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Nonsubsampled Contourlet Transform based Video Compression using Huffman and Run Length Encoding for Multimedia Applications

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ABSTRACT

The process of encoding a video file that devours less memory space than the original video file is known as video compression. It is faster to transmit over the network. It reduces the size of video formats by eliminating unnecessary and redundant data from the original file. Video processing holds the most important role in different application fields such as medical, education, video conferencing, etc. The main objective of this video compression technique using a non-subsampled contourlet transform with Huffman encoding and run-length encoding is to achieve a high Compression Ratio (CR) and acceptable Peak Signal to Noise Ratio (PSNR) with less Mean square Error (MSE) without affecting the quality of the video. The design and development of the proposed algorithm for high-quality video compression are obtained through web cameras and surveillance cameras.

Key words: Video compression, Contourlet transform, Huffman, Run-length encoding, CR, PSNR, MSE.

1. INTRODUCTION

The new video compression standard must be compatible and more progressive than the formerly developed ones. The compression standard should use minimum storage space and less bandwidth for transmission. The two major groups that are involved in creating the video standards are Moving Picture Experts Group (MPEG) from International Standardization of Organization(ISO)/International Electrotechnical Commission (IEC) and Video Coding Experts Group (VCEG) from ITU-T (International Telecommunication Union).

Video technologies are declining and discarding the unnecessary video data, because of this idea, the digital video file can be capably sent over a network and stored on a computer disk. With well-organized compression techniques, a notable reduction in file size can be obtained with less or noworse effect on the quality of the video[17][18]. The visual quality, still, it can be affected if the file size is moreover decreased by increasing the compression level for given compression techniques. Because of the limitations on the bandwidth and storage capacity, a video can be converted into frames, and this frame needs to be compressed before the transmission process or the storage process [19]. Hence it is necessary to study a literature survey, to understand the appropriate methods during compression.

Ahmed and Salama have jointly proposed a novel technique for compressing video using a fast curvelet transform. In this technique, the authors exhibit a fast curvelet transform in combination with run-length and Huffman coding for video compression [1]. The main objective of this work is to compress the video in a lossless manner. Hence it can be produced by using a reduced bit rate for transmission and the storage of information can be obtained by maintaining the video quality. The video was compressed and their results are analyzed through the compression ratio (CR), Peak Signal to Noise Ratio (PSNR), and storage similarity (SSIM).

Mithila M and Razia S have proposed a technique for video summarization using contourlet transform with k-means clustering. Contourlet transform is multi-directional transforms that can maintain the edges and detecting the shot boundaries. K-means clustering is used for extracting the keyframes. In this, video is segmented into different frames, then Contourlet transform is applied to establish the starting and end of each shot. From them, a keyframe is extracted and represented by K- means clustering [2]. Hence, they are used for summarization by eliminating duplicate ones. Results are analyzed through the video having 100% accuracy with no similarities among others.

Cheriet has proposed a technique for the optical flow of video sequences using Ridgelet transform. This approach is fast and capable to estimate the optical flow with low complexity. Ridgelet transform overcame two troubles such as lack of shift-invariance and poor directional selectivity. The motion estimation is used in this method to find the velocity field between two successive images. In this method, the optical flow of an image sequence is calculating based on Ridgelet transform. It conquers in projecting the optical flow vectors on a basis of Ridgelet transform [7][8]. This method results in a way of fast and low-cost computing optical flow [3]. This transfer tends to permit the energy of a regular signal into a series of pieces to contain the coefficients as well as the wavelet transform. Then it passing through the Fourier transform, it consists of the radon projection of an image. The experiment concludes that Ridgelet transform is more accurate in the optical flow estimation.

Hosam and Amir have proposed a technique for compression of the video in three-Dimensional with less buffering requirements. In this approach,3-D coding for video sequences can be obtained factually accurate in the temporal direction(time-domain) decomposition with less buffering requirements. By the usage of 3D wavelet, the images in the video are correlated and quantized to provide transform coefficients by encoding technique. If the video content is not quick or fast produce low-frequency components, thus the high-frequency components are eliminated [4]. Applying the wavelet transform with some types of filters may introduce errors. After decoding, finally, the compressed video has been obtained with less buffering requirements.

