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Underwater image enhancement by using integrated techniques AGP, DCP and GABOR FILTER

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ABSTRACT

Image enhancement technique is one of the widely used techniques to improve the image quality by enhancing the visibility of the images. This research presents several image enhancement techniques. These techniques have been used in a number of applications such as underwater images, medical images etc. In this research, different enhancement techniques have been evaluated. It is found that there are certain limitations in the existing techniques. Existing researchers have not considered many issues such as noise issues; even no one has focused on integrated approach of the Adaptive gamma correction and Dark channel prior and uneven illuminations; Due to light absorption, light reflection, bending of light and scattering of light or poor visibility of underwater images, there is need to improve the quality of an underwater image. This research work has evaluated and compares the performance of the image enhancement using Gabor filter, dark channel prior and Adaptive gamma correction which have been avoided in existing research.

General Terms

Image enhancement, Gabor filter, DCP, AGP.

Keywords

Gabor filter, histogram stretching, dark channel prior, adaptive gamma correction.

1. INTRODUCTION

Today with the rising of interest in digital image processing such as digital high definition television (HDTV), Internet protocol television (IPTV), and video-phone, image enhancement makes an important topic in the research. These techniques are applied for enlargement of images, but the enlargement makes the image blurred because there is no power in the

high-frequency component of enlarged image. So to improve such kind of images, image enhancement is very important technique. Image enhancement is a process of changing an image so that the result is more suitable than the original for a particular application. High pass filter is used as a pre-processing method in typical image enhancement for enhancing an image by un-sharp masking and high-boost filtering. In non-linear image enhancement, high pass filter is replaced with non linear operations. Image enhancement commonly used in computer graphics and it is the sub area of image processing. Various enhancement schemes are used for enhancing an image which includes gray scale manipulation, Histogram equalization and filtering. Image enhancement techniques can be divided into two broad categories: Spatial domain methods and Frequency domain methods. Due to light absorption and scattering effects of the light and inherent structure less environment, underwater images increase new challenges and impose new problems. For the last few years, underwater activities of images are exploring, understanding and investigating. Today, scientists are eager to search the mysterious underwater world. However, still there is lacking in image processing analysis techniques and methods that are used to improve the quality of underwater images. Under the water, mostly background of the images appears blue and green and light also decreases. The reason behind the light reduction in water is absorption and scattering of sun light. And secondly the reason behind the blue and green background is that the wavelength becomes shorter gradually according to light spectrum from red to violet. According to the nature of water, visible light is absorbed first because its wavelength is the longest, then red light is absorbed as second longest wavelength. So wavelength of blue and green is shorter than red light.



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According to Rayleigh scattering theory, scattering intensity is inversely proportional to the wavelength, so shorter wavelengths will scatter much more than the longer wavelengths. Blue color has a shorter wavelength than red color so blue color will scatter much more than red color. It is concluded that water scatters the blue and violet color when sun light spread on it and absorbs red due to longer wavelength. The wavelength of green light is between the wavelength of red and blue light, but much closer to the blue so reduction of green light only results from scattering. So for an outdoor haze image, due to suspended particles scattering is the major factor resulting in light attenuation. So it is clear from the above theory that there are significant difference between atmospheric haze images and underwater images in physical process.

2. Image enhancement technique

2.1 Non-linear image enhancement techniques

Non-linear enhancement is a technique whose output is not a linear function of its input. That is, if this technique gives output intensity R and S for two input pixels r and s individually, but does not always output $\alpha R + \beta S$ when the input is a linear combination $\alpha r + \beta s$. There are some basic drawbacks of the transform-based image enhancement methods such as they introduce certain artefact and cannot concurrently enhance all parts of the image very well and it is difficult to automate the image enhancement procedure. So to overcome this problem the luminance and contrast enhancement of V component of the input image has been described. The shape of the nonlinear transfer function for luminance enhancement remains same for all the pixels, but the illumination on the all regions of the image has not been same, some regions may be dark and some may be bright. So while enhancement of the color image, locality has to be considered. In order to achieve this goal firstly the value component image in HSV image space has been divided into smaller overlapping blocks. In contrast enhancement process, for each pixel the amount of enhancement has been calculated depending upon the center pixel itself and its surrounding pixel values. Fig. 1 shows the block diagram of the proposed method. In general, color images are represented in RGB color space. HSV space is closer to human perception in which the (H) refers to the spectral composition of color, saturation (S) defines

the purity of colors and (V) refers the brightness of a color or just the luminance value of the color.

$$V_{le} = \frac{V^{(0.75x+0.25)} + 0.4(1-x)(1-V) + V(1-x)}{2} \quad (1)$$

The RGB values of an image are converted into HSV values. The luminance enhancement is the first step for enhancing the images captured under low or non-uniform illumination conditions, which has been applied to the V component of the input image using specially designed non-linear transfer function. The Luminance enhancement is also known as process of dynamic range compression. The V channel image has been subjected for luminance enhancement. Suppose VLE be the transferred value by applying non-linear transfer function defined below.

Nonlinear contrast enhancement often involves histogram equalizations through the use of an algorithm. The nonlinear contrast stretch method has one major disadvantage. Each value in the input image can have several values in the output image, so that objects in the original scene lose their correct relative brightness value. There are two methods of nonlinear contrast Enhancement.

