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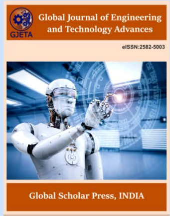

(REVIEW ARTICLE)

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Subject review: Image Compression Techniques

Amal Abbas Kadhim, Wedad Abdul Khuder Naser * and Safana Hyder Abbas

Department of computer science, University Al Mustansiriyah, Baghdad, Iraq.

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Abstract

Research on image compression is now a hot area for both commercial and military academics. picture compression is required because of the quick expansion of digital media and the ensuing demand for less storage and efficient picture transmission. In order to retain the apparent visual quality of a picture while requiring fewer bits to express it digitally, image compression is used.

Keywords: Image Compression; Image processing; Data redundancy; Lossy compression; Lossless compression

1. Introduction

In order to be processed, stored, and transmitted, the picture has been converted from its original analog form into a 2-dimensional digital signal , makes up a sizable amount of the data[1]. Numerous picture types, which are crucial in the fields of remote sensing and healthcare, among others. Data sharing and transmission have expanded as a result of media communication and social networking sites, needing a lot of bandwidth and storage space. Contrarily, media compression algorithms are designed specifically for formats like picture, audio, and video files. If photographs are compressed before being saved and delivered, their size may be proportional to the degree of compression employed, but uncompressed images will take longer to transport and require more bandwidth. Picture compression techniques lower the size of the files, which reduces the amount of storage space and bandwidth needed and allows for quicker picture transmission. While maintaining essential picture information, image compression attempts to recreate the image in as few bits as feasible [2,3]. Digital pictures are redundant bit arrays of pixels These bits are eliminated using compression techniques, which also eliminates extraneous information from the image. While irrelevant reduction leaves out less crucial information, redundancy reduction eliminates unnecessary bits. Three types of data redundancy may be categorized [4].

Lossless and lossy image compression are the two different types of compression techniques. The original picture should be a perfect reproduction of the compressed image in the first approach. Lossless image compression has a wide range of applications, including digital radiography [5,7]. Where any loss of information in the original image might result in an inaccurate diagnosis [8].

2. 2- Lossless and Lossy Compression Techniques

Following the compression stage, a reconstructed picture formed using lossless compression techniques is numerically equal to the original image. Lossless compression, on the other hand, can only result in a little amount of data reduction. The quality of a picture is reduced when it is rebuilt following lossy compression compared to the original.. This is usually true since the compression approach completely removes all extraneous information. information completely after lossy compression. On the other side, lossy compression techniques may achieve substantially greater degrees of

* Corresponding author: Wedad Abdul Khuder Naser

compression. According to the criteria we have described, image compression techniques may be roughly classified into the two main classes that are mentioned below [9,10].

2.1. Lossless Compression Technique

In this method, every pixel is processed, and every bit of the original data file is still present after the file is uncompressed, resulting in reconstructed images that are numerically identical to the original image. Next, all of the information is fully restored, and lossless compression uses a small amount of compression [11,12,13].

Methods for lossless image compression are:

- Run-length encoding – used as default method in PCX and as one of possible in BMP, TGA, TIFF.
- DPCM and Predictive Coding
- Entropy encoding
- Adaptive dictionary algorithms such as LZW – used in GIF and TIFF.
- Deflation – used in PNG, MNG, and TIFF.
- Chain codes.
- Huffman Encoding.

2.2. Lossy Compression Techniques

Lossy compression, as the name implies, causes part of the information being compressed to be lost. Although the compressed version and the original uncompressed picture are comparable to one another, they are not exactly the same since, during the compression process, some image-related information was lost. Images frequently fit them perfectly. The most prevalent example of a format that makes advantage of lossy compression is JPEG. Lossy techniques are any algorithms that alter the presentation while keeping the original image's quality constant. When adopting a lossy compression strategy, it is vital to assess the picture quality because the reconstructed image is an approximate representation of the original image. a lossy compression technique that usually produces lossless data. The following are significant elements influencing the effectiveness of a lossy compression strategy[14]:

- Compression ratio
- Signal to noise ratio
- The rate at which information may be encoded and decoded.

