UNDERWATER IMAGE ENHANCEMENT USING COLOR BALANCE AND FUSION

A PROJECT REPORT

Submitted by

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BONAFIDE CERTIFICATE

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INTERNAL EXAMINER **EXTERNAL EXAMINER**

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ABSTRACT

Underwater images when captured for different applications and analysis, they are degraded in quality and visual parameter; also there is sometimes information loss. Here the project presents the methodology to improve the quality of underwater images which has been degraded due different distortions like noise, light, motion blur, scattering, waves of water, color change etc. The first approach is to implement white balance for reducing color cast efficiently and enhancing the underwater images called mixture Contrast Limited Adaptive Histogram Equalization (CLAHE) color model. The method operates Contrast Limited Adaptive Histogram Equalization on RGB and HSV color model and Euclidean norm is used to combine both results together. The combined results show less mean square error and high peak signal to noise ratio (PSNR) than other methods of underwater image enhancing. It shows that the proposed method is capable of classifying coral reefs particularly when visual cues are visible. Finally the weights are one of the ways where we restore specific required information in image for better image fusion results. After fusion, the underwater image quality is enhanced thus making it more informative.

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LIST OF ABBREVIATIONS

Abbreviations	Description
CLAHE	Contrast Limited Adaptive Histogram Equalization
PSNR	Peak Signal To Noise Ratio
HSV	Hue Saturation Value
MSE	Mean Square Error
RGB	Red Green Blue
WB	White Balance
AHE	Adaptive Histogram Equalization
JPG	Joint Photographic Experts Group
PNG	Portable Network Graphics
API	Application Program Interface
M-FILES	Matlab files
CNN	Convolutional Neural Networks
AI	Artificial Intelligence
WT	Wavelet Transform

CHAPTER-1

INTRODUCTION

Reconstruction of underwater object from sequence of images distorted by moving water waves is challenging task. Underwater image processing is necessary due to quality of image captured. This image suffers from quality degradation, distortion, blurring. When taking a picture of an underwater object from outside the water container, waves on the surface cause distortion. If series of pictures are taken at various times, different distortions will be seen in each picture. The image seen by the camera is distorted by refraction as a function of both the angle of the water surface normal at the point of refraction and the amplitude of the water waves. If the water is perfectly flat (i.e., there are no waves), there will be no distortion due to refraction However, if the surface of the water is being disturbed by waves, the nature of the image distortion becomes considerably more complex. Underwater imaging is widely used in ocean exploration and other fields; however, due to absorption and scattering effects from the environment, serious degradation exists in underwater images, mainly in the form of noise, blur, etc. Reconstruction of underwater image is challenging task. Underwater images may contain distortions. Distortion may be due to both motion blur and refraction. It also contains some quality degradation, so that it is necessary to improve the quality of images. Reconstruction of images from blurred and noisy images may improve the quality of images. To recover the object from such distorted images is challenging task.

1.1. IMAGE

An image is an array or a matrix of square pixels (picture elements) arranged in columns and rows. An image (from Latin: imago) is an artifact, for example a two-dimensional picture, that has a similar appearance to some subject usually a physical object or a person.

1.1.1. PIXEL

Image processing is subset of the electronic domain where the image is converted

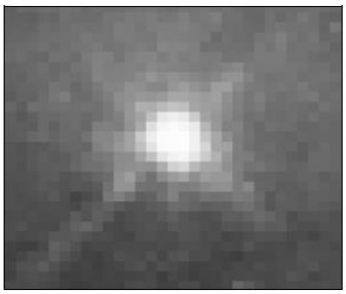


Figure 1.1: An Example Image

to an array of small integers, called *pixels*, representing a physical quantity such as scene radiance, stored in a digital memory and processed by computer or other digital hardware.

Suppose we take an image, a photo, say. For the moment, let's make things easy and suppose the photo is black and white (that is, lots of shades of grey), so no colour. We may consider this image as being a two-dimensional function, where the function values give the brightness of the image at any given point, as shown in figure 1. We may assume that in such an image brightness values can be any real numbers in the range 0.0 (black) to 1.0 (white). The ranges of x and y will clearly depend on the image, but they can take all real values between their minima and maxima.

A digital image differs from a photo in that the x, y, and f(x, y)values are all discrete. Usually they take on only integer values, so the image shown in figure 1.2 will have x and y ranging from 1to 256 each, and the brightness values also ranging from 0 (black) to 255 (white). A digital image can be considered as a large array of discrete dots, each of which has a brightness associated with it. These dots are called picture elements, or more simply pixels. The pixels surrounding a given pixel constitute its neighbourhood.

A neighborhood can be characterized by its shape in the same way as a matrix: we can speak of a 3*3 neighborhood, or of a 5*7 neighborhood. Except in very special circumstances, neighborhoods have odd numbers of rows and columns; this ensures that the current pixel is in the center of the neighborhood.

