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DEVELOPMENT OF AN ENHANCED LIFTING WAVELET TRANSFORM (LWT) FOR VIDEO FRAME COMPRESSION USING BRIGHTNESS IMPROVEMENT TECHNIQUE

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ABSTRACT

Information dissemination in both mobile networks and television today makes compression a very important business in multimedia communications. In this paper we introduced an enhanced lifting wavelet transform using luminance improvement method. A total of six (four acquired and two benchmark) sample video data were used to implement

Introduction

Image compression is considered as the application of data compression on digital images. The objective is to reduce redundancy of the image data for storage or transmission purposes (Keshika and. Rohit, 2014). This technique provides reduction in the cost of storage and transmission. It also speeds up transmission (Tejas *et al.*, 2013). In the age of information technology, pictures have become important information carriers, and massive

the developed technique. Frames were extracted from the video data and stored in the form of images in a buffer. The input image sample from the processed sample video (frame) was split into even and odd sets of samples for the efficient lifting filter to ensure appropriate approximation and detail extraction. This is to determine the efficiency of the developed technique. Simulation results showed that, the developed method was efficient with an improved compression ratio and peak to signal Noise ratio. Simulation results showed that, the proposed method was efficient for the respective individual sample video frames of NAERLS1.avi, NAERLS2.avi, NTA1.avi, and NTA2.avi and the bench mark, video frames with the following PSNR percentage improvement over the ordinary LWT compression method by 6.30%, 5.16%, 3.38%, 3.91%, 4.00%, and 6.71%.

Index Terms: Video Frames, Luminance Pixel Enhancement, LWT Compression

amounts of image data can lead to enormous transmission and storage pressures (Yuting Bao *et al.,* 2022). Compression in image processing plays a significant role in many fields. Areas that benefited immensely in image compression includes; medical diagnosis, satellite remote sensing, telecommunication industry, high-definition television and robotics. The main objective of image compression is to reduce the size of the image while maintaining the quality and information of the image (Zainab *et al.,* 2022), (Meera *et al.,* 2019). Digital images are enormous in size therefore occupy larger space for storage. Their enormous size makes them to occupy larger bandwidth and longer time to be uploaded or download through the Internet. This makes it so difficult to be stored as well as used in file sharing. Generally, images are compressed straight after capturing to decrease data size while preserving image quality for human visualization, which disregards the

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edition to intellect computer visualization response (Linfeng Liu *et al.,* 2022), (Walaa *et al.,* 2020). There are many lossy compression methods. Present standards for compression of images (Joint Photographic Experts Group compression algorithm) use discrete cosine transform (DCT), which represent an image as a superposition of cosine functions with different discrete frequencies (Adil and Kamil, 2019). To overcome this problem, the images are subjected to compression in size using various techniques (Pankaj Mohindru, 2016) Two types of wavelets existed. The first is continuous wavelet transform and the second is the discrete wavelet transform (Prabhjot, 2015). The advancement of fields like, computer vision, multimedia, and image processing affect directly the production of videos and images of stellar quality with precise detail. Compression is able to be implemented on different components of multimedia like image, graphics, audio, text and videos (Arwa Sahib *et al.,* 2022) At low data rates, the DCT based transforms suffer from a "blocking effect" due to the unnatural block partition that is required in the computation. Other drawbacks include mosquito noise (that is, a distortion that appears as random aliasing occurs close to object's edges) and aliasing distortions (Frank, 2010). Furthermore, the DCT does not improve the performance as well as the complexities of motion compensation and estimation in video coding. Due to the shortcomings of DCT, Discrete Wavelet Transform (DWT) has become increasingly important. The main advantage of DWT is that it provides space–frequency decomposition of images, overcoming the DCT and Fourier transform that only provide frequency decomposition (Frank, 2010). By providing space–frequency decomposition, the DWT allows energy compaction at the low-frequency sub bands and the space localization of edges at the high-frequency sub bands. Furthermore, the DWT does not present a blocking effect at the low data rates (Frank, 2010). The basis of DWT is wavelet function that satisfies requirement of multi-resolution analysis (Christian *et al.,* 2009). DWT represents

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image on different resolution levels that is, it possesses the property of Multi-resolution. DWT converts an input image coefficients series into one high-pass wavelet coefficient series and one low-pass wavelet coefficient series. In practice, such transformation is applied recursively on the low-pass series until the desired number of iterations is reached (of length n/2 each) (Priyanka, *et al.,* 2011). The lifting scheme has been introduced for the efficient computation of DWT. For image compression, it is very necessary that the selection of transform should reduce the size of the resultant data as compared to the original data set. So, this new lossless image compression method is used. Wavelet using the lifting scheme significantly reduces the computation time and speeds up the computation process. The lifting transform even at its highest level is very simple. It performs three operations: split, predict, and update (Chesta, *et al.,* 2011).

