An Efficient Innovative Approach Towards Color Image Enhancement

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ABSTRACT

Image Enhancement works as a first mandatory criteria for an efficient image analysis task. Removing noises and managing the contrast are the two major tasks that need to be accomplished in an image enhancement process. In this article, an innovative approach for color image enhancement is proposed. The proposed approach is a two-step technique. The first step is the noise removal step. Here, an improved median filter, Improved_Median(), is introduced to smooth the noises which exist in the original color image. Then, in the second step, local contrast enhancement is done. For that, an improved version of CLAHE, AA_CLAHE() is proposed for the local contrast management of the filtered image. The V-channel of HSV color space is used for the color computations involved in the local contrast management process. The overall enhancement done by the proposed approach is found to be satisfactory and outperforms the same produced by other state-of-the-art algorithms through experiments on several noisy and poor contrast color images obtained from different standards databases.

KEYWORDS

Color Image Enhancement, Contrast Limited Adaptive Histogram Equalization, Entropy, HSV Color Space, Median Filter, Noise Filtering

1. INTRODUCTION

Digital Image processing is the use of algorithms to analyze an image to bring out the hidden pattern or meaningful information from it. So, in the field of pattern recognition, digital image processing plays a major role in discovering interesting patterns. But, to extract a satisfactory output, we should always provide a correct and error-free input. Similarly, in the case of image analysis, we should have a noise free and well contrast image to get a better extraction of information from it. This is the reason, why we need image enhancement as the first and also a mandatory process to be adopted to achieve a better result. Two major tasks need to be included in an image enhancement process are 1. Removal of noises if present, and 2. Contrast management. So, in this paper, we have introduced an innovative approach for color image enhancement which has included both of these two tasks. We have considered color image enhancement rather than gray image enhancement as color image processing is found more prolific in pattern recognition research than gray image processing (Abidi, 2008; Bora, 2017). Although, the same can be adopted for gray image enhancement also. In our proposed approach, the first very step is reserved for noise analysis of input color image. For this, we have carried out an improved median filtering of all the three channels of the input RGB image separately and then merge them to obtain the noise free (to the desired level) image for the next step of our enhancement approach. In the next step, we concentrate on local contrast management and hence introduced an improved adaptive CLAHE for the same. This technique is a kind of greedy approach
trying to perform a better contrast enhancement continuously till we find the optimal one. As, the proposed approach is designed for color image enhancement, so we have adopted HSV color space for the color arrangement and computations involved during the contrast enhancement part. Actually, this work is the extended version of the work that we have introduced in the paper (Bora, 2017).

The rest of the paper is organized as follows: Section 2 presents a review of the related works carried out in the field as well as motivation towards the proposed work. Section 3 shows the steps involved in the proposed approach. The involved techniques are discussed in its subsections. Section 4 is the experiment and result discussion section. Finally, the conclusion is drawn in Section 5.

2. RELATED WORKS AND MOTIVATION

Yadav et al. (2010) enhanced the visibility level of the foggy image with CLAHE. They enhanced the video quality in real time video system. The video frames are read one at a time. Intensity is adjusted for the foggy frame. First RGB image is converted to gray level and then CLAHE is applied. The resultant enhanced frame is a new structure. Finally, the enhanced De-foggy video is obtained after processing every frame with the above-mentioned step.

Zhao et al. (2010) proposed a novel method to achieve real-time subject-independent automatic facial feature enhancement and detection by combining CLAHE and multi-step integral projection. First, they used a sigma filter to remove noises. After that, they applied CLAHE for enhancing the facial features of the noise-free image obtained from the first step. They then did a multi-step integral projection to detect the useful facial feature regions automatically. Finally, Gabor transformation is used to extract the detected facial feature region and SVM classified the final facial expression recognition. They tested their proposed approach on JAFFE database and claimed a high recognition rate of 95.318% on trained data.

A new method called mixture Contrast Limited Adaptive Histogram Equalization (CLAHE) color models is proposed for underwater image enhancement (Hitam et al., 2013). The proposed method operates CLAHE on RGB and HSV and both the results are combined together using Euclidean norm. The experimental results prove that the proposed approach significantly improves the contrast of underwater images and also reduces noise and artifacts.

Wen et al proposed an image enhancement algorithm for the medical X-ray image with low brightness, low contrast, and noise which is based on wavelet-domain homomorphic filtering and CLAHE (Wen et al., 2016). They first decompose the image into low-frequency and high-frequency coefficients of 1st layer of wavelet domain using wavelet transformation. The low-frequency coefficients are processed and linearly amplified with an improved homomorphic filter and the high-frequency coefficients are processed by wavelet threshold shrinkage followed by wavelet reconstruction. Finally, CLAHE is used for modifying the image histogram and thereby final enhanced version of the image is obtained. Both the subjective and objective evaluation is done for the evaluation of the proposed algorithm. The experimental results prove that the proposed algorithm can effectively enhance the texture detail of medical X-ray images, increasing the brightness and contrast, suppress noise and results are better than those obtained by the general traditional enhancement algorithms.

An improved version of CLAHE is introduced by Al-Ameen et al to provide a good brightness with decent contrast for CT images (Al-Ameen et al., 2015). In this new technique, an initial phase of a normalized gamma correction function is added which helps to adjust the gamma of the processed image so that the common errors of the basic CLAHE like the excess brightness and imperfect contrast can be avoided. The results of the experiment claim that the proposed technique produces acceptable results with no visible artifacts and outperformed all the comparable techniques.

A scalar objective function to estimate average local contrast of an image is introduced (Subr et al., 2005) where the authors tried to maximize this objective function with respect to strict constraints for the local gradients and the color range of the image. Where the first constraint controls the amount
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