RESEARCH ARTICLE OPEN ACCESS

Underwater Video Enhancement by SWT Based Fusion

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ABSTRCT
The Videos captured in water is hazy due to the several effects of the underwater medium. The underwater medium is not friendly for imaging data and brings low contrast and fades color issues. Therefore, the video is processed and divided into frames, during any image based exploration and inspection activity, it is essential to enhance the imaging data before going for further processing. In this use we consider underwater video and present a stationary wavelet-based fusion method to enhance the hazy underwater videos by addressing the low contrast and color alteration issues. While publicly available fog underwater videos can be qualitatively enhanced with some advanced techniques, quantitative study of video quality illustrates good results.
Keywords: Video Processing, Wavelet transforms, Stationary Wavelet Transform

Date of Submission: 01-10-2020 Date of Acceptance: 14-10-2020

I. INTRODUCTION

These days, research area trends in the ocean have increased. But in order to work on aquatic objects, it is necessary to obtain clear images of underwater objects. While the air interface deals with environmental and camera issues such as dust particles, natural light, reflection, vision, distance, underwater images also face the same problems. Underwater image quality depends on water density, water depth, distance between camera and object, artificial light, water particles. As the water depth increases, the water becomes denser due to sand, moss and minerals. As density increases, the camera light gets deviates back and deflects by particles for some time along the path to the camera and other part of camera light gets absorbed by the particles. This scattering effect causes the reduced visibility of image with low contrast. Also, the color change effect depends on the wavelength of light travel in the water.

Fusion is an important technique within many disparate fields such as remote sensing, robotics, and medical applications. Image fusion algorithm based wavelet transform is that, the two images to be processed are sampled to the one with the same size and they are respectively decomposed into the sub images using forward wavelet transform, which have the same resolution at the same levels and different resolution among different levels; and information fusion is performed based on the high-frequency sub images of decomposed images; and finally the resulting image is obtained using inverse wavelet transform. The result of image fusion is a single image which is more suitable for human and machine perception or further image- processing tasks. However, there are many image-base methods in underwater image enhancement. Global and local image contrast enhancement is widely used to improve the appearance of underwater images. Hitam et al. [6] proposed a method called mixture Contrast Limited Adaptive Histogram Equalization (CLAHE). CLAHE is operated on RGB and HSV color models, and the two results are combined together with Euclidean norm. Ahmad et al. [7] proposed a new method called dualimage Rayleigh-stretched contrast-limited adaptive histogram specification, which integrated global and local contrast correction.

Most of the image enhancement implementations found in the literature are based on MATLAB. MATLAB is a high performance language for technical computing and the excellent tool for algorithm development and data analysis. The main problem observed in underwater videos are de-hazing of video that is produce of noise, the visual quality is low. In order to overcome the above problems, in this paper stationary wavelet transform is used for filtering of noise present in the underwater video.

II. LITERATURE SURVEY

We have done literature survey on the underwater image and conclude that the hybridization of algorithms is done for better visualization like wavelet fusion and contrast enhancement, improving contrast and color correction etc. J. Wang, et al. [1], proposed.The image fusion method is mainly divided as three ways: the first is a direct fusion method, which is used to fuse two source images of spatial registration into an image using some simple processions such as direct selecting or weighted average. The second algorithm is based on pyramid decomposition and reconstruction, which is eventually formed through reconstruction. The third method is the fusion algorithm based on the wavelet transform, which fuses images pertinently in the feature fields of each layer using multi- resolution analysis and Mallat fast algorithm. Due to the virtue of its multi-resolution, directivity, and non-redundancy, wavelet transform has been applied in image processing field successfully.

Alex, et al. [2], proposed on adaptive histogram equalization technique to improve the enhancement of images. In the adaptive histogram equalization technique, the pixels are mapped based on it local gray scale distribution. In this method, the enhancement mapping applied to a particular pixel is a function of the intensity values of pixels immediately surrounding the pixel. Hence the number of times that this calculation should be repeated is the same as the number of pixels in the image. They have implemented their algorithm on FPGA for hardware implementation. They are improving the performance by doing the parallel processing. The algorithm is implemented in Xilinx Spartan 3 AM on Altium Nano board NB3000 board using Altium Designer.

