1. INTRODUCTION

1.1 IMAGE COMPRESSION

In today’s electronic world, digital still pictures and video images play a significant role in multimedia based knowledge exchange applications. Such high resolution digital pictures require a lot of memory space for image storage, processing and retrieval by digital computers. Satellite and aerial images generate big data files demanding large transmission time for image transfer. In internet applications, such big data transmission slows down the net speed.

Image compression techniques [1] – [5] aim at reducing the transmission file size, by using lesser bits for the images. This is realized by using fewer bits per pixel of the image. Normally this bit reduction will affect the quality of the image reproduced at the receiver. This process is known as ‘Lossy Image Compression’ [10] - [15]. But images could also be compressed without reduction in quality by employing suitable coding techniques. Inherently, such ‘Lossless Image Compression’ methods [40] yield less compression, compared to ‘Lossy’ methods [16]. The ‘Compression ratio (CR)’, the ‘Peak Signal to Noise Ratio (PSNR)’ and the ‘Contrast (C)’ are the parameters used to measure the quality of image compression.

Both time-domain (spatial) [7], [18] and frequency - domain (spectral) [34] – [35] image compression techniques are employed in image compression. Block Truncation Coding (BTC) is an apparently elegant and efficient time-domain compression technique, developed by Delp and Mitchell [10]. An extensive literature survey on various image compression techniques has been carried out and reported in section 1.2.

1.2 LITERATURE SURVEY ON IMAGE COMPRESSION

1.2.1 Spatial Domain based Image Compression.

Some of the spatial domain based image compression techniques reported in the literature is briefly listed below.
In the year 1981, Healy D.J. and Mitchell O.R., [1] presented a technique for bandwidth compression coding of sequential digitized video imagery. This method uses a single bit quantization of the small blocks in a video frame. It can be used for low altitude aircraft imagery with moderate video quality.

In the year 1983, Arce, G and Gallagher N.C., [2] proposed a BTC Image Coding using “Median Filter Roots”. In this algorithm, the BTC bit plane is represented with fewer coefficients than the conventional BTC bit plane. By this, the bit rate is reduced and efficient transmission of the block truncated image is done.

In the year 1990, Davignon A., [3] proposed a block classification scheme using Binary Vector Quantization. In this method, the blocks of an image are classified into shaded blocks and edge blocks. This classification of blocks depends on the threshold value for each block. The code book for vector quantization is then partitioned according to the visual perception of the blocks.

In 1991, Rabbani, M and Jones, P.W [4] published a tutorial on “Digital Image Compression Techniques”, wherein various methods for compression of digital images are discussed. This is a valuable tutorial providing the groundwork for understanding many of the useful image compression techniques.


In 1994 Chan, Y.K [7] presented a method for improved spatial domain image compression by splitting the image into sub blocks of 2 * 2 and then each block is compressed without much loss of detail by encoding it to 1, 2, or 3 intensity values.

In 2004 Tao, T and Mukherjee, A [8] used a spatial domain compression based on the Lempel Ziv Welch algorithm to compress still images. The improvements include multipattern matching and a faster implementation for "simple patterns", with no symbol appearing more than once.

In 2011, Amin. A et al [9] proposed a lossless spatial compression technique with improved compression ratio using Run Length Encoding (RLE). Larger sequences are broken into small sequences using bit stuffing.

1.2.2 Image Compression based on Block Truncation Coding.

Some of the image compression techniques, based on Block Truncation Coding and its variants, which have been reported in the literature, are listed below.

In 1979 Edward J. Delp and Robert Mitchell, O [10] used a two-level (one-bit) nonparametric quantizer in the Block Truncation Coding (BTC) algorithm that preserves the mean and variance (first and second moments) of the blocks in the image. This quantizer produces good quality images at data rates of 1.5 bits/pixel. No large data storage is required, and the computation is small.

In the year 1984, Lema M.D and Mitchell O.R., [11] presented an absolute moment BTC for application to color images. This paper is based on preserving the sample absolute moment of each block in the image and this can be extended to color images as well.

