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Multiscale Combination for Improving Underwater Images

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RESEARCH ARTICLE

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Abstract— This research proposes an improvement strategy for underwater photos. Images taken underwater go through processes like attenuation and scattering. Numerous methods for improving underwater images have been suggested, most of which rely on the qualities of light. Light signal characterisation is difficult, and the underlying system that relies on light will make it much more difficult. The suggested method blends two pictures created from a single underwater photograph to achieve image fusion. White balancing and gamma correction are pre-processed for the initial picture. White balancing and sharpening are pre-processes applied to the second picture. Better improvement is achieved both temporally and specifically when white is balanced by color channels. In every geospatial location, a standard undersea picture is highlighted by white balance, Gama correction, and sharpening. An improved underwater picture is created by the multi-scale fusion of the Gama-corrected and sharpened image. Numerous underwater photos are used in simulations, and it has been determined that the suggested method outperforms cutting-edge methods.

Index Terms— multi-scale fusion, enhancement, Gamma correction, sharpening, underwater images

1 INTRODUCTION

Because of the underwater environment, both underwater image enhancement and restoration are difficult undertakings. The water's characteristics and light attenuation lead the visuals to deteriorate in an underwater setting. various color channels experience light attenuation in various ways [1]. This is an extra issue that arises in an underwater setting but is not present in many outside settings. In an outdoor setting, signal attenuation will happen in relation to distance. The whole signal or picture is attenuated. The signal won't be divided into separate components by attention, nor will it vary depending on the component. However, in the case of underwater photos, the signal is divided into multiple color channels due to the underwater environment [2]. This makes improvement and repair very challenging. While the blue channel may go up to several meters, the red channel is attenuated at relatively short distances. The underwater characteristics are presented in Fig. 1, where it is shown that the red channel attenuates 100% at extremely low depths. At a depth of five meters, the dark yellow is dimmed by around 75%. At a depth of 15 meters, the light yellow channel is attenuated by around 35%. Additionally, at a depth of 25 meters, the light green channel is attenuated by around 17%. In addition to attenuation, underwater light dispersion will make restoration and enhancement more difficult. In an outdoor setting, light information will also be scattered [3]. However, basic elements like haze and snow are the particles that rise and disperse in the open environment. However, underwater particles may vary from tiny water molecules to large things that can totally block light.

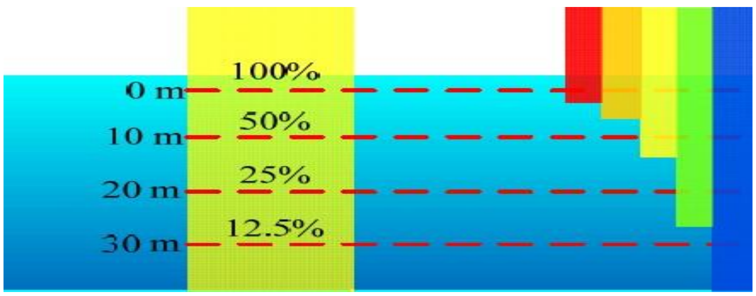

Fig. 1. Light Absorption in Water

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2 UNDERWATER IMAGE MODEL

The wavelength affects how attenuated underwater pictures are. The attenuation is considerable for a band with a longer wavelength. Because the red channel has a longer wavelength than the green and blue channels, its attenuation is much larger. As a result, photographs taken underwater have a blue or green tone [4][5]. An essential component known as a transmission map must be investigated if we want to create a mathematical model of an underwater picture. The transmission map describes how an underwater picture is impacted by both attenuation and scattering. The transmission map provides a greater mathematical tolerance to reflect the characteristics of the undersea environment by accounting for distance. Fig. 2 shows the outside setting and light behavior. This is solely necessary to comprehend the transmission map [6][7].

