Lossless Video Compression Using Prediction and RLE

Hayder Waleed Shnain
Computer Engineering Department
Baghdad, Iraq

Mohammed Najm Abdullah
Computer Engineering Department
Baghdad, Iraq

Hassan Awheed Jeiad
Computer Engineering Department
Baghdad, Iraq

Abstract- Video compression is an application of data compression. It reduces the size required for video storage and the time needed to send it over the transmission media. Run-length-Encoding (RLE) is always effective in image compression of a binary image. In this paper, Lossless JPEG is used to compress video with color frames. RLE has been used after predicting the Pixels and applying 3-bit instead of 8-bit as a counter to the repletion of identical consecutive pixels and that led to an improvement in the compression ratio. The obtained results showed that by using 8-bit to represent the repetition counter of RLE the compression ratio was only 1.18 while the compression ratio became 1.4 through using 3-bit for representing the counter in RLE. Also, the results showed that the obtained video compression ratio for considering the prediction approach with 3-bit for the counter of RLE has been improved to be equal to 1.7412.

Keywords – Video Compression, Lossless JPEG, RLE, Predictor

I. Introduction

Any video consists of a set of successive still images which are called frames and it is often the temporal interval for any video is 25 fps or 30 fps [1]. Each frame consists of a matrix of integer values the represents the pixels arranged in columns and rows as shown in figure1. Moreover, the main goal of video compression is to reduce the space required to store video and reduce the time required to transmit video [2]. There is a high nexus between consecutive frames as the video is compressed by removing this close association between these frames [3]. Generally, There are two types of compression methods used to compress a video: lossless compression and lossy compression. lossless compression works to reduce the size of the video with the possibility of restoring the original video without any change or loss of data. On the contrary, the other type which is the lossy compression causes loss of part of the details in addition to reducing the size of the video and thus the loss of part of the data during the restoration of the original video [4].

H. Shnain, et al. [5] using FPGA to implement RLE lossless compression method using RLE with 3 bit for the repetition counter. H. Husseen, et al. [6] used lossy data compression to purpose modified run-length encoding. The authors proposed that if the next pixel is equal or greater by 10 or less by 10 than the first pixel it's considered in run and counter will be increased. By using the technique mentioned, the work in [6] achieved a high compression ratio but suffering from loss data after compression and decompression. Zaid H. and Maher K. [7] used RLE in a certain way that identical data (runs of data) are stored as a data value 8 bit and count value 16 bit that means a maximum value of count equal to 2^{16}. That method improved the compression ratio when the input sequence has very large identical data.

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This paper is organized as follows: Section II describes the frame differencing. the proposed method is shown in Section III. Section IV explains the results of the test videos. Section V gives the conclusion.

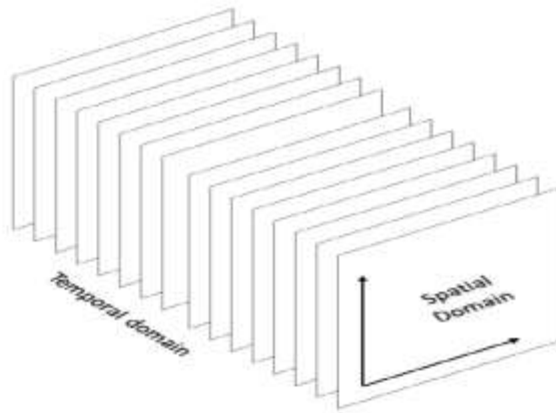

Figure 1 : Video Structure.

II. Frame Differencing

Generally, each video has two domains which are the temporal domain and the spatial domain, and by exploiting repetition founded in both domains the video is compressed by using the simple classical frame differencing the unlinking of the successive frames where each frame is subtracted from the one preceding it [7]. The difference between the frames will be as shown in figure 2.