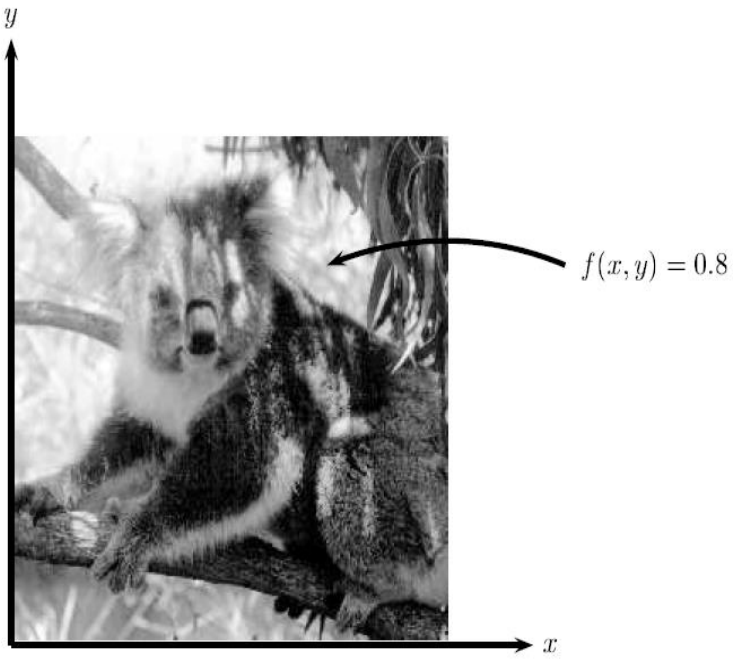


Figure 1.2: A Gray Scale Image

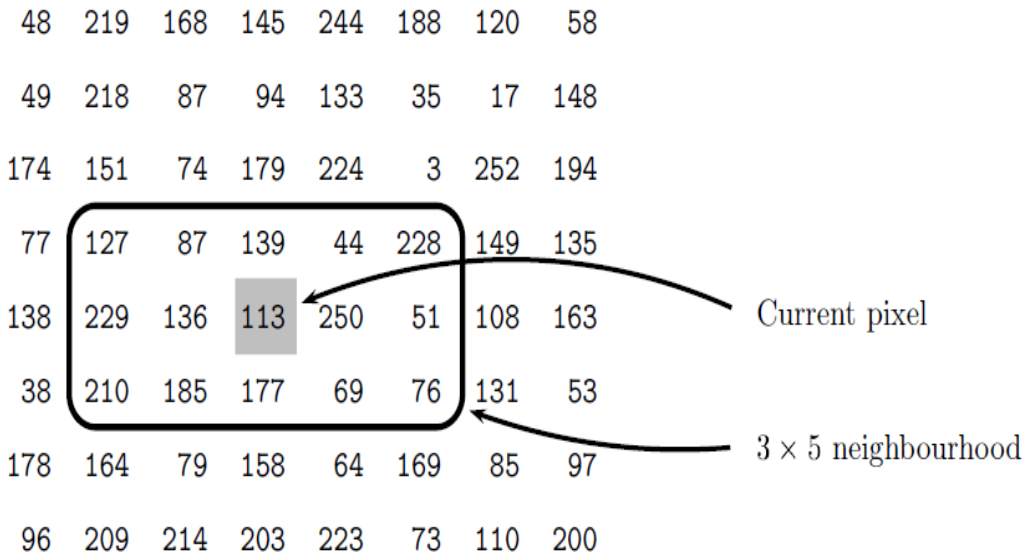


Figure 1.3: Pixel Representation

An example of a neighborhood is given in figure 1.3. If a neighborhood has an even number of rows or columns (or both), it may be necessary to specify which pixel in the neighbourhood is the "current pixel".

1.1.2. IMAGE RESOLUTION:

Pixels transform into inches through what is called "resolution", the number of pixels per square inch on a computer. Resolution allows to transform pixels into inches.

Two resolution definitions are often used in place of one another. Pixel resolution is the size (in bytes) of your image or its appearance on a computer screen. This number is tied directly to how big your image is on your hard drive. The byte-size of the image file is directly proportional to the pixel count and its size on your computer screen, which simply displays all the pixels in a fixed one-to-one grid.

Embedded resolution is different. Embedded resolution tells your printer how far apart to spread the pixels in a printed image. It determines how "fine grained" the printed image will look. It is completely independent of the pixel count (file size) of the image. A high-pixel-count image can have a low embedded resolution or vice versa. Given the same pixel count, a high embedded resolution will result in a smaller printed image (the pixels are packed together more tightly), and a low embedded resolution will result in a larger image (the pixels are more spread out).

1.1.3. IMAGE BRIGHTNESS

'Brightness' is a problem word, used in most descriptions of image quality. Often, if an image looks bad we will say that it's not 'bright', when it merely lacks contrast. So what does 'brightness' actually mean? Brightness actually describes how we experience light and not 'how it is'. If we are going to describe light and 'brightness' properly, there are two essential terms:

Luminance and Illuminance

Luminance is the light we see: reflected or radiating from objects. It is Measured in candela per square metre (cd/m^2 and the same as 'nit').

Illuminance is light we can't see directly – it is so-called ambient light, light passing through air, actually invisible until it reflects off an object (which we then see as luminance). It is Measured in lux (lx or lm/m^2).

Our eyes are exposed to such dramatic changes in light levels (far greater than a million to one) that our optical systems have to protect them. We can read newspaper headlines by the light of a full moon, which might be 0.2 lux of illuminance. Yet we can

also read outside in direct sunshine, in more than 100,000 lux. So our eyes constantly adjust – our irises contract and expand – to maintain vision consistently, protecting against damage to the retina at the back of the eye. (That reflex to look away from bright lights is important!) Right away we can understand why a screen that looks so bright in a showroom can be barely visible in a shop window!

1.1.4. CONTRAST

Contrast refers to the difference between black and white levels in images, whether on a flat panel display or a projection screen. Without good contrast, images appear to lack 'brightness', colour and definition.

The image contrast ratio refers to the difference between the luminance of the white part of an image, divided by the black part. So if the white part is one hundred times brighter than the black part, it will be 100:1, and so on.

1.2. IMAGE PROCESSING

Image processing is any form of signal processing for which the input is an image, such as a photograph or video frame; the output of image processing may be either an image or a set of characteristics or parameters related to the image. Most image-processing techniques involve treating the image as a dimensional signal and applying standard signal-processing techniques to it.

Image processing usually refers to digital image processing, but optical and analog image processing also are possible. This article is about general techniques that apply to all of them. The acquisition of images (producing the input image in the first place) is referred to as imaging

Image processing allows one to enhance image features of interest while attenuating detail irrelevant to a given application, and then extract useful information about the scene from the enhanced image. This introduction is a practical guide to the challenges, and the hardware and algorithms used to meet them.

An image is digitized to convert it to a form which can be stored in a computer's memory or on some form of storage media such as a hard disk or CD-ROM. This digitization procedure can be done by a scanner, or by a video camera connected to a frame grabber board in a computer. Once the image has been digitized, it can be operated upon by various image processing operations.

Image processing operations can be roughly divided into three major categories, Image Compression, Image Enhancement and Restoration, and Measurement Extraction. Image compression is familiar to most people. It involves reducing the amount of memory needed to store a digital image.

Image defects which could be caused by the digitization process or by faults in the imaging set-up (for example, bad lighting) can be corrected using Image Enhancement techniques.

Once the image is in good condition, the Measurement Extraction operations can be used to obtain useful information from the image.

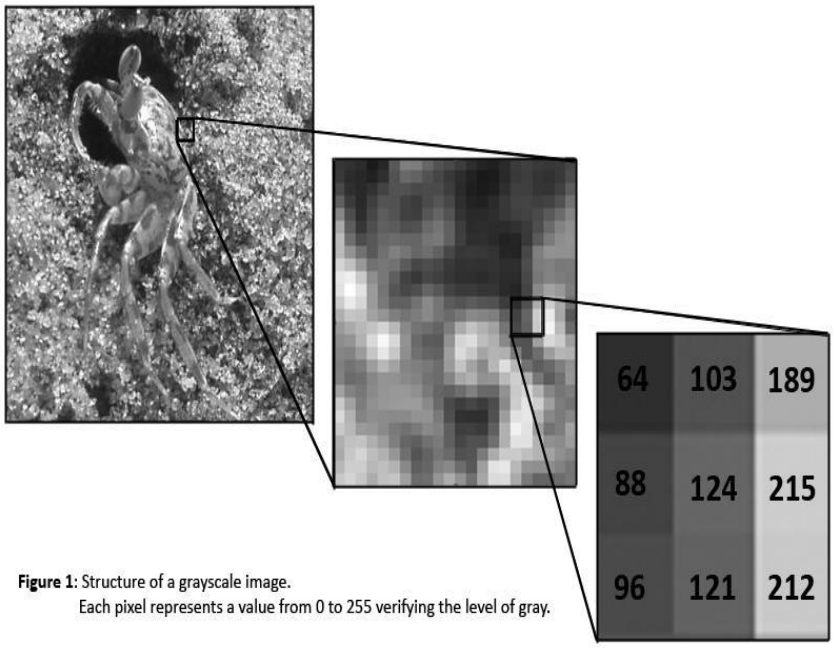


Figure 1.4: Structure of grey-scale image

The example in figure 1.4 operate on 256 gray-scale images. This means that each pixel in the image is stored as a number between 0 to 255, where 0 represents a black pixel and 255 represents a white pixel and values in-between represent shades of gray.