Histogram Equalizations

Adaptive Histogram Equalization

2.1.1 Histogram equalization

Histogram equalization (HE) is popular method of contrast adjustment using the image's histogram and also enhances a given image. In this method, transformation T is to be designed in such a way that the gray value in the output is equally distributed in $[0, 1]$. It is also called histogram flattening. Histogram equalization method in which histogram is modified by spreading the gray level areas. When an image's histogram is made equal, all pixel values of the image are redistributed so there are approximately an equal number of pixels to each of the user-specified output gray-scale classes e.g., 32, 64, and 256. Contrast is increased at the most populated range of brightness values of the histogram. For very bright or dark parts of the image, It automatically reduces the contrast associated with the ends of a normally distributed histogram. It can also divide pixels into different groups, if few output values are over a wide range. But this method is effective only



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when the original image has poor contrast to start with, otherwise it may degrade the image quality.



(a)



(b)

Fig. 2. (a)Original image (b) histogram equalization based image

Consider a discrete grayscale image $\{x\}$ and let n_i be the number of occurrences of gray level i . The probability of an occurrence of a pixel of level i in the image is

$$p_x(i) = p(x = i) = \frac{n_i}{n}, 0 \leq i < L \quad (2)$$

L being the total number of gray levels in the image (typically 256), n being the total number of pixels in the image, and $p_x(i)$ being in fact the image's histogram for pixel value i , normalized to $[0,1]$.

Let us also define the cumulative distribution function corresponding to p_x as

$$cdf_x(i) = \sum_{j=0}^i p_x(j) \quad (3)$$

Which is also the image's accumulated normalized histogram. We would like to create a transformation of the form $y = T(x)$ to produce a new image $\{y\}$, with a flat histogram. Such an image would have a linearized CDF across the value range, i.e. for some constant K .

$$cdf_y(i) = iK \quad (4)$$

The properties of the CDF allow us to perform such a transform it is defined as

$$cdf_y(y') = cdf_y(T(k)) = cdf_x(k) \quad (5)$$

Where k is in the range $[0, L]$.

Notice that T maps the levels into the range $[0, 1]$, since we used a normalized histogram of $\{x\}$. In order to map the values back into their original range, the following simple transformation needs to be applied on the result:

$$y' = y \cdot (\max\{x\} - \min\{x\}) + \min\{x\} \quad (6)$$

2.1.2 Adaptive Histogram Equalization

Adaptive histogram equalization is other image processing technique that is extended version of histogram equalization. This method is differs from histogram equalization because it computes several histograms, each parallel to a different section of the image, and uses them to redistribute the brightness values of the image. Therefore adaptive method is suitable for improving the local contrast of an image. In Adaptive histogram equalization, the image is divided into several rectangular domains, along with compute an equalizing histogram and modifies levels so that they match across boundaries. Adaptive histogram equalization uses the histogram equalization mapping function supported over a certain size of a local window to determine each enhanced density value. Therefore regions occupying different gray scale ranges can be enhanced simultaneously. But still, the image may have a problem in local contrast. Therefore need to apply histogram modification to each pixel based on the histogram of pixels that are neighbors to a given pixel. This will probably result in maximum contrast enhancement.

However, AHE has a tendency to ended intensify noise in relatively identical regions of an image. It represents a characteristic length scale. Contrast at smaller scales is enhanced, while contrast at larger scales is reduced. Due to the nature of histogram equalization, the result value of a pixel under AHE is proportional to its rank among the pixels in its neighborhood. An

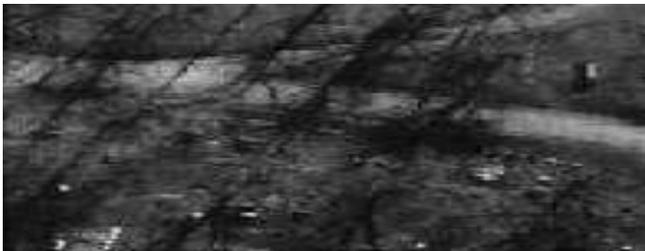


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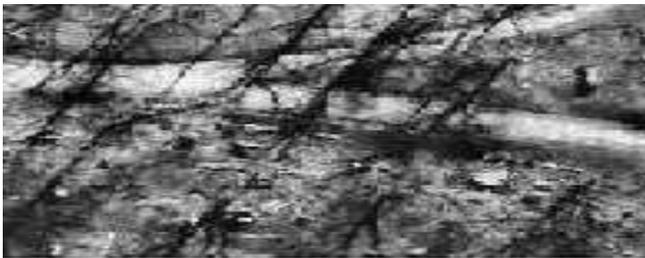
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efficient implementation on specialist hardware is allowed by this method that can compare the center pixel with all other pixels in the neighborhood. An un-normalized result value can be calculated by adding 2 for each pixel with a smaller value than the center pixel, and adding 1 for each pixel with equal value. When the image region neighboring a pixel is quite identical, its histogram is strongly hit the highest pointed, and the transformation function map a narrow range of pixel values to the whole range of the result image. That is why AHE to over enlarge small amounts of noise in largely identical regions of the image.



(a)



(b)

Fig3. (a) Original image (b) adaptive histogram equalization based image

2.1.2.1 Contrast Limited AHE

Adaptive histogram equalization divides an image into regions and selects a sliding window. The sliding window is processed by means of local histogram equalization. AHE can enhance the contrast of each region. Even AHE is applied widely and revealed effectively, though, there are two problems in adaptive histogram equalization slow speed and the enhancement of noise in relative homogeneous regions. When the relative region is fixed, the local histogram of a pixel is the same as the pixel which is in the center of the Rectangular Window. Only the pixels within the local area are considered while others are neglected. But according to the characteristic of human vision, the visual

systems change with the relative region and they are affected by the surrounding environment

This method is variant of adaptive histogram equalization called *contrast limited adaptive histogram equalization* (CLAHE) prevents this problem by preventing the amplification of noise.