Wadd S and B Patil have proposed a technique for Video compression using a Discrete Cosine Transform. Using this transform, each pixel can be reconstructing values as an 8*8 block. It is a lossless and reversible process. In the temporal redundancy, it is the repetition of frames with each other. The consecutive frames can be isolated from them which will give a temporal compression in the video. The bitstream of a MPEG is decoded by using run-length decoder and it is converted into an original coefficient of DCT. Then the coefficients of DCT are quantized using the quantization matrix to an original DCT [5][6]. By taking Inverse DCT it will give an appropriate component of a frame. Then the frames are motion-compensated through a motion estimation algorithm. The chrominance component is a major part to resample into the original form. Again, the frames are converted back to RGB form. Finally, the sequence of frames is converted, which is the final compressed video.

2. TRANSFORM AND CODING FOR COMPRESSION

2.1 Contourlet Transform

Do and Vetterli proposed the contourlet transform in 2002 and it is a two-dimensional transform for the representations of images. The human visual system was inspired by the contourlet transform. Contourlet transform is used to capture the distinct shape of the images in different directions which are shown in Figure 1. The properties of the contourlet transform are multire solution, localization, directionality, and also their basic functions such as multiscaling and multidimensional[9][10].

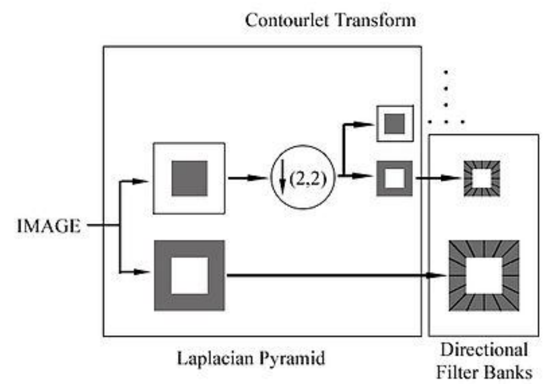

Figure 1: Contourlet transform decomposition

In the contourlet transform, the double filter bank is used to get the distinct shape of images. In the double filter bank, the discontinuities in the images are captured by the Laplacian pyramid first and then discontinuities are converted into linear structures using a directional filter bank. The double filter bank is a combination of LP and DFB and it is also known as a pyramid double filter bank.

2.2 Non subsampled Contourlet Transform

The contourlet transform was proposed and developed by da Cunha Zhou and Do in 2006. The development of NSCT is mainly, because of the contourlet is not shift-invariant. Non-Subsampled contourlet transform has been used in different applications such as synthetic aperture radar despeckling, image enhancement, and texture classification.

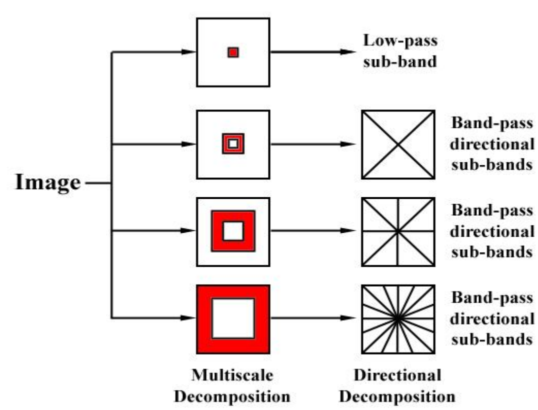

Figure 2: Nonsubsampled contourlet transform

To maintain the directional and multiscale properties of the transform, the Laplacian pyramid was exchanged with a non-subsampled pyramid structure to keep the multiscale property and it is also useful for directionality which is shown in Figure 2. Thereby, up-sampling and down-sampling are removed from the process. Alternately, the filters in the

Laplacian pyramid and the directional filter banks are up-sampled [11][12]. It reduces the shift variance is now present with aliasing and the directional filter bank[13][14]. The coarser level of the pyramid is on processing there arises the potential for aliasing and loss in resolution. The case that lies with this transform is the design of the filters for both filter banks. Some properties that are desired in this transform are perfect reconstruction, a sharp frequency response, easy implementation, and linear phase filters. These properties were implemented by first removing the frame requirement and then mapped to design the filters, and implementing a ladder-type structure. These changes will lead to a non-subsampled contourlet transform which is not efficient but performs well in comparison with other similar, and in other cases, it is more advanced transforms when denoising and enhancing images.