In figure each pixel represents a value from 0 to 255 verifying the level of gray. These operations can be extended to colour images too.

Figure 1.5: A greyscale image

In a (8-bit) greyscale image each picture element has an assigned intensity that ranges from 0 to 255. A grey scale image is what people normally call a black and white image, but the name emphasizes that such an image will also include many shades of grey.

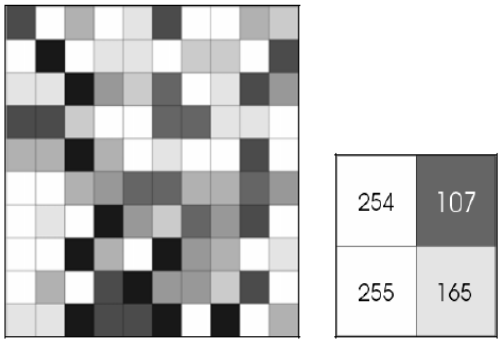


Figure 1.6: Different shades of grey

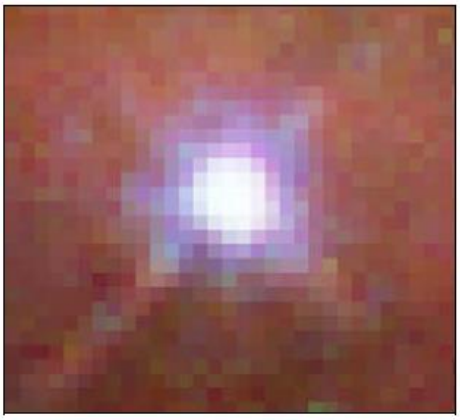


Figure 1.7: Colour image

A normal greyscale image has 8 bit colour depth = 256 greyscales. A "true colour" image has 24 bit colour depth = 8 x 8 x 8 bits = 256 x 256 x 256 colours = ~16 million colours.

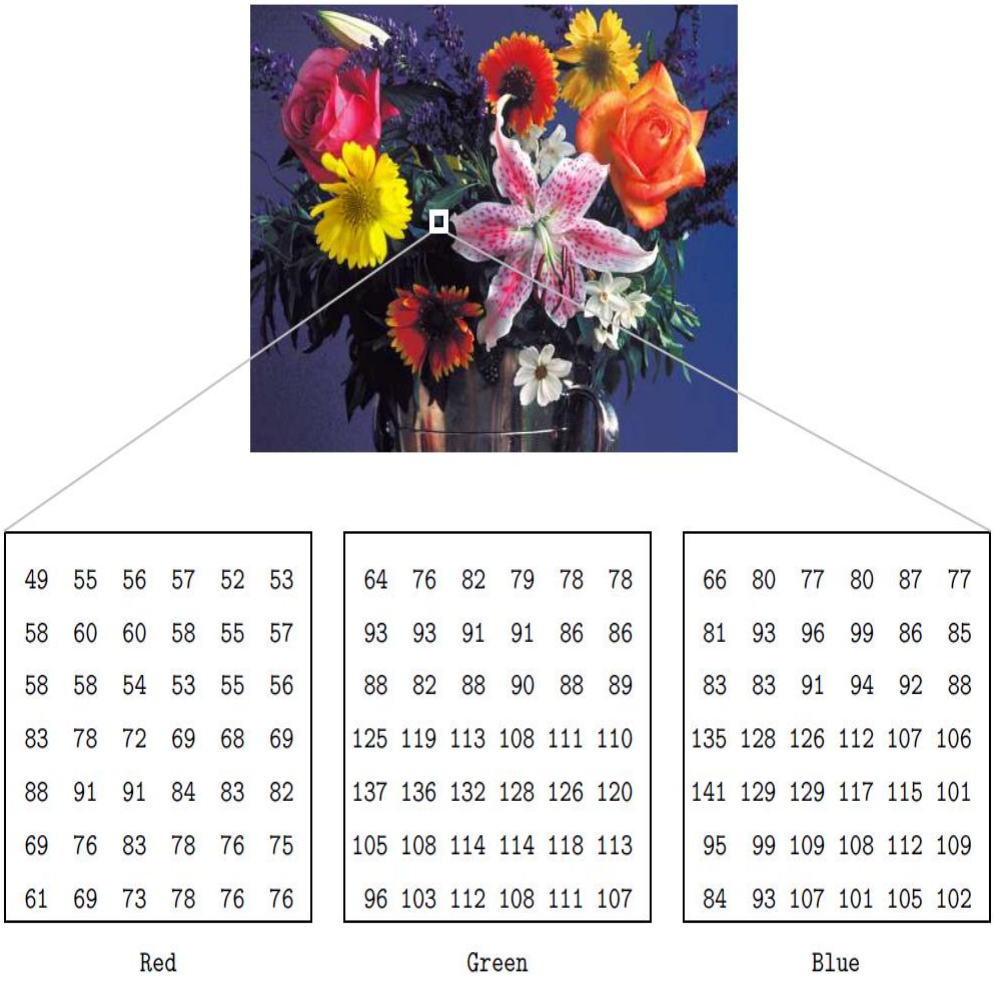


Figure 1.8: A true colour image

1.2.1. IMAGE ENHANCEMENT

Image enhancement is the improvement of digital image quality (wanted e.g. for visual inspection or for machine analysis), without knowledge about the source of degradation. If the source of degradation is known, one calls the process image restoration. Both are iconical processes, viz. input and output are images.

Many different, often elementary and heuristic methods are used to improve images in some sense. The problem is, of course, not well defined, as there is no objective measure for image quality. Here, we discuss a few recipes that have shown to be useful both for the human observer and/or for machine recognition. These methods are very problem-oriented: a method that works fine in one case may be completely inadequate for another problem.

Apart from geometrical transformations some preliminary grey level adjustments may be indicated, to take into account imperfections in the acquisition system. This can be done pixel by pixel, calibrating with the output of an image with constant brightness. Frequently space-invariant grey value transformations are also done for contrast stretching, range compression, etc. The critical distribution is the relative frequency of each grey value, the grey value histogram.

Image editing encompasses the processes of altering images, whether they are digital photographs, traditional photochemical photographs, or illustrations. Traditional analog image editing is known as photo retouching, using tools such as an airbrush to modify photographs, or editing illustrations with any traditional art medium. Graphic software programs, which can be broadly grouped into vector graphics editors, raster graphics editors, and 3D modelers, are the primary tools with which a user may manipulate, enhance, and transform images. Many image editing programs are also used to render or create computer art from scratch.