3. Literature Survey

In the year 2009, Sadashivappa and AnandaBabu , describe a larger set of wavelet functions for use in an SPIHT-based still image compression system . In order to create wavelet coefficients for sub-band coding, MATLAB's wavelet functions and filters are examined in detail. Peak signal to noise ratio (PSNR) and its relationship to bit rate were used to unbiasedly assess image quality. Investigated is how different parameters affect various wavelet functions. The findings offer wavelet-based coder application developers a good road map.impact of various parameters on various wavelet functions is investigated. The results serve as a useful guide for wavelet-based coder application makers [15].

In the year 2010], Somasundaram and Vimala suggested a new strategy called Efficient Block Truncation Coding (EBTC). The suggested solution is a lossy picture compression method that further reduces bit rate by making use of inter-pixel redundancy. It is well knowledge that neighboring pixels have intensity levels that are almost identical. The image is divided into two categories, low detail blocks and high detail blocks, each consisting of four 4* 4 pixel squares. When the intensity values of the closest pixels diverge, the block is said to have high detail, and when the gap between the intensity values is smaller, it has poor detail. In comparison to conventional BTC, the suggested technique offers outstanding PSNR and bit rate performance[16].

In the year 2011, Mohammed and Abou-Chadi , Block truncation coding, which is thought of as a lossy image compression approach, was the subject of a research to examine picture compression. The two algorithms, Original Block Truncation Coding (BTC) and Absolute Moment Block Truncation Coding (AMBTC), were selected. The picture is split into non-overlapping chunks by the two methods using a two-level quantization. To apply the ideas, various test pictures with 256 grey levels were created using 512512 pixels and 8 bits per pixel. The reconstructed pictures have a 1.25 bits per pixel bit rate. An 85 percent compression ratio results from this. The Bit Rate (BR), Peak Signal to Noise Ratio (PSNR), Weighted Peak Signal to Noise Ratio (WPSNR), and Structural Similarity Index (SSI) were used to measure image quality (SSIM). The results show that the ATBTC algorithm performs better than the BTC algorithm. It has been established that, for a given bit rate of image compression, AMBTC produces images of higher quality than BTC. The AMBTC is also a lot quicker than the BTC [17].

Block Truncation Coding (BTC) and Enhanced Block Truncation Coding (EBTC), two lossy compression methods that operate with grayscale pictures to reduce correlation and spatial redundancy between pixels, may both be improved[17]. In the year 2011, Kumar and Singh, suggestions that are helpful for maintaining the quality and compression ratio of an image. The results show that the ETBTC algorithm works better than the BTC algorithm. It has been shown that utilizing EBTC for picture compression results in better image quality than using BTC for image compression at the same bit rate. On a range of grayscale photos of varying sizes, this approach was tested. Structural Similarity Index, Peak Signal to Noise Ratio, Weighted Peak Signal to Noise Ratio, and Bit Rate were used to assess the quality of the images. When the reconstructed pictures have a bit rate of 1.25 bpp, or an 85% compression [18].

In the year 2014 , Bhavana Patil and Asharani Patil , conducted research to create a DCT and wavelet-based picture compression technique that is both computationally efficient and effective. The study focuses on wavelet image compression using the Haar Transformation with the goal of reducing processing requirements by applying various compression criteria for the wavelet coefficients and achieving results in only a few seconds while enhancing the quality of the reconstructed picture. A simplified model of a sub and coder is used to study important design issues. Compared to DCT, the Haar wavelet yields a greater compression ratio and PSNR. More PSNR is a sign of improved image quality. In addition to Haar wavelets, they are adaptively quantized utilizing a high-frequency sub band with improved resolution. These two compression techniques offer well-structured directed edges and sizable homogenous areas because they use separable wavelets filters and clustering with spatial restrictions. When compared to the original sub-band pictures, the bit rate of sub band coding is significantly lower [19].

In the year 2015, Zhou, Bai, and Wang ,carried out research. The suggested method for picture reduction uses the discrete cosine transform (DCT). This method creates a DPCM hybrid technique by fusing differential pulse code modulation with vector quantization. DCT is used in this system to convert images from the spatial domain to the frequency domain. Following zigzag order vector translation, the block data is subsequently condensed. The vector is then split into its DC and AC coefficients. Scale quantization is followed by DPCM coding of the DC coefficient. The AC coefficients are encoded using multistage vector quantization (MSVQ). Then, entropy encoding is carried out individually on index tables and DC parts. Both the hybrid DCT-VQ method and the traditional VQ algorithm are outperformed by the suggested methodology. The sole complex operation of the approach in comparison to the JPEG scheme is the codebook design procedure, which is enhanced by employing numerous small-sized codebooks instead of one large codebook. The experimental findings show that the proposed method has a higher PSNR value than the JPEG standard [20].