2.3 Quantization

Vector quantization is a generalization of scalar quantization to the quantization of a vector. It also makes use of linear and nonlinear dependencies that exist among the components of a vector and it is superior when the components of the random vector are statically independent of each other.

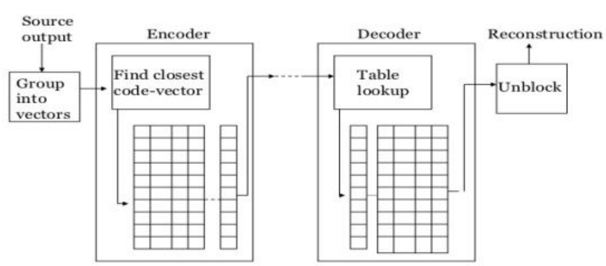

Figure 3: Vector quantization

A vector quantizer Q of dimension K and size N is a mapping from a vector (or a "point" in R^K), into a finite set C $=\{y_1, y_2, y_3 \ldots\ldots y_N\}$, $y_j \in R^K$, the codebook of size N which is shown in Figure 3.

Q:$R^K \longrightarrow$ C it partitions R^K into N regions or cells, R_i for i ∈ j = (1,2,….N} $R_i = \{x \in R^K : Q(X) = y_i\}$

2.4 Encoding techniques

Run-length encoding (RLE) is possibly the simplest compression technique. The algorithms used in the RLE are lossless and it depends on searching of bits, bytes, or pixels of the identical value and encoding the length of the bits and the value of the run. Run-length encoding will lead to results in images acquires a large area of contiguous color, particularly monochrome images[15][16].

Complex color images like photographs do not compress well. At that time RLE can increase the file size. In the common use, there is a number of RLE variants, are encountered in the TIFF, PCX, and BMP graphics formats.

Huffman coding is an algorithm used for compressing data in a lossless manner. The code should have the prefix – free property, for any two symbols, the code of one symbol must not be a prefix of the code of the supplementary symbol. Huffman algorithm is a greedy approach to generating optimal prefix-free binary codes. Optimality refers to the property that no other prefix code uses fewer bits per symbol than the code constructed by Huffman's algorithm.

The idea behind Huffman's algorithm, that the shortest length code can be used by a variable-length code and the least likely symbols can use the longest code words. This leads to a reduction in the average code length. In this way, the average code length will be reduced. The algorithm assigns code words to symbols by constructing a binary code tree.

The code of a given symbol will responds to a unique path from the root to the leaf, with 0 or 1 is added to the code, for every edge during the path, and it depends on whether the left or right child of a given node occurs next along the path.

3. PROPOSED METHOD

The objective of this work is to compress the data in the video frames using nonsubsampled contourlet transform along with the run length and Huffman encoding techniques. To achieve high PSNR and compression ratio and minimum MSE without affecting the quality of the video.

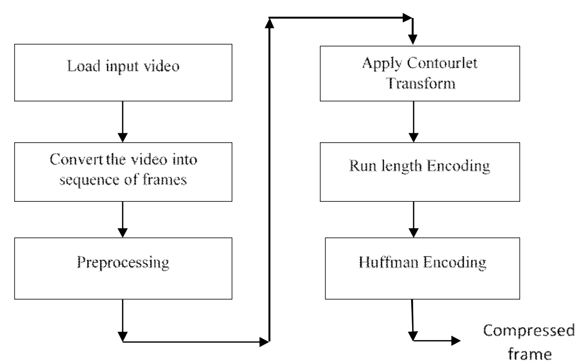

Figure 4: Flow diagram of compression process

In the proposed method, we are using non-sub sampled contourlet transform for video compression. Contourlet transform can save details of the image better than other transforms because it is multi-scale and oriented. This transform can recognize discontinuity such as edges.The flow diagram of the proposed compression process is shown in Figure 4. The input video is converted into several frames and each is compressed based on non-subsampled contourlet transform. Three-level decomposition is used for transforming the image into coefficients. The transformed coefficients are quantized using vector quantization followed by encoding. In this method, Run-length and Huffman encoding are the coding techniques to build the compression. Comparing the performance parameters of both the encoding process, obtaining the original video with less size.

