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Video Resolution Enhancement using DWT, SWT and CLAHE

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Abstract— **One of an image details which has been always an vital concern in various image and video-processing applications, such as video resolution enhancement, feature extraction, and satellite image resolution enhancement is resolution. In recent advances Video Resolution enhancement has been envisioned to help in numerous applications and has turned out to be a hot research area. This opens up several technical challenges and immense application possibilities. The paper describes the three main categories - Contrast limited adaptive histogram equalisation (CLAHE), Discrete Wavelet Transform(DWT), Stationary Wavelet Transform(SWT). DWT uses filter for building the multi-resolution. SWT is an extension of the Standard Discrete Wavelet Transform to enhance the general details of an image. This study presents a novel resolution enhancement methods with future research area.**

Index Terms— **CLAHE, DWT, SWT, Interpolation.**

I. INTRODUCTION

Video is sequence of images to form a moving picture. Resolution of an image provides details of image. In video, resolution refers to number of pixels displayed on screen. Resolution is classified into two types. Spatial and Temporal Resolution.

Spatial Resolution is the number of pixels in a frame.

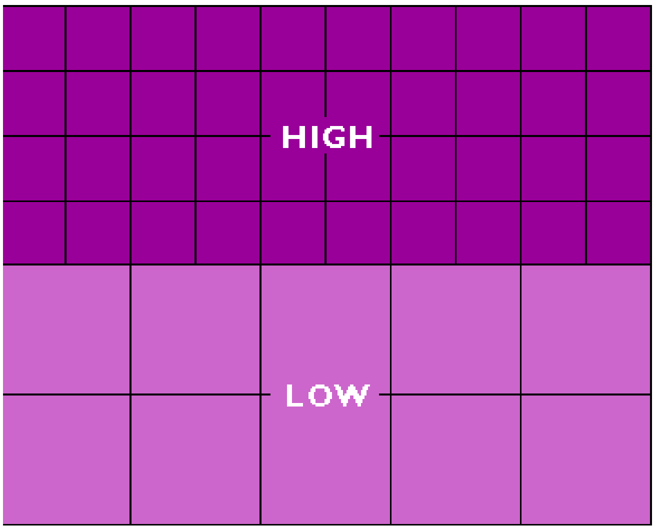

Fig.(a). Spatial Resolution

Digital image with higher spatial resolution indicates more detailed content.

Temporal Resolution is number of frames displayed per second(frame rate).

Video is formed by displaying a sequence of still images rapidly in succession. At lower frame rates as shown in Fig.(b) first example there are less images per second which leads to larger skip between images. This result in a noticeably jerky video.

More images are displayed in the same amount of time when frame rate is high as shown in second example of Fig.(b). This results in smoother video along with increased element as there are more total pixels presented overall.

Fig.(b). Temporal Resolution

Since video is sequence of images, to analyze the video, it is converted into frames. After processing, the sequence of frames are converted to video.

With raising security treats, recording activities 24/7 has become a vital part of life. With increase in security measures almost all areas install image and video capturing application to avoid crime. Substantial improvements are achieved in present digital cameras including resolution and sensitivity. Even with these improvements, there is a limitation in the quality of videos captured in dim light scenarios. First limitation, videos captured in dim light condition have deprived dynamic range. User cameras depend on automatic exposure control to confine High Dynamic Range (HDR) images. Drawback of increased exposure time is it leads to motion blur. Second limitation, SNR (Signal-to-noise ratio) is very low in images acquired in low light condition. To modify the level of input signals, sensitivity of the camera can be increased. The key characteristics of low-light video are low dynamic range and low SNR (high level of noise).

The next part of this paper provides a brief review of related work, describes the proposed DWT-SWT-CLAHE image enhancement method in detail with experimental results, and the final conclusions.

II. LITERATURE SURVEY

Various method has been proposed for resolution enhancement of images [1-3]. Novel image enhancement method named CLAHE-Discrete Wavelet Transform (DWT) was proposed by Huang[1]. CLAHE-DWT combines the

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CLAHE with DWT. At first, DWT decomposes the original image into low-frequency and high-frequency components. Then, low-frequency coefficients are enhanced using CLAHE keeping the high-frequency coefficients unchanged. Lastly, restructure the image by taking inverse DWT of the new coefficients. In DWT, due to down sampling information is lost.