Rahman et al. , made the decision to carry out a thorough analysis of the most popular photo compression techniques. We presented a thorough analysis of run-length, entropy, and dictionary-based lossless photo compression methods, along with a standardized numerical example to facilitate comparisons. Following that, a review of the most innovative techniques is offered using a few benchmark images. Ultimately, we use traditional metrics like average code length (ACL), compression ratio (CR), pick signal-to-noise ratio (PSNR), efficiency, encoding time (ET), and decoding time (DT) to assess how well the state-of-the-art techniques perform[21]..

Yi-Fei Tan, et al , combine reference points coding with threshold values to compress pictures . A lossy-and-lossless picture compression technique is put forth in this study. Different threshold values can result in different compression ratios, and lossless compression can be achieved by setting the threshold to zero. The proposed method decides how well a picture will compress. Then The suggested approach employs lossless compression if the threshold value is 0. Lossy compression is produced by positive threshold values. The appropriate threshold T can be determined by more investigation [22].

Dharanidharan et al. , the original file is split and changed, and he offers a revolutionary modified international data encryption technique to safely encrypt the entire image. Segmented picture files are combined into a single image using the Huffman technique. Finally, the picture is understood. Following that, they send encrypted photos to multipath routing. In order to produce a trustworthy, effective image, they now employ a multipath routing approach. The previously compressed image was transferred to a single channel[23].

K. Rajkumar et al. , offer a multiwavelet transform coding solution for lossless picture compression. This study investigated the IMWT's performance for lossless, commonly known as the integer multiwavelet transform. If the IMWT is used on the reconstructed picture, the results are good. In the current study, the performance of the IMWT for magnitude set coding-based lossless image compression is shown. The transform coefficient is encoded in the recommended technique utilizing a methodology that uses both a magnitude set of coding and a run length encoding method. It was determined if the integer multiwavelet transform could effectively compress picture data without introducing any loss [24,25].

Kumar R. and et al. , developed a powerful matrix completion method for retrieving image quality while preserving compression. The proposed approach completes low-rank matrices by thresholding and singular value reduction. To deconstruct a picture into low rank image data that may be estimated in compressed form, singular value decomposition (SVD) is utilized. The visual quality of the compressed image is subsequently restored using the single value thresholding method. The comparative analysis is also taken into account as evidence that explains the suitability of the proposed method in comparison to cutting-edge techniques and conventional techniques like JPEG200. The proposed method is easily applicable for various visual characteristics of the image for various compression efficiencies. Depending on the application, an SVT-based quality retrieval technique can potentially enhance visual quality. The simulation outcomes demonstrate that the suggested approach can compress pictures at high speeds. The effectiveness of the suggested strategy has been thoroughly examined in terms of compression and quality recovery. Studies reveal that the human vision system (HVS) can handle a maximum compression of 80% while still retaining adequate visual quality [26].

In the year 2019, Li and Jia . offering a model of the coding bit-rate inside the high bit-rate in terms of the mean absolute difference and the coding quantization parameters for predictive coding. In order to develop a rate control strategy for near compression, the model for JPEG-LS is next applied. Quantitative parameters are piecemeal changed in accordance with the model in order to control the bit rate throughout a certain picture coding process. Experiments show that the final coding rate using the suggested method can be rather close to the desired rate. It is feasible to prevent quantitative parameters from fluctuating within a wide range using the precise bit rate model, which is not achievable with other techniques. As a result, the recommended method can produce rate-distortion performance that is very near to perfect [27].