Basics of Image Editing

Raster images are stored in a computer in the form of a grid of picture elements, or pixels. These pixels contain the image's color and brightness information. Image editors can change the pixels to enhance the image in many ways. The pixels can be changed as a group, or individually, by the sophisticated algorithms within the image editors. This article mostly refers to bitmap graphics editors, which are often used to alter photographs and other raster graphics. However, vector graphics software, such as Adobe Illustrator, CorelDRAW, Xara Designer Pro, PixelStyle Photo Editor, Inkscape or Vectr, are used to create and modify vector images, which are stored as descriptions of lines, Bézier curves, and text instead of pixels. It is easier to rasterize a vector image than to vectorize a raster image; how to go about vectorizing a raster image is the focus of much research in the field of computer vision. Vector images can be modified more easily, because they contain descriptions of the shapes for easy rearrangement. They are also scalable, being rasterizable at any resolution.

Automatic Image Enhancement

Camera or computer image editing programs often offer basic automatic image enhancement features that correct color hue and brightness imbalances as well as other image editing features, such as red eye removal, sharpness adjustments, zoom features and automatic cropping. These are called automatic because generally they happen without user interaction or are offered with one click of a button or mouse button or by selecting an option from a menu. Additionally, some automatic editing features offer a combination of editing actions with little or no user interaction.

Digital Data Compression

Many image file formats use data compression to reduce file size and save storage space. Digital compression of images may take place in the camera, or can be done in

the computer with the image editor. When images are stored in JPEG format, compression has already taken place. Both cameras and computer programs allow the user to set the level of compression.

Some compression algorithms, such as those used in PNG file format, are lossless, which means no information is lost when the file is saved. By contrast, the JPEG file format uses a lossy compression algorithm by which the greater the compression, the more information is lost, ultimately reducing image quality or detail that can not be restored. JPEG uses knowledge of the way the human brain and eyes perceive color to make this loss of detail less noticeable.

Image Editor Features

Listed below are some of the most used capabilities of the better graphic

manipulation programs. The list is by no means all inclusive. There are a myriad of choices associated with the application of most of these features.

Selection

One of the prerequisites for many of the applications mentioned below is a method of selecting part(s) of an image, thus applying a change selectively without affecting the entire picture. Most graphics programs have several means of accomplishing this, such as:

- A marquee tool for selecting rectangular or other regular polygon-shaped regions,
- A lasso tool for freehand selection of a region,
- A magic wand tool that selects objects or regions in the image defined by proximity of color or luminance,
- Vector-based pen tools,

As well as more advanced facilities such as edge detection, masking, alpha compositing, and color and channel-based extraction. The border of a selected area in an image is often animated with the marching ants effect to help the user to distinguish the selection border from the image background.

Layers

Another feature common to many graphics applications is that of Layers, which are analogous to sheets of transparent acetate (each containing separate elements that make up a combined picture), stacked on top of each other, each capable of being individually positioned, altered and blended with the layers below, without affecting any of the elements on the other layers. This is a fundamental workflow which has become the norm for the majority of programs on the market today, and enables maximum flexibility for the user while maintaining non-destructive editing principles and ease of use.

Image Size Alteration

Image editors can resize images in a process often called image scaling, making them larger, or smaller. High image resolution cameras can produce large images which are often reduced in size for Internet use. Image editor programs use a mathematical process called resampling to calculate new pixel values whose spacing is larger or smaller than the original pixel values. Images for Internet use are kept small, say 640 x 480 pixels which would equal 0.3 megapixels.

Cropping an Image

Digital editors are used to crop images. Cropping creates a new image by selecting a desired rectangular portion from the image being cropped. The unwanted part of the image is discarded. Image cropping does not reduce the resolution of the area

cropped. Best results are obtained when the original image has a high resolution. A primary reason for cropping is to improve the image composition in the new image.

Histogram

Image editors have provisions to create an image histogram of the image being edited. The histogram plots the number of pixels in the image (vertical axis) with a particular brightness value (horizontal axis). Algorithms in the digital editor allow the user to visually adjust the brightness value of each pixel and to dynamically display the results as adjustments are made. Improvements in picture brightness and contrast can thus be obtained.

Noise Reduction

Image editors may feature a number of algorithms which can add or remove noise in an image. Some JPEG artifacts can be removed; dust and scratches can be removed and an image can be de-speckled. Noise reduction merely estimates the state of the scene without the noise and is not a substitute for obtaining a "cleaner" image. Excessive noise reduction leads to a loss of detail, and its application is hence subject to a trade-off between the undesirability of the noise itself and that of the reduction artifacts. Noise tends to invade images when pictures are taken in low light settings. A new picture can be given an 'antiqued' effect by adding uniform monochrome noise.

Removal of Unwanted Elements

Most image editors can be used to remove unwanted branches, etc., using a "clone" tool. Removing these distracting elements draws focus to the subject, improving overall composition.

Image Orientation

Image editors are capable of altering an image to be rotated in any direction and to any degree. Mirror images can be created and images can be horizontally flipped or vertically flopped. A small rotation of several degrees is often enough to level the horizon, correct verticality (of a building, for example), or both. Rotated images usually require cropping afterwards, in order to remove the resulting gaps at the image edges.

Perspective Control and Distortion

Some image editors allow the user to distort (or "transform") the shape of an image. While this might also be useful for special effects, it is the preferred method of correcting the typical perspective distortion which results from photographs being taken at an oblique angle to a rectilinear subject. Care is needed while performing this task, as the image is reprocessed using interpolation of adjacent pixels, which may reduce overall image definition. The effect mimics the use of a perspective control lens, which achieves a similar correction in-camera without loss of definition.

Enhancing Images

In computer graphics, the process of improving the quality of a digitally stored image by manipulating the image with software. It is quite easy, for example, to make an image lighter or darker, or to increase or decrease contrast. Advanced photo enhancement software also supports many filters for altering images in various ways. Programs specialized for image enhancement are sometimes called image editors.

Sharpening and Softening Iimages

Graphics programs can be used to both sharpen and blur images in a number of ways, such as unsharp masking or deconvolution. Portraits often appear more pleasing when selectively softened (particularly the skin and the background) to better make the subject stand out.[citation needed] This can be achieved with a camera by using a large aperture, or in the image editor by making a selection and then blurring it. Edge enhancement is an extremely common technique used to make images appear sharper, although purists frown on the result as appearing unnatural. Another form of image sharpening involves a form of contrast. This is done by finding the average color of the pixels around each pixel in a specified radius, and then contrasting that pixel from that average color. This effect makes the image seem clearer, seemingly adding details. An

example of this effect can be seen to the right. It is widely used in the printing and photographic industries for increasing the local contrasts and sharpening the images. Examples of simple grey level transformations in this domain are:

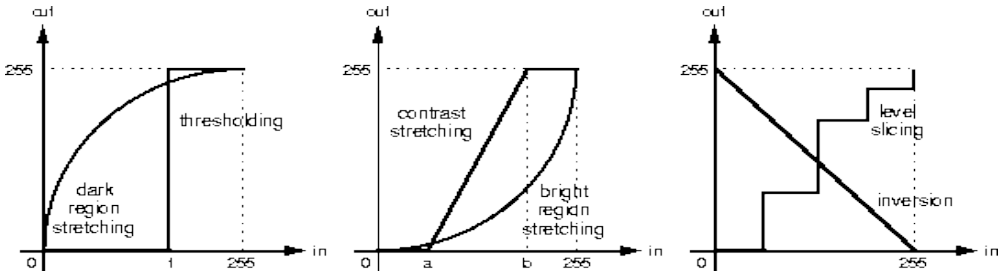


Figure 1.9: The grey value histogram

Grey values can also be modified such that their histogram has any desired shape, e.g. flat (every grey value has the same probability). All examples assume *point processing*, viz. each output pixel is the function of one input pixel; usually, the transformation is implemented with a look-up table:

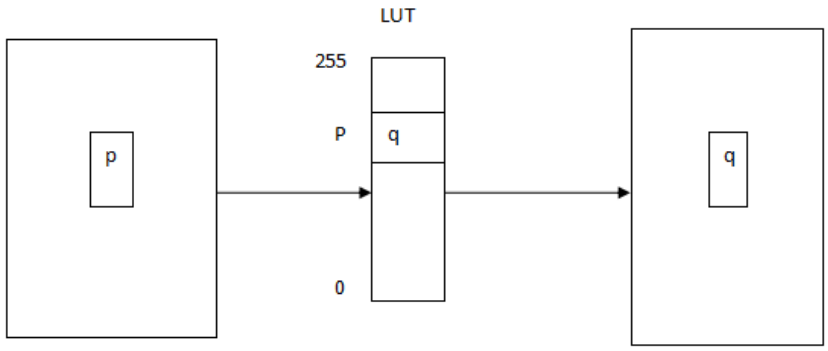


Figure 1.10: Lookup table

Physiological experiments have shown that very small changes in luminance are recognized by the human visual system in regions of continuous grey value, and not at all seen in regions of some discontinuities. Therefore, a design goal for image enhancement often is to smooth images in more uniform regions, but to preserve edges. On the other hand, it has also been shown that somehow degraded images with enhancement of certain features, e.g. edges, can simplify image interpretation both for a

human observer and for machine recognition. A second design goal, therefore, is image sharpening. All these operations need neighbourhood processing, viz. the output pixel is a function of some neighbourhood of the input pixels:

These operations could be performed using linear operations in either the frequency or the spatial domain. We could, e.g. design, in the frequency domain, one-dimensional low or high pass filters (Filtering), and transform them according to the two-dimensional case. Unfortunately, linear filter operations do not really satisfy the above two design goals; in this book, we limit ourselves to discussing separately only (and superficially) Smoothing and Sharpening.

Here is a trick that can speed up operations substantially, and serves as an example for both point and neighbourhood processing in a binary image: we number the pixels in a 3x3 neighbourhood like:

5	6	7
4	8	0
3	2	1

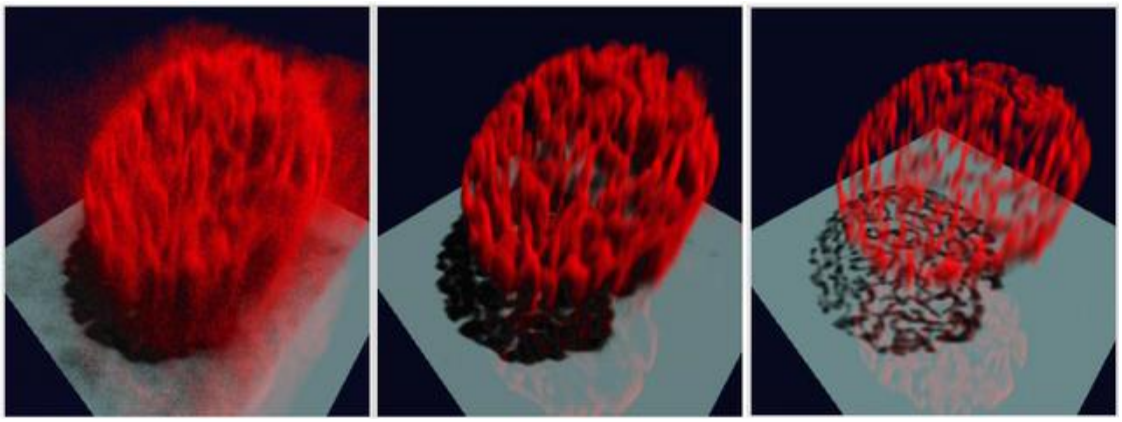
Figure 1.11: The grey value histogram

and denote the binary values (0,1) by b_i (i = 0,8); we then concatenate the bits into a 9-bit word, like $b_8b_7b_6b_5b_4b_3b_2b_1b_0$. This leaves us with a 9-bit grey value for each pixel, hence a new image (an 8-bit image with b_8 taken from the original binary image will also do). The new image corresponds to the result of a convolution of the binary image, with a 3 x 3 matrix containing as coefficients the powers of two. This neighbour image can then be passed through a look-up table to perform erosions, dilations, noise cleaning, skeletonization, etc. Apart from point and neighbourhood processing, there are also global processing techniques, i.e. methods where every pixel depends on all pixels of the whole image. Histogram methods are usually global, but they can also be used in a neighbourhood.

(a) (b)

Figure 1.12: Image enhancement (a) original image (b) enhanced image

1.2.2. IMAGE RESTORATION



(a) (b) (c)

Figure 1.13: Image restoration (a) original image (b) partially restored image(c) fully restored image basis.

The purpose of image restoration is to "compensate for" or "undo" defects which degrade an image. Degradation comes in many forms such as motion blur, noise, and camera misfocus. In cases like motion blur, it is possible to come up with a very good estimate of the actual blurring function and "undo" the blur to restore the original image. In cases where the image is corrupted by noise, the best we may hope to do is to compensate for the degradation it caused. In this project, we will introduce and implement several of the methods used in the image processing world to restore images.

CHAPTER 2

LITERATURE REVIEW

Michele Ruta; Floriano Scioscia; Giuseppe Loseto; Eugenio Di Sciascio, ”Underwater image processing: state of the art of restoration and image enhancement methods”, 2013.

In this paper, the authors presented restoration of underwater Images by fusion method. In the paper they presented novel strategy which enhances the visibility of underwater images effectively. They have focused on image fusion which is contributed by different weight map images. The algorithm consists of different inputs mainly computed from minmax enhanced and white balanced of input distorted image.

Liming Chen; Chris Nugent; George Okeyo, ”Underwater image processing: state of the art of restoration and image enhancement methods”,2014.

In this paper, the authors presented novel strategy to enhance underwater images and videos by fusion. Their approach was first to decrease the temporal coherent noise from the image. They have also defined different weight map for videos as Laplacian contrast weight, Local contrastWeight, Saliency weight, exposedness weight. Then fused image is obtained by fusion of input image with the weights.