Thus, according to the application of Contrast Limited Adaptive Histogram Equalization (CLAHE), it is more suitable alternative as it fulfils all the desired objectives such as image clarity (fullest intensity), equalizing the contrast projection, and preventing over-amplification of noise signals by impressive restrictive characteristic.

The contrast amplification in the neighbourhood of a given pixels value is given by the slope of the transformation function. This is proportional to the slope of the neighbourhood cumulative distribution function and therefore to the value of the histogram at the pixel value. The general equation for contrast limited adaptive histogram equalization is

$$N_{aver} = \frac{N_{CR-xp} \times N_{CR-yp}}{N_{gray}} \quad (7)$$

Where N_{aver} is average number of pixels, N_{gray} is number of gray level in the contextual region, N_{CR-xp} is the number of pixel in the X-dimension in the contextual region, N_{CR-yp} is the number of pixel in Y-dimension in the contextual region.



(a)





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(b)

Figure4. (a) Original image b) contrast limited adaptive histogram equalization based image

2.1.2.2 Dark channel prior

The dark channel prior is based on haze-free outdoor images: in most of the non-sky area, at least one color channel has very low intensity at some pixels. For example in color images, any one of the red, blue and green colors may have a less intensity. In other words, the minimum intensity in such an area should have a very low value. Formally, for an image \mathbf{J} , we define

$$J_{\text{dark}}(x) = \min_{c \in \{r, g, b\}} \left(\min_{y \in \Omega(x)} (J_c(y)) \right) \quad (8)$$

Where J_c is a color channel of \mathbf{J} and $\Omega(x)$ is a local patch centered at x . Observation says that except for the sky region, the intensity of J_{dark} is low and tends to be zero, if \mathbf{J} is a haze-free outdoor image. J_{dark} is the dark channel of \mathbf{J} .



(a)



(b)

Figure5. (a) Original image (b) dark prior channel based image

The low intensities in the dark channel are mainly due to three factors: a) shadows. *e.g.*, the shadows of cars, buildings and the inside of windows in cityscape images, or the shadows of leaves, trees and rocks in landscape images; b) colorful objects or surfaces. *e.g.*, any object (for example, green grass/tree/plant, red or yellow

flower/leaf, and blue water surface) lacking color in any color channel will result in low values in the dark channel; c) dark objects or surfaces *for example* dark tree trunk and stone. As the natural outdoor images are usually full of shadows and colorful, the dark channels of these images are really dark!

2.1.2.3 Dominant brightness level

Dominant brightness level method enhances the overall image quality and visibility of local details effectively, and minimizes the pixel distortions in low and high intensity. Remote sensing and Digital Cameras are the applications of this technique. The standardized dominant brightness varies from zero to one, but practically in the range between 0.5 and 0.6 in most images. For safely including the practical range of dominant brightness, we used 0.4 and 0.7 for the low and high bounds, respectively.

Existing histogram-based contrast enhancement methods cannot preserve edge details and exhibit saturation artifacts in low and high intensity regions so a novel contrast enhancement algorithm is prepared for remote sensing images using dominant brightness level-based adaptive intensity transformation as shown in Fig.6.

Even if intensity distributions vary spatially, the correspondingly contrast-enhanced images may have lose image details and intensity distortion in some regions. For prevail over the intensity distortion problems, we decompose the input image into multiple layer of single dominant brightness levels. Since low-intensity values are dominant in the dark region, and high-intensity values are dominant in the bright region, the dominant Brightness at the position (x, y) is computed as

$$D(x, y) = \exp \left(\frac{1}{N_L} \sum_{(x,y) \in S} (\log l(x, y) + \varepsilon) \right) \quad (9)$$

where S represents a rectangular region encompassing (x, y) , $L(x, y)$ represents the pixel intensity at (x, y) , N_L represents the total number of pixels in S , and ε represents a sufficiently small constant that prevents the log function from changing to negative infinity. In the low-intensity layer, the dominant brightness is lower than the pre-specified low bound and vice versa. The middle-intensity layer has the dominant brightness in between low and high bounds.



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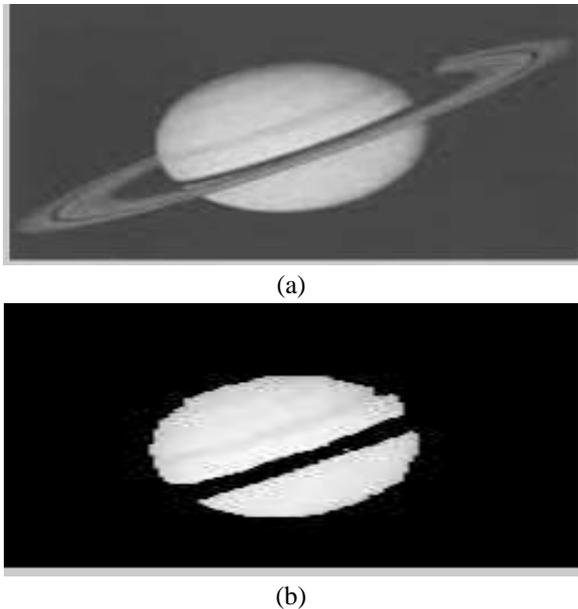