Xiu Li, et al. [3], proposed two parameters due to underwater images quality degraded. These are light scattering and color distortion. Also, they defined that the light scattering occurs due to light be reflected and deflected a number of times by the suspended particles in the water and color distortion due to absorption degrees and its vary according to the wavelength. They proposed a novel technique based on dark channel prior and luminance adjustment. Their technique resolves these.

C. Ancuti, et al. [4], proposed Classical image enhancement techniques have been modified to adapt to the underwater imaging. These methods do not depend on physical modeling of underwater scenario. The most popular method is underwater image and video enhancement using fusion to combine different weighted images using saliency, luminance, and chrominance via filtering. This was the first recorded work for the enhancement of underwater images using fusion approach based on Laplacian pyramid. The authors also validated the selection of white balancing algorithm for underwater images. Although the contrast of the output images appears increased, the problem associated with it is, as reflected in the results section, the processed images are not uniformly enhanced and does not appear natural.

M. S. Hitam, et al. [5], there are many image-base methods in underwater Image enhancement. Global and local image contrast Enhancement is widely used to improve the appearance of underwater images. Hitam et al., proposed a method called Mixture contrast limited adaptive histogram equalization (clahe). Clahe is operated on RGB and HSV color models, and the two results are combined together with Euclidean Norm. Ahmad et al. A. S. A. Ghani and n. A. M. Isa [6], proposed a new method called dual image Rayleigh-stretched contrast-limited adaptive histogram Specification, which integrated global and local contrast correction.

Yafei Wang, et al. [7], proposed fusion process involves two inputs which are represented as color corrected and contrast enhanced images extracted from the original underwater image. Both the color corrected and contrast enhanced images are decomposed into low frequency and high frequency components by three-scale wavelet operator. The low frequency and high frequency components are fused via a multiscale fusion process. The low frequency components are fused by weighted average, and the high frequency components are fused by local variance. These fused low frequency and high frequency components can be reconstructed as a final enhanced image. In this paper, an efficient fusion-based underwater image enhancement approach using wavelet decomposition is presented. The experimental results demonstrate that the proposed approach effectively improves the visibility of underwater images and can be utilized in image matching application for underwater environments.

III. PROPOSED ALGORITHM STATIONARY WAVELET TRANSFORM

The Stationary wavelet transform (SWT) is a wavelet transform algorithm designed to overcome the lack of translation-invariance of the discrete wavelet transform (DWT). Translation-invariance is achieved by removing the down samplers and up samplers in the DWT and up sampling the filter coefficients by a factor of in the level of the algorithm. The SWT is an inherently redundant scheme as the output of each level of SWT contains the same number of samples as the input – so for a decomposition of N levels there is a redundancy of N in the S- wavelet coefficients.

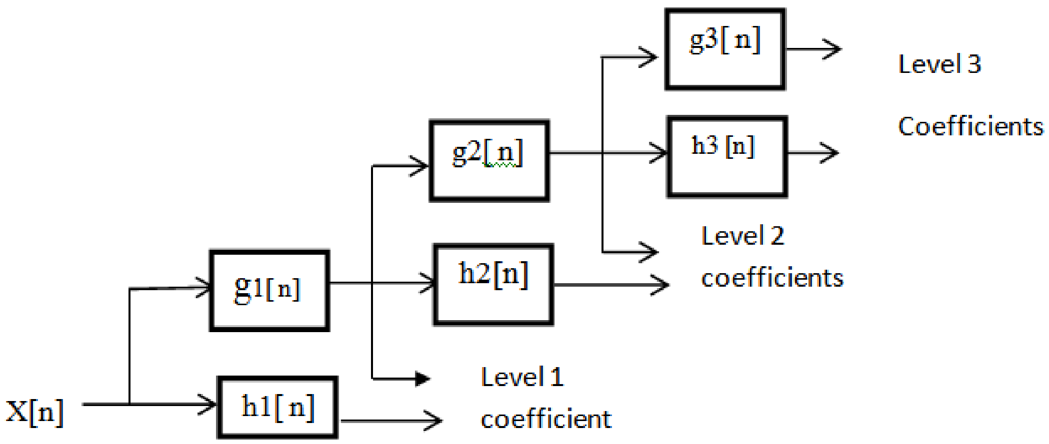


Figure 1. 3 Level SWT filter bank

Algorithm Steps
Step 1. Consider input video
Level 1 coefficient
Step 2. Divide the video into number of frames
Step 3. Perform colour enhancement and apply SWT Step 4. Perform contrast enhancement and apply SWT Step 5. Fusion of output obtained from step 3 and step 4 Step 6. Apply ISWT
Step 7. Obtain the Enhanced output

