Underwater Image Enhancement using DIP

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***Abstract*— A high-quality underwater image is essential to many industrial and academic applications in the field of image processing and analysis. Unfortunately, underwater images frequently demonstrate poor visual quality of low contrast, blurring, darkness, and color diminishing. The image captured in water is hazy due to the several effects of the underwater medium. These effects are governed by the suspended particles that lead to absorption and scattering of light during image formation process. The underwater medium is not friendly for imaging data and brings low contrast and fade color issues. Therefore, during any image-based exploration and inspection activity, it is essential to enhance the imaging data before going for further processing. In our project we plan to incorporate the use of several techniques to achieve this. We successfully applied half a dozen of techniques and finally solved this problem. We were able to produce a much clearer images with appropriate amount of light and sharpness.**

We have deployed algorithms like, Gamma Correction, Histogram Equalization, MATLAB Fusion, Color Balancing and others and have tries to develop a python script that takes an image as input and gives a much better and restored image as output.

Keywords—underwater image enhancement, gamma correction, histogram equalization, MATLAB fusion

I. INTRODUCTION

Firstly, we introduce the key causes of quality reduction in underwater images, in terms of the underwater image formation model (IFM). Then, we review underwater restoration methods, considering both the IFM-free and the IFM-based approaches. Next, we present a comparative evaluation of underwater image enhancement methods, considering also the prior-based parameter estimation algorithms of the IFM-based methods, using both subjective and objective analysis. Starting from this study, we pinpoint the key shortcomings of existing methods, drawing recommendations for future research in this area.

We have studied various algorithms to target certain specific factors that determine image clarity. These are some of the techniques:

- Histogram Equalisation & Transformation
- Unsupervised Colour Correction Method (UCM)
- Fusion-Matlab
- Gamma Correction
- Dark Channel Prior.

II. PROBLEM STATEMENT AND MOTIVATION

Often the image taken underwater is not clear and blurry, this happens due to absence of proper light and sufficient disturbance in the path of light that is available there. As a result, the image is blurry and of poor quality.

III. LITERATURE SURVEY

[1] Underwater image restoration based on image blurriness and light absorption.
Propose a depth estimation method for underwater scenes based on image blurriness and light absorption, which can be used in the image formation model (IFM) to restore and enhance underwater images.

[2] An in-depth survey of underwater image enhancement and restoration.
Provide detailed objective evaluations and analysis of the representative methods on five types of underwater scenarios, which verifies the applicability of these methods in different underwater conditions.

[3] Automated underwater image restoration and retrieval of related optical properties.
The images are then restored using measured or modelled PSFs. An objective image quality metric, tuned with environmental optical properties, is designed to gauge the effectiveness of the restoration, and serves to check the optimization approach.

[4] Underwater image restoration based on a new underwater image formation model.
Medium transmission estimation method for underwater image based on joint prior is proposed, which, respectively, predicts the medium transmissions of three channels of an underwater image.

[5] Underwater image restoration based on convolutional neural network.
Propose an effective convolutional neural network (CNN) based approach for underwater image restoration, which consists of a transmission estimation network (T-network) and a global ambient light estimation network (A-network)

[6] An efficient nonlocal variational method with application to underwater image restoration.
Perform a Gamma correction operation on the recovered image. Both the real underwater image application test and the simulation experiment demonstrate that the proposed underwater nonlocal total variational (UNLTV) approach achieves superb performance on dehazing, denoising, and improving the visibility of underwater images.

[7] Fusion of underwater image enhancement and restoration.
A novel technique named Fusion of Underwater Image Enhancement and Restoration (FUIER) has been proposed which enhances as well as restores underwater images with a target to act on all major issues in underwater images, i.e., colour cast removal, contrast enhancement and dehazing.

IV. PROPOSED SYSTEM

To achieve the result as in the image on the right side, we have devised this project in a way that we have included four major domains of underwater image restoration, that help us to remove the blurriness of an image by varying various factors such as sharpness, saturation, RGB index and many more.