Figure6. (a) Original image (b) dominant brightness level based image

3. LITERATURE SURVEY

Saibabu and Vijayan[1] introduced an Adaptive and Non Linear Technique for Enhancement of Extremely High Contrast Images for some extremely bright and dark regions in the night images. Authors found that some previous methods worked well for dark images and some for bright images, but not worked well for both type of images. So they used three methods such as adaptive intensity enhancement, contrast enhancement and color restoration to make the algorithm more adaptable to the image characteristics. **Alexander Wong and William** [2] presented a new perceptually-adaptive technique for enhancement of information within still images for persons who were suffering from dichromacy. They applied a non-linear hue remapping method to the still images for improving color differentiation while preserving the visuals of the images by stretching dynamic range of red-green or blue-yellow colors of images. Authors observed that previous techniques did not preserve the visual of the original color image. So they gave this new technique for producing enhanced images that preserve visual detail along with maintain the aesthetics of the original image. **Junxuan and Ke Zhang**[3] described Adaptive Color Restoration and Luminance Based Multi Scale Retinex Scheme to improve the visual quality of color images under poor

lighting condition. They declared that Red, Green, Blue color bands improved by amending luminance which automatically enhanced to a proper range based on Human Visual System using the adaptive parameter. Authors found in the previous research that A luminance based Multiscale Retinex improved darker images in the poor lightening areas along with saving CPU time largely, but it doesn't work in other images as effectively as 'darker objects with brighter background' in the images and 'whole black background' images. So they improved the previous Luminance Based Multi Scale Retinex by extended into Adaptive Color Restoration Luminance Multiscale retinex to achieve better visual results by perceiving more details and without varying percentage of R, G, and B in the three bands. **N. M. Kwok and et al.** [4] demonstrated local sector enhancement technique to address the problems such as to preserve the color information content while enhancing the contrast and image quality by making use of local contrast information and fusing the enhanced image with the original. They introduced that enhanced sectors were modulated by a Gaussian mask to mitigate unexpected changes at the sector boundaries. Local sectors with higher contrast dominated the others thus achieving overall global contrast enhancement. They claimed performance of this approach was evaluated by using a collection of color images taken under dissimilar conditions. Authors had found some limitations in previous research that had been exposed in global histogram equalization approaches including unnatural artifacts produced and loss of object details. **Kota and et al.** [5] studied that HE caused an effect on brightness, shadow in some almost homogeneous area. So to control enhancement degree and maintain brightness, they proposed two methods such as HE with variable enhancement degree and Brightness preserving Bi-HE with Variable Enhancement Degree which are extended version of HE and Brightness Preserving Bi-HE respectively. They claimed that later method realized the natural enhancement and permitted some different mean brightness between the original image and the enhanced image. They introduced Modified Histogram Equalization for Image Contrast Enhancement method in which the image histogram is divided into two parts and after that two histograms are independently equalized. **Fan Yang, Jin Wu**[6] introduced an improved image contrast enhancement based on HE, which is especially



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suitable for multiple-peak images. They found some disadvantages in previous research that some algorithms increased contrast of the images but they usually produce certain undesirable effects in the results. So they claimed that new method presented an efficient algorithm in achieving widely dynamic range and improving contrast of the images. They applied Gaussian filter for removing noise in images and the valley values of the image histogram divided the original histogram into different areas. Histogram equalization method applied on each segment separately. They also proved that present method was better than as compared with HE and Bi-HE.

Deepak and Joonwhoan Lee [7] introduced a Nonlinear Transfer Function-Based Local Approach for Color Image Enhancement method for enhancing the color image in which pixel neighborhood method and overlapped window based method applied on only V component of the Hue Saturation Value color image, but H and S component are not changed to prevent the degradation of color balance between HSV components. Authors found in previous research that HVS and compressed Discrete Cosine Transform domain method enhanced both dark and bright region of an image equally well but not enhance all parts of the image very well. A local approach was applied on V components instead of global approach. Luminance all over the image was not same, some regions may be dark or bright so the image locality was to be considered while enhancing. **M. C. Hanumantharaju and et al. [8]:** introduced a new algorithm and architecture suitable for Field Programmable Gate Array implementation of adaptive color image enhancement based on Hue-Saturation-Value color space. By stretching dynamic range, the saturation component was enhanced to get rich color display. In order to avoid color alteration, Hue was retained. They found in previous research that traditional arithmetic mean filter tends to lose image detail such as edges and sharpness when compared to geometric mean filter and reconstructed quality of image using this scheme was generally not satisfactory. So an adaptive luminance enhancement was attained by using a simple geometric mean filter instead of arithmetic mean filter and also used to achieve very good quality reconstructed images. For speed up the enhancement process, Pipelining and parallel processing techniques had been adapted. **Apurba and Ashish [9]:** introduced Particle Swarm Optimization based hue preserving color image

enhancement technique to improve image quality by maximizing the details in the input image and to solve the optimization problem. They stated that parameterized transformation function used to enhance the quality of the intensity image, in which parameters were optimized by Particle Swarm Optimization based on an objective function. This function also used local and global information of the input image and the objective function considers the entropy and edge information to measure the image quality. They found that algorithm gave better results as compared with Hue-Preserving Color Image Enhancement without gamut problem and a Genetic Algorithm based approach to Color Image Enhancement. **Zhiyuan and et al. [10]** introduced Example-based Dist-Stretched contrast enhancement algorithm to enhance the image contrast effectively. They described problems of traditional HE methods and also stated that resulted images from this method had more natural looking than those of traditional HE based methods. So they proposed classical version of HE that used globally redistribute pixel values in the stretched dynamic range by creating a linear cumulative histogram. Therefore, by studying the associated properties of the histogram of the example image, the target image enhanced towards similar visual appearance of the example image. **Yi-Sheng Chiu and et al. [11]** introduced an Efficient Contrast Enhancement Using Adaptive Gamma Correction and Cumulative Intensity Distribution method in which an automatic transformation technique used to improve the brightness of dimmed images based on the gamma correction and probability distribution of the luminance pixel. They firstly described histogram analysis which provided the spatial details of the single image based on probability and statistical inference. Authors stated the weighting distribution for smoothing and gamma correction for enhancing. They claimed that it provided better contrast based on the comparison with previous research techniques which didn't attain the proper balance between the image trend preservation and the image enhancement. **Junjun and et al.[12]** introduced a novel Modified Multiscale Contrast Enhancement technique based on manipulating the Discrete Cosine Transform coefficients was an improved version of previous methods. They proposed a technique that used an image contrast measure Second-Derivative-like Measure of Enhancement to choose the optimal parameters and to demonstrate the effectiveness of the methods. Authors



