Underwater Image Enhancement Using Hybridized Concept of White balancing and Image Fusion

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Abstract

The image taken underwater is degrade due to various effects like absorption and scattering of light in medium. These effect are because of the suspended particles that leads to absorption and scattering of light during image formation process. To overcome this issue, different image enhancement technique is used to get better quality of the degraded image. Image fusion is one of the most useful technique which is commonly used to enhance the hazy and degraded image. To reduce the haziness a new effective method is proposed in this paper that use white balancing and image fusion along with gamma correction on the same image, the novelty of this technique is the hierarchy in which processing is done. First, input image is processed by white balancing then its sharpening is done and the output is again processed by gamma correction. This same process is done again but instead of sharpening, contrast stretching is used and the two resultant images is processed through image fusion technique which gives better and enhanced image. The software used for this enhancement method is MATLAB and results are verified on the image quality parameters.

***Keywords*-Image enhancement, white balancing, image sharpening, contrast stretching, gamma correction and image fusion.**

I.INTRODUCTION

Image enhancement is a technique of processing an image to enhance certain features of the image which gives better information about the image. Images are 2D light intensity function $f(x, y)$ which is discretised both in brightness and spatial domain [1]. Due to underwater investigation, the underwater image processing is become more popular among scientific and research communities. While taking image underwater several parameters of an image can be compromised because of underwater condition. For example when light travel underwater it gets attenuated because of absorption and scattering of suspended particles and due to which visibility gets compromise and the energy of the light attenuate. Images taken underwater might get blurred and having low contrast because of forward scattering and backword scattering which can be removed by enhancement technique. The amount of absorption of light depends on the wavelength of different light (green, blue, red) because of which problem of colour cast occur in the image taken underwater [2]. And to avoid those effects several image enhancement technique has been proposed to enhance and restore the visibility of the degraded image. Some of the technique are wavelet decomposition based enhancement processes which also include image fusion process [3].

However, there are many methods for the underwater image enhancement which is used to increase the intensity, visibility, contrast and the other parameters which is gives proper information from the image.

The contrast enhancement which is widely used as Global contrast enhancement and local contrast enhancement to increase the dynamic range of the gray level in the image being processed which improve the quality of underwater images. A method on mixture Contrast Limited Adaptive Histogram Equalization (CLAHE) has been proposed by Hiram et al [4] in which CLAHE is operated on HSV and RGB colour models and then their results are amalgamate together with Euclidean norm. A new method has been proposed by Ahmad et al called dual image Rayleigh-stretched contrast-limited adaptive histogram specification in which integrated local and global contrast correction has been used. [5]

There has been many multi-step methods that blend different operation of image enhancement. These methods can give better results than the single procedure to reduce some problems which degrade image such as non-uniform illumination, low contrast, blurring, noise and colour cast. A fusion-based method is proposed by Ancuti et al [6] for underwater images and video enhancement without concentration on particular challenges. In their method two inputs are obtained from original degraded input image by bilateral filtering and white balancing and after that Gaussian pyramid is applied for the fusion of different weights which are derived from the two inputs version of underwater image. There has been also another method proposed by Li et al. [7] for the underwater image enhancement by histogram distribution prior and dehazing with minimum information loss. In addition to these method, another method is also applied on underwater image enhancement which is learning-based methods and that is proposed by Fahimeh et al. [8] which used sparse representation to dehaze the hazy image and for the colour cast correction, adaptive colour correction has been used. In past few years, various work using single image has been proposed to restore the hazy image. Although, these methods gives better in restoring the quality of the underwater image but most of them did not give much improved.

In this proposed algorithm, the original degraded image is improve by enhancing the edge, reducing the poor illuminance and removing the colour cast so that the degraded property could be eliminated (i.e. absorption and scattering). Initially, the degraded underwater image is processed with white balancing and then contrast and sharpening is done to enhance the brightness and to enhance the edges of the image because of which information would be more clear and enhanced. Our image enhancement approach adopts a multi-step strategy, combining white balancing, gamma correction and image fusion, to improve underwater images. In this approach, white balancing focus on the removal of the colour cast caused by the selective absorption of colours with depth, and gamma correction is applied to avoid the low contrast while image fusion is used to enhance the fine details of the scene, to mitigate the loss of contrast resulting from backscattering. The process is detailed in further section.

II. PROPOSED METHOD

Fusion is rapidly adopted phenomenon to solve different problem in signal and image processing field [9]. The proposed algorithm is blending of two images i.e. image fusion based on alpha factor in which one image is used as background image and another one is used as foreground image for enhancing the degraded underwater images. In order to neutralize the colour cast we use white balancing at the initial phase. The proposed work process is presented as shown in Fig.1.