METHODOLOGY

The steps procedure adopted in this research, which includes the development of an improved method of video frame compression using lifting wavelet transform (LWT) are presented as follows:

1. Video data Acquisition on which the developed technique was implemented
2. Implementing the standard Lifting Wavelet Transform (LWT)
3. Applying the developed Brightness Improvement model

Video Acquisition

A total of four acquired video data and two benchmark video data were used in order to professionally determine the performance of the achieved methods under different conditions. The sample of these video frames are accessible in Figure 1.

Figure 1: Sampled Videos Frame (Abdulkareem1 *et al.*, 2018)

From Figure 1, the first four sample videos NAERLS1.avi, NAERLS2.avi, NTA1.avi and NTA2.avi were obtained using a video camera and the last two are benchmark videos were also obtained from data base of image processing. The Matrix Laboratory (MATLAB R2015a) image processing toolbox command was used to obtain the video details given in Table 1.

Table 1 Simulation Results of Sample of Video Data (Abdulkareem1 *et al.*, 2018), (Abdulkareem2 *et al.*, 2018), (Abdulkareem3 *et al.*, 2018)

Sample of Video Data	Collected Data		
	File Name Size (*.avi)	***File***	***File Frames***
1	NAERLS1.avi	18.1Mb	157
2	NAERLS2.avi	10.3Mb	155
3	NTA1.avi	9.6Mb	152
4	NTA2.avi	11.2Mb	200
5	Akiyo.avi	11Mb	300
6	Foreman.avi	7.25Mb	100

Videos are frames of dynamically changing images. The images are usually derived from video cameras which comprised of video frames. Therefore, the video data given in Table 1, were initially converted into frame of static images for easy processing and analysis.

Implementation of standard Lifting Wavelet Transform

The Lifting Wavelet Transform (LWT) is a computational efficient transform method developed to address some of the challenges of DWT. Thus, the LWT implementation is similar to the DWT, except that the total number of samples at each stage is the same as the initial set of samples. In this research, the input image sample from the processed sample video was split into even and odd sets of samples for the efficient lifting filter to ensure appropriate approximation and detail extraction.

The step-by-step procedural approach for the implementation of the enhanced LWT based compression is highlighted as follows:

Step One

Input the sampled enhanced frames, that is, $F(i, j)$, where, $i = 1, 2, ..., N$ and j = 1, 2, … M+1. The three stages (split, prediction, and update) of LWT on the image were then performed as:

i. The input image signal was split into even, f_e and odd, f_o samples as follows:

$$f_e(m,n) = F(m,2n) \quad (1)$$

$$f_o(m,n) = F(m,2n+1) \quad (2)$$

ii. The integer positions of the odd samples from the neighbouring even samples were predicted as follows:

$$h(m,n) = f_o(m,n) - p_e(m,n) \quad (3)$$

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where, $h(m,n)$ is the resulting prediction residuals or high sub-band coefficients.

Assuming the sample pixels have a strong correlation in the angle θ_v and the integer pixels are marked by "O", the half pixels by "+", and the quarter pixels by "×". The prediction of $f(m,2n+1)$ is taken as a linear combination of the even samples as follows:

$$P_e(m,n) = \sum_i \alpha_i x_e(m + sign(i-1)\tan\theta_v,\ n+1) \quad (4)$$

Where,

$$sign(\mathrm{f}) = \begin{cases} 1 & f \geq 0 \\ -1 & otherwise \end{cases} \quad (5)$$

The weighting factor α_i is given by the filter coefficients.

iii. In the updating step, the even samples are replaced using the following equation:

$$l(m,n) = f_e(m,n) + u_h(m,n) \quad (6)$$

The values of $l(m,n)$ are always located at an integer position which is one of the characteristics of the LWT.

Applying the Developed Brightness Enhancement Model

At the first stage, the pixel values throughout the image are extracted and stored in a buffer (B). The dimensional size of the image was first determined and stored as X for number of rows and Y for number of columns. The pixel values extraction formulation is given as in (Abdulkareem1 *et al.*, 2018), (Abdulkareem2 *et al.*, 2018), (Abdulkareem3 *et al.*, 2018)

The brightness (luminance) enhancement technique was applied to the input at the transform stage, where the LWT is implemented for compression. Subsequently, the output reconstructed to enhance the video signals makes the LWT different from the standard LWT used by other researchers.