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stated that proposed method behaved low frequency and high frequency coefficients differently to suppress the block artifacts and protect large edge details in the low frequency components. Alpha rooting and logarithmic enhancement function to the band enhancement provided high flexibility to modify the Discrete Cosine Transform coefficients and also provided more balanced results than applying the individual techniques alone. **Rajib Kumar and et al. [13]** introduced a internal noise induced contrast enhancement of dark images in which Dynamic Stochastic Resonance was applied on DCT coefficient iteratively to enhance the image energy by making a energy transition into another state, or with inter-well transition of a particle in a bi-stable double well system. They found that present method gave least iteration in comparison others techniques and due to adaptive sub-block selection or Dynamic Stochastic Resonance, it enhanced very dark as well as low contrast images very effectively with negligible loss of information at the bright areas. It was not only adjusted the background illumination but also improve contrast while preserving enhancing color information. **Farhan and et al. [14]** introduced a Weighted Average Multi Segment HE method using Gaussian filter which applied on original images for preserving mean brightness and reducing noise. They found that the brightness of the input image shifted to the mid gray level and failed to preserve brightness. Some previous techniques preserved brightness but introduced undesirable artifacts. They declared that mean brightness of processed image located in the middle of the input mean and the middle gray level and Weighted Average Multi Segment HE was a hybrid form of three methods such as Multi Peak HE with Brightness Preserving method, Minimum Within-Class Variance Multi HE and Recursive Mean-separate HE. These three methods provided better results together. **H. D. Cheng and Yingtao Zhang [15]** focused that Over-enhancement lead to the loss of edges, textures, fine details, and unnatural images which was the major problem of image contrast enhancement algorithms. They claimed that a novel method which investigated, analyzed and detected reasons of over-enhancement and located the over enhanced areas accurately and effectively, and provided a quantitative criterion. They found that there was no accurate, effective method for detecting over-enhancement yet. Authors also stated that to avoid over-enhancement, some algorithms controlled

the intensity range of the processed images but the major drawback of under-enhancement which made some parts of the images enhanced insufficiently. Some algorithms studied the performance of the enhancement only using the contrast ratio without investigating and discussing the over enhancement; therefore, the results often had serious over-enhancement separation measure. They claimed that over-enhancement was detected if the value of SMO was greater than a threshold T . **Sunanda S. Alur and Hanumantharaju [16]** introduced a novel wavelet-based dynamic range compression algorithm to improve the visual quality of images and it had limited capability of dynamic range for both dark and brighter regions of a scene. They claimed that for each block dynamic range compression, Gabor filter applied on approximation coefficients using nonlinear transfer function which provided better results than previous filters. Authors described that the enhancement was applied to the value component and saturation of the image, and by stretching its dynamic range to get rich color display. The Hue component was preserved for balancing in HVS. The wavelet transform technique used to reduce the dimension of the image. The detail coefficients were also modified to prevent the edge distortion. **Devan and et al.[17]** introduced Color Image Enhancement Using Non-linear Transfer Function And Quality Measurement Using Reduce Reference Metrics to improve an image. It was based on two independent processes luminance enhancement and contrast enhancement. Authors found in previous research that when an image was converted from one form to other, it degraded some time, so to remove degradation such images, enhancement techniques are applied. They studied that for the luminance enhancement, only V component of the image are changed which didn't affect the original color of enhanced image. Luminance enhancement applied to the image through a pixel intensity transformation that was implemented by using a nonlinear transfer function. They also declared that this transfer function was adjusted to achieve appropriate luminance enhancement. Four new reduced references metrics methods produced better images. **Haocheng Wen and Yonghong Tian [18]:** introduced that due to spreading of light in water, the clarity of images or videos captured under water was usually decreased by varying degrees. So they declared that according to the difference in light reduction between in atmosphere and under water, a new



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underwater optical model proposed which described the formation of an underwater image in the true physical process. Authors also claimed that a new underwater dark channel was derived to estimate the scattering rate, the background light in the underwater optical model. They also improved adaptability and flexibility. **Yuan Mei, Bo Zhao, and et al.[19]**: introduced a Orthogonal curved-line Gabor filter for fast fingerprint enhancement technique which used to improve the clarity of fingerprint ridge structure in the previous research, curved Gabor method achieved a state of art enhancement effect but high computation makes a drawback so this novel technique removed it by Gabor filter. They stated that to overcome the high computation 1-D low pass Gabor filtering and 1-D band pass filtering applied on parallel and perpendicular curved lines to the edge orientation respectively. This new algorithm was 42 times faster than previous. **Muhammad Suzuri Hitam, and et al. [20]** had introduced that due to poor visibility of underwater images that is caused by physical properties of the water medium, there was need to improve the quality of an underwater image. They also presented mixture Contrast Limited Adaptive Histogram Equalization color models that specifically developed for underwater image enhancement. The method operates CLAHE on RGB and HSV color models and both results were combined together using Euclidean norm. They had taken underwater images from Redang Island and Bidong Island in Terengganu, Malaysia. Authors found that this approach improved the visual quality of underwater images by enhancing contrast, as well as reducing noise and artifacts. They declared that this algorithm produced the lowest MSE and the highest PSNR values. **Prabhakar and Praveen Kumar[21]** has introduced an image based preprocessing technique to enhance the quality of the underwater images. They have declared that the underwater images usually appeared similar with haze images cause of non-uniform lighting, low contrast, blur and diminished colors. So they applied combination of four filters such as homo-morphic filtering, wavelet de-noising, bilateral filter and contrast equalization, but these filters are applied sequentially on degraded underwater images. The previous researchers revealed that for smoothing the image, the anisotropic filter is applied instead of standard filter. But existing researchers have found that there are some drawbacks in anisotropic filter such as iterative in nature and computation time is