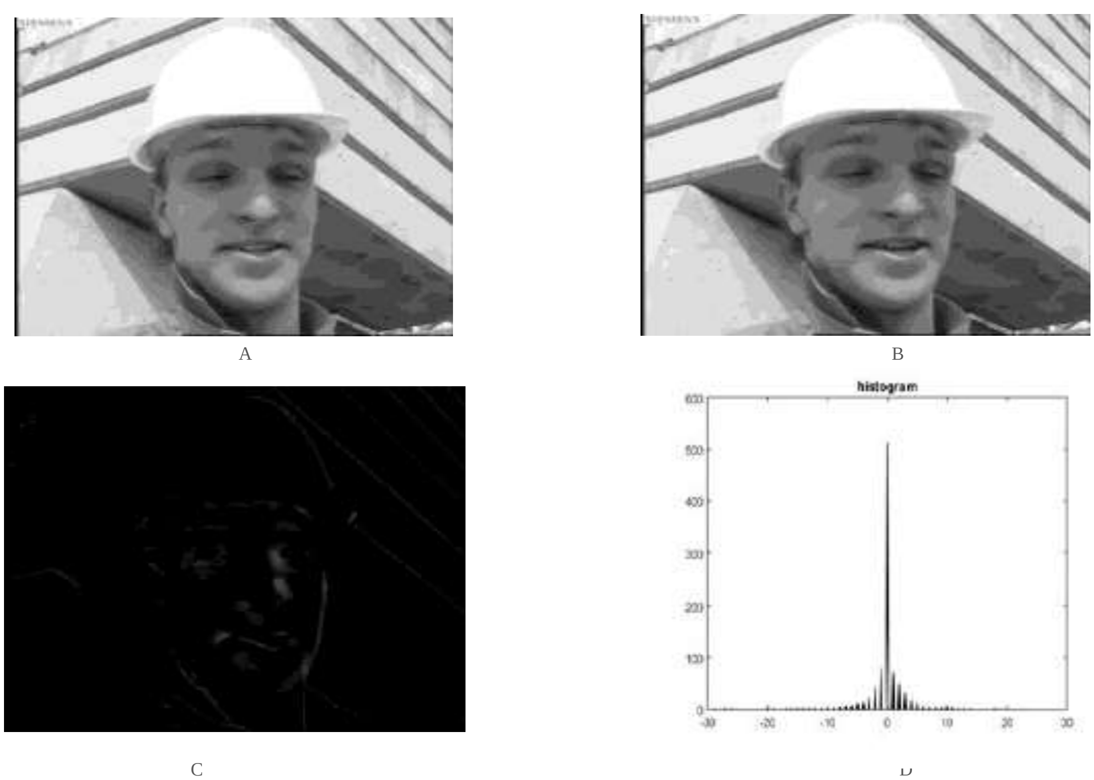

FIGURE 2 : AN EXAMPLE OF FRAME DIFFERENCING

(A) FRAME 1 OF THE FOREMEN SEQUENCE. (B) FRAME 1 OF THE FOREMEN SEQUENCE.

(c) Differential frame. (d) Histogram of the differential frame.

III.Lossless JPEG

Lossless JPEG was found to ensure that the original data was recovered after the decompressed process, unlike lossy Compression who suffers from data loss after decompression as it depends on discrete cosine transform (DCT). Essentially, lossless JPEG consists of two stages: predictor and entropy encoder as shown in figure 3 [4][8].

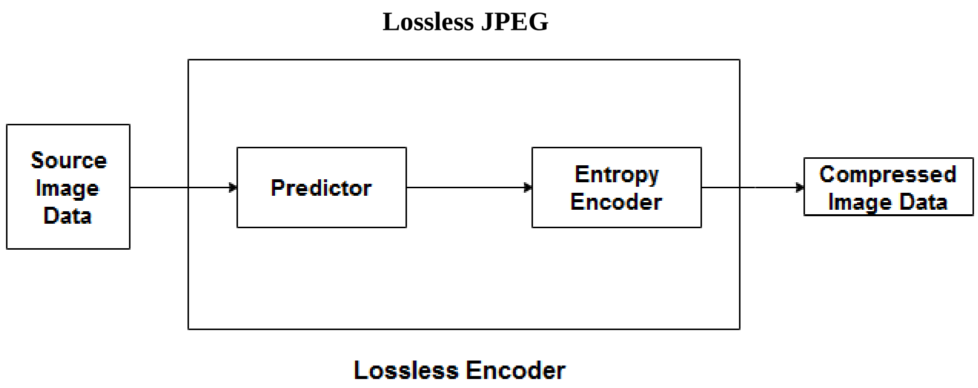

FIGURE 3 : BLOCK DIAGRAM OF LOSSLESS JPEG.

