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Peak Signal to Noise Ratio analysis in single image restoration technique

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ABSTRACT

Images have a wide significance these days for detailed observation in different fields like remote sensing, and navigation. When images got captured by the image acquisition equipment, they got affected by environmental effects. These environmental effects are haze, smog, fog which cannot be ignored while acquisition. Such type of effects should be reduced so that images can be accurately observed. These effects can be considered as noise in our work. These effects are difficult to reduce efficiently while acquisition. Therefore, here arises a need of algorithm to process the noisy image after capturing. In our work, Dark Channel Prior (DCP) technique is used for the de-noising purpose and our focus is on the refining of the estimated transmission map so that a noise-less image can recovered. The efficient noise reduction is determined by the Peak Signal to Noise Ratio (PSNR) value. PSNR value is the evaluation parameter which is used to determine that the proposed work has improved the performance compared to recently introduced approaches. An analysis of our proposed method and other research work is shown.

Keywords— *Haze removal, Noise reduction, Dark Channel Prior (DCP), Peak Signal to Noise Ratio (PSNR)*

1. INTRODUCTION

Image restoration is the processing technique used for the improvement of the visibility and clarity of the image. These days, this is done by the help of machine. The word machine is related to the computer which gives birth to the new field named Computer Vision. Computer vision describes the capability of the computer to see. The system which can understand the human visual system comprises computer vision. Images play a very important role in data processing these days in the fields like remote sensing, and navigation [1]. The weather conditions cause noise in the image which reduces the clarity of elements in image, so there is a need of image restoration system. Image restoration is the developing area these days needs to be efficient and effective [2]. The number of research performed in this developing and growing area. De-noising and de-blurring technique is used with Gaussian filter utilization [3]. Wavelet analysis is efficiently used for image processing [4].

In our work, a digital image restoration system is proposed to de-noise the noisy image with help of Dark Channel Prior (DCP) technique [5]. The restoration of noisy image depends on how effectively refining process of transmission map has been done.

2. PROPOSED WORK

The Image Formation Model [6] is given by an equation:

$$I(x) = J(x)t(x) + A(1 - t(x)) \tag{1}$$

Where, $I(x)$ is the observed intensity at pixel$x$, $J(x)$ is the scene radiance, A is the ambient light, transmission map represented by $t(x)$. According to the DCP, the dark channel of scene radiance is close to zero. For each pixel x in an image, the DCP determines the minimum value among RGB channels in a patch $\alpha(x)$ centered at x, that is: [5]

$$J_D(x) = \min_{y\in\alpha(x)} \{\min_{\{r,g,b\}} J(y)\} = 0 \tag{2}$$

Where, $J_D(x)$ is the dark color channel and $\alpha(x)$ is a patch centered at x. To calculate the dark channel, apply the minimum operator on both sides of equation (1) after dividing by ambient light A, we get

$$\min_{y\in\alpha(x)}\left(\min_{\{r,g,b\}}\frac{I(y)}{A}\right) = t(x)\min_{y\in\alpha(x)}\left(\min_{\{r,g,b\}}\frac{J(y)}{A}\right) + 1 - t(x) \tag{3}$$

Applying equation (2) in equation (3), we get:

$$\min_{y\in\alpha(x)}\left(\min_{\{r,g,b\}}\frac{I(y)}{A}\right) = t(x)J_D(x) + 1 - t(x) \tag{4}$$

Dark channel is the lowest intensity channel. The estimation of dark channel is done by determining the minimum value among the three channels according to (2). Apply $J_D(x)$= 0 according to equation (2), we get

$$\min_{y\in\alpha(x)}\left(\min_{c}\frac{I(y)}{A}\right) = 1 - t(x) \tag{5}$$

Now, we get the expression of transmission map $t(x)$ as function of Observed intensity and ambient light, given by:

$$t(x) = 1 - \min_{y \in \alpha(x)} \left(\min_{c} \frac{I(y)}{A} \right) \quad (6)$$

This expression of transmission map needs a refining expressed by $t_R(x)$ which is used to recover the de-hazed image. The estimated transmission map needs to be defined by Refining Algorithm (RA).