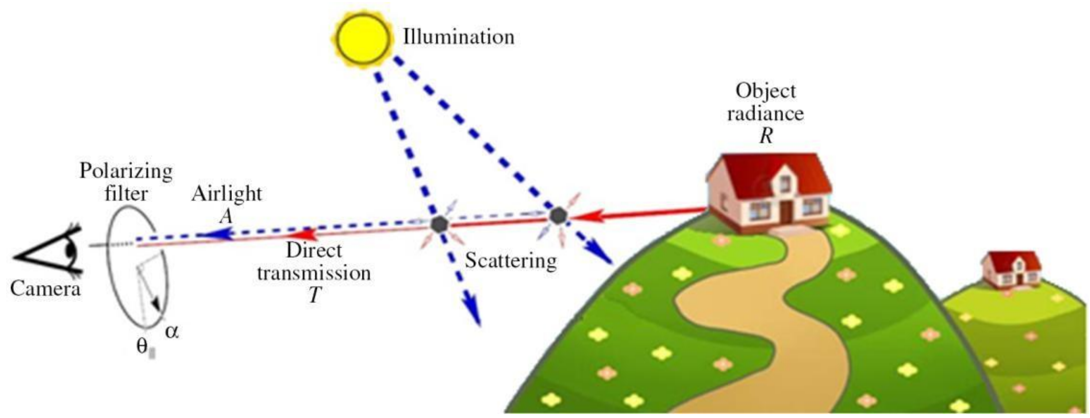

Fig. 2. Light characteristics in Outdoor environment

The underwater image can be mathematically modeled by the following equation.

$$I(x) = J(x)t(x) + (1-t(x))B$$

J(x) is the original intended picture in the statement above [8][9]. The mathematical model is more closely associated with picture restoration, even if underwater image processing may be considered both enhancement and restoration. Nevertheless, it may be used to comprehend general underwater light phenomena. B is background light and t(x) is the transmission map in the model. The light that travels from the object's surface to the camera without being dispersed is represented by the first term in the model [10][11]. The color cast of the light signal as a result of scattering is represented by the second term.

3 PROPOSED TECHNIQUE

Blending two photos created from a single underwater photograph is the foundation of the suggested method. Fig. 3 shows the block diagram for the suggested method. The input picture is initially used for white balancing, which improves color channel-wise. Gama correction and sharpening are then applied to the white-balanced underwater picture. The final improved underwater photos are produced by applying the resultant images to multi-scale fusion.

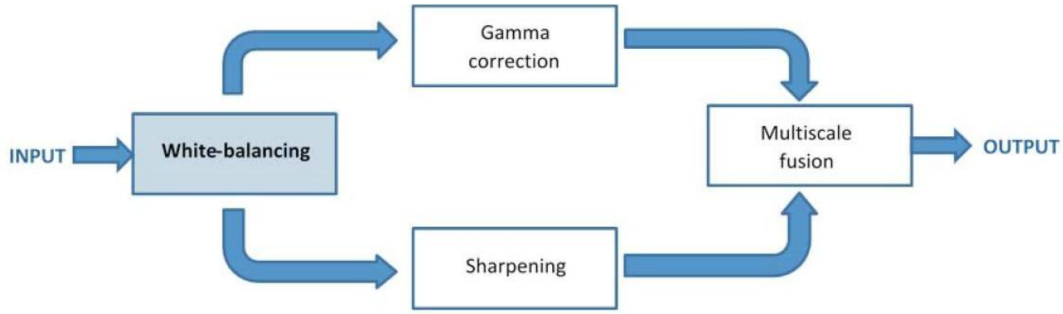

Fig. 3 Block diagram of proposed model

a. White-balancing

In the literature, many underwater image enhancement schemes are proposed. Some of the schemes that best remove the blue tone suffer from heavy red artifacts. Those schemes that best restore red channel suffer from blue tone artifacts. Based on the analysis the following observations are made, using which the white balancing is devised by enhancing red and blue channels.

a. Out of all the colors, red color will be lost at lower distances. To recover the red color, the opposite color which is green need to be used to compensate red as well as blue channels.
b. The green channel contains the colour information of opposite channel. The red channel is considered as the opposite channel of green channel. Hence the part of green channel maybe added in compensation to red channel.
c. Red channel and green channel maybe estimated by the difference between green and red channels. Hence the compensation maybe arrived by designing a quantity in proportion to the difference between red and green channels.
d. If the red channel does not get attended at that distance the green channel will not have a significant effect to retrieve the information in other regions hence the green channel cannot be transferred to other regions if the red channel does not get attenuated.

To account for the above observations than hands red channel is given as follows:

$$I_{rc}(x) = I_r(x) + \square.(\bar{I}_g - \bar{I}_r).(1 - I_r(x)).I_g(x)$$

Here '*r*' represents red channel '*g*' represents green channel '*rc*' represents compensated red channel and I stands for image. $\bar{I}_r$ and $\bar{I}_g$ represents average value of red and green channels. In the expression, there are two terms. The first term is the original red channel. The second term contains four components. The first component is a constant. The second one is the difference between average green channel and average red channel. The third one is an inverse red of channel. The fourth component is the green channel. The multiplication of green channel with the difference between average green and average red channel corresponds to second observation. The consideration of green channel attributed in the last component from the second observation.