A. The Predictor

In the prediction process, three adjacent pixels were selected, namely A, B, and C for pixel x for which the predictive value is to be found as shown in figure 4.

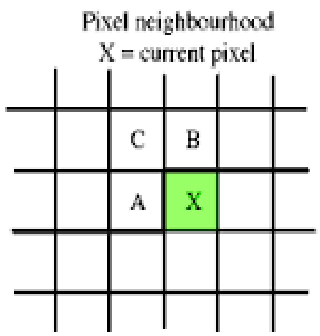

FIGURE 4 : THREE NEIGHBORING SAMPLES AROUND PIXEL X THAT NEEDS TO BE PREDICTED.

Table 1 lists eight different predictors that can be considered for the prediction process. In this paper, predictor number four (A+B-C) was used.

TABLE 1. EIGHT TYPES OF PREDICTORS.

Encoder type	Prediction method
0	No prediction
1	A
2	B
3	C
4	A + B – C
5	A + ((B – C) / 2)
6	B + ((A – C) / 2)
7	(A + B) / 2

Moreover, padding is applied through adding a row and column of zeroes to the top and left of each frame of the video to get three adjacent pixels for border pixels as shown in figure 6. After predicting all of the pixels, the next step of lossless jpeg which is the entropy encoding is applied to the difference between P and X. Where P is the predicted value of pixels, and X is the original pixel value.

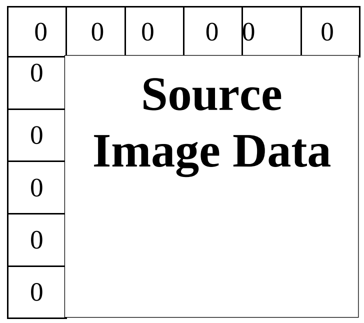

Figure 5 : Add padding to the image data

2. Entropy encoder

Generally, there are many types of entropy encoders like Huffman coding, Arithmetic coding, and RLE. In this paper, a modified RLE is used as an entropy encoder.

Traditional RLE and Modified RLE

RLE is used in video compression to store a consecutive set of pixels that have the same value (identical pixels) in a single value and a single counter [9]. RLE is always effective in image compression of the binary image while it is not useful in color images [10]. moreover, there is the possibility of enlarging the image size instead of reducing it. The latter notice refers to the case when RLE used directly to encode the color image with its raw pixel values and without any prior process like the prediction for these values of image pixels.

In this paper, RLE was used after a prediction procedure for pixels, as mentioned earlier, with a different size of bits for the repetition counter, for example, if RLE with 3 bit for a counter is applied to the sequence of 8-bit data:

[5,5,5,5,3,7,7,7,7,7,6,6,5,5,5,5,5,5,5,5,5,5,5,5,5]

The encoded output for the traditional RLE that uses 8 bits for the repetition counter will be: [(5,4) ، (3,1) ، (7,5) ، (6,2) ، (5,13)], while the encoded output for the modified RLE that based on 3-bit counter will be: [(5,4) ، (3,1) ، (7,5) ، (6,2) ، (5,7) ، (5,6)]. It can be noticed that in traditional RLE there is a reduction in the sequence from 25 digits that uses 8 bits to represent each of them to 10 digits of the size of 8 bits. Thus, the number of bits reduced from 200 bits for the original sequence to 80 bits for the encoded sequence by using the traditional RLE. On the other hand, for modified RLE there is reduction in sequence size from 25 digits with 8 bits for each to 12 digits and these 12 digits were divided into two groups. The first group consists of 6 digits which are the first number of each of the two values enclosed in parentheses in the encoded sequence. These 6 digits will be represented by 8 bits and it is the real value of the repeated pixel. So, the second group is the rest 6 digits of the encoded sequence that represents the repetition counter which is proposed in this work to be represented by just 3 bits for each. That means there will be a reduction in the number of bits required to represent the original sequence from 200 bits to 66 bits only.