A filtering algorithm for fast image enhancement is described in [2]. With minimum modification of original image noise smooth image is obtained using this algorithm. The filtered image is a weighted combination of four sub images obtained from low-pass filtering of the original image along four major directions. This algorithm reduces noise in the image and enhances the image. This algorithm is tested on several Magnetic Resonance(MR) images which are obtained from low field strength MR imaging system.

As stated in [3], a satellite image resolution enhancement technique based on complex wavelet transform is proposed. In this technique input image is decomposed in different sub bands using dual tree complex wavelet transform. Then the input image and high frequency sub bands are interpolated. Finally to combine these entire images inverse DT-CWT is applied to generate high resolution image. The visual and quantitative results that is peak signal-to-noise ratio (PSNR) show the superiority of the proposed technique over the conventional resolution enhancement techniques.

A satellite image resolution enhancement technique[4] based on the interpolation of input image and DWT produced the high-frequency sub bands is proposed. Then, Inverse Discrete Wavelet Transform(IDWT) is used to generate high resolution image on interpolated images. Intermediate stage is proposed in order to achieve a sharper image. This technique is tested on satellite benchmark images.

III. PROPOSED SYSTEM

The proposed method involves application of DWT, SWT and CLAHE methods to enhance the resolution of the video.

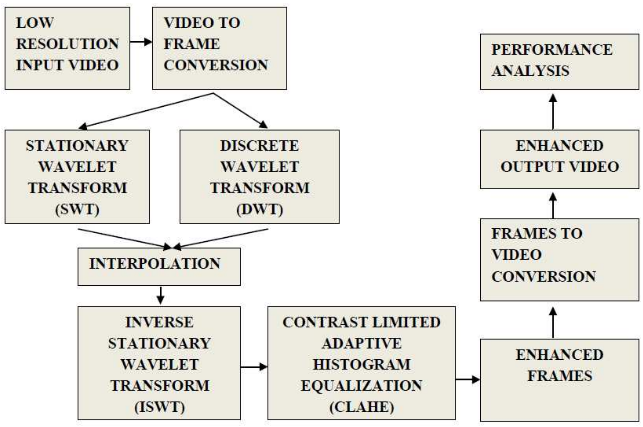

Fig.(c) Block diagram of process flow of proposed method

A. Discrete Wavelet transform

The discrete wavelet transform uses filter for building the multi-resolution time frequency plane. The DWT uses multi-resolution filter banks and special wavelet filters for the analysis and reconstruction of signals. In 2-D wavelet decomposition of an image, the 1-D discrete wavelet transform (DWT) is first applied along the rows of image and then along the columns. DWT produces four decomposed sub band images that are low-low (LL), low-high (LH), high-low (HL), and high-high (HH) as shown in Fig.(d).

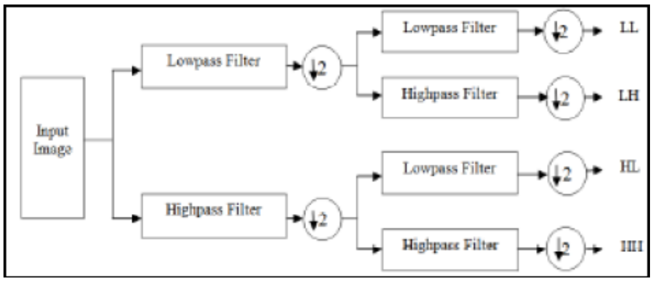

Fig. (d)Discrete wavelet transform

B. Stationary Wavelet Transform

The stationary wavelet transform is an extension of the standard discrete wavelet transform. Stationary wavelet transform uses high and low pass filters. SWT apply high and low pass filters to the data at each level and at next stage produces two sequences. The two new sequences are having same length as that of the original sequence. In SWT, instead of decimation we modify the filters at each level by padding them with zeroes. Stationary wavelet transform is computationally more complex.

C. Interpolation

Interpolation is the procedure of calculating the values of a continuous function from distinct samples. Image Reduction, Image Magnification, Pixel Image Registration, Correcting Spatial Distortions, and Image Decompression are few uses of interpolation in Image Processing applications.

