

## **A REVIEW ON IMAGE COMPRESSION**

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*Abstract*— Storage, connection, and quicker computation are the three most important components that the world of image processing requires at the moment. In order to facilitate the transfer of these three features to programs that deal with image processing, picture compression is utilized. There is a large variety of algorithms and methods that can be utilized for both lossless and lossy image compression. This piece of work provides a comprehensive literature review of image compression techniques, which includes an analysis of the underlying principles and approaches that are available, as well as the requirements for further research. A model is proposed for the purpose of reinforcing ROI-based compression approaches. This model is based on the dissociation of ROI and Non-ROI sections of the image. Huffman Encoding is used to compress ROI, and Quad Tree Decomposition is used to compress non-ROI components. Compression Ratio (CR), Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR), and Bits Per Pixel are the evaluation metrics that are utilized in order to assess the effectiveness of the image compression approaches that have been explored (BPP). According to the results of the performance evaluation, the technique that was suggested functions better than other possible techniques.

*Index Terms*— *Image Compression, Arithmetic Coding, Run Length Encoding, MSE, PSNR*

## **I. INTRODUCTION**

Image compression refers to both the art and the science of reducing the amount of data that is necessary to represent an image. [1] This is one of the most useful and effective ways for digital image processing that may be used in commercial transactions. In the current climate, there is a great quantity of data that can be taken use of. Anything could be considered a piece of data. There is the potential for text, images, music, video, and graphics to be implemented. A significant quantity of duplicated data is required for these types of data, which in turn necessitates a significant amount of storage space and transmission time. As a means of tackling these challenges, data compression is absolutely necessary. The compressor is utilized to reduce the number of bits, which in turn results in a reduction in the size of the original data. A decompressor is a device that returns data that has been compressed or reduced to its initial state. It is the picture quality and the compression ratio that are the most fundamental markers of the performance of image compression. Compression can be broken down into two categories: lossless compression and lossy compression alike. Lossless compression is essential for applications that require photographs to be recovered in their original state without any imperfections. There are situations in which lossy compression is advantageous, such as when data loss is acceptable. Lossless and lossy compression are the two types of image compression that are combined to form the third category, which is hybrid image compression. When it comes to compression ratio and image quality, hybrid image compression offers the highest possible results. When compared to lossy compression, lossless compression has a lower compression ratio; nevertheless, the image quality that is achieved by lossless compression is far higher. While the compression ratio is high with lossy compression, the image quality is low. Lossy compression is the opposite of lossless compression. An increase in the PSNR value results in an improvement in the image quality. The PSNR value decreases whenever there is an increase in the CR. PSNR, which stands

for peak signal to noise ratio, and MSE, which stands for mean signal to noise ratio, are both examples of compression performance measurements [2-3].

Square Error (SR), Compression Ratio (CR), Bandwidth Ratio (BR), and Bit Rate (Bit Rate) are all acronyms. Inversely proportional relationships exist between the image quality and the compression ratio.

After conducting an analysis of the work, it was discovered that there is a lack of systematic literature review and performance evaluation of existing approaches for image compression. This is the case despite the fact that there is a great amount of review work for compression methods.

It will investigate the gaps in research as well as the statistical knowledge that is needed for future study.

In the following, you will find a breakdown of the structure of the paper: Image compression is discussed in Section 2, which provides an overview of the subject matter, including fundamental ideas and compression techniques. The review methodology is discussed in Section 3, which also includes a review of the literature on a few compression algorithms, as well as the primary research issues, significant research areas, and research gaps described in the previous section. In the fourth section, the experimental findings of the performance evaluation of the compression technique are presented, together with the performance metrics that were utilized in the research. In Section 5, we take a look at the conclusions that were reached based on both qualitative and quantitative data. In Section 6, we provide a summary of the findings of the study and give some suggestions for additional research [4-5].

Examples of compressed data include text, photos, music, video, and graphics. Compressed data also includes signals. When it comes to data and image compression, the most important requirements are storage, transmission, and speedy computations. Applications that deal with imaging have quite high storage requirements. The fundamental objective of image and data compression is to lessen the amount of space required for storage by decreasing the number of bits, while at the same time enabling the image to be rebuilt using the reduced data. As the amount of data decreases, the amount of memory that is required increases. The amount of time it takes to transmit an image is directly proportional to the size of the image. Data reduction makes it possible to send data more quickly and with less effort. A reduction in the amount of data involved simplifies the design of algorithms and enables faster algorithm performance.

### **Different Compression Techniques**

#### **Lossless Compression:**

The process of decorrelation is a method that can be utilized to eliminate inter-pixel or spatial redundancy [6]. There is a phenomenon known as inter-pixel redundancy that occurs when pixels are similar to their neighbors. The signal is a representation of the correlation that exists between the samples.