Problem Statement
There are a few problems occur in underwater images such as limited range visibility, low contrast, non-uniform lighting, blurring, bright artefacts, color diminished and noise

IV. PROPOSED WORK

SWT Fusion Based Methodology

Fusion is the procedure that combines data coming from numerous images of the view. Caused by image spinal fusion can be a brand-new image that stores probably the most worthy selective information in addition to characteristics of every suggestions impression information. Merger will be the incorporating two or more source photos directly into composite pictures together with elongated details articles.

Fusion based provides an efficient way to merge the visual information from different Images files extracted from the video. These extracted fused images contains complete information for better human or machine perception and computer-processing tasks, such as image restoration, enhancement, segmentation, feature extraction, and object recognition in image processing. Fusion based can be done in pixel level, signal level and feature based. The traditional image fusion schemes performed the fusion right on the source images, which often have serious side effects such as reducing the contrast of object.

In signal and image processing the fusion is used to solve different problems [4]. Our method is based on the fusion of images using stationary wavelet transform [6] for the enhancement of the underwater videos. In our proposed method low contrast and color attenuation of the hazy videos and images are addressed. Therefore, we are employing CLAHE

[7] and histogram stretching techniques for contrast enhancement and color correction. The complete procedure for S-wavelet based fusion approach is shown in Fig. 2. Initially, the hazy underwater image is replicated into two versions. These versions are processed in parallel to enhance color profiles and image contrast. Then, the s-wavelet-based decomposition, fusion, and inverse composition are performed to obtain the colour and contrast enhanced image.

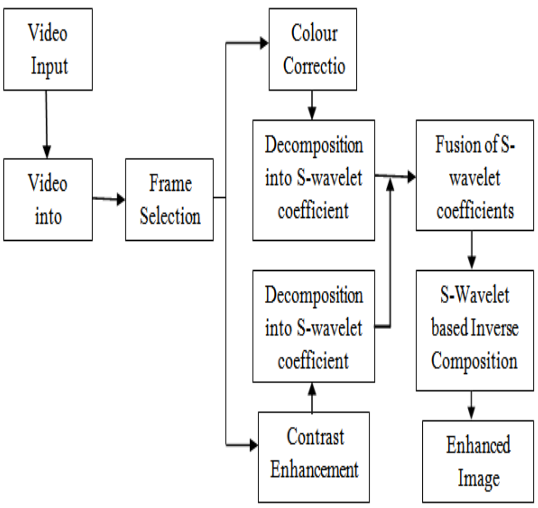


Figure 2. S-wavelet based fusion approach for underwater video Enhancement

A. Color and Contrast Enhancement

For color correction, the image (frames) is converted from RGB (Red-Green-Blue) to HSV (Hue-Saturation-Value) color space. In HSV color space the histogram of the Value component is stretched over the whole range. This operation improves the brightness of the available colors in the image. Then the Hue and Saturation are concatenated with the corrected value component and hence the image is converted back to the RGB color space. In RGB color space, once again the histogram is stretched over the whole range (0 to 255) to achieve the color correction in all three channels. The histogram stretching is based on the mathematical expression given below,

$$P_{out} = (P_{in} - i_{min})\left(\frac{o_{max}-o_{min}}{i_{max}-i_{min}}\right) + o_{min} \quad (1)$$

where P_{out} and P_{in} are the pixels of output and input images respectively. i_{min}, i_{max}, o_{min} and o_{max} are minimum and maximum values of intensities for input and output images respectively. To enhance the contrast of the underwater images, we adopted the contrast limited adaptive histogram equalization (CLAHE) [8].