In our proposed work, estimated transmission map is passing through refining algorithm which smoothen the pixels of estimated transmission map. The morphological operations are mathematical operations. The proposed algorithm uses the concepts of opening and closing for image reconstruction, which are based on techniques such as gray-scale erosion, gray-scale dilation [7].

For the recovery of the de-hazed image from equation (1), expression of scene radiance is given by:

$$J(x) = \frac{I(x) - A}{t_R(x)} + A \quad (7)$$

Ambient light is assumed to be the maximum pixel value among RGB channels represented by A [4]. This assumed value will be substituted in equation (7) to recover the de-hazed image. The flow chart of utilized method is given in fig 1.

3. RESULTS

The results obtained from our proposed method are compared on the basis of parameter Peak Signal-to- Noise Ratio (PSNR). The proposed algorithm was implemented on Python. PSNR is the proportion between the maximum possible power of an image and the power of corrupting noise that affects the visibility of its representation [5].

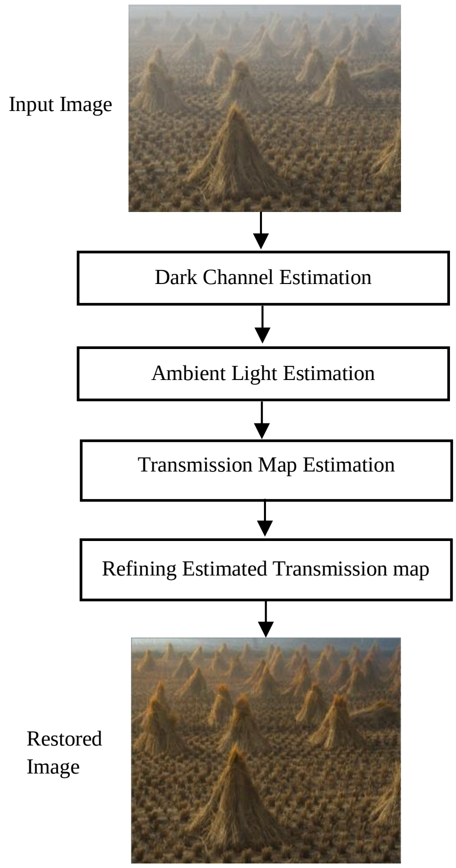

Fig. 1: Flow chart of utilized method

$$PSNR = 10 \log_{10} \frac{Squared\ Max\ possible\ Pixel}{Mean\ Square\ Error}$$

Here, Mean Square Error (MSE) is the power of corrupting noise. Ideally PSNR must be having high value for the better image approximation. Table 1 shows the PSNR values obtained from the processing under proposed algorithm.