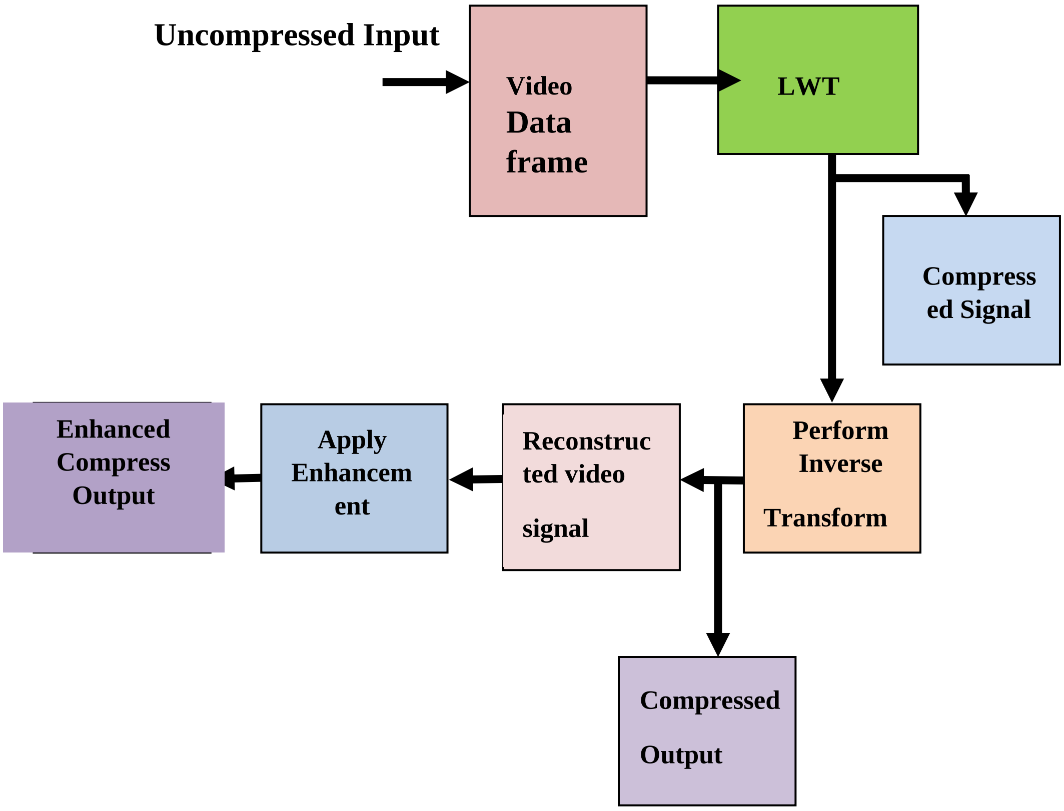

Figure 2: Block Diagram of the achieved result

In the implementation as shown in Figure 2, the sampled uncompressed video data served as input into the algorithm at the transformation stage of the DWT, to achieve video compression. The inverse transform was then implemented to regain back the signal and the enhanced video output was reconstructed to achieve efficient compression. For analysis, the compr ession ratio metric was used to determine the performance of the enhanced LWT. This metric is expressed as (Wei, 2010):

$$Cr = \frac{size\left(F(x,y)\right)}{\sum_{i=1}^{N} Pixels} \qquad (13)$$

The numerator of equation (13) is the total size of the image frame, the denominator is the total number of pixels and Cr is the compression ratio. The flowchart for the implementation of the enhanced LWT is given in Figure 3.