We have developed a python code for different techniques and by taking a blurry image as input we have tried our best to enhance to the maximum possible level and generate that restored image as an output. Also, we have included a MATLAB based technique known as Fusion MATLAB

A. MODULES AND THEIR DESCRIPTION

So, we have divided our project into four modules and prepared codes for them as per our requirement. The four techniques that we have deployed are:

- Fusion MATLAB
- Gamma Correction
- Histogram Equalization
- Integrated Colour Model

Gamma Correction

Gamma is an important but seldom understood characteristic of virtually all digital imaging systems. It defines the relationship between a pixel's numerical value and its actual luminance. Without gamma, shades captured by digital cameras wouldn't appear as they did to our eyes (on a standard monitor). It's also referred to as gamma correction, gamma encoding or gamma compression, but these all refer to a similar concept. Understanding how gamma works can improve one's exposure technique, in addition to helping one make the most of image editing.

Gamma refers to the brightness of a monitor or computer display. It is a setting that determines how bright the output of the display will be. Therefore, "gamma correction" is used to alter the output levels of a monitor.

While the gamma setting affects the brightness of a display, it is not identical to the brightness. This is because gamma adjustments are not linear, like brightness levels are. Instead, the gamma setting applies a function to the input levels, which produces the final output level.

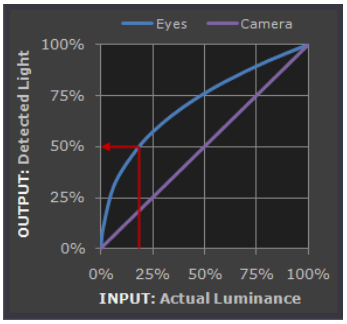

Figure 1 Trend between the Detected light and Actual Luminance

Gamma Correction for Underwater image restoration

Firstly, by analysing the attenuation characteristics of RGB channels, the intensity and the edge information of red channel are compensated by weighting the attenuation coefficient ratio between different channels to correct the chromaticity. Then the gamma correction model is employed to stretch the intensity range to enhance the contrast which makes the image look clearer. The experimental results show that the proposed algorithm can correct the colour cast effect and improve the contrast by nearly 2 times for the underwater images with too much red component attenuation.

Histogram Equalization

Histogram Equalization is an image processing technique that adjusts the contrast of an image by using its histogram. To enhance the image's contrast, it spreads out the most frequent pixel intensity values or stretches out the intensity range of the image. By accomplishing this, histogram equalization allows the image's areas with lower contrast to gain a higher contrast.

Why Do You Use Histogram Equalization?

It can be used when you have images that look washed out because they do not have sufficient contrast. In such photographs, the light and dark areas blend together creating a flatter image that lacks highlights and shadows.

Histogram Equalization in Underwater image restoration

Firstly, an underwater image is separated into its R (Red), G (Green), B (Blue) components and is converted from RGB colour space to HSV colour space. Secondly, extension of V element is coordinated under the control of the start and the end of the interval. Then, it is converted from HSV colour space to RGB colour space and the histogram equalization is applied to each R, G, B

components. After that, R, G, B components are combined to form a colour image. Finally, Gaussian low-pass filter is applied to the underwater image.

Integrated Colour Model

The objective of this approach is twofold. Firstly, the contrast stretching of RGB algorithm is applied to equalize the colour contrast in images. Secondly, the saturation and intensity stretching of HSI is used to increase the true colour and solve the problem of lighting.

Integrated Colour Model in Underwater image restoration

To restore underwater images, we propose a Red Channel method, where colours associated to short wavelengths are recovered, as expected for underwater images, leading to a recovery of the lost contrast. The Red Channel method can be interpreted as a variant of the Dark Channel method used for images degraded by the atmosphere when exposed to haze. Experimental results show that our technique handles gracefully artificially illuminated areas, and achieves a natural colour correction and superior or equivalent visibility improvement when compared to other state-of-the-art methods.