There is entropy. Because of coding, superfluous coding is eliminated. In entropy coding, the symbols that are most frequently used are assigned the shortest codewords, while the symbols that are used the least frequently are assigned the longest codewords [7]. Because of the techniques involved in encoding, coding redundancy occurs.

#### **(A) Run Length Coding**

There is a way to code the length of a run using this method. The run length coding method is the most straightforward lossless compression technique. It yields the best results when applied to images that are monochromatic and contain colors that are contagious [8]. The usefulness of this increases when there are a greater number of repetitions, but the size of the file increases when there are less repetitions. It has the capability of compressing data that is composed of any combination of symbols.

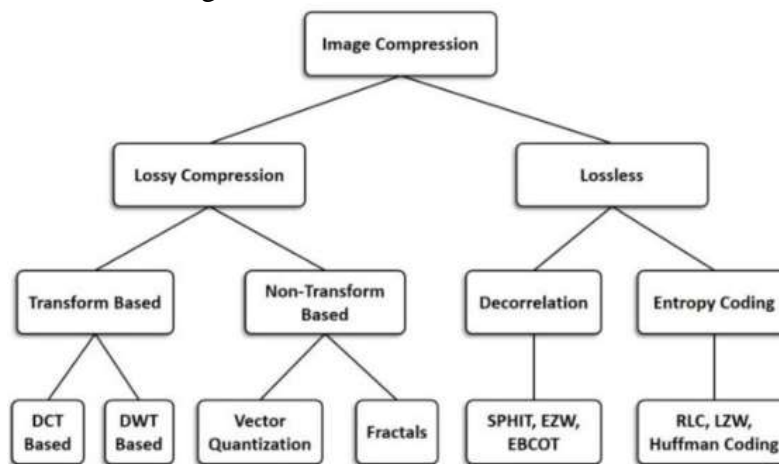
#### **(B) Arithmetic Coding**

Entropy coding is utilized in the process of arithmetic coding, which is a lossless compression method. Arithmetic coding necessitates the use of symbols, a probability range, and an image sequence in order to execute the encoding process [9]. The process of arithmetic coding involves the splitting of the range

of values between zero and one in order to generate codewords [9]. Numerology based on binary fractions is utilized.

**(C) Huffman Coding**

Entropy coding is the foundation of the Huffman coding technique, which is a lossless data compression method. The pixels that make up the image are considered to be symbols [3]. It is based on the notion of using fewer bits to encode material that is frequently repeated [4]. Huffman coding is a method that works. Static and adaptive varieties of Huffman algorithms are the two sorts that are available. A technique for encoding data that uses two passes is known as the static Huffman method. In the first pass, it is necessary to compute the frequency of each symbol, and in the second pass, it is necessary to construct the Huffman tree. The Huffman algorithm, which is the foundation of the adaptive Huffman technique, is capable of producing the Huffman in a single pass; nevertheless, it requires a greater amount of memory allocation than the static Huffman algorithm [10].



**Fig 1: Image Compression Methods**

**Lossy Compression:**

.Lossy compression is beneficial in situations where data loss is tolerable.

**(A) Transform Coding**

This method is considered to be a lossy one when it comes to natural data, such as audio signals or photographic images. The output of transform techniques is of a significantly lower quality compared to the copy that was initially created. A wide range of methods, such as discrete Walsh-Hadamard transforms (WHT), discrete cosine transforms (DCT), and discrete Fourier transforms (DFT), are utilized for transform techniques. Since its introduction, the Discrete Cosine Transform (DCT) has emerged as the most often used transform coding technique.

**(B) Quantification of vectors**

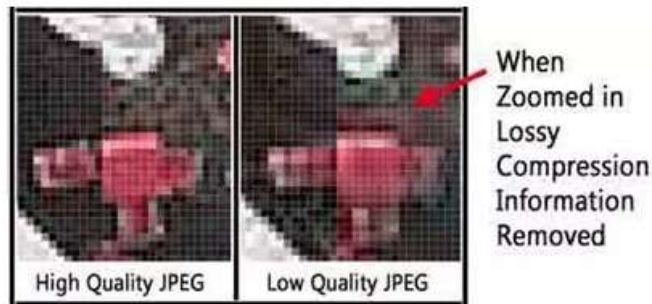
It is a signal processing approach that is Lossy. It's also known as "Pattern Matching Quantization" or "Block Quantization." It divides a huge number of points (vectors) into groups with about the same number of points nearest to them [11].

**(C) Block Truncation**

The Lossy method is utilized when dealing with photographs that are in grayscale. Following the creation of the first image, a number of blocks have been developed. The quantizer is responsible for reducing the number of grey levels present in each block in order to maintain the same mean and standard deviation. In addition to that, it has been utilized to encode video.