The red channel degrades the information contained in blue channel also. Hence the compensated red channel alone cannot enhance the underwater image. Correspondingly, the compensation needs to be extended for blue channel also. Hence, the blue channel is compensated by the mathematical operation given below. The process of compensation of blue channel is similar to that of red channel.

$$I_{bc}(x) = I_b(x) + \square.(\bar{I}_g - \bar{I}_b).(1 - I_b(x)).I_g(x)$$

b. Gamma Correction

Gama correction converts the pixel domain from one range to another range. It may be treated as a tone mapping operator which can decrease or increase the dynamic range of the image. The Gama correction can affect the lightness or darkness of the image. The Gama correction is a common task before giving a print of any photographic image. The effect of Gama correction maybe either increasing the lightness or darkness, that depends on a factor called Gamma. The mathematical expression relating the original value of the image pixel and new value is given below:

$$new\_val(x) \square x^{1/\square}$$

Based on the value of Gamma, the pixels of the image gets either bright or dark. If the value of Gamma is 1, then there is no change in that corrected value. If the value of Gamma is less than 1, then the darker images get resulted. If the gamma value is greater than 1 then bright image will result. This mapping of value of Gamma with respect to the structure of the image is given in the Fig. 4.

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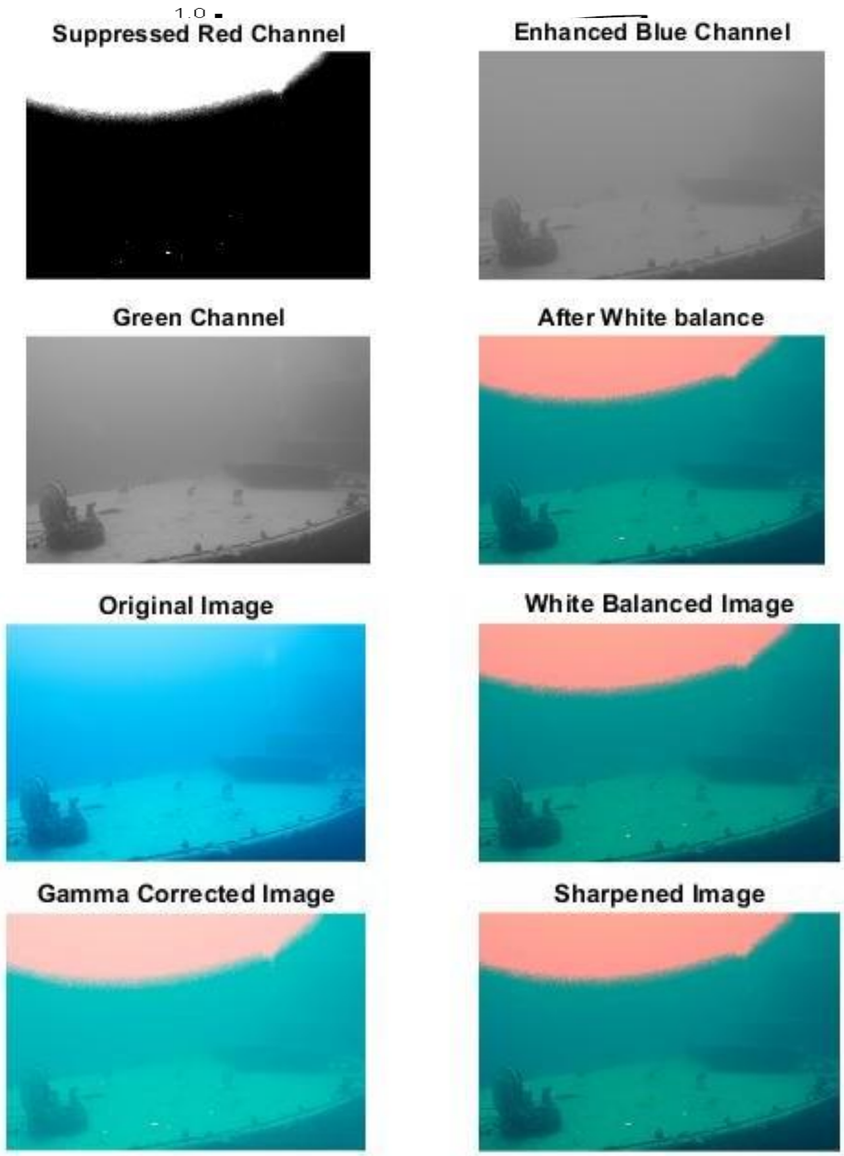