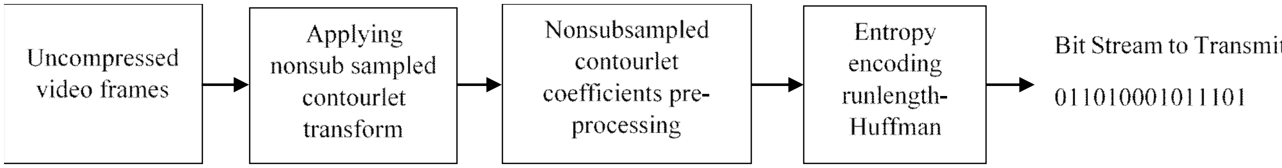

Figure 5: Proposed encoding video compression scheme

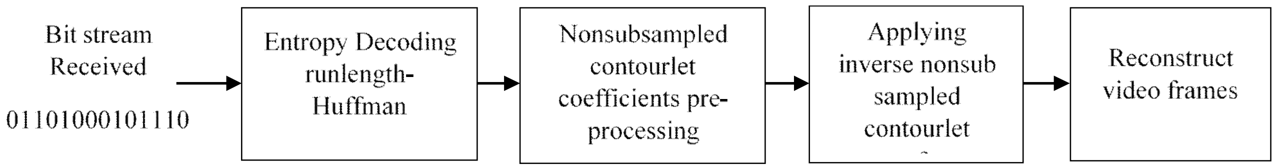

Figure 6: Proposed decoding video

The basic steps of the proposed video compression algorithm are shown in Figure 5 and Figure 6.

4. PERFORMANCE PARAMETERS

The Performance of any video compression can be determined by the parameters such as PSNR (Peak Signal-to-noise ratio), CR (Compression Ratio).

$$PSNR = \frac{20*\log_{10}(Max.Pixel\ value)}{\sqrt{MSE}} \qquad (1)$$

where, MSE represents the mean squared error

$$MSE = \frac{1}{N}\sum_i \sum_j (f(i,j) - F(i,j))^2 (2)$$

Where N denotes the total number of pixels.
f(i,j) denotes the pixel value in the original image.
F(i,j) denotes the pixel value in the reconstructed image.

$$CR = \frac{size\ of\ the\ compressed\ image}{Total\ number\ of\ pixels} \qquad (3)$$

Non-Sub sampled Contourlet transform-based video compression gives improved Peak Signal to Noise Ratio, Compression Ratio, without degradation in the video quality. It reduces the storage space required to store the videos. It is efficient for static regions of the image, while maintaining low complexity and adaptability to the receivers' resources.

5. RESULTS AND DISCUSSION

Non-Sub sampled Contourlet transform based video compression gives improved Compression Ratio and Peak Signal to Noise Ratio without degradation in the video quality. It reduces the storage space required to store the videos. It is efficient for static regions of the image, while maintaining low complexity and adaptability to the receivers' resource.

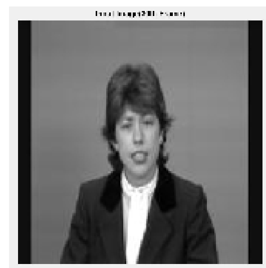

Figure 7 (a): Input image (30th frame of video1)

Figure 7 (b): Reconstructed image (30th frame of video1)

Figure 8 (a): Input image (30th frame of video2)

Figure 8 (b): Reconstructed image (30th frame of video2)

Figure 9 (a): Input image (30th frame of video3)

Figure 9 (b): Reconstructed image (30th frame of video3)

Table 1: Comparison of performance parameters for video1 (Claire)

Method	Input	Format of the video	Size of the input video	PSNR (dB)	CR	MSE	BPP	Size of compressed video
Proposed	Video1	AVI	2.51 MB	27.07	89.9	127.4	0.72	1.54MB
DWT	Video1	AVI	2.51 MB	20.3	70.1	100.1	0.52	2.21MB
DCT	Video1	AVI	2.51 MB	18.6	65.6	95.4	0.45	2.09MB

