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AHE, DWT and KLT based image enhancement technique for underwater images and low contrast poor quality images

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ABSTRACT

Image enhancement is the simplest and most popular area of digital image processing. The idea behind enhancement is to bring out the details in the image that are obscured. It also highlights the certain features of the interest in an image. Image resolution is always a key feature of all kinds of image. Underwater Image Enhancement is the most challenging task in an image processing. The quality of any underwater image depends on the depth of water, the density of water, artificial light, distance between camera and object, water particles, etc. So, the low resolution underwater image suffers a lot from the phenomenon of quality degradation. This study proposes an efficient method for the quality improvement in degraded underwater low resolution low contrast image.

Keywords: Adaptive Histogram Equalization, Discrete Wavelet Tranform, Underwater Image Enhancement, KL Transform.

I. INTRODUCTION

Resolution is an important aspect of an image. Resolution is the details hold by an image. Higher resolution means more detail of an image. Resolution enhancement is generally done with the help of interpolation techniques. There are three well known interpolation techniques. These techniques are nearest neighbour interpolation, bilinear interpolation, and bicubic interpolation. Visual system is more sensitive to contrast of an image. Contrast of an image is always determined by its dynamic range. Contrast is defined as the ratio between brightest pixel intensities and the darkest pixel intensities. In order to increase the quality of the super-resolved image, preserving the edges is essential.

Underwater image enhancement is the most difficult tasks in an image processing. Light can penetrate only 20 meters in clear water and few meters in turbid water. The reason behind this is as the depth of water increases, the problems related to clear image capturing becomes more. The problems may vary according to the amount of light, , the distance between camera and object, type of water, depth of water, etc. There exist many methods to enhance resolution and to enhance contrast separately. But the proposed technique works for improving the overall quality of an underwater images and other poor quality images with respect to resolution as well as contrast enhancement simultaneously.

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II. LITERATURE REVIEW

1.1 Histogram Equalization:

Histogram equalization is used to increase the contrast of low contrast images. Histogram equalization is generally performed when the important data of an image is represented by its close contrast values. Histogram equalization spreads out the most frequent intensity values equally. This method is useful for both bright & dark regions. This method is simple, fast and we get acceptable results for many applications, these are the main advantages of this method. The histogram equalization is operated on an image in three steps:

- Histogram Formation
- New Intensity Values calculation for each Intensity Levels

New intensity values are calculated for each intensity level by applying the following equation:

$$S_k = T(r_k) = G_{max} \sum_{i=0}^{k} hi \qquad \text{For } 0 \le k \le \text{Gmax}, \; h_i = \frac{n_i}{n_t}.$$

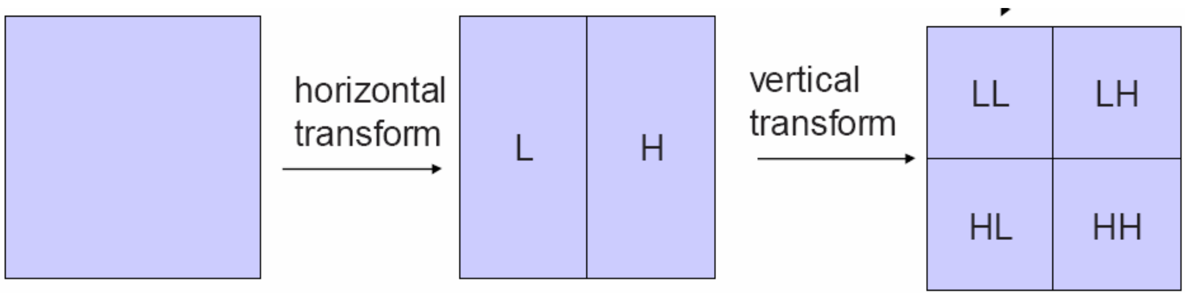
Where hi is the normalized histogram of the image.