high compared to bilateral filter. So in this algorithm, they employ a bilateral filter for smoothing the image in addition to other three filters. This novel technique enhances the quality of the underwater images and can be utilized prior to apply computer vision techniques. **Cosmin Ancuti and et al. [22]** has described a novel strategy to enhance underwater videos and images. They also introduced that this fusion based strategy derives the inputs and the weight measures only from the degraded version of the image. They have defined two inputs that represent color corrected and contrast enhanced versions of the original underwater image to overcome the limitations of the underwater medium. But to increase the visibility of the distant objects degraded due to the medium scattering and absorption, they applied four weight maps and found that fusion framework also supports temporal coherence between adjacent frames by performing an effective edge preserving noise reduction strategy. They improved the enhanced images and videos by reducing noise level, better exposedness of the dark regions, improved global contrast while the finest details and edges are enhanced significantly. **John Y. Chiang and Ying-Ching Chen[23]** has introduced that there are two sources of distortion such as Light scattering and color change for underwater photography. They found that light scattering is caused by light incident on objects reflected and deflected multiple times by particles present in the water before reaching the camera. This way, it lowers the visibility and contrast of the image captured. They has also explained that color change mean the varying degrees of attenuation encountered by light traveling in the water with different wavelengths, rendering ambient underwater environments dominated by a bluish tone. They declared that existing underwater processing techniques cannot handle light scattering and color change distortions suffered by underwater images, and the possible presence of artificial lighting simultaneously.

They introduced a novel systematic technique to enhance underwater images by a dehazing algorithm, to compensate the attenuation inconsistency along the propagation path, and to take the control of the possible presence of an artificial light source.

4. RESULTS AND DISCUSSIONS

This technique has been designed and implemented in the MATLAB using image processing toolbox. Various

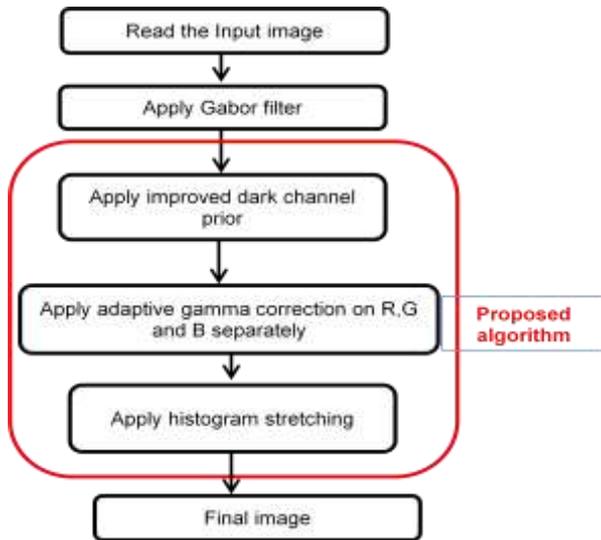


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kinds of standard color images have also been used in order to evaluate the effectiveness of the developed technique.



5. EXPERIMENTAL SETUP

Here is some representation [(a)-(h)] of proposed algorithm to enhance the images under water. Firstly underwater input image is shown below:-



Fig. 5.1 (a) input image

The figure 5.1(a) shows the input image which is captured from sea water to detect the fine edges which are not clear.



Fig. 5.1(b) Gabor filtered image

The figure 5.1(b) shows a Gabor filter image which is a linear filter used for edge detection and appropriate for texture representation and discrimination.



Fig. 5.1 (c) dark channel prior image

The figure 5.1(c) shows the dark channel prior image which provides an estimation of the haze element present in the image. Dark Channel provide a good solution for most of the outdoor haze images and for exceptionally white image content over a white background, haze itself becomes invisible.



Fig. 5.1 (d) input depth image

The figure 5.1(d) shows the input depth image which provides the depth of the scene.



Fig. 5.2 (e) filtered depth image



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The figure 5.1(e) shows the filtered depth image which shows the clarity of the depth of the image.



Fig. 5.1 (f) proposed image



Fig. 5.1 (g) gamma correction image

The figure 5.1(g) shows the gamma correction image which is the name of a nonlinear operation used to code and decode luminance or tri-stimulus values of image systems.

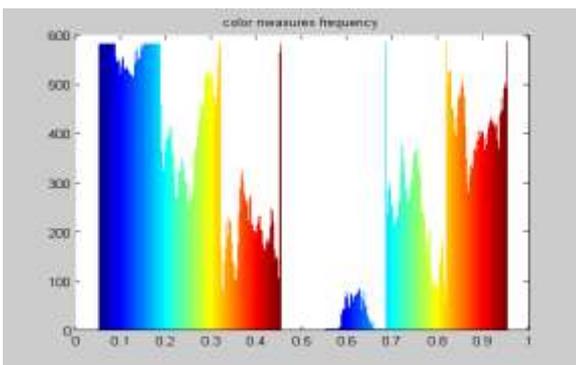


Fig. 5.1 (h) color measures frequency

The figure 5.1(h) shows the color measures frequency which defines effect of the colors on images.