version. Wavelet-based image fusion is performed to the sharpened and white-balanced images. The merged picture is finally shown. The suggested scheme's simulation results for four test photos are shown in Figs. 5 to 8.

Fig. 5. Simulation Results on Test Image - 1

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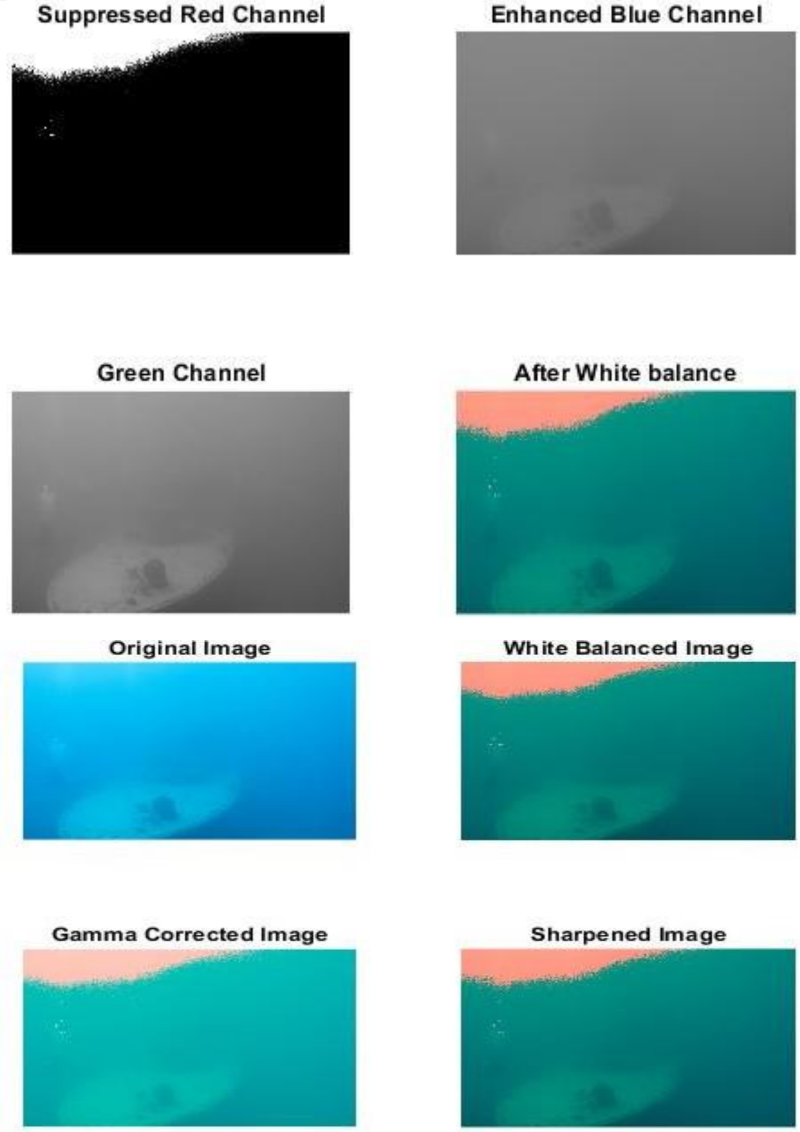
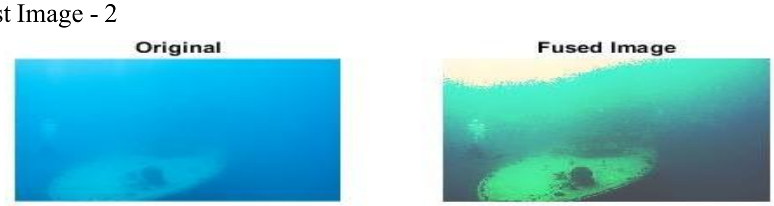