- Replace the previous Intensity values with the new intensity values

1.2 Discrete Wavelet Transform

DWT decomposes the image into four sub bands of different frequency resolutions. LL sub-band is nothing but low resolution of original image which contains illumination information so can be used for enhancing contrast [1]. LL subband is called coarse level coefficient because it contains the maximum information in all the decomposition levels and LH, HL, and HH represent the detail wavelet coefficients. High frequency sub-band contains high frequency component, it contains edge information so can be used for increasing resolution. The transformed coefficients in all the subband levels are useful for texture analysis and discrimination. The coefficients obtained in the sub-band images and/or their combinations uniquely describe the texture of the image. In 2D discrete wavelet transform at 1st level decomposition, the image is decomposed i.e. divided in four sub-bands and namely LL, LH, HL and HH as shown below,

Low resolution Sub-band (LL)



Transform each row | **Transform each column in L & H** | **3 detail sub-bands (LH, HL, HH)**

1.3 Interpolation

Interpolation is usually used for image resolution enhancement. Interpolation has been widely used in many image processing applications such as facial reconstruction, multiple description coding and super resolution enhancement. Interpolation is the process of using known data values to estimate unknown data values. Interpolation is estimation of the value of the discrete function at unknown positions based on the given and

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known surrounding samples [2]. There are three well known interpolation techniques. These techniques are nearest neighbour interpolation, bilinear interpolation, and bi-cubic interpolation. Bi-cubic interpolated image is sharper and does not contain any disjoint appearance [3].

1.4 K-L Transform

Karhunen-Loeve Transform (KLT) which was built on statistical-based properties. The outstanding advantage of KLT is a good de-correlation. In the MSE (Mean Square Error) sense, it is the best transform, and it has an important position in the data compression technology. KLT has 4 main characteristics:

- De-correlation
- Energy concentration
- Under measuring of the MSE
- Not quick algorithm and the different signal sample collection has different transformation matrix. [4]

1.5 Adaptive Histogram Equalization

This the modification of the Histogram Equalization method. It enhances the contrast of images by transforming the values in the intensity image under experiment. It usually works on the small data regions instead of the entire image. Each tile's contrast is individually enhanced and finally the all neighbouring tiles are combined using bilinear interpolation in order to eliminate artificially induced boundaries. By using this technique, the contrast in homogeneous areas can be limited in order to avoid amplifying the noise which might be present in image. [5]

II. OBJECTIVES OF THE STUDY

- To perform adaptive histogram equalization on underwater image.
- To perform Discrete wavelet transform on enhanced image.
- To perform KL transform on low frequency part of an image.
- To optimize high freq. part of an DWT transformed image.
- To reconstruct underwater image using Inverse Discrete Wavelet Transform.
- To analyse results using various performance measures qualitative and quantitative methods.

III. PROPOSED METHODOLOGY

The proposed system works on the blurred low resolution low contrast underwater images using certain image processing operations like Adaptive Histogram Equalization, Discrete Wavelet Transform (DWT), KL Transform and Inverse Discrete Wavelet Transform (IDWT) to enhance its quality. Firstly, the system improves the contrast of the captured input image by using adaptive histogram equalization technique. Equalization process evenly distributes the gray levels in an image by reassigning the brightness values of pixels. It provides more visually pleasing results across wider range of images. It differs from generalized histogram equalization. Adaptive histogram equalization is more suitable for improving the local contrast and enhancing the of edges in each region of an image.

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The proposed system consists of two significant parts. The first part is applying the DWT to the low resolution underwater image and decomposing into four sub-bands namely LL, HL, LH and HH. The LL sub-band corresponds to the low frequency that is the smooth areas. The other three sub-bands represent the high frequency components such as edges. As LH, HL, HH sub-bands contain different details, so enhancement is done on all LH, HL and HH components.

The second part of the proposed work is applying the KL transform over the LL sub-band and preserving the details in turn reducing the random noise. The difference image is obtained by subtracting the KLT enhanced and LL sub-band with the interpolated components obtained. The high frequency sub-bands such as HL, LH, HH are up-sampled by the factor of two using the bicubic interpolation technique in order to be added with the difference image. Now all the components are enhanced and the high-resolution image is obtained by applying the inverse discrete wavelet transformation on all of the enhanced sub-bands. The block diagram of the proposed system is shown in Fig. 1 below,