6. PERFORMANCE EVALAUTION
Parameter results for underwater images

6.1. Mean Square Error

Table 6.1(a) is showing the quantized analysis of the mean square error. As mean square error need to be reduced therefore the proposed algorithm is showing the better results than the available methods as mean square error is less in every case.

Table 6.1(a) MSE values of underwater images for existing and proposed algorithm.

Images	Existing	Proposed
1.jpg	0.0065	0.0024
2.jpg	0.1007	0.0221
3.jpg	0.2372	0.0013
4.jpg	0.0345	0.0181
5.jpg	0.1341	0.0977
6.jpg	0.0190	0.0013
7.jpg	0.0015	0.0013
8.jpg	0.0490	0.0360
9.jpg	0.0237	0.0077
10.jpg	0.0192	0.0026
11.jpg	0.02188	0.0456
12.jpg	0.0496	0.0034

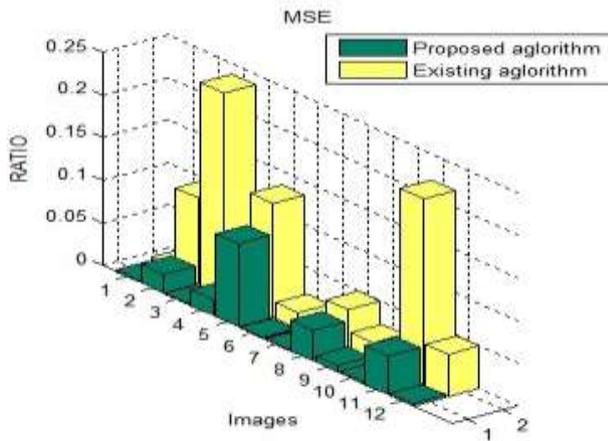
Table 6.1(a) shows the result of MSE for many underwater images, the two corresponding values for each image shows the difference between the existing and proposed algorithm. Here in this the values are decreased for each image from existing to proposed algorithm.



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Graph 6.1(a): figure of merit (MSE)

Graph 6.1(a) shows the various images on X-axis and rate on Y-axis, the two bar lines indicate the results according to the values of existing and proposed parameters of previous MSE table and results shows the figure of merit for MSE.

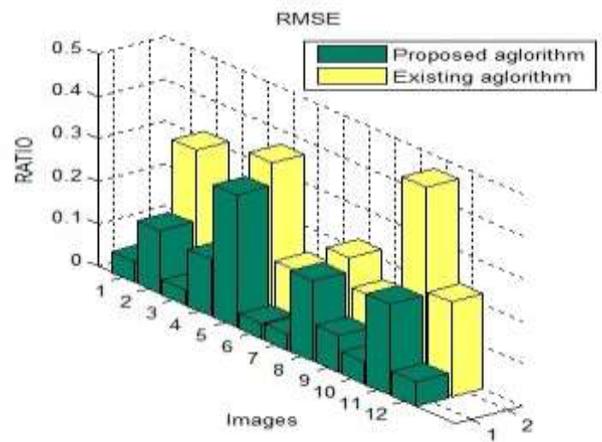
6.2. Root Mean Square Error

Table 6.1(b) RMSE values of underwater images for existing and proposed algorithm

Images	Existing	Proposed
1.jpg	0.0805	0.0490
2.jpg	0.3174	0.1487
3.jpg	0.04870	0.0355
4.jpg	0.1859	0.1344
5.jpg	0.3662	0.3126
6.jpg	0.1379	0.0360
7.jpg	0.0392	0.0365
8.jpg	0.2214	0.1898
9.jpg	0.1538	0.0877
10.jpg	0.1385	0.0507

11.jpg	0.4677	0.2135
12.jpg	0.2228	0.0582

Table 6.1(b) shows the result of RMSE for many underwater images, the two corresponding values for each image shows the difference between the existing and proposed algorithm. Here in this the values are decreased for each image from existing to proposed algorithm.



Graph 6.1(b): parameter figure of merit (RMSE)

Graph 6.1(b) shows the various images on X-axis and rate on Y-axis, the two bar lines indicate the results according to the values of existing and proposed algorithm of previous RMSE table and results shows the parameter figure of merit for RMSE.

6.3. Peak Signal Noise Ratio

Table 6.1(c) PSNR values of underwater images for existing and proposed.

Images	Existing	Proposed
1.jpg	70.0131	74.3244
2.jpg	58.0998	64.6862
3.jpg	54.3804	77.1181
4.jpg	62.7471	65.5650



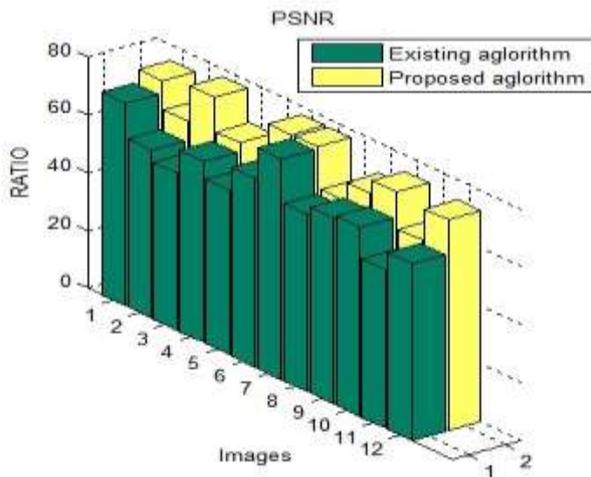
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5.jpg	56.8572	58.2310
6.jpg	65.3397	77.0050
7.jpg	76.2707	76.8964
8.jpg	61.2280	62.5660
9.jpg	64.3906	69.2723
10.jpg	65.3026	74.0241
11.jpg	54.7307	61.5412
12.jpg	61.1727	72.8329

Table 6.1(b) shows the result of PSNR for many underwater images, the two corresponding values for each image shows the difference between the existing and proposed algorithm. Here in this the values are increased for each image from existing to proposed algorithm.