In 1987 Udpikar V.R and Raina J.P [13] proposed a vector quantized Block Truncation Coding, where the statistical overhead and the truncated block exhibit properties that can be effectively used for their quantization as vectors. The process of vector quantization results in reduced bit rates for the encoder.

In 1991, Wu, Y and Coll, D. C [14] proposed BTC-Vector Quantized-Discrete Cosine Transform, an algorithm combining the simple computational and edge preserving properties of BTC, and the high fidelity and high-compression ratio of adaptive DCT, along with the high-compression ratio and good subjective performance of VQ. This algorithm is claimed to have significantly reduced coding delays than either VQ or DCT alone.

In 1991, Kamel, M et al [15] presented a variable BTC algorithm for image compression. It is shown that there exists an optimal threshold for the quantization in BTC algorithms (fixed and variable) that minimizes the errors. Compared to the fixed BTC (fBTC), the variable BTC (vBTC) gives better performance on all the tested images. The use of vBTC with optimal threshold leads to a reduction of the error in the reconstructed images by almost 40% of the error in the reconstructed images obtained by fBTC. This enhanced performance suggests that the vBTC with optimal threshold is a better alternative to the fixed block truncation coding.

In 1993, Oshri, E, Shelly, N and Mitchell, H.B. [16] proposed an interpolative block truncation coding with three levels for compression of images. This method of interpolation improves the quality of images for a specified bit rate.

In the year 1993, Kurita, T and Otsu, N., [17] proposed a color image block truncation coding for compression wherein the truncated errors are reduced to achieve better quality for the color images.
In the year 1995, Ramana Rao, Y.V and Eswaran, C [18] proposed a new BTC algorithm using look up tables. This algorithm produced images with better subjective quality.


In 1998, Wu, Y.G and Tai, S.C [20] proposed an efficient BTC compression method using a moment preserving technique to achieve the low-bit rate block truncation coding (BTC). Compared with transform coding and vector quantization, conventional BTC compression has the advantage of simple and fast computation. The proposed technique is based on variable bit rate selection for the blocks in the image. This method reproduces the images with moderate image quality and bit rate of 0.5-1.0 bit/pixel.

In 1999, Kuo, C.H., et al [21] presented a compression algorithm based on Classified Interpolative Block Truncation Coding improved with Vector Quantization. The bit rate and PSNR of this classified interpolative BTC algorithm with VQ are better than those of the interpolative BTC algorithm with Vector Quantization.

In 1999, Chang, L.W., et al [22] proposed a variable block truncation coding with optimal quadtree segmentation (VBTC) to compress still images. The distortion of the reconstructed image is minimal. A bit plane reduction scheme is applied to achieve lower bit rates.

In 2000, Ma, K.K et al [23] developed an adaptive BTC algorithm ESPO, *(Equal Sign Position Optimization)* for optimum pixel classification. Incorporation of the ESPO algorithm into conventional Absolute Moment Block Truncation Coding or AMBTC achieves minimum Mean Square Error.
In 2000, Beghdadi, A and Iordache, R [24] proposed a BTC method which uses a contrast enhancement technique.

In 2001, Chang, K.W et al, [25] presented a Block Truncation Coding (BTC) for real-time image coding at moderate bit-rate, with low computation and storage demands.

In the year 2001, Kuo, C.H and Chen, C.F [26] proposed a multilevel block truncation coding method to search for an optimal threshold value to quantize the pixels in each block.

In 2003, Hu, Y.C et al [27] described an image compression scheme based on moment preserving block truncation coding (MPBTC). To reduce the bit rate of the traditional MPBTC scheme, the block search order coding technique is employed to exploit the similarity among neighbouring image blocks. In addition, smooth blocks (blocks having same intensity values) and complex blocks (blocks having varied intensity values) are processed using different methods.

In the year 2006, Dhara, B.C and Chanda, B [28] proposed a colour image compression based on block truncation coding using pattern fitting principle. In this method the authors have exploited the high correlation present in the RGB plane of the colour images. This correlation is reduced and new set of planes are obtained for the BTC images. This method consumes less time than other methods such as JPEG.