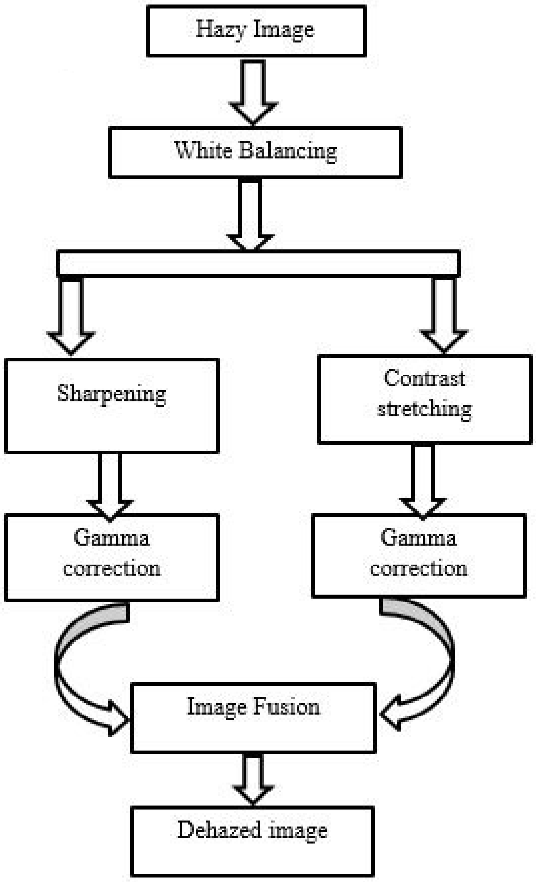


Fig.1. Proposed work

The above figure shows the proposed work to be incorporated to get better result by blending of two images derived from sharpening and contrast stretching of single hazy image. The proposed algorithm consist following steps.

Step 1: Get the coloured hazy image and convert this image into its white balanced version using Grey-World algorithm.

Step 2: Apply sharpening and Contrast stretching on the same image followed by white balancing.

Step 3: Apply gamma correction to enhance the image taken individually by sharpening and contrast stretching.

Step 4: Now blend the two image after gamma correction using alpha factor to get enhanced image.

2.1 White Balancing: The white balancing technique which is used in this paper is gray world. It focus on the improvement of the image aspect, first by removing the undesired colour castings which is present because of various illumination or medium attenuation properties. To eliminate this atmospheric distortion, we have used grey world technique to compute the white balanced image [10]. One of the most used and simple techniques for estimating the colour of the light is the Grey-World algorithm.

Grey-World (GW) technique is the most common and widely used white balancing algorithm. GW algorithm produce an estimate of illuminance by computing the mean of each channel of the image. An image S (m, n) of the size P×Q, where m and n denote the indices of the pixel position. The first step of the GW technique is to calculate the average of the each channel shown as follows,

$$R_{avg} = \frac{1}{P \times Q} \sum_{m=1}^{P} \sum_{n=1}^{Q} S_r\,(m, n\,) \quad (1)$$

$$G_{avg} = \frac{1}{P \times Q} \sum_{m=1}^{P} \sum_{n=1}^{Q} S_g\,(m, n) \quad (2)$$

$$B_{avg} = \frac{1}{P \times Q} \sum_{m=1}^{P} \sum_{n=1}^{Q} S_b\,(m, n) \quad (3)$$

Where,

S_r(m,n), S_g(m,n) and S_b(m,n) are the channel value of each channel. Thus the standard value, Z_{avg}, can be calculated as follows,

$$Z_{avg} = \frac{R_{avg} + G_{avg} + B_{avg}}{3} \quad (4)$$

According to Gray-World technique, for every pixel the final colour values are adjusted by the following equation,

$$S_r'(m,n) = S_r(m,n) \times \frac{Z_{avg}}{R_{avg}} \quad (5)$$

$$S_g'(m,n) = S_g(m,n) \times \frac{Z_{avg}}{G_{avg}} \quad (6)$$

$$S_b'(m,n) = S_b(m,n) \times \frac{Z_{avg}}{B_{avg}} \quad (7)$$

2.2 Contrast enhancement: Because of the poor illumination and lack of dynamic range low contrast images can be created. Dynamic range is the capacity of the sensor to record the minimum intensity and maximum intensity and the difference between them is called as dynamic range of the sensor. So, to avoid low contrast, contrast stretching can be used which means we increase the dynamic range of the gray level in the image being processed. The main purpose of the contrast stretching is to process such image whose contrast is low so that the dynamic range of the image will be quit high and because of which the difference details in the object present in the image will be clearly visible.

2.3 Sharpening: The main objective of the sharpening is to highlight the fine details or enhance the detail that has been blurred.

2.4 Gamma Correction: In past few years gamma correction has become very important in the field of image enhancement because the use of digital image has been increased over the internet for the commercial use. The value of gamma used in this paper is depend upon the requirement of brightness in the input image.