**(D) Fractal Coding**

This method is a lossy strategy for digital photographs that are based on fractals. The fractal properties of a picture can be depicted using this mathematical approach, which can be applied to examples of photographs taken from the actual world. The things that are compressed using fractals contain redundant evidence in the form of fractals, which are patterns that are similar and repeat themselves. Millions of iterations are required in order to identify the fractal patterns that are present in an image. On the other hand, fractal decoding is the opposite of fractal encoding [12-13].



**Fig 2:** Lossy Compression

## II. LITERATURE REVIEW

In order to create the Evaluation Model for literature modeling, the following stages were carried out: You should do a systematic review of the compression techniques that are currently in use, as well as identify research gaps and important areas of research.

Consider the following questions:

Because research questions are the fundamental elements that scientists use to organize and carry out any kind of research, the formulation of such questions is of the utmost importance. The following is a list of some of the most often asked questions that we came across while conducting our research [14 to 18]:

- What kinds of compression methods, tools, and algorithms are currently accessible to use?

In the existing body of research, what are the gaps that exist?

How would you rank the most significant areas of research in the field of picture compression?

Table 1 contains the answer to the questions (a) and (b) that were listed in the previous sentence.

Major Research Topics: Image and data compression is beneficial to a variety of industries, including geophysics, telemetry, non-destructive evaluation, medical imaging, video coding, signal coding, and others.

Article	Research	Research gaps
Author: M. Zhang, X. Tong, Z. Wang, and P. Chen Title: Joint Lossless Image Compression and Encryption Scheme Based on CALIC and Hyperchaotic System (2021) [14]	Lossless picture compression may always be thought of as a two-step process. a. Entropy coding b. Decorrelation Predictive approaches have a higher compression	Unless equivalent data sets and performance measurements are employed, comparing the performance of compression techniques is impossible. Some strategies work well with particular types

	ratio than transform techniques.	of data but not with others. Significant gains will very certainly necessitate far more complicated and computationally intensive source models.
Author: Y. Zhang, J. Jiang, and G. Zhang Title: Simultaneous Encryption/Compression of Images Using Alpha Rooting (2021) [15]	<ol style="list-style-type: none"> <li>1. The proposed approach is a hybrid of lossless and lossy algorithms.</li> <li>2. Snack scanning and Huffman coding are utilised.</li> <li>3. It compresses the image according to region priority.</li> <li>4. There is a good compression ratio.</li> <li>5. Hardware complexity is reduced</li> <li>6. High compression and good image quality</li> </ol>	For more redundant data, the suggested method outperforms existing methods, but for less redundant data, the new method improves the outcomes of existing methods just little.
Author: R. Mustafa, B. Ahmedi, and K. Mustafa Title: Compression of Monochromatic and Multicolored Image with Neural Network (2021) [16]	For comparison, many algorithms are utilised. When opposed to standard block-based approaches, a ROI-based algorithm is applied, which	A significant portion of the ROI has a lower compression ratio.

	increases the CR.	
Author: A. Jeromel and B. Zalik Title: An efficient lossy cartoon image compression method, <i>Multimed . Tools Appl.</i> (2020) [17]	This document provides an overview of different Lossless and Lossy approaches.	There is a need for an efficient algorithm that can mitigate the flaws of present algorithms.
Author: D. Ariatmanto and F. Ernawan Title: Adaptive scaling factors based on the impact of selected DCT coefficients for image watermarking (2020) [18]	Performance measures such as CR, PSNR, and BPP are used to compare different Lossless Image Compression algorithms.	For more redundant data, the proposed method outperforms previous methods, but for less redundant data, the proposed method only improves the outcomes of existing methods slightly.

### III. REINFORCEMENT OF THE ROI BASED COMPRESSION METHOD SUGGESTED METHODOLOGY

A technique that is based on the separation of ROI and NROI regions for medical images has been created [19,20]. This technique was developed in order to improve the ROI-based compression strategy. In order to complete the procedure, the following stages must be completed:

1) Following the selection of an image from a collection of images, compression is then applied to the image that was selected.

2) A piece of the image is designated as the ROI, while the remaining portion is designated as the non-ROI region. First, the region of interest (ROI) component of the image that is being examined is chosen, and then the Huffman encoding technique is applied to that piece of the image.