In the year 2020, Ariatmanto and Ernawan , Discrete Cosine Transform (DCT) coefficients used in picture watermarking that utilize specific rules to prevent distortion have a new scaling factor developed for them. The embedding locations are determined by the image blocks with the lowest pixel variances. The optimal scaling factors for the provided DCT coefficients on the middle frequencies are determined using the best image quality. The results show that the proposed method achieves higher Normalized Cross-Correlation (NC) values of watermark recovery against various attacks than existing schemes, and that this scheme also maintains watermarked images with a PSNR value of 45 dB in quality. The scaling factors are used to carry out the embedding procedure[28].

In the year 2020 , Aljaz Jeromel and Borut Zalik , developed a cutting-edge lossy method for cartoon picture compression. The picture is initially separated into sections that are roughly the same color. The chain codes are then established for each location. The sequence of obtained chain code symbols is transformed using the Burrows-Wheeler Transform, RLE, and Move-To-Front transformations. An arithmetic encoder can be used in the last stage to further compress the output binary stream. The suggested technique is asymmetric, which means that it does not reverse all of the compression steps during decompression. The given method yields significantly superior compression ratios than JPEG2000, WebP, JPEG, PNG, SPIHT, and two of the algorithms specialized in cartoon images compression: the quad-tree algorithm and the RS-LZ algorithm, according to the experimental results [29].

In the year 2021, Ragmi Mustafa, Basri Ahmedi, and Kujtim Mustafa, conducted a study. The suggested study is about neural network-based lossy picture compression. They studied the BEP-SOFM method, which quickly obtains initial weight values for the Self-Organizing Feature Maps technique by using the Backward Error Propagation algorithm. The compressed picture was made by using quadtree segmentation to divide the original image into portions of equal size. According to the study, using quadtree segmentation for the BEP-SOFM approach results in lower error rates than breaking the image up into identical-sized blocks. The technique of picture compression is significantly influenced by the image size. When compared to the results produced using the simple splitting approach, quadtree segmentation for small images did not, or only marginally, improve image quality. However, the quality of larger photographs is improved. This is because the input vector components have the same value after breaking the training image into smaller blocks by changing the pixels' value to the average value. This indicates that the color value of the decompression process will be the same. However, for a larger image, these blocks are lacking in detail. The results are presented in terms of mean square error (MSE) and peak signal to noise ratio (PSNR) [30].

In 2021,Zhang and et. al. in order to reduce remotely detected astronomical pictures, created a wavelet-based sensing technique, presenting a novel wavelet-based CS framework. The revised scaling matrix with dual scaling rate assignment offers the best scaling rate assignment method. The improved measurement matrix preserves the most important frequency domain data at low measurement rates. A two-dimensional discrete waveform transformation (DWT), which provides the picture frequency information, is the first step in the procedure. The new ordered wavelet coefficients are rearranged according to the parent-child connection between the sub-bands. We provide a measurement matrix that has been refined with a twofold scaling rate assignment and build scanning modes for high-frequency sub-bands using trend data. Using a single scaling matrix, larger scaling rates may be concurrently applied to sparse vectors holding more information and higher energy coefficients. A two-assignment approach can be used to enhance image sampling. When decoding a picture, orthogonal matching (OMP) and inverse discrete wavelet transform (IDWT) are used to rebuild the original. With the help of this technology, high-quality reconstruction at low measurement rates was made possible, and a high-performance method for compressing astronomical images for remote sensing was established [31].

In 2021 , Zhang M., a combined lossless image compression and encryption method based on the hyper-chaotic system and context-based adaptive lossless image codec (CALIC) is suggested, By utilizing CALIC's features, four encryption locations are created to achieve joint image compression and encryption: encryption for the final prediction error, encryption for the final prediction error and two lines of pixel values required by prediction mode, and encryption for the entropy coding file. A novel four-dimensional hyper-chaotic system and plaintext-related encryption based on table lookup are also used to increase security. The test results show that the suggested methodologies give a high level of security and decent performance for lossless compression [32] .

4. Conclusion

Image compression has developed into a fascinating and active area in recent years. where several researchers presented various picture compressing formats and methods. Some of these studies were covered in this review, leading us to the conclusion that they are all helpful in the relevant field. This field is always developing, showing us new studies every day with improved outcomes. In order to provide other scientists working on this subject with a useful resource, this study also provided a Studies description that provided an abstract of the approach, method, and work for each research included in the survey.

Compliance with ethical standards

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Disclosure of conflict of interest

All authors declare that they have no conflict of interest

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