In order to enhance the contrast of underwater images, CLAHE is operated on HSV color model which describes colors in terms of Hue (*H*), Saturation (*S*), and Value (*V*). CLAHE is applied to *S* and *V* components, and *H* remains unchanged. In HSV color model, *Sclahe* and *Vclahe* are calculated by:

$$S_{clahe} = (S_{max} - S_{min}) * P(f) + S_{min} \quad (2)$$

$$V_{clahe} = (V_{max} - V_{min}) * P(f) + V_{min} \quad (3)$$

Where *Smax*, *Smin*, *Vmax* and *Vmin* are the maximum and minimum pixel values of *S* and *V* . *Sclahe* and *Vclahe* represent pixel values after CLAHE.

B. Decomposition, Fusion and Inverse Composition

The S-wavelet based fusion algorithm consists of a sequence of low pass and high pass filter banks that are used to eliminate unwanted low and high frequencies present in the image and to acquire the detail and approximation coefficients separately for making the fusing process convenient [12].

In Fig. 3, decomposition of the input image into its detail and approximation coefficients is described. Each input image is filtered and downsampled by a factor of 2. The factor of 2 in the algorithm is used to divide the information contained in the input signal into two equal parts at each step of filtering so that the information can be analysed deeply. In this scope of the study, we are using two levels of decomposition, but in Fig. 4.4, decomposition is shown. There are two steps in level one; the first step is achieved by applying the low pass and high pass filters with downsampling on the rows of the input image *x(r, c)*. This generates horizontal approximations and horizontal details respectively. In the next step, the columns in the horizontal coefficients are filtered and down-sampled into four sub images [13]: Approximate (LL), Vertical detail (LH), Horizontal detail (HL), and the Diagonal detail (HH) as shown in Fig. 3.

