Stereo pair Image Compression process using the effective Extended Block Truncation Coding Algorithm

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Abstract: **Stereopsis is the ability to perceive three dimensions by integrating two slightly different views of the same scene. A stereo image is produced by taking photographs of the identical scene from two slightly different positions. The distance between these positions is called the stereo base. Many cameras have the ability to stereoscopically image by sequentially taking two images. Stereo images provide an improved sense of presence, and have been found to be operationally useful in responsibilities requiring remote manipulation or judgment of spatial relationships. A stereo system with a single left-right pair needs twice the raw data as a monoscopic imaging system. As a result there has been increasing attention given to image compression methods specialized to stereo pairs. In the general concept of stereo image compression method, first compress the reference (left image) image only, after that the block matching algorithm is applied between left and right image to identify the disparity values and they are encoded separately rather than compressing the whole right image. In this paper I wish to illustrate the effectiveness of stereo pair image compression Algorithm using Extended Block Truncation Coding with higher image quality after decompression.**

Keywords: **Stereo pair Images, Compression, Decompression, Block truncation Coding, PSNR.**

I. Introduction to Image Compression

The purpose of the image compression is to convert the image to a space efficient compressed form so that the data of image is protected when decompressing the encoded image. The objective of image compression is to reduce the redundancy of the image and to transmit and store data in an efficient form. Compressing an image is significantly different than compressing raw binary data[1]. The general purpose of compression programs can be used to compress images, but the result is less than optimal. This is because images have certain statistical properties which can be exploited by encoders specifically designed for them. Also, some of the finer details in the image can be sacrificed for the sake of saving a little more bandwidth and storage space. Image compression algorithms fall into two categories: Lossy compression achieves its effect at the cost of a loss in image quality, by removing some image information[2]. Lossless compression techniques reduce size whilst preserving all of the original image information, and therefore without degrading the quality of the image[3].

Lossy compression techniques should be treated with caution; if images are repeatedly migrated over time between different lossy formats, the image quality will be increasingly degraded at each stage[4][5]. However, in some circumstances the use of lossy compression may be required, for example, to enable very large volumes of high-quality color images to be managed economically. In such circumstances, visually-lossless compression should be used, which only removes image information which is invisible to the human eye at normal magnification

II .Stereoscopic image compression

Stereopsis is the ability to perceive three dimensions by merging two slightly different views of the same scene. A stereo image is produced by taking photographs of the same scene from two slightly different positions.[6] The distance between these positions is called the stereo base. Many cameras have the ability to stereoscopically image by sequentially taking two images. Parallax, the apparent displacement of objects in the stereo scene, is achieved by horizontally shifting the camera between photographs with Stereo images provide an improved sense of presence, and have been found to be operationally useful in responsibilities requiring remote manipulation or judgment of spatial relationships[7][8].

Fig 2.1 Left and Right Image of Stereo pair

A conventional stereo system with a single left-right pair needs twice the raw data as a monoscopic imaging system[9]. As a result there has been increasing attention given to image compression methods specialized to stereo pairs. In the general concept of stereo image compression method, first compress the reference (left image) image only, after that the block matching algorithm is applied between left and right image to identify the disparity values and they are encoded separately rather than compressing the whole right image[10].

III. Image Compression using Block truncation method

Block Truncation Coding is a lossy image compression technique. It is a simple technique which involves less computational complexity. BTC is a recent technique used for compression of monochrome image data. It is one-bit adaptive moment-preserving quantizer that preserves certain statistical moments of small blocks of the input image in the quantized output. The original algorithm of BTC preserves the standard mean and the standard deviation σ.

The statistical overheads Mean and the Standard deviation are to be coded as part of the block. The truncated block of the BTC is the one-bit output of the quantizer for every pixel in the block. Block Truncation Coding (BTC) is a well-known compression scheme proposed in 1979 for the grayscale images[19]. It was also called the moment-preserving block truncation, because it preserves the first and second moments of each image block.