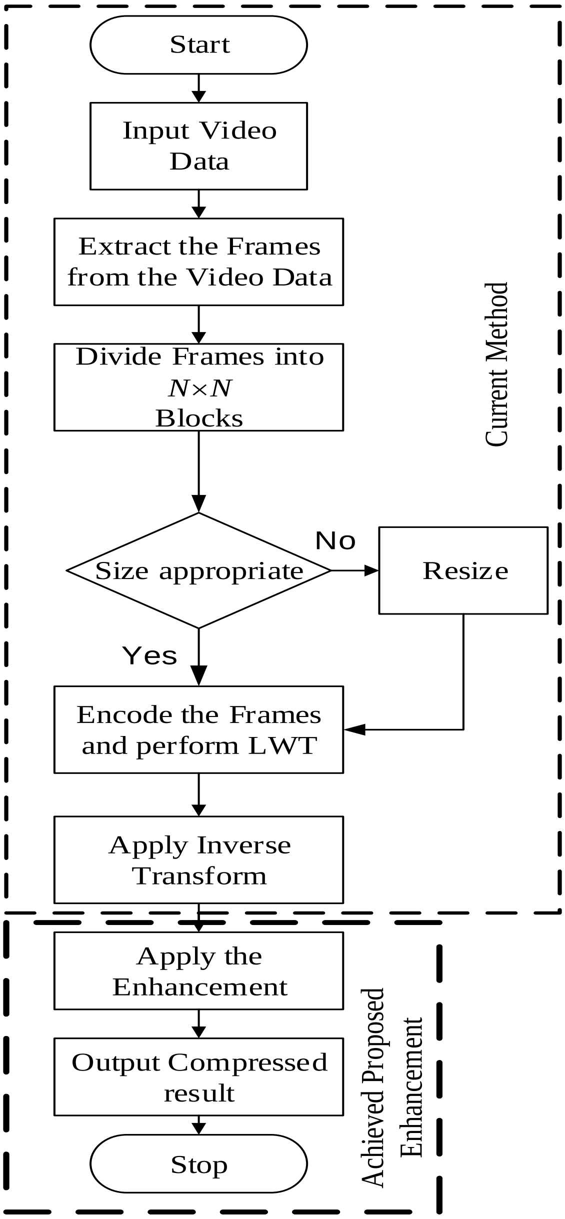

Figure 3 Implementation of the Enhanced LWT.

The video is read from the first block after start. The process involves importing the video into the MATLAB simulation environment and determining the total number of frames. At this point the video sample is converted into frames in the first part of Appendix C and the converted frames are extracted. The frames are then divided into segmented blocks of N x N. The decision box decides if the segmented blocks are divided into appropriate sizes. If "No" then the blocks must be resized and if "Yes" the process goes ahead to encode the frames and perform the LWT. The inverse transform is then applied to regain the compressed image. The brightness enhancement model is then applied.

RESULTS AND DISCUSSION

The acquired video samples were read and converted into image frames. The resulting image frames were resized appropriately. Implementing the LWT and subsequently application of the brightness enhancement technique on the four samples frames and the two bench mark frames yielded a significant improvement. Since the essence of compression is to reduce the size of the video data for easy transmission, the performance of the LWT is evaluated using sample size (bytes), compression ratio, and peak signal-to-noise ratio in dB.

Table 2: Simulation Result of Performance Comparison of the Sample Size after LWT Compression.

Sample	Original Size	LWT
NAERLS1.avi	18.1Mb	6.41Mb
NAERLS2.avi	10.3Mb	5.30Mb
NTA1.avi	9.60Mb	5.06Mb
NTA2.avi	11.2Mb	7.12Mb
Akiyo.avi	11.0Mb	2.11Mb
Forman.avi	7.25Mb	0.196Mb

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From Table 2, it is observed that a significant amount of size has been reduced using the LWT. These compressed sizes were obtained before the application of the brightness enhancement techniques. However, the pixel intensity is improved by histogram distribution to achieve better image representation. The results of the compression ratio analysis of the LWT when subjected to the brightness enhancement model with respect to the four video sample data of NAERLS, NTA and the two Bench marks of Akiyo and Foreman are given in
Table 3.

Table 3: Simulation Result of Compression Ratio Analysis for LWT

Sample	LWT
NAERLS1.avi	22.983
NAERLS2.avi	11.656
NTA1.avi	17.901
NTA2.avi	14.710
Akiyo.avi	18.424
Forman.avi	14.081

As the compression ratio increases the image quality degrades because of the artefacts (noise) resulting from the block-based scheme. This implies that, high compression ratio is an indication of how much signal reduction was achieved due to compression. Table 4: shows PSNR results of LWT before and after its enhancement and the percentage of improvement.

Table 4: Simulation Results of Peak Signal-to-Noise Ratio (PSNR) of LWT Techniques before and after their Enhancement

Sample	LWT	E_LWT	%
NAERLS1.avi	21.89dB	23.36dB	6.30
NAERLS2.avi	16.92dB	17.84dB	5.16

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NTA1.avi	16.01dB	16.57dB	3.38
NTA2.avi	16.94dB	17.63dB	3.91
Akiyo.avi	20.17dB	21.09dB	4.00
Forman.avi	18.64dB	19.98dB	6.71

Table 4 shows considerable amount of PSNR improvement achieved by the enhanced LWT. This is a clear indication of how effective and robust the technique when applied to graphical image compression.

CONCLUSION

This report has presented the development of an improved method of video compression using lifting wavelet transform (LWT). A total of six (four acquired and two benchmark) sample data were used in implementation of the developed technique. Simulation results showed that the developed method achieved considerable amount of improvement when the enhanced LWT was used. The peak to signal noise ratio evaluation of LWT techniques before and after enhancement showed the efficiency and signal quality of the developed method.

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