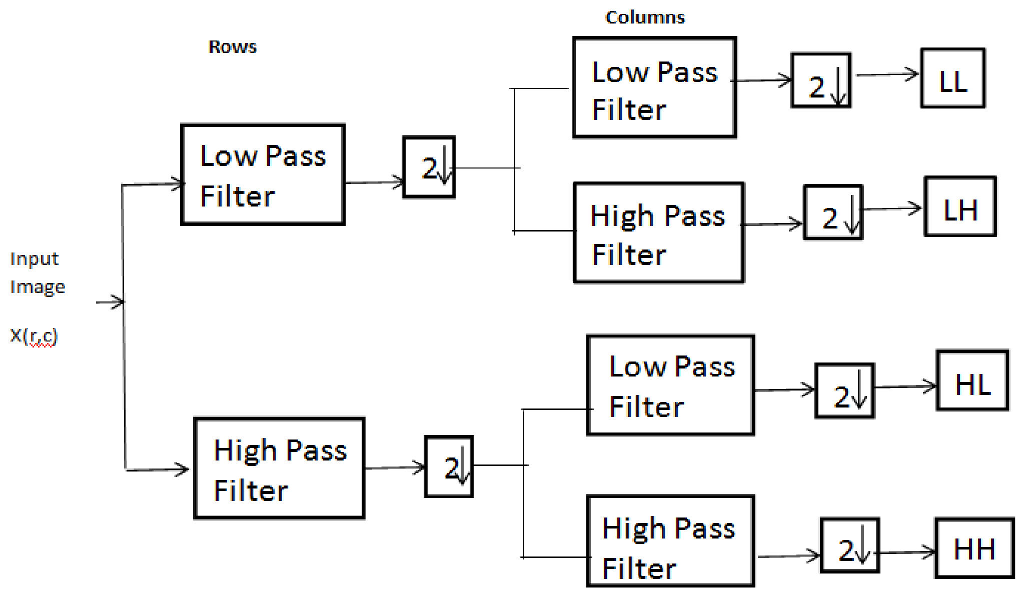


Figure 3.S-wavelet-based image decomposition

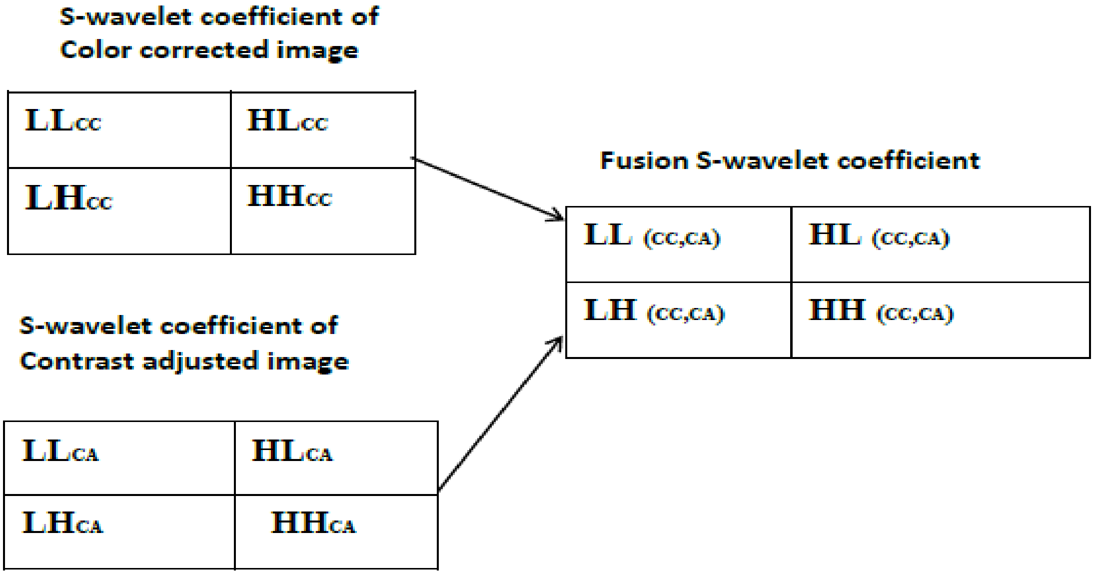


Figure 4: - Fusion of decomposed S-wavelet coefficients

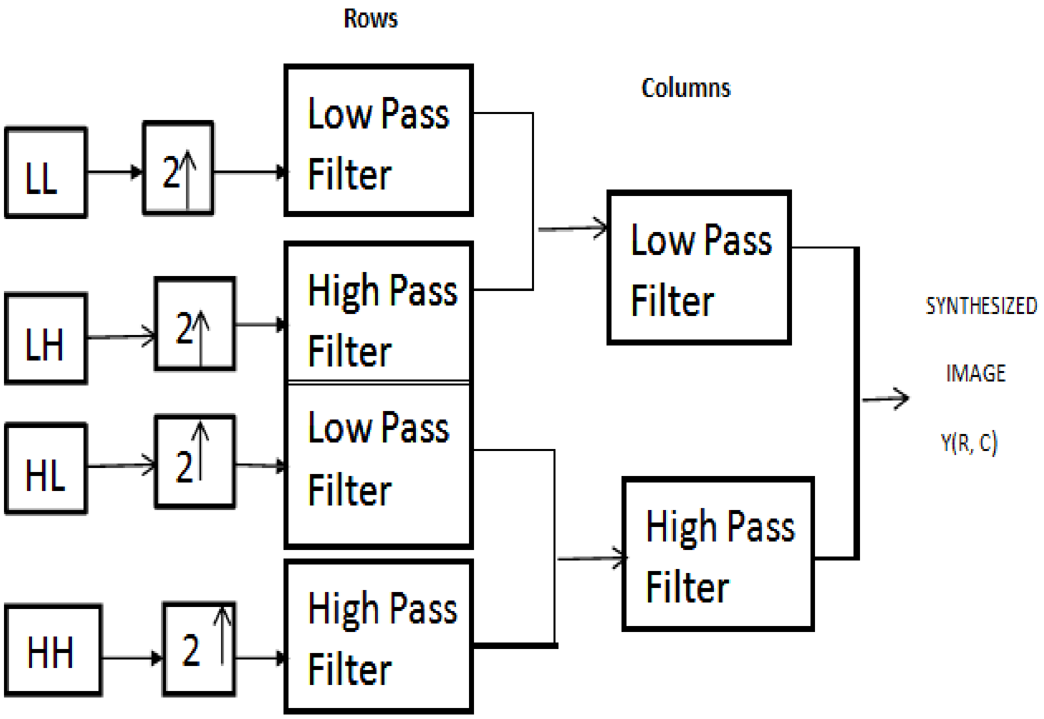


Figure 5:- stationary wavelet-based inverse composition

After combining coefficients of both enhanced images into fused coefficients, the inverse composition applied to get the synthesized image. For the inverse composition, the reverse process is carried out with the help of upsampling and filtering steps using filter banks to get a synthesized or enhanced image *y(r, c)*, see Fig. 5. Since we are dealing with stationary data sets so in digital image processing, each input image is decomposed into its coefficients and inversely composed into a synthesized image by using S-wavelet transform (SWT) and Inverse S- wavelet transform (ISWT) respectively. In Fig. 6, a complete picture of two level Stationary wavelet-based decompositions, fusion and inverse composition of enhanced image is shown.