Nearest neighbor, Bilinear and Cubic Convolution are the most common interpolation techniques.

Nearest-neighbor interpolation (proximal interpolation) is multivariate interpolation in one or more dimensions. Interpolation is the process of estimating the value of a unknown point given some colors of neighborhood points.

This algorithm selects the value of the nearest point and ignores values of neighboring points, yielding a piecewise-constant interpolant. The algorithm is very simple to implement. Commonly used in real-time 3D rendering to choose color values for a textured surface.

Bilinear interpolation is a re-sampling techniques used to produce a convincingly practical image. An algorithm is used to map a screen pixel location to a corresponding point on the texture map. A weighted average of the attributes of the four surrounding pixels is computed and applied to the screen pixel. This process is carried out for each pixel to produce the object being textured. To scale up an image, every pixel of the original image has to be moved in a certain direction depending on the scale constant. However, few pixels(holes) are not assigned appropriate pixel values when scaling up an image by a non-integral scale factor. These *holes* should be assigned proper RGB/grayscale values to avoid non-valued pixels in output image. Bilinear interpolation can be used where perfect image transformation with pixel matching is impossible.

Bicubic interpolation is an expansion of cubic interpolation for interpolating points on a 2-D normal grid. The interpolated surface is smoother than that obtained by bilinear or nearest-neighbor interpolation.

D. CLAHE

Contrast limited adaptive histogram equalisation (CLAHE) is an effective algorithm to enhance the local details of an image.

The contrast limited adaptive histogram equalisation (CLAHE) proposed by Pizer etc. is a classic Local Histogram Equalisation based image enhancement method, which first separates the image into numbers of continuous and non-overlapped sub-blocks, then enhances every sub-block individually and finally uses an interpolation operation to reduce the block artefacts.

E. Implementation

In this proposed method, one level DWT (with Daubechies filter) is applied on an input image to obtain four sub-band images. Three high frequency sub-bands (LH, HL and HH) consists of high frequency components of the input image. Bicubical interpolation with enlargement factor of 2 is applied to sub-bands LH, HL and HH images. DWT down sampling information loss occurs in the respective sub-bands. To overcome this issue, SWT is employed to minimize this loss. Since SWT high frequency sub-bands and interpolated high frequency sub-bands are of same size, they are added. The input image and correlated high frequency sub-bands are interpolated further for higher enlargement. In the wavelet domain, the low resolution image is obtained by low pass filtering of the high resolution image. In other words, low frequency subband is the low resolution of the original image. Therefore, instead of using low frequency subband, which contains less information than the original high resolution image, we are using the input image for the interpolation of low frequency subband image. Using input image instead of low frequency subband increases the quality of the super resolved image. Fig. (c) shows the block diagram of the proposed image resolution enhancement technique. After interpolation, Inverse Stationary Wavelet Transform (ISWT) is applied to all the interpolated sub bands. The output image has sharper edges than the interpolated image obtained by interpolation of the input image directly

IV. EXPERIMENTAL RESULTS

Two metrics PSNR and MSE are used to measure the enhancement produces by the proposed methods.
Below are the equation used to calculate PSNR and MSE.

$$PSNR(dB) = 10 * \log\left(\frac{255^2}{MSE}\right) \qquad (1)$$

$$MSE = \sum_{i=1}^{x}\sum_{j=1}^{y}\frac{\left(\left|A_{ij} - B_{ij}\right|\right)^2}{x * y} \qquad (2)$$

Video used in experiment was captured during night with very dim light. The experiment shows high PSNR and low MSE leading to enhanced video.