Fig. 6. Simulation Results on Test Image - 2



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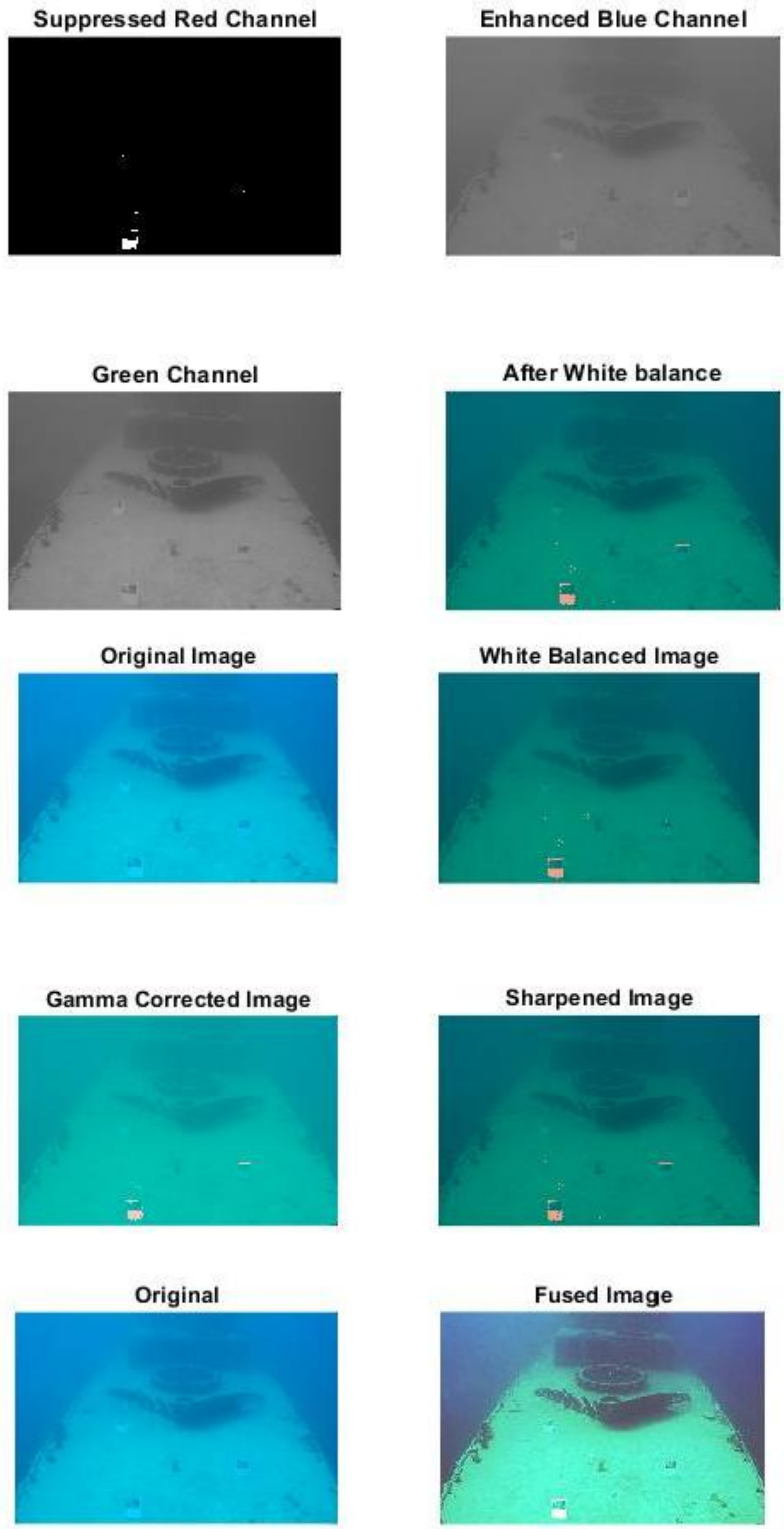