Jin Wang; Jiayi Cao; Bin Li; Sungyoung Lee; R. Simon Sherratt ,”Control of underwater vehicles in full unsteady flow”,2015.

Multisensor image fusion technique for reconstruction of images, wavelet based image fusion technique was used to get improvement in resolution of images. Multi-sensor image fusion is a synthesis technique that can fuse source images from multiple sensors into a high-quality image with comprehensive information. The technique is widely used in visual sensor networks, such as security monitoring, and image inpainting.

Luigi Atzori; Antonio Iera; GiacomoMorabito , ”Enhancing underwater images and videos by fusion”,2014.

It has compared different image fusion techniques with PSNR peak signal to noise ratio, EN entropy, and MSE mean squared error. Thus image fusion using wavelet transform gives better results as compared to other methods. Review results thatspatial domain provide high spatial resolution, But spatial domain has image blurring problem. Wavelet transform is a very good technique for image fusion which provides high quality spectral content.

CHAPTER 3

PROPOSED SYSTEM

3.1 EXISTING SYSTEM

- There have been several attempts to restore and enhance the visibility of such degraded images. Since the deterioration of underwater scenes results from the combination of multiplicative and additive processes traditional enhancing techniques such as gamma correction, histogram equalization appear to be strongly limited for such a task.

3.1.1 DISADVANTAGES

- Existing system having number of issues that reduce their practical applicability.
- Cannot reduce color cost efficiently.

3.2 PROPOSED SYSTEM

- In proposed system we use 3 approach. firstly, to implement white balance for reducing color cast efficiently and Enhancing the underwater images called mixture Contrast Limited Adaptive Histogram Equalization (CLAHE) color model.
- The method operates Contrast Limited Adaptive Histogram Equalization on RGB and HSV color model and Euclidean norm is used to combine both results together.
- The combined results show less mean square error and high peak signal to noise ratio(PSNR) then other methods of under water image enhancing. It shows that the projected method is capable of classifying coral reefs particularly when visual cues are visible .

- Finally the weights which are one of the ways where we restore specific required information in image for better image fusion results. After fused to overall enhance the underwater image quality thus making it more informative.

3.3. BLOCK DIAGRAM

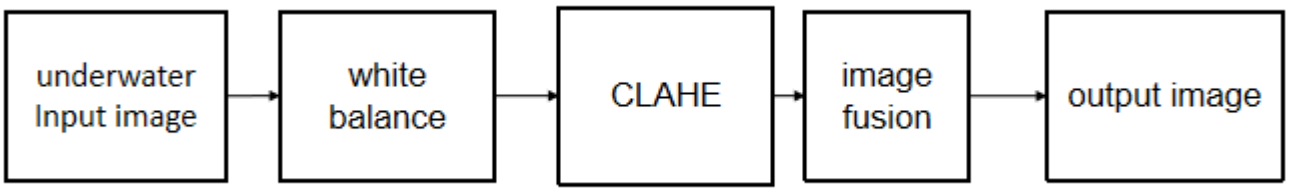


Figure 3.1: Block Diagram

In proposed system we use 3 approach. firstly, to implement white balance for reducing color cast efficiently and Enhancing the underwater images called mixture Contrast Limited Adaptive Histogram Equalization (CLAHE) color model. The method operates Contrast Limited Adaptive Histogram Equalization on RGB and Lab color model and Euclidean norm is used to combine both results together. The combined results show less mean square error and high peak signal to noise ratio(PSNR) then other methods of under water image enhancing. It shows that the projected method is capable of classifying coral reefs particularly when visual cues are visible . Finally the weights which are one of the ways where we restore specific required information in image for better image fusion results. After fused to overall enhance the underwater image quality thus making it more informative.

3.3.1. WHITE BALANCE

White balance (WB) is the process of removing unrealistic color casts, so that objects which appear white in person are rendered white in your photo. Proper camera white balance has to take into account the "color temperature" of a light source, which refers to the relative warmth or coolness of white light.

Initially distorted underwater images are preprocessed for restoration, where we are balancing the white content and enhancing the contrast. This white balance method focuses on restore the colors which are degraded due to absorption white light propagate through the water. The main problems of underwater images are the greenish-blue appearance due to scattering of waves when the depth is increasing. Higher wavelength waves get absorbed first. So red will be absorbed first and so on. The loss of color depends on the distance between the observer and the plane. This include two steps, one is compensating the red channel and apply Gray-World Algorithm to calculate the white balanced image. Compensating the red channel is based on four observations

Red channel is degraded first when it passes through the water and green channel is almost safe because of shorter wavelength compared to red channels.

Compensating Compensate the red channel by adding the fraction of green channel to the red channel to restore the red channel to retrieve the natural appearance of the underwater images.

Compensation of red channel by using the green channel is done with the mean values of green channel and red channel. The difference between the mean values of green channel and the mean value of red channel must be proportional to get the balanced output

To eliminate the degradation of red channel during the Gray World step follows the compensation of red channel; firstly affect the small red channel pixel values. That is, the green channel pixel information will not be given to red channel where the red channel information is already significant. So avoid the appearance of reddish in the over regions which are exposed using Gray World algorithm. The highly degraded red channel will be compensated and the less attenuated red channel which is near to the observer need not be compensated due to less degradation of red channel.

Mathematically express the above observations, the compensated red channel Irc at every pixel location () as follows:

$$\mathbf{Irc() = Ir() + .(g r).(1 Ir()).Ig(),} \quad \mathbf{(1)}$$

Where, Ir and Ig is the channels of red color and green color of image I, at the interval of [0, 1], r and g denote the mean value of Ir and Ig. In second term of the Equation 1, each factor results from one of the above four observations, and denotes a constant parameter, usually the value of = 1 for different acquisition settings and the illumination conditions.

When blue channel is highly degraded and the if restoration of the red channel results to be insufficient, also restore the blue channel degradation, i.e. the compensated blue channel Ibc is computed as:

$$\mathbf{Ibc() = Ib() + .(g b).(1 Ib()).Ig(),} \quad \mathbf{(2)}$$

Where, Ib and Ig is the channels of blue color and green color of image I, and is set to the value one. Rests of the results are formulated based on the red color compensation (optionally the blue color). Using assumption of Gray-World algorithm to calculate and restore the illuminant color cast.

Despite white balancing is important to retrieve the colors which are attenuated when light passes through the water. This is not sufficient in the case of edges and to resolve the dehazing difficulty by the scattering effects. Therefore introducing an effective fusion relying on CLAHE and gamma correction and sharpening to reduce the fogginess of image which is white balanced.

3.3.2. CLAHE

Enhancing the underwater images called mixture **CONTRAST LIMITED ADAPTIVE HISTOGRAM EQUALIZATION** (CLAHE) color model. The method operates Contrast Limited Adaptive Histogram Equalization on RGB and HSV color model and Euclidean norm is used to combine both results together. The combined results show less mean square error and high peak signal to noise ratio(PSNR) then other

methods of underwater image enhancing. It shows that the projected method is capable of classifying coral reefs particularly when visual cues are visible.