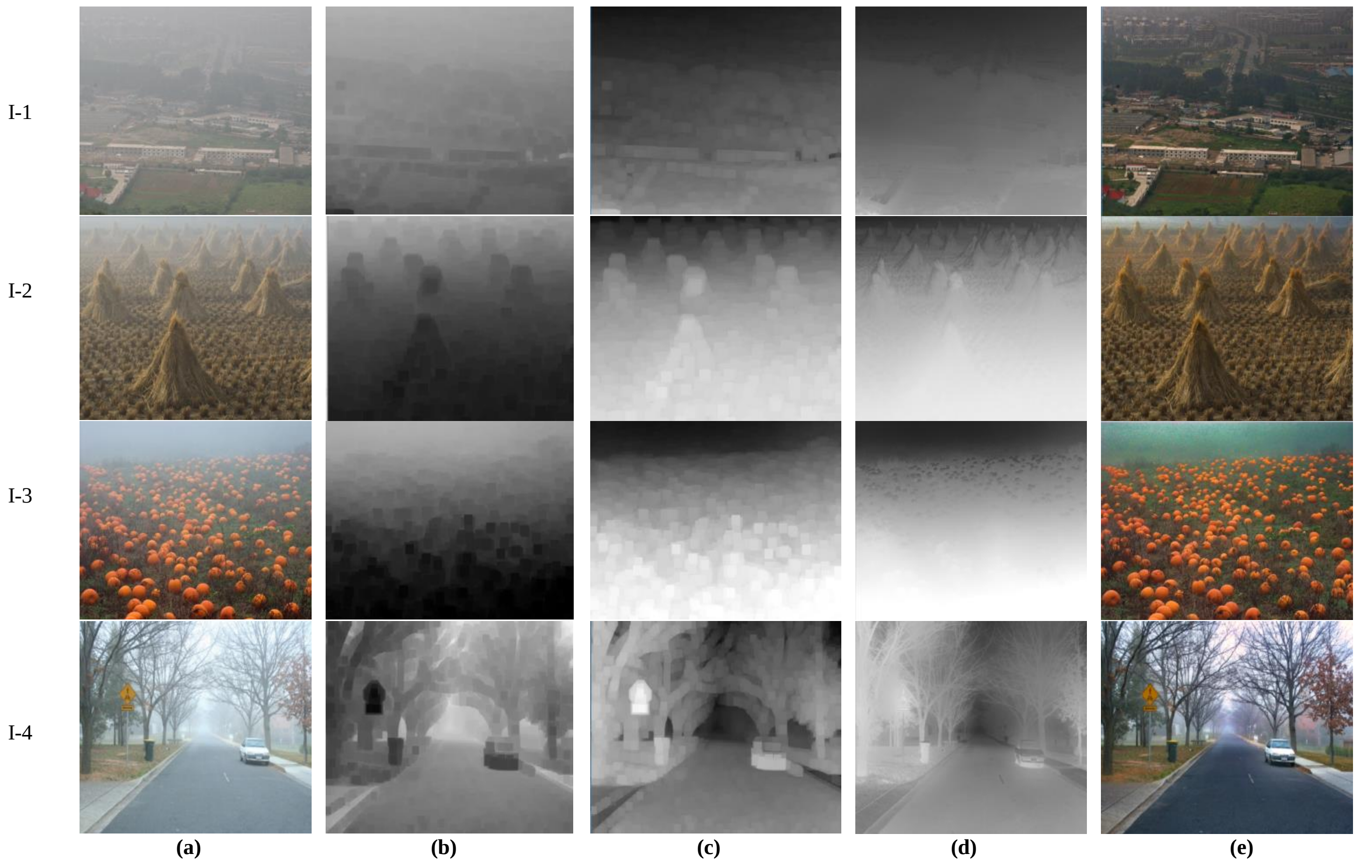

Fig. 2: Results of proposed work (a) Input images (b) Dark channel of input images (c) Transmission map of images (d) Refined transmission Map of Images (e) Output Images

Table 1: PSNR observation

Name of images (with file format)	Dimensions of input image	PSNR	Dimensions of output image
I-1	600*525	16.9385	600*525
I-2	465*384	23.9202	465*384
I-3	600*400	20.6598	600*400
I-4	512*340	11.9111	512*340
Average		**18.3574**	

The visual results of processing are shown in fig. 2. The depth map of input images are shown in fig 2(b). The estimated trasmission map of input images are shown in fig 2(c) which are derived from equation (6).

The comparison of PSNR value for the image restoration techniques in last few years are shown in Fig 3. Fig 3 is the analysis of PSNR value determined in research work already done in image restoration field. PSNR values shows how effective the image restoration has been done.

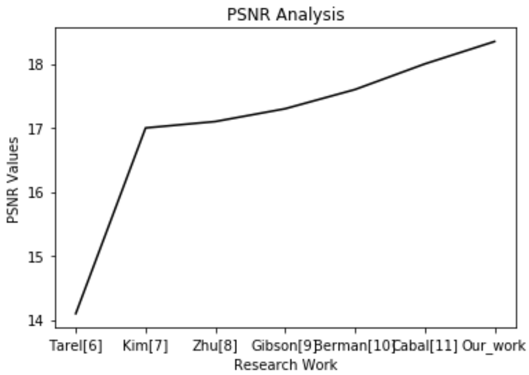

Fig. 3: PSNR Analysis

4. CONCLUSION

Outdoor images experience weather conditions, which reduces the clarity of image. Our work focuses on restoring of image which increases the visibly in the image without effecting the information and dimensions in it. Quantitatively, the reduction of noise is shown in fig 3 with the help of PSNR value. Therefore, the proposed work for image de-noising technique offers high performance technique.

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