Fig. 7. Simulation Results on Test Image - 3

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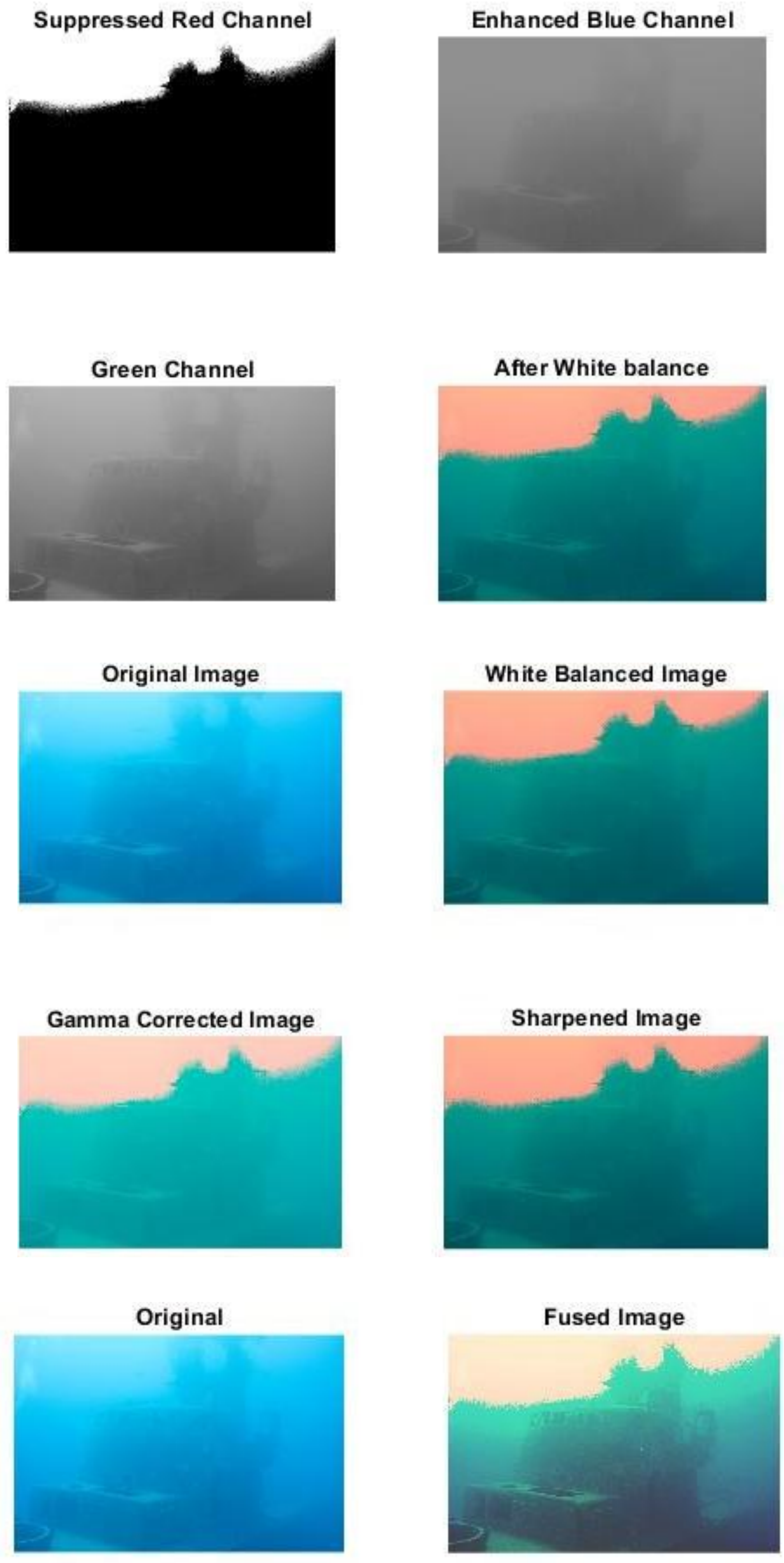

Fig. 8. Simulation Results on Test Image - 4

4 CONCLUSIONS

Numerous natural light effects are present in underwater photos, and a variety of elements affect their quality. The majority of the time, color content is lost in varying amounts, making reversal a difficult operation. Enhancement or restoration may be used to improve the quality of underwater photos. The literature offers several methods for restoring and improving underwater images. While enhancement schemes see the work as enhancing the image's quality or emphasizing certain key elements, restoration methods view the task as restoring lost information. The suggested method is based on a single picture fusion method, in which a single underwater image serves as the input for the fusion. White-balanced and sharpened images are the inputs for image fusion. The input picture's RGB channels are enhanced to create a white-balanced image. A few pre-processing steps, such as gamma correction, are used to create the sharpened picture. The suggested scheme's performance is shown by the simulation results, which demonstrate that depth has no impact on performance.

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