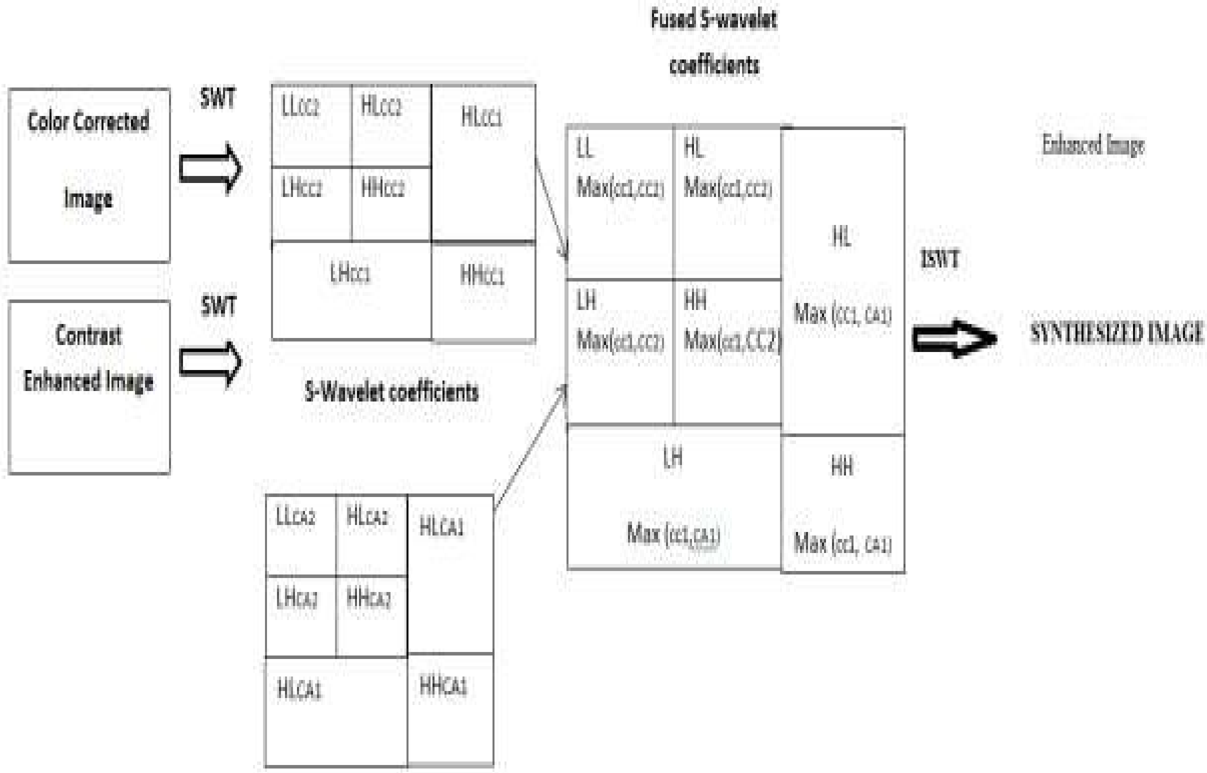


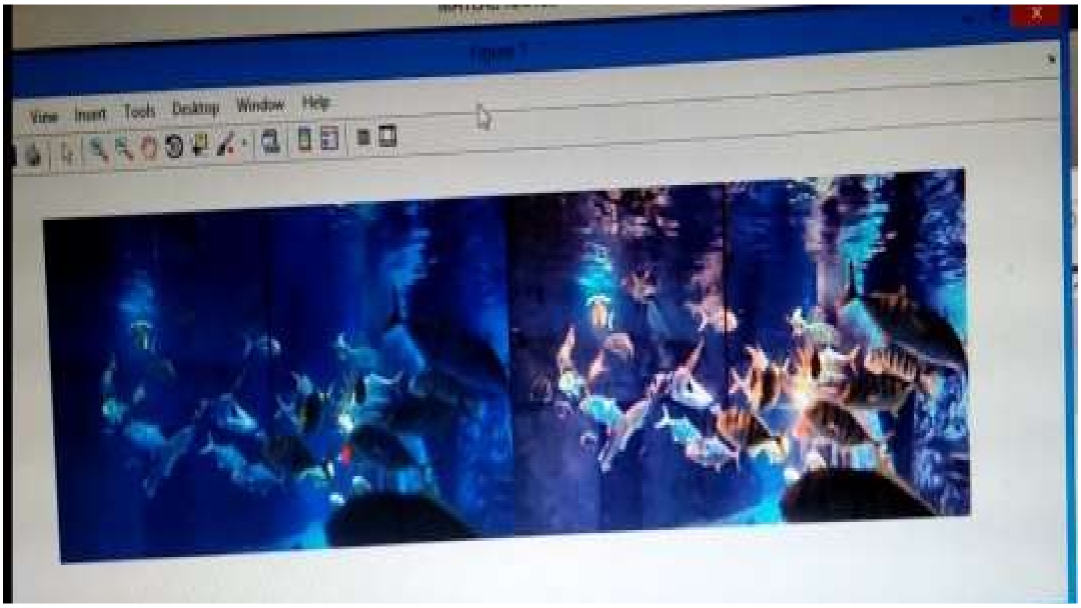
Figure 6: Decomposition, fusion of coefficients and image

V. RESULTS

The performance of the proposed method is observed using the following evaluation metrics.

Case 1.

Case 2.



Case 3.

Figure 6: Outputs of underwater video enhancement by stationary wavelet based fusion

Input video and enhanced video using SW based Fusion is shown and the 'parametric values are calculated and shown in table 1. Different types of videos are considered and their respective parametric values are observed.

Parameters Evaluated:
RMSE:
Let the images be of size MxN pixels i.e., x = 1,2,......M and y= 1,2,.....,N. The MSE and RMSE is defined as

$$MSE = \sum_{x=1}^{M} \sum_{y=1}^{N} \frac{[f(x,y)-f(x,y)]^2}{M \times N} \quad (3)$$

$$RMSE = \sqrt{MSE} \qquad (4)$$

Another related image quality measure is Peak Signal-Noise Ratio (PSNR) which is inversely proportional to RMSE; its units are in decibels (dB). It is the ratio of Peak Signal Power to Noise Power. It is defined by

$$PSNR = 20\ log_{10}\left[\frac{255}{RMSE}\right](dB) \qquad (5)$$

Where 255 is the Maximum Pixel Value for an 8 bits/gray-scale image.

Structural Similarity Index

It is a perceptual metric that quantifies image quality degradation caused by processing such as data compression or by losses in data transmission. It is a full reference metric that requires two images from the same image capture- a reference image and a processed image.

	PSNR	MSE	SSIM	MoE Hazy	MoE Enhance
Case 1	23.86	4.03	0.905	6.65	7.09
Case 2	17.87	30.85	0.734	7.00	7.55
Case 3	12.04	56.55	0.558	7.77	7.84

Table1. Parameters evaluated for different videos

By using rmse we are calculating root mean square error between original signal and our calculated noise signal.

VI. CONCLUSION

In this paper, the hazy underwater video have been considered and divided into frames, each frame enhanced in term of color and contrast using S-wavelet based fusion (SWBF) approach. The qualitative results depict that the proposed method has enhanced the quality of the hazy underwater images. The quantitative analysis shows the quality of the image is also maintained. In future, a comprehensive comparative study will be performed on state of the art methods for quantitative analysis with the proposed method.

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