Enhancement of Underwater Images by Image Fusion Using Wavelet Decomposition

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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 paper 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 the weights which are one of the ways where we restore specific required information in image forbetter image fusion results.After Wavelet decomposition, these all weight maps are fused to overall enhance the underwater image quality thus making it more informative.

Keywords *-image processing, white balancing, enhanced contrast, saliency, luminance, chromatic weight map*

I. 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 suchdistorted images is challenging task.

Here we have implemented the underwater image restorations with different min max filters; stretching the contrast, white balancing in the image.

In this paper, we are restoring underwater image information required for analysis. Strategy is to construct one single image which contains the important specific information with fusion principle.

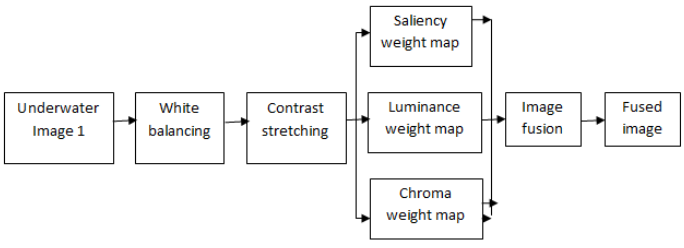

Fig 1. Basic Block diagram

The proposed restoration algorithm consists of one input image from which three images are computed to retain different information these images are white balanced, stretched contrast and min max enhanced.

For fusion process it takes weights maps which include the information of luminance, Chroma and the original saliency.

II. LITERATURE REVIEW

CodrutaOrnianaAncuti, CosminAncuti, Tom Haber and Philippe Bekaert 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. [1]

For the fusion process, suggested four different weights maps they are luminance, original saliency, chroma and global contrast.

CosminAncuti, CodrutaOrnianaAncuti, Tom Haber and Philippe Bekaert 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 contrast weight, Saliency weight, exposedness weight. Then fused image is obtained by fusion of input image with the weights. [2]

Naveen Kumar and ManinderKaurpresented Multi-sensor image fusion technique for reconstruction of images, wavelet based image fusion technique was used to get improvement in resolution of images. [4]

Deepak Kumar Sahu, M.P.Parsai 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 that spatial 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. [5]

Z. Wang and A. Bovik, proposed new universal objective image quality index. An index was designed by modeling any image distortion as a combination of three factors: loss of correlation, luminance distortion and contrast distortion, instead of using traditional error summation methods.Although the index was mathematically defined and no human visual system model was explicitly employed,experiments on various image distortion types indicate that it performs significantly better than the widely used distortion metric mean squared error. [3]

III. SYSTEM DEVELOPMENT

Pre Processed images:

Initially distorted underwater images are preprocessed for restoration, where we are balancing the white content and enhancing the contrast. These preprocessed images are given as inputs to fusion process.

(a)

(b)

(c)

Fig 2.Preprocessed Images:(a)Original Image (b) Contrast Enhanced (c) White Balanced

Other inputs are the weight maps used to preserve and obtain different specific information in the image. Weights are defined as luminance, chromaand saliency.

Different Weights:

A. Luminance weight map:

Generally a degraded photo tends to become flat in final result where we are controlling its luminance gain. It defines the standard deviation between luminance L and every R, G, and B color channels while preserving each input region.

This map enhances degraded input but it may reduce the color and image contrast. For this reduced color and contrast we have defined other weights as Chroma (color) and saliency (global contrast)

Fig 3.Luminance Enhancement

B. Chromatic weight map:

It controls saturation gain in the result image, using gauss curve

$$d = \exp\left(-\frac{(S-Smax)^2}{2\sigma^2}\right) \quad \ldots\ldots\ldots (1)$$

With standard deviation **σ**= 0.3 (computes the distance between saturation value 'S' and maximum of saturation range) "**σ**" indicates saturation. Higher saturation images are always preferred.

Fig 4.Chromatic Enhancement

C. Saliency weight map:

It defines the quality which contributes to degree of conspicuousness with respect to the neighborhood regions. The saliency weight for any pixel at position (x,y) of input I^K is given by

$$W_s(x,y)\left\|I_u^K - I_{whe}^K\right\| \ldots\ldots\ldots (2)$$

Where I^K_u is arithmetic mean pixel value of input image I^K

I^K_{whe} is blurred version of the same input which has its objective to remove high frequency noise and textures.

Fig 5.Saliency Enhancement

IV. PROPOSED METHODOLOGY

The technique of image fusion combines the clear parts of input images. It produces a single image from a set of input images. Complete information should be given by fused image which is more useful for human or machine perception. There are four types of image fusion techniques:

1. Signal level
2. Pixel level
3. Feature level and
4. Decision level

Here we will be using pixel level based image fusion technique. Objective of Image Fusion schemes are to extract all the useful information from the source images.

Software Implementation:

The basic steps of image fusion are as follows

1) Preprocessing of Images: Image acquisition and preprocessing is first. There are many preprocessing methods used for underwater images. This involves contrast stretching, adjustment of brightness, white balancing.
2) Finding different weight maps images that are Luminance, Chrominance, and Saliency.
3) Decompose the images by using wavelet analysis. It will decompose at first level. The purpose of decomposition is to obtain high and low resolution frequency bands. Four frequency bands are produced by one level of decomposition i.e. Low-Low (LL), Low-High (LH), High-Low (HL) and High-High (HH). Based on fusion rules, fusion will be carried out. Fusion rules will be used for selection of wavelet coefficient. It includes –
    a) Selection of low frequency sub band
    b) Reconstruction of high frequency sub band coefficient in horizontal and vertical orientation
    c) Selection of diagonal high frequency sub band coefficient
4) Fused wavelet coefficient map will be constructed
5) Images are fused to get better results

(a) (b)

Fig 6. (a)Original image (b) Fused Image

Figure 6 shows the result original image and fused image, where it can be seen that fused image is more clear and informative as compared to original image.

V. RESULTS

Measuring parameters:

There are different parameter with which we can measure the quality of images, but for underwater images as we are enhancing them for clear view and more information content.

So visual clearance is one of the parameter with which we can define quality of underwater images.

Entropy:

Entropy gives us the measure of information content in an image.

The entropy H of an image is defined as

$$H = -\sum_{k=0}^{M-1} p_k \log_2(p_k) \ldots\ldots (3)$$

Where M is the number of gray levels and p_k is the probability associated with gray level k.

Fusion Methods	ENTROPY
Average	7.2280
Select maximum	7.2071
Laplacian Pyramid	7.2297
Morphological Pyramid	7.2053
SWT	7.2322
Proposed Method	7.2465

Table 1: Entropy values for different fusion methods [5], and proposed method.

The calculated entropy of fused image by our method is 7.2465, which is greater than the entropy value of all other methods given in table 1. As entropy is the measure of information content in an image we conclude that the proposed method gives better result.

VI. CONCLUSION

We presented a different weight map and input images for fusion process. The weight consists of chromatic, luminance, and saliency which preserve different specific information from the image. Also as input images are the preprocessed version of degraded images, which restoresand improves the underwater images visual parameter to greater extent.

These input images and weights after fusion gives improved image quality as compared to the original input image.Wavelet fusion used here gives clearer and informative image.

Our results show that they are more clear and informative, as the entropy value of the fused image is better than other methods. For future work algorithm can be extended for videos, we can also merge the methods as per the requirement of application.

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