Contrast limited adaptive histogram equalization (CLAHE) is used for improve the visibility level of foggy image. Adaptive histogram equalization (AHE) is different from normal histogram equalization because AHE use several methods each corresponding to different parts of image and used them to redistribute the lightness value of the image and in case of CLAHE `Distribution' parameter are used to define the shape of histogram which produce the better quality result compare then adaptive histogram equalization (AHE). In this algorithm Rayleigh distribution parameter is used which create bell shaped histogram. The drawback of AHE is work over homogeneous fog but CLAHE applied over both homogeneous and heterogeneous fog and single image and video system. And the second drawback of AHE is used ‘cumulation function' which applied over only gray level image but CLAHE used both images colored and gray level.

ADVANTAGES

- High accuracy
- Able to recover important faded features and edges

3.3.3. IMAGE FUSION

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, multi sensor 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.

In remote sensing applications, the increasing availability of space borne sensors gives a motivation for different image fusion algorithms. Several situations in image processing require high spatial and high spectral resolution in a single image. Most of the available equipment is not capable of providing such data convincingly. Image fusion techniques allow the integration of different information sources. The fused image can have complementary spatial and spectral resolution characteristics

Image fusion combines two or more registered images of the same object into a single image that is more easily interpreted than any of the originals. The goal of image fusion, especially in medical imaging, is to create new images that are more suitable for the purposes of human visual perception. The simplest image fusion technique is to take the average of two input images. Applied directly, this leads to a feature contrast reduction. A solution to this technique offers a Laplacian pyramid-based image fusion , but at the cost of introducing blocking artifacts. Better fusion results were achieved based on the Wavelet Transform. The steps are:

- Computation of WT for each image,
- Selection at every point of the coefficients having the highest absolute value, and
- Computing the inverse WT for the new image. It is well known that the larger absolute value transform coefficients describe sharper brightness changes, and thus represent the salient features at different scales.

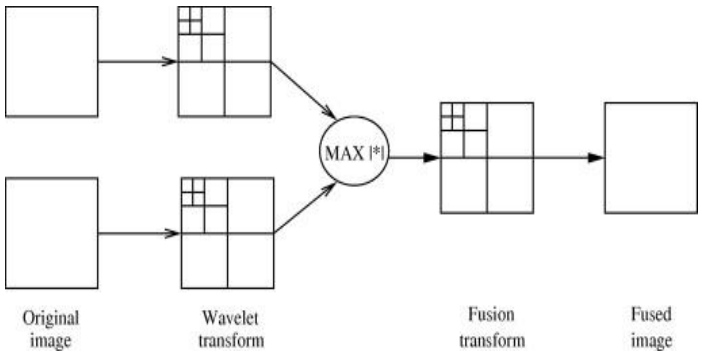


Figure 3.2 Image fusion

CHAPTER-4

SOFTWARE REQUIREMENT

4.1. SYSTEM REQUIREMENTS

Operating Systems

- Windows 10
- Windows 8.1
- Windows 8
- Windows 7 Service Pack 1
- Windows Server 2016
- Windows Server 2012
- Windows Server 2008 R2 Service Pack 1

Processors

- Any Intel or AMD x86-64 processor
- AVX2 instruction set support is recommended
- With Polyspace, 4 cores is recommended

Disk Space

- 2 GB for MATLAB only,
- 4–6 GB for a typical installation.

RAM

- 2 GB
- With Simulink, 4 GB is required
- With Polyspace, 4 GB per core is recommended

Graphics

- No specific graphics card is required.

- Hardware accelerated graphics card supporting OpenGL 3.3 with 1GB GPU memory is recommended.

4.2. MATLAB

What Is MATLAB?

MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. Typical uses include:

•Math and computation

•Algorithm development

•Modeling, simulation, and prototyping

•Data analysis, exploration, and visualization

•Scientific and engineering graphics

•Application development, including graphical user interface building

MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. This allows you to solve many technical computing problems, especially those with matrix and vector formulations, in a fraction of the time it would take to write a program in a scalar noninteractive language such as C or Fortran.

The name MATLAB stands for *matrix laboratory*. MATLAB was originally written to provide easy access to matrix software developed by the LINPACK and EISPACK projects. Today, MATLAB uses software developed by the LAPACK and ARPACK projects, which together represent the state-of-the-art in software for matrix computation. MATLAB has evolved over a period of years with input from many users. In university environments, it is the standard instructional tool for introductory and advanced courses in mathematics, engineering, and science. In industry, MATLAB is the tool of choice for high-productivity research, development, and analysis.

Toolboxes

MATLAB features a family of application-specific solutions called *toolboxes*. Very important to most users of MATLAB, toolboxes allow you to *learn* and *apply* specialized technology. Toolboxes are comprehensive collections of MATLAB functions (M-files) that extend the MATLAB environment to solve
particular classes of problems. Areas in which toolboxes are available include signal processing, control systems, neural networks, fuzzy logic, wavelets, simulation, and many others.

The MATLAB System

The MATLAB system consists of five main parts:

Development Environment.

This is the set of tools and facilities that help you use MATLAB functions and files. Many of these tools are graphical user interfaces.

It includes the MATLAB desktop and Command Window, a command history, and browsers for viewing help, the workspace, files, and the search path.

The MATLAB Mathematical Function Library.

This is a vast collection of computational algorithms ranging from elementary functions like sum, sine, cosine, and complex arithmetic, to more sophisticated functions like matrix inverse, matrix eigenvalues, Bessel functions, and fast Fourier transforms.

The MATLAB language.

This is a high-level matrix/array language with control flow statements, functions, data structures, input/output, and object-oriented programming features. It allows both "programming in the small" to rapidly create quick and dirty throw-away programs, and "programming in the large" to create complete large and complex application programs.

Handle Graphics®.

This is the MATLAB graphics system. It includes high-level commands for two-dimensional and three-dimensional data visualization, image processing, animation, and presentation graphics. It also includes low-level commands that allow you to fully customize the appearance of graphics as well as to build complete graphical user interfaces on your MATLAB applications.

The MATLAB Application Program Interface (API).

This is a library that allows you to write C and Fortran programs that interact with MATLAB. It include facilities for calling routines from MATLAB (dynamic linking), calling MATLAB as a computational engine, and for reading and writing MAT-files.

Image processing in matlab

Images and pictures. As we mentioned in the preface, human beings are predominantly visual creatures: we rely heavily on our vision to make sense of the world around us. We not only look at things to identify and classify them, but we can scan for di_erences, and obtain an overall rough _feeling_ for a scene with a quick glance. Humans have evolved very precise visual skills: we can identify a face in an instant; we can differentiate colours; we can process a large amount of visual information very quickly.

However, the world is in constant motion: stare at something for long enough and it will change in some way. Even a large solid structure, like a building or a mountain, will change its appearance depending on the time of day (day or night); amount of sunlight (clear or cloudy), or various shadows falling upon it. We are concerned with single images: snapshots, if you like, of a visual scene. Although image processing can deal with changing scenes, we shall not discuss it in any detail in this text.