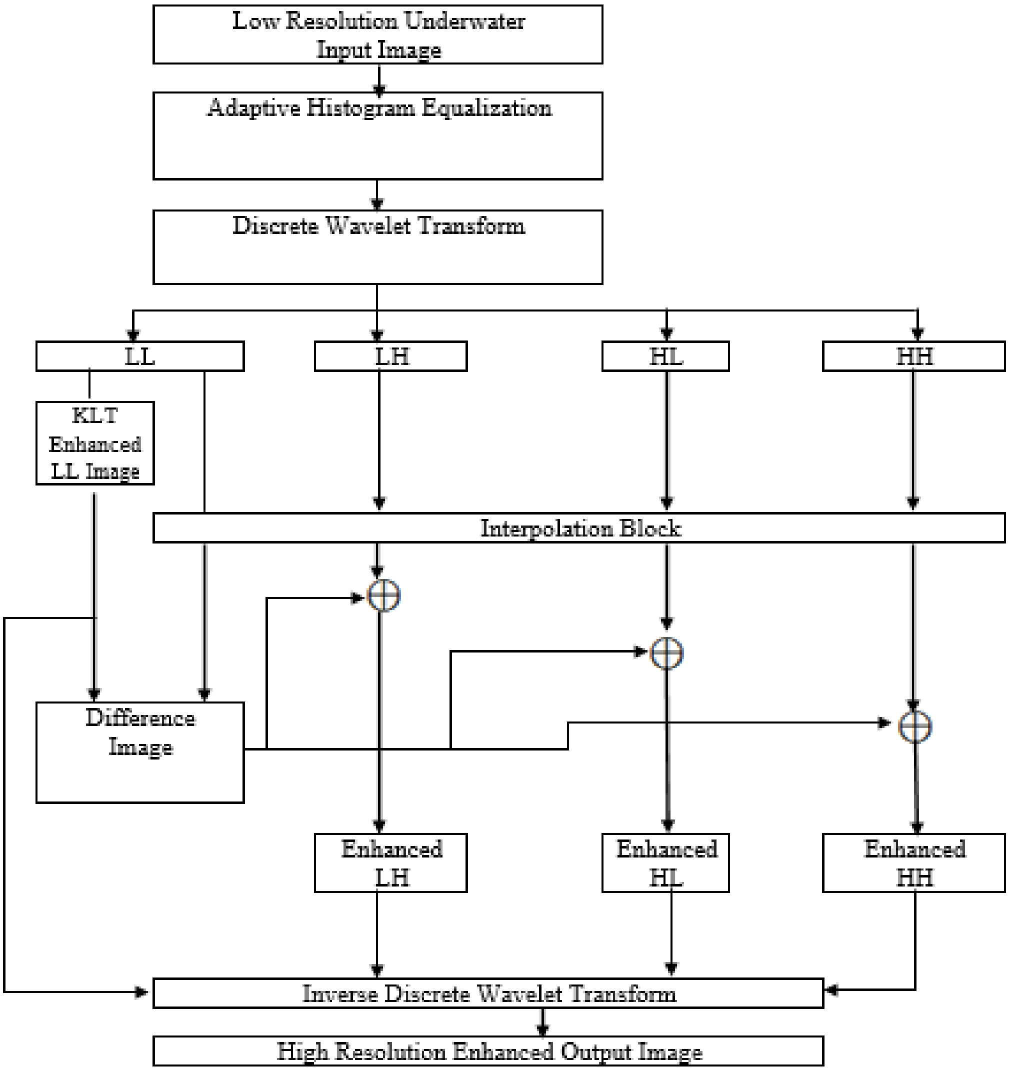

Fig. 1 : Proposed system to enhance underwater images.

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IV. RESULTS

5.1 Qualitative Results

	
Original Test Image 1	**Enhanced Image 1**
	
Original Test Image 2	**Enhanced Image 2**

5.2 Quantitative Results

Following are the qualitative results of the test image.

TABLE I : Quantitative results for test image

Parameter	MSE	PSNR in dB	MSE	PSNR in dB
With DWT & KLT	6873.60	9.75	13139.04	6.94
With AHE, DWT & KLT	6869.29	9.76	13138.52	6.94

VI. CONCLUSION

From the results, it is cleared that the proposed system gives properly enhanced underwater image output with respect to resolution and contrast as well. The quality of the image is good and up to the mark regarding contrast and resolution. The PSNR value of the image is higher than other methods like GHE, DWT-KLT, DWT-SVD, GHE-DWT-KLT. We have got the better results with proposed algorithm for both qualitative and quantitative measures.

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