Table 2: Comparison of performance parameters for video2 (Miss-America)

Method	Input	Format of the video	Size of the input video	PSNR (dB)	CR	MSE	BPP	Size of compressed video
Proposed	Video2	AVI	4.86 MB	28.9	86.2	125.5	0.65	3.56MB
DWT	Video2	AVI	4.86 MB	24.6	65.4	96.2	0.45	3.24MB
DCT	Video2	AVI	4.86 MB	20.3	62.7	90.1	0.42	3.10MB

Table 3: Comparison of performance parameters for video3 (Foreman)

Method	Input	Format of the video	Size of the input video	PSNR (dB)	CR	MSE	BPP	Size of compressed video
Proposed	Video3	AVI	3.96 MB	26.4	84.2	122.5	0.78	3.4MB
DWT	Video3	AVI	3.96 MB	20.3	72.5	97.4	0.34	3.81MB
DCT	Video3	AVI	3.96 MB	18.7	61.2	90.6	0.25	3.75MB

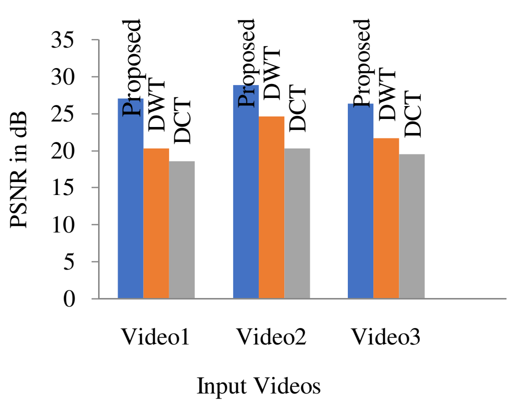

Figure 10: Comparison of PSNR values

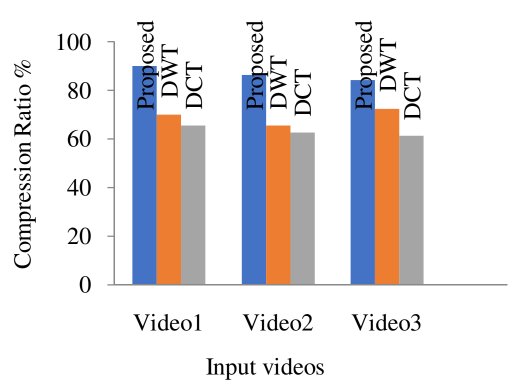

Figure 11: Comparison of Compression Ratio Values

The performance of the proposed algorithm is tested on different video sequences of the database available at http://see.xidian.edu.cn/vipsl/database_Video.html.

Performance parameters obtained for input video1 (Claire), video2 (Miss-America), and video3 (Foreman) are tabulated in table 1, table 2, and table 3 respectively. It is observed that the proposed technique produces a maximum of 89% compression ratio.

The sample video frame of input video1 is shown in Figure 7. The 30th frame of the input video1 is shown in Figure 7 (a) and its reconstructed frame is shown in Figure 7 (b). The sample video frame of input video2 is shown in Figure 8. The 30th frame of the input video2 is shown in Figure 8 (a) and its reconstructed frame is shown in Figure 8 (b). The sample video frame of input video3 is shown in Figure 9. The 30th frame of the input video3 is shown in Figure 9 (a) and its reconstructed frame is shown in Figure 9 (b). The simulation was done using MATLAB software. The size of the compressed video is less than the original video with the same quality.

Comparison of PSNR values of proposed methodology with DWT and DCT is shown in Figure 10. Comparison of Compression Ratio values of proposed methodology with DWT and DCT is shown in Figure 11.

6. CONCLUSION

In this paper, we proposed the non-subsampled contourlet transform with Huffman and run-length encoding to compress the real-time videos for multimedia applications. The proposed method takes advantage of both Huffman and run-length encoding techniques to provide a high compression ratio. The proposed technique is suitable for multimedia applications that use a collection of multiple media sources. A new standard should use minimum storage space and less bandwidth for transmission. For real-time video transmission or storage process, this compression technique is most suitable. In the future, the non-subsampled contourlet transform can be used with different encoding techniques to improve peak signal to noise ratio

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