Fusion MATLAB

The image fusion process is defined as gathering all the important information from multiple images, and their inclusion into fewer images, usually a single one. This single image is more informative and accurate than any single source image, and it consists of all the necessary information. The purpose of image fusion is not only to reduce the amount of data but also to construct images that are more appropriate and understandable for the human and machine perception. In computer vision, multisensory image fusion is the process of combining relevant information from two or more images into a single image. The resulting image will be more informative than any of the input images. Many methods exist to perform image fusion. The very basic one is the high pass filtering technique. Later techniques are based on Discrete Wavelet Transform, uniform rational filter bank, and Laplacian pyramid.

Why image fusion?

Multi sensor data fusion has become a discipline which demands more general formal solutions to a number of application cases. Several situations in image processing require both high spatial and high spectral information in a single image. This is important in remote sensing. However, the instruments are not capable of providing such information either by design or because of observational constraints. One possible solution for this is data fusion.

Fusion MATLAB for Underwater image enhancement

This is MATLAB image fusion method using wavelets. It requires a toolbox called 'wfusimg'. The basic principle of image fusion using wavelets is to merge the wavelet decompositions of two images using fusion methods.

V. EXPERIMENTAL SETUP

- OPENCV: OpenCV is a huge open-source library for computer vision, machine learning, and image processing.
- MATLAB: Image Processing Toolbox™ in MATLAB provides a comprehensive set of reference-standard algorithms and workflow apps for image processing, analysis, visualization, and algorithm development.
- Numpy: By reading the image as a NumPy array ndarray , various image processing can be performed using NumPy functions. By the operation of ndarray, you can get and set (change) pixel values, trim images, concatenate images, etc.
- You will need to install the following libraries:
  cv2, scipy, numpy, matplotlib, scikit-image, natsort, math, datetime

VI. IMPLEMENTATION AND RESULTS

Gamma Correction:
We used a gamma value of 1.5 this corrected the overall brightness of the image. The method decreased the brightness, the output image is now clearer.

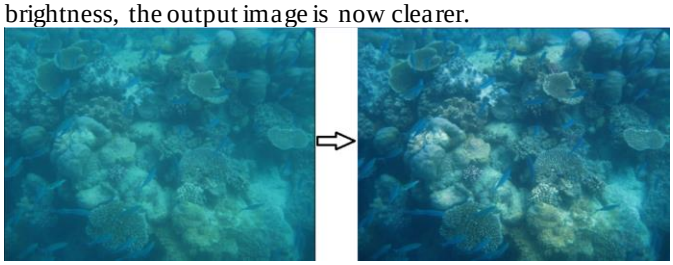

Figure 2 Gamma corrected image

Histogram Equalization:
We used histogram equalization to correct the image. This technique improves the overall contrast of the image. When we analyzed the histogram of the input images, we found that there were steep spikes in the blue and green pixel values. After equalization all the other colors were visible and the contrast was improved.

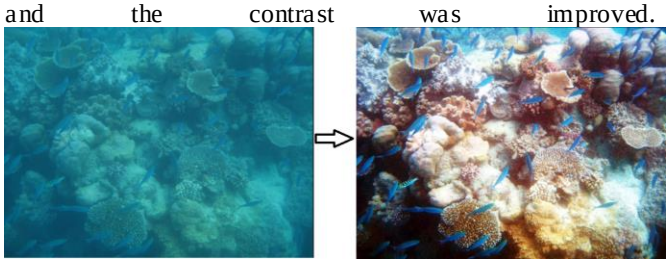

Figure 3 Histogram equalized image

Integrated color Model:
The integrated color model takes some time to process an image as it is applying stretching on many components of the image. The output obtained was very clear, the greenish-blueish tinge was removed. The original colors were maintained.

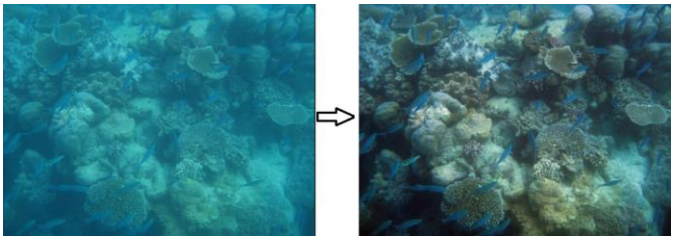

Figure 4 Integrated color model output

MATLAB Fusion:
This is MATLAB image fusion method using wavelets. It requires a toolbox called 'wfusimg'. The basic principle of image fusion using wavelets is to merge the wavelet decompositions of two images using fusion methods.
It can also be described as a restoration of a image from its two fuzzy images or blurred and hazed images using fusion. First of all we require two images for the wavelet function. Taking Gamma corrected and sharpened image as input. First the input image is converted into Grayscale image so that less information needs to be provided for each pixel value to enhance the contrast.

