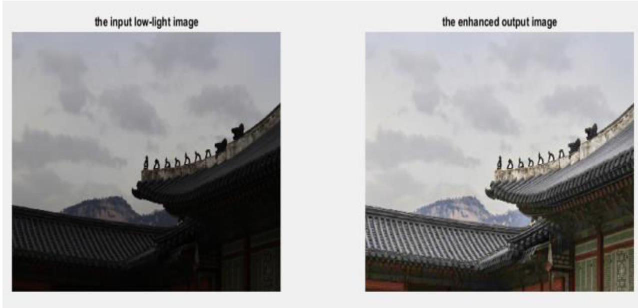

Image 3

Fig-2 Low light input image and enhanced output image

A natural low light image with information buried due to low brightness is taken as input. The image taken has almost no visibility towards the left end as seen in Fig-2. The enhanced image obtained after the refinement of initial illumination map by sped up solver method is a lot better than the input image in terms of brightness.

4. CONCLUSIONS

In this paper, effective and efficient frameworks to enhance normal and low-light images have been proposed. The main purpose of low-light image enhancement is to make visible the important contents of an image and to preserve the overall image quality. Therefore, enhancement schemes must enhance images with less distortion and good efficiency. However, the main experimental contributions of this paper are as follows: First, the camera parameters and exposure were set to estimate an illumination map and the Retinex algorithm was utilized to remove dark areas from images. To handle factor like dense fog and to keep the balance between contrast and brightness, a dehazing algorithm and an intensity transformation algorithm were used. Furthermore, the color constancy significantly improved the color appearance, setting the true color of an image. A detail manipulation algorithm was also added, which was based on the weight least squares method and served to boost the details of the image to create an enhanced result with better visual quality. The experimental results revealed that the proposed model performed multiple tasks and it was effective as compared with other state-of-the-art techniques.

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