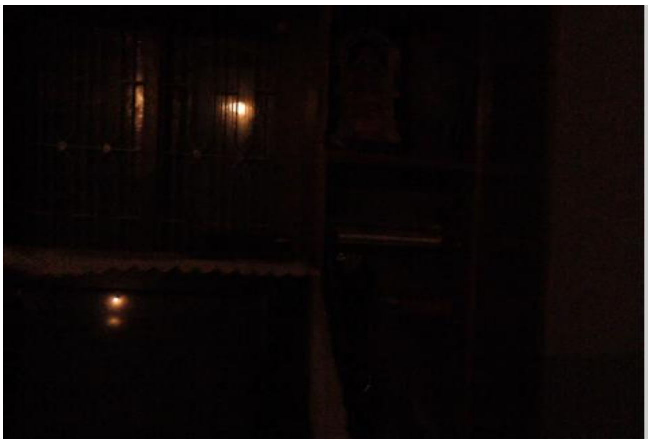

Fig. (e) Input image

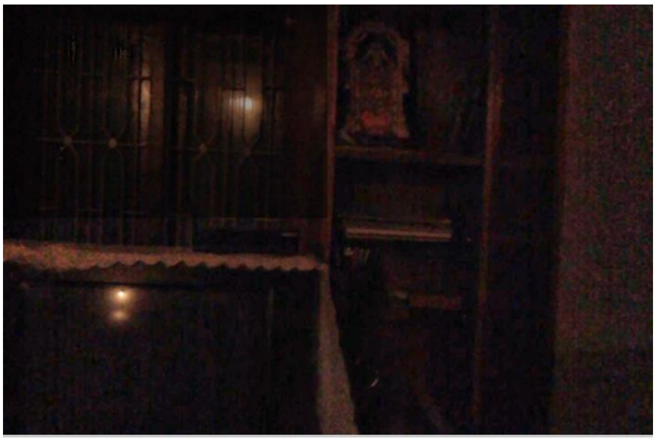

Fig. (f) Output Image

Fig.(g) depicts PSNR of video. PSNR is plotted against number of frames. x axis in the graph represent number of frames considered for enhancement while y axis represent PSNR value. The edges provide the PSNR value of particular image. The increasing curve indicates the enrichment of input image quality.

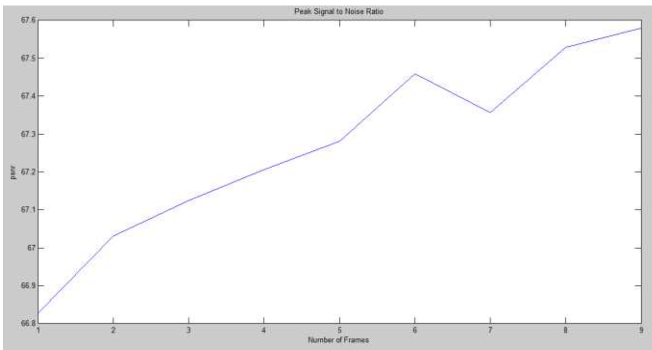

Fig. (g) PSNR v/s Number of frames

MSE is calculated between original and output image for each frames in the video and plotted as shown in Fig.(h). x axis in graph represent Number of frames which are considered for enhancement while y axis represent MSE between input and output image. The depriving curve indicates the noise is eradicated and image is improvised.

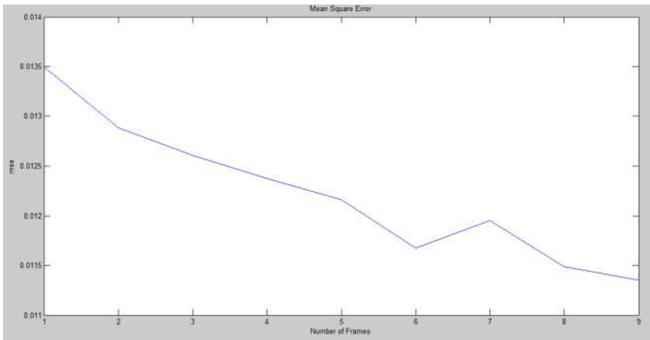

Fig. (h) MSE v/s Number of Frames

V. CONCLUSION

Low light videos characteristics are studied and an effectual framework to enrich the feature of video is projected. An adaptive histogram amendment with clipping thresholds may amplify noise. Hence combination of DWT, SWT and CLAHE is applied. Evaluation attributes PSNR and MSE show significant enhancement.

Future work may include different combination and order of SWT, DWT and CLAHE. DWT comes with different wavelet families which is used as filters while decomposition of input frames. These wavelet families can be explored as part of future enhancement. Also numerous interpolation methods can be tested as part of future enhancement.

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