This Fusion method takes places in several steps:
a.) Input image is converted to a white balanced image with red and blue channel correction.
b.) White balanced image is taken as input for the Gamma Correction and gamma corrected image is obtained by setting the gamma value as 0.5.
J = imadjust(white_balanced_img,[],[],gamma)
c.) Sharpening is done to the white balanced image using unsharp masking. (white balanced image + (white balanced – gaussian filter))
d.) Wavelet transform is applied on Gamma corrected image and Sharpened image. Syntax: XFUS = wfusimg (Gamma_corrected_img, Sharpened_img,'sym4',5,'max','max').

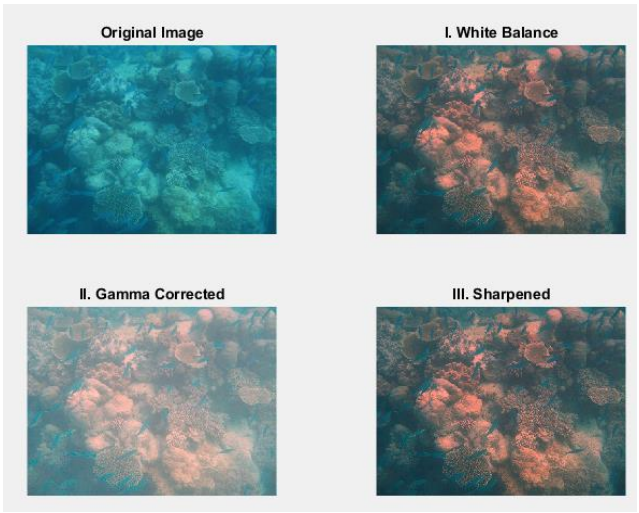

Figure 5 MATLAB Fusion output-1

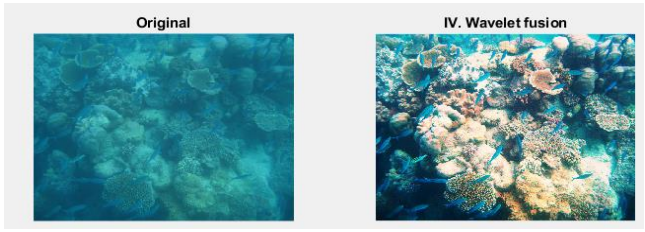

Figure 6 MATLAB Fusion output-2

VII. ACKNOWLEDGMENT

We would like to thank and express our gratitude to our teacher Dr. Geeta S. who gave us the opportunity to work and research on such an intellectual and much needed topic. We hope that our research on the topic Underwater Image Enhancement proves useful to others as well. We learnt many new concepts and also understood their practical application by implementing it and developing an interface that restores any kind of underwater image and we have tried our best to deliver amazing results.

We are overwhelmed in all gratitude and humbleness to acknowledge our depth to all those who helped us put all these ideas and thoughts, well above the level of simplicity and into something solid. We would like to express our gratitude towards our teachers, our friends, our parents and each and every one out there who helped us in accomplishing this project.

Any attempt at any level can't be satisfactorily completed without the support and guidance of our parents who helped us a lot in gathering the necessary information, collecting data and supporting us from time to time during the entire course of this project.

VIII. CONCLUSION

Through this paper we have done a thorough study and we found the common problems that happen in underwater images and photography. We studied them and did the analysis of various algorithms that help in underwater image enhancement. Fusion MATLAB was found to be the best algorithm for enhancement and provided the most improved output by eliminating greenish-bluish tint and blur that happened due to scattering of light under water.

IX. REFERENCES

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