I.V RESULT

In this paper, Lossless JPEG encoding has been applied to still image with different sizes of the repetition counter of RLE, video without frame differencing, and video with frame differencing. Applying these different suggestions is aimed to evaluate the compression ratio for them. The next subsections describe how the compression ratio is evaluated.

A. Still image

For a still image, RLE was applied with three different suggestions. The first is RLE with a size of 8-bit of repetition counter. Secondly, RLE is considered with an 8-bit counter size with prediction. Finally, RLE with a 3-bit counter size with prediction is taken. However, these three suggestions were taken to a still image to evaluate how efficient are in terms of reducing the spatial domain. The three suggestions were applied to three 480x640 color images (RGB) Akiyo, Foremen, Cartoon, as shown in Figure 6 and the results are as shown in Table 2. it can be noted that the highest value obtained of the compression ratio for RLE with the counter size of 3 bit with applying the prediction approach of the pixels.

FIGURE 6 : THREE TEST IMAGES (AKIYO, FOREMEN, CARTOON).

TABLE 2. COMPRESSION RATIO FOR THE DIFFERENT COUNTER SIZE OF RLE AND PREDICTION.

	Compression Ratio		
Image	RLE (8-bit)	RLE (8-bit) with prediction	RLE (3-bit)with prediction
Akiyo	1.18	1.4	1.7412
Foremen	1.002	1.1	1.4463
Cartoon	1.119	1.09	1.4248

B. Video frames

The same three suggestions mentioned in the subsection above were applied to three 480x640 color videos (RGB) Akio, Foremen, Cartoon was to evaluate the effect of Lossless JPEG through, firstly, considering the frames of each video sample without taking the difference between the consecutive frames, and secondly, taking the differencing between the consecutive frames of sample videos. The duration time for the three videos was 10 seconds and an average of 30 frames per second. Table 2 shows the compression ratio obtained for the scenario suggested above. Table 2 illustrates that the highest compression ratio was achieved for the three videos when the differencing approach is applied.

TABLE 3: COMPRESSION RATIO FOR VIDEO FRAMES

video	Compression Ratio	
	Video without frame differencing	Video with frame differencing
Akiyo	1.6028	5.3338
Foremen	1.1544	2.2961
Cartoon	1.2056	4.007

C. Different counter size of RLE

To study the effect of the size of the repetition counter of RLE on the compression ratio, Lossless JPEG with the different counter size of RLE were used to a still image. RLE with 2 through 8 bites counter size was applied to three 480x640 RGB color images which are Akiyo, Foremen, and Cartoon. The results are as shown in table 4. It can be noted that the highest value obtained from the compression ratio is when RLE counter size is of 3 bits. That means according to the taken sample images it is suitable for the counter size to be 3 bits to give the highest compression ratio since the length of almost sequence of identical pixels not exceeds 7 in general.

TABLE 4: COMPRESSION RATIO FOR LOSSLESS JPEG WITH DIFFERENT COUNTER SIZES OF RLE.

The number of bits of RLE	Compression Ratio		
	Akiyo	Foremen	Cartoon
8	1.4428	1.1047	1.0935
7	1.5364	1.1775	1.1652
6	1.635	1.2584	1.2444
5	1.7262	1.3425	1.3267
4	1.7353	1.4176	1.3907
3	1.7412	1.4463	1.4248
2	1.4894	1.3341	1.3182

IV.CONCLUSION

In this paper, lossless JPEG is used to compress still images and video with considering different sizes for the repetition counter size of RLE. The different RLE counter sizes where used, firstly, without calculating the predictive values of the pixels, secondly, the predictive value for pixels was calculated and the RLE with different counter sizes was applied. The results showed that applying the prediction approach and using 3-bit instead of 8-bit as a size for the repetition counter of RLE gives the highest compression ratio since the length of almost sequence of identical pixels not exceeds 7 in general.

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