The Block Truncation Coding (BTC) algorithm involves the following steps: The given image is divided into non overlapping rectangular regions[20]. For the sake of simplicity the blocks were let to be square regions of size m x m. For a two level (1 bit) quantizer, the idea is to select two luminance values to represent each pixel in the block. These values are the mean x and standard deviation.

$$mean\,\overline{X} = \frac{1}{n}\sum_{i=1}^{n} x_i \quad \text{------(3.1)}$$

$$SD = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - \overline{x})^2} \quad \text{-------(3.2)}$$

Where xi represents the i^th pixel value of the image block and n is the total number of pixels in that block. The two values x and σ are termed as quantizer of BTC. Taking x as the threshold value a two-level bit plane is obtained by comparing each pixel value xi with the threshold. A binary block, denoted by B, is also used to represent the pixels. We can use “1” to represent a pixel whose gray level is greater than or equal to x and “0” to represent a pixel whose gray level is less than

$$B = 1 \,|\, when\ x_{i \geq} \overline{x}$$
$$B = 0 \,|\, when\ x_{i \prec} \overline{x} \quad \text{----(3.4)}$$

By this process each block is reduced to a bit plane. For example, a block of 4 x 4 pixels will give a 32 bit compressed data, amounting to 2 bit per pixel (bpp). In the decoder an image block is reconstructed by replacing ‘1’s in the bit plane with H and the ‘0’s with L, which are given by:

$$H = \overline{X} + \sigma\sqrt{\frac{P}{q}}$$

$$L = \overline{X} - \sigma\sqrt{\frac{q}{p}} \quad \text{-----(3.5)}$$

Where p and q are the number of 0’s and 1’s in the compressed bit plane respectively.

The process will be explained by a simple example. A 256x256 pixel image is divided into blocks of typically 4x4 pixels. For each block the Mean and Standard Deviation are calculated. These values change from block to block[21]. These two values define what values the reconstructed or new block will have, in other words the blocks of the BTC compressed image will all have the same mean and standard deviation of the original image. A two level quantization on the block is where we gain the compression, it is performed as follows:

$$y(i,j) = \begin{cases} 1, & x(i,j) > \bar{x} \\ 0, & x(i,j) \leq \bar{x} \end{cases} \quad \text{---(3.6)}$$

Where $x(i,j)$ pixel elements of the original are block and $y(i,j)$ are elements of the compressed block. In words this can be explained as: If a pixel value is greater than or equal to the mean it is assigned the value "1", otherwise "0". Values equal to the mean can have either a "1" or a "0" depending on the preference of the person or organization implementing the algorithm. This 16 bit block is stored or transmitted along with the values of Mean and Standard Deviation. Reconstruction is made with two values "a" and "b" which preserve the mean and the standard deviation. The values of "a" and "b" can be computed as follows:

$$a = \overline{x} - \sigma\sqrt{\frac{q}{m-q}} \quad \text{---(3.7)}$$

Where σ is the standard deviation, m is the total number of pixels in the block and q is the number of pixels greater than the mean ($\bar{x}$)

$$b = \bar{x} + \sigma\sqrt{\frac{m-q}{q}}$$ ------(3.8)

To reconstruct the image, or create its approximation, elements assigned a 0 are replaced with the "a" value and elements assigned a 1 are replaced with the "b" value.

$$x(i,j) = \begin{cases} a, & y(i,j) = 0 \\ b, & y(i,j) = 1 \end{cases}$$ -------(3.9)

This demonstrates that the algorithm is asymmetric in that the encoder has much more work to do than the decoder. This is because the decoder is simply replacing 1's and 0's with the estimated value whereas the encoder is also required to calculate the mean, standard deviation and the two values to use. In Encoding ,For example ,take a 4x4 block from an image can be used.

245	239	249	239
245	245	239	235
245	245	245	245
245	235	235	239

Fig 3.1 pixel value of 4 x 4 test Image

Now there is a need to calculate two values from this data that is the mean and standard deviation. The mean can be computed to 241.875. The standard deviation is easily calculated at 4.36. From this the values of "a" and "b" can be calculated using the previous equations. They come out to be 236.935 and 245.718 respectively. The last calculation that needs to be done on the encoding side is to set the matrix to transmit to 1's and 0's so that each pixel can be transmitted as a single bit.

1	0	1	0
1	1	0	0
1	1	1	1
1	0	0	0

Fig 3.2 Bit stream of 4 x 4 test Image

Now at the decoder side all we need to do is reassign the "a" and "b" values to the 1 and 0 pixels. This will give us the following block:

As can be seen, the block has been reconstructed with the two values of "a" and "b" as integers. When working through the theory, this is a good point to calculate the mean and standard deviation of the reconstructed block. They should equal the original mean and standard deviation. Remember to use integers; otherwise much quantization error will become involved, as we previously quantized everything to integers in the encoder.