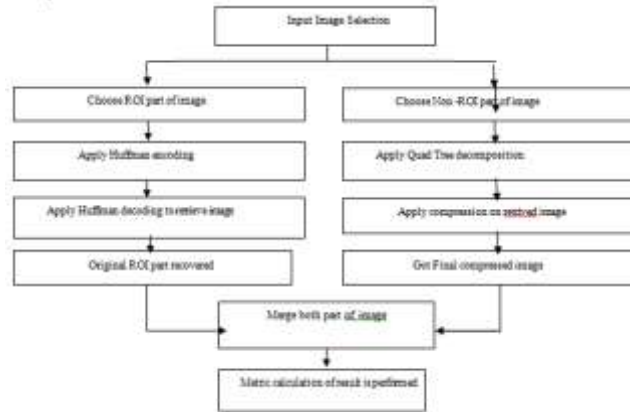
3) After the image has been encoded, the next step is to decode it by employing the Huffman decoding technique. This technique was used to encode the image in the first place, using the Huffman encoding algorithm. One is able to obtain the ROI that was initially calculated.

4. Apply Quad Tree decomposition [21,22] to the area of the seen image that does not contain the region of interest, and then compress the image. After the compression process is complete, the final image is obtained.

In this stage, the parts of the image that have been compressed and those that have not been compressed are combined. After the compression process is complete, the final image is obtained.

6) The Compression Ratio (CR), Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE), and Bits Per Pixel (BPP) of the image are computed by utilizing both of the aforementioned processes.

The performance of the recommended compression method will be proven using the estimated parameters, which brings us to the seventh and last point.



**Fig 3:** Illustration of Proposed Approach

### Performance Metrics

The term peak signal-to-noise ratio (PSNR) is expressed as the ratio of maximum possible value of a signal and the power of distorting noise that affects the quality of its representation. The dimensions of the two images must be the same. Mathematical representation of the PSNR is as follows:

$$PSNR = 20 \log_2 \left( \frac{MAX_f}{\sqrt{MSE}} \right)$$

Where the MSE (Mean Squared Error) is:

$$MSE = \frac{1}{mn} \sum_0^{m-1} \sum_0^{n-1} |f(i,j) - g(i,j)|^2$$

Where, f is the matrix data of the original image, g is the matrix data of processed image, m and n represents the numbers of rows and the columns of pixels of the images and i and j represents the index of row and the column respectively. MAX<sub>f</sub> is the maximum signal in image f.

### Compression Ratio (CR)

Compression Ratio is ratio between memory space needed to store compressed data. i.e code stream [23]

$$CR = \frac{Original Image Size}{Compressed Image Size}$$

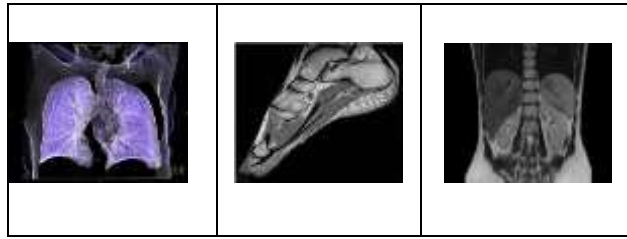
### Bits Per Pixel (BPP)

- Bits per pixel (BPP) give the number of bits that can be able to store in one pixel of the given input image [24].

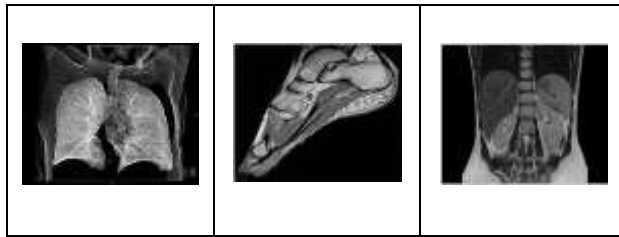
$$BPP = \frac{Compressed file Size}{Entire number of pixel in image}$$

Experimentation are set up in MATLAB (R2020b) using an Intel Core i7-6700HQ 2.60 GHz CPU, 8.00 GB of installed memory (RAM), to do evaluation and comparison studies of the above described methods. For both subjective and objective assessment, the compression outputs of a few images from the examined image set are shown.

Input Images



Decompressed Images By Huffman Coding



Decompressed Images By Arithmetic Coding



Decompressed Images By Run Length Encoding



Decompressed Images By Proposed Method



Table 2. Experimental Results Of Image Compression Techniques

Methods	MSE	PSNR	CR	BPP
Huffman Coding	6.5	40	0.9	0.92
Arithmetic Coding	6.5	40	2.6	0.51
Run Length Encoding	6.7	39	2.5	0.61
Proposed Method	4.8	43	3.7	0.42

With the help of image compression, the size of an image can be reduced, allowing for the storage of additional information. When compared to lossy compression, lossless compression has a lower compression ratio; nevertheless, the image quality that is achieved by lossless compression is far higher. In contrast, lossy compression has a high compression ratio but a low image quality. Lossy compression is frequently used. An increase in the PSNR value results in an improvement in the image quality. The PSNR value decreases whenever there is an increase in the CR. Compression Ratio (CR), Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR), and Bits Per Pixel (BPP) are the different metrics that are utilized in order to assess the effectiveness of the image compression algorithms that have been investigated. The experimental data for a