2.3 Image fusion: It is the process of blending of two images of a scene into a single image which gives more information and better result which is more suitable for visual perception [11]. The main aim of image fusion is to minimize redundancy and reduce uncertainty in the output while maximizing relevant information particular to an application or task. Depending upon application different fused images can be created using same set of input images. The benefits of using image fusion is temporal and wider spatial coverage, uncertainty gets reduced, reliability gets improved and robustness of the system performance gets increased [4]. In this paper the image fusion used is based on alpha factor which involves blending of foreground and background of same input image having different derivatives using sharpening and contrast stretching.

III. RESULT AND ANALYSIS

Our approach has been tasted against degraded images shown in Fig. 3. The efficiency have been tested and proven by mean square error (MSE) and peak signal to noise ratio (PSNR) that are considered as one of the most significate parameters for image quality, they represents measure of peak error and the cumulative squared error between the original image and enhanced image, respectively. Therefore, we can say that for an image to be visually interpretable and readable, it should possess high PSNR value and low MSE value.

The following equation is used to calculate MSE,

$$MSE = \frac{\sum_{i=0}^{n} P,Q[J_1(p,q)-J_2(p,q)]^2}{P\times Q} \quad (8)$$

Where J_1 and J_2 represents original Image (input image) and enhanced image (resultant image), respectively. PSNR can be calculated by the following equation:

$$PSNR = 20\log_{10}\left(\frac{2^c-1}{\sqrt{MSE}}\right) \quad (9)$$

Where, c is the bit per sample. In this paper the value of c is 8 as the images taken in this paper is in the ranges Of 0 to 255.

Original Image

White Balance

Sharpening and contrast

Gamma correction

Enhanced Image

(a) (c) (e)

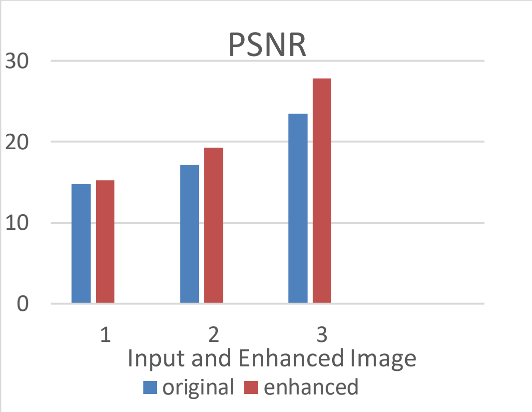
(b) (d) (f)

Fig 2. Original image and its linear colour corrected image and white balanced image (a), (b) are original image (c), (d) are linear colour corrected image (e), (f) are white balanced image.

Original Image

Enhanced Image

1 2 3



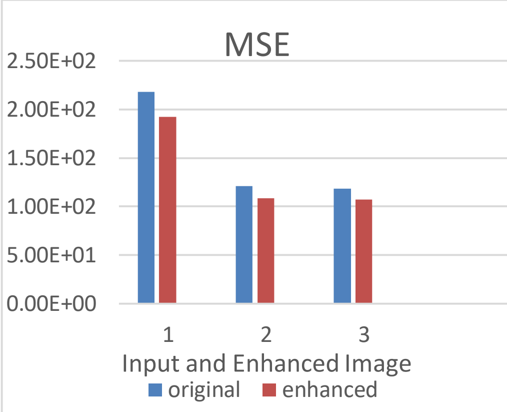


Fig 2. Comparision in PSNR and MSE of original image and enhnaced image through graph plotting

Table 1: Comparison of PSNR and MSE

Parameters	**Input Image**			**Enhanced Image**		
	1	**2**	**3**	**1**	**2**	**3**
PSNR	**14.7505**	**17.1631**	**23.5216**	**15.2385**	**19.3040**	**27.8049**
MSE	**217.9**	**120.7**	**118.65**	**192.3**	**108.4396**	**107.3786**

Percentage Variation of the PSNR can be obtained by previous PSNR value and the proposed PSNR value and this is shown below:

$$Percentage\ Variation = \frac{[PSNR(proposed) - PSNR(previous)]}{PSNR(previous)} \times 100$$

$$PV_1 = \frac{15.2385 - 14.7505}{14.7505} \times 100 = 3.03\%$$

$$PV_2 = \frac{19.3040 - 17.1631}{17.1631} \times 100 = 12.47\%$$

$$PV_3 = \frac{27.8049 - 23.5216}{23.5216} \times 100 = 16.93\%$$

IV.CONCLUSION

The alrorithmhas has been proposed in this paper is pipelining architechture of white balancing, gamma correction and image fusion. The result were implemented using MATLAB R2016a (64 bit). The parameters which are used to check the performance of the system are PSNR and MSE. From the above table and calculation of percentage variation of PSNR it is clear that the proposed work gives better result than the previous value i.e. PSNR value of proposed work is greater than the input values and MSE value is less as compare to input values.

V. REFERENCES

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