For our purposes, an image is a single picture which represents something. It may be a picture of a person, of people or animals, or of an outdoor scene, or a microphotograph of an electronic component, or the result of medical imaging. Even if the picture is not immediately recognizable, it will not be just a random blur.

What is image processing?

Image processing involves changing the nature of an image in order to either improve its pictorial information for human interpretation, render it more suitable for autonomous machine perception. It is necessary to realize that these two aspects represent two separate but equally important aspects of image processing. A procedure which satisfies condition,

- A procedure which makes an image look better may be the very worst procedure for satisfying condition
- Humans like their images to be sharp, clear and detailed; machines prefer their images to be simple and uncluttered.

Applications

Image processing has an enormous range of applications; almost every area of science and technology can make use of image processing methods. Here is a short list just to give some indication of the range of image processing applications.

1. Medicine

- Inspection and interpretation of images obtained from X-rays, MRI or CAT scans,
- Analysis of cell images, of chromosome karyotypes.

2. Agriculture

- Satellite/aerial views of land, for example to determine how much land is being used
- Different purposes, or to investigate the suitability of the regions for different crops,
- Inspection of fruit and vegetables, distinguishing good and fresh produce from old.

3. Industry

- Automatic inspection of items on a production line,
- Inspection of paper samples.

4. Law enforcement

- Fingerprint analysis,
- Sharpening or de-blurring of speed-camera images.

CHAPTER 5

RESULT & CONCLUSION

RESULT

Figure 5.1: Input Image

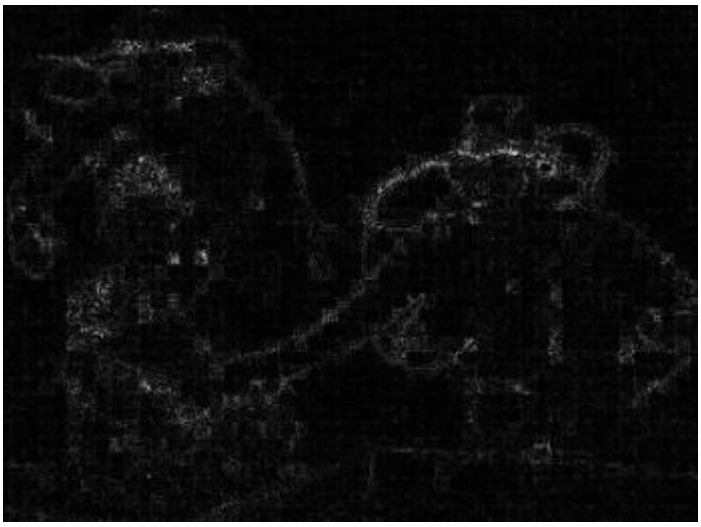


Figure 5.2: White Balanced Image

```
<--------------- Median  filter  --------------------------->
Mean Square Error
   2.5063e-05

Peak Signal to Noise Ratio
   94.1405

<------------------------------------------------------------>
```

Figure 5.3: MSE and PSNR Values

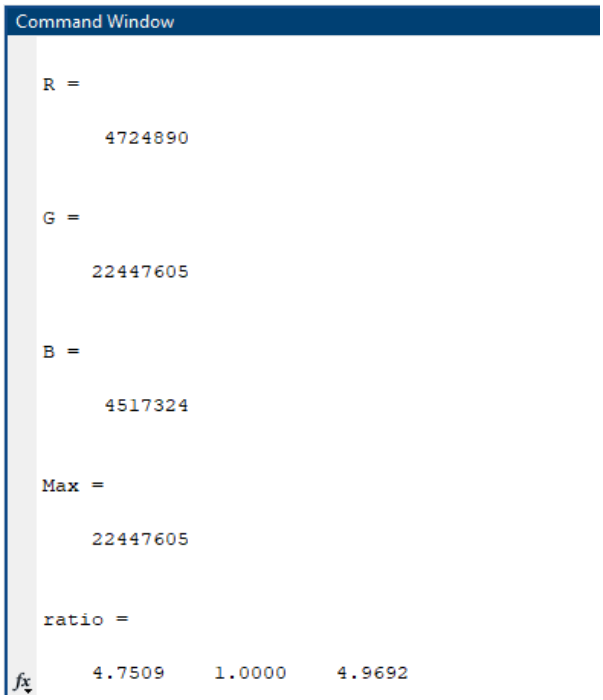


Figure 5.4: RGB Values of the Image

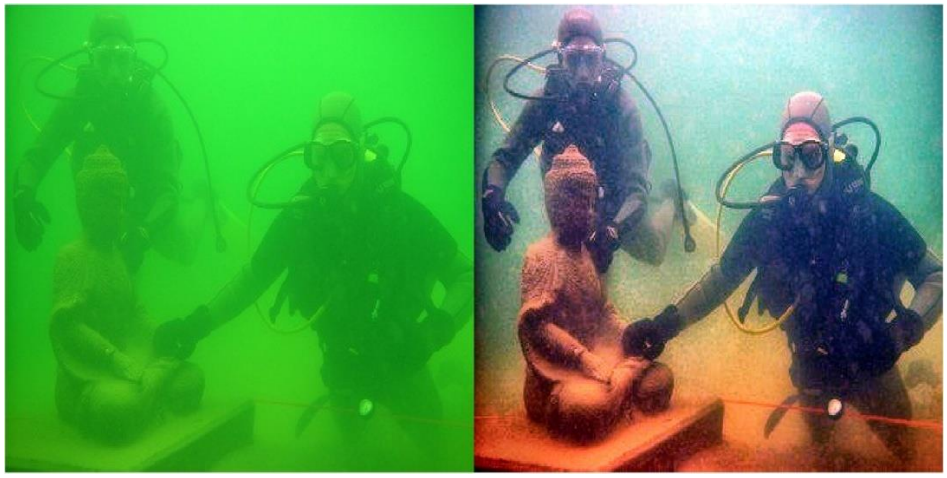


Figure 5.5: Output Image

CONCLUSION

In underwater, visibility is low due to the light absorption and radiation. As a result of these problems, underwater images have low contrasts and resolutions. In this study, an underwater image enhancement approach employing differential evolution algorithm based contrast enhancement has been proposed. The proposed approach aims to improve contrast of underwater image in each RGB component, where the contrast

limits are specified by using different algorithm. The proposed method is used on different underwater images and according to the obtained results, it can be said that the approach effectively improves the visibility of underwater images.

FUTURE WORK

- Integrating this with CNN Model can result in more accurate Image De-hazing and sharpening with respect to both speed and precision.
- CNN models slow output speed can be solved by providing first crude output using Contrast driven Image-Segmentation Technique
- That Image can be further refined by using CNN model only if need arise, hence reducing system and resource load.
- In future, this technique can be used for self drive automated vehicles when incorporated with AI to provide better representation of surrounding to the system in foggy or hazed weather

CHAPTER 7

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