In 2010, Rhoma, E.M [29] proposed a least mean square error method for Block Truncation Coding. The compression ratio is improved by coding only half of the bits in the BTC bit plane of each block; the other half will be interpolated at the receiver. The proposed interpolative algorithms minimize the errors caused by the two level quantizer.
In 2011, Yang, Y et al [30] presented a fast BTC method based on a truncated $K$-means algorithm. This utilizes the image inter-block correlation and the convergence property of the $k$ – means clustering algorithm. This algorithm produces an optimum solution with good processing speed.

In the year 2011, Liu Y.F, Guo, J.M and Lee, J.D [31] presented a halftone image classification using Least Mean Square algorithm and naive Bayes classifier. The authors have developed a least mean-square filter for improving the robustness of the extracted features, and employed the naive Bayes classifier to verify all the extracted features for classification.

In 2013 Kekre, H.B et al [32] proposed an image compression method using Multilevel Block Truncation Coding for image classification. Feature vectors are extracted with four levels of Block Truncation Coding to classify the several categories of images for performance comparison in six different color spaces.

1.2.3 Spectral Domain based Image Compression.

Some of the spectral domain based image compression techniques reported in the literature are briefly described below.

In 1990, Wallace, G.K [33] wrote “Digital compression and coding of continuous tone still images” on the Joint Photographic Experts Group (JPEG) standard. This standard describes the compression of still images by using discrete cosine transform on the pixels and then a lossless coding technique is applied to the DCT coefficients.

In 1993, Pennebacker, W. B and Mitchell, J. L [34] scripted the book titled “JPEG Still Image Compression Standard”, detailing the Joint Photographic Experts Group (JPEG) standard on color still image data compression. This new guide to JPEG and its technologies offers detailed information on the new JPEG signaling conventions and the structure of JPEG compressed data.
In 1993 Shapiro J.M [35] presented “Embedded image coding using zero trees of wavelet coefficients”, where the bits in the encoded bit stream are generated in order of importance yielding an embedded code.


In 2000, Weinberger, M.J, Seroussi, G and Sapiro, G [37] proposed a method for the lossless JPEG and near lossless compression of continuous tone images.

In the year 2000, Marcellin, M.W et al [38] proposed the JPEG 2000 standards for still image compression. The encoder of the transmission system was designed based on the JPEG 2000 format.

In the year 2002, Wu, Y.G [39] presented a work based on Image Compression by sampling DCT Coefficients. In this paper an adaptive sampling algorithm is used by calculating the difference area between correct points and predicted points to decide the significant coefficients.

In the year 2010, Pan, Z et al [40] presented a technique where the image is divided into independent bit planes, and then, the probability of bit “0” is computed. This is compared with a predefined threshold for each bit plane, in order to select the optimal block size. After this step, a modified quadtree coding method is done to encode the block data.

In 2010, a 3D mesh geometrical image compression schemes for hyperspectral images was proposed by Bayazit, U et al [41]. The proposed coder is based on the region adaptive transform in the spectral mesh compression method.
In the year 2011, Douak, F et al [42] proposed a lossy image compression algorithm based on Discrete Cosine Transform. Here, after performing DCT in each block, the block is adaptively scanned in order to obtain maximum runs of zeros. This improves the compression ratio of the image.

The objectives of this research are:

i) To improve the contrast of BTC images by suitable modification of traditional BTC algorithm and compare the performance of traditional and modified BTC algorithms.

ii) To develop an algorithm for least mean square error based BTC and to evaluate its comparative performance with traditional and modified BTC.

This thesis of the research is organized as under.

This introductory Chapter 1 mainly deals with the literature survey on Image Compression and the objectives of the research.

Chapter 2, explains the traditional BTC algorithm and its performance appraisal for various parameters such as Compression Ratio, PSNR and Contrast, for various block sizes.

In Chapter 3, the proposed modifications, to improve the contrast of the reproduced image, are described. The performance parameters CR, PSNR and Contrast of the modified BTC methods are compared with the traditional BTC.
In Chapter 4, a Least Mean Square Error (LMSE) based algorithm is developed for improving the PSNR of the BTC image. The results of this LMSE based BTC (LMSE-BTC) method is compared with traditional BTC and modified BTC.

The concluding Chapter 5 summarizes the contributions made in this thesis and indicates the scope for further research in this area.