IV. Extended Block Truncation coding Algorithm for Stereo Image Compression

Block truncation coding algorithm is a simple technique used for compression of Still Images, The researcher proposed an algorithm called EBTC (Extended block truncation coding) algorithm for stereo pair image compression for the purpose of analysis of compression methods In the procedure for performing extended block truncation compression for stereo images, the left image is divided into non overlapping rectangular regions of size 4 x 4, then select two luminance values to represent each pixel in the block. These values are the mean x and standard deviation σ. By performing the two level quantization on the block , we gain the compression, it is performed by taking x as the threshold value, bit plane is obtained by comparing each pixel value xi with the threshold. If a pixel value is greater than the mean it is assigned the value "1", otherwise "0". To reconstruct the image, elements assigned a 0 are replaced with the "a" value and elements assigned a 1 are replaced with the "b" value.

To compress the right image: Since the left and right images are similar to each other, the disparity vectors between the two images are estimated. The resulting disparity vectors only are compressed using above procedure.

Algorithm for compressing Stereo pair images using EBTC

Steps of Extended BTC algorithm
Encoding Process: For left image,

Step 1: The image is divided into non overlapping rectangular regions of size m x m.
Step 2: select two luminance values to represent each pixel in the block. These values are the mean x and standard deviation σ.
Step 3: Take x as the threshold value, bit plane is obtained by comparing each pixel value xi with the threshold.
Step 4: Use “1” to represent a pixel whose Gray level is greater than or equal to x and “0” to represent a pixel whose gray level is less than X. so that each pixel can be transmitted as a single bit. This is the compressed form of the image.
Step 5: For right image, the disparity vectors are identified between the corresponding blocks of left image and the above procedure is executed for decoding process with block matching algorithm. Now the image is compressed and the encoding process is over.

Decoding Process:

Step 1: To reconstruct the left image, elements assigned a 0 are replaced with the "a" value and elements assigned a 1 are replaced with the "b" value.

Step 2: For the right image, The blocks having difference only undergo the above process

The above algorithm was executed for various image pairs with the help of JAVA implementation of 7.0. The result will be tabulated below with the graph representation.

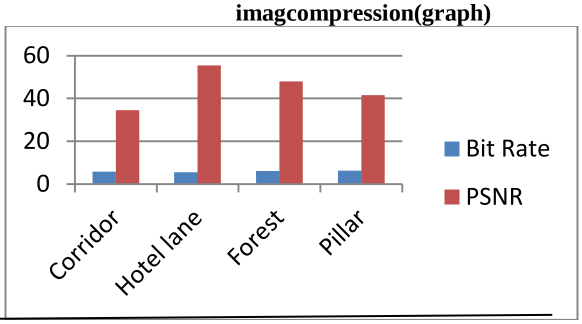
V. Experiments and Results

The experiments can be carried out for various stereo pair images by implementing the Extended Block Truncation Coding Algorithm in JAVA 7.0

Table 4.1 Performance of EBTC Stereo image compression

Image	Bit Rate	PSNR	Size of original	Size of Compressed Image	Compression Ratio
Corridor	5.790975	34.5	27KB	8.09KB	3.337
Hotel lane	5.560821	55.5	26 kB	6.52 kB	3.987
Forest	6.189299	48.0	33 kB	6.97 kB	4.734
Pillar	6.349051	41.5	38 kB	8.72 kB	4.357

Fig 4.1 Performance of EBTC Stereo imagcompression(graph)



The table 4.1 and the Fig 4.1 illustrate the characteristics of the stereo pair image compression algorithm using EBTC image transformation. it shows the PSNR and Bit rate value of the images and the size of original image as well as compressed image with their compression ratio.

VI. Conclusion and future work

Image coding based on models of human perception, scalability, robustness, error resilience, and complexity are a few of the many challenges in image coding to be fully resolved and may affect image data compression performance in the years to come. Most image data compression techniques achieve high data compression ratio. The tradeoff between data compression remains one of the difficult problems. Maintaining high compression ratios with good image quality is possible at a more or less high computational cost. One of the main goals for image data compression is to reduce redundancy in the image block a much as possible. That is, it is very important to represent an image with as few bits as possible while maintaining good image quality.

The DCT-based Stereo image compression such as JPEG performs very well at moderate bit rates; however, at higher compression ratio, the quality of the image degrades because of the artifacts resulting from the block-based DCT scheme[18]. Wavelet-based coding provides substantial improvement in picture quality at low bit rates because of overlapping basis functions and better energy compaction property of wavelet transforms. Because of the inherent multi-resolution nature, wavelet-based coders facilitate progressive transmission of images thereby allowing variable bit rates[19]. In Extended Block truncation coding both compression and decompression algorithms should be simple and efficient. It yields perfect PSNR value for displaying stereo images in the field of video conferencing and other 3D image display systems. EBTC is one of the simple and easy to implement image compression algorithm for compressing Stereo pair images.

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