Graph 6.1(c): Pratt figure of merit (PSNR)

Graph 6.1(c) shows the various images on X-axis and rate on Y-axis, the two bar lines indicate the results according to the values of existing and proposed Pratt of previous PSNR table and results shows the Pratt figure of merit for PSNR.

Table 6.1(d) structural contents values of underwater images for existing and proposed.

Images	Existing	Proposed
1.jpg	0.9124	1.0558
2.jpg	0.2462	0.4691
3.jpg	0.2730	0.3828
4.jpg	0.8286	1.2816
5.jpg	0.2913	0.3351
6.jpg	0.8959	1.0222
7.jpg	0.9558	0.9958
8.jpg	0.5631	0.6048
9.jpg	0.5990	0.8030
10.jpg	0.7675	1.0841
11.jpg	0.1550	0.3457
12.jpg	0.4728	0.0582

Table 6.1(d) shows the result of structural contents for many underwater images, the two corresponding values for each image shows the difference between the existing and proposed parameters. Here in this, the values are increased for each image from existing to proposed parameters.

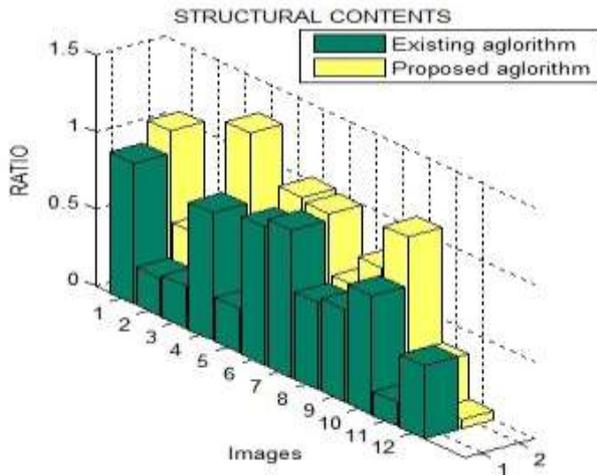
6.4. Structural Contents



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Graph 6.1(d): figure of merit (structural contents)

Graph 6.1(d) shows the various images on X-axis and rate on Y-axis, the two bar lines indicate the results according to the values of existing and proposed parameters of previous structural contents table and results shows the parameters figure of merit for structural contents.

6.5. Maximum Difference

Table 6.1(e) maximum difference values of underwater images for existing and proposed.

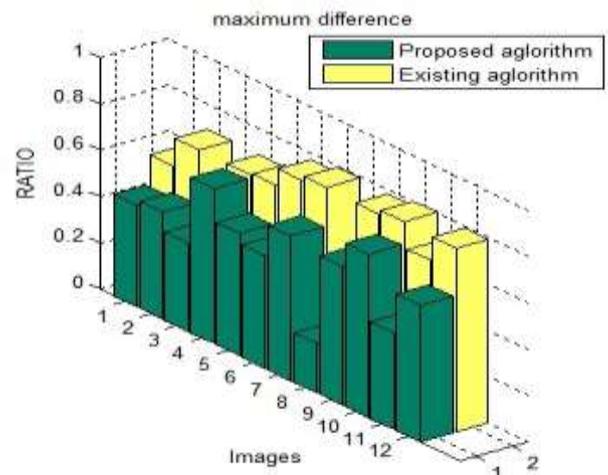
Images	Existing	Proposed
1.jpg	0.5636	0.4400
2.jpg	0.6876	0.4620
3.jpg	0.2730	0.3828
4.jpg	0.6844	0.6709
5.jpg	0.6967	0.5292
6.jpg	0.7696	0.4843
7.jpg	0.7913	0.6241

7. CONCLUSION

Image enhancement algorithms become more useful for many vision applications. Image enhancement technique is one the popular techniques of digital image processing

8.jpg	0.2582	0.2121
9.jpg	0.7808	0.5989
10.jpg	0.8029	0.7042
11.jpg	0.6871	0.4163
12.jpg	0.7913	0.5891

Table 6.1(e) shows the result of maximum difference for many underwater images, the two corresponding values for each image shows the difference between the existing and proposed parameters. Here in this the values are decreased for each image from existing to proposed parameters.



Graph 6.1(e): figure of maximum difference

Graph 6.1(e) shows the various images on X-axis and rate on Y-axis, the two bar lines indicate the results according to the values of existing and proposed parameters of previous maximum difference table and results shows the figure of merit for maximum difference.

which is used to improve visibility of the images. There are a number of image enhancement techniques which has been developed for improving the quality of the digital images. In this research, different enhancement



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techniques have been evaluated. It is found that there are certain limitations in the existing techniques. Existing researchers have not considered many issues such as noise issues; even no one has focused on integrated approach of the Adaptive gamma correction and Dark channel prior and uneven illuminations; no technique is accurate for different kind of circumstances. And they also have avoided the use of histogram stretching and Gabor filter to reduce the noise problem which will be presented in the output image of the existing image enhancement algorithms. This research work will evaluate and compare the performance of the image enhancement using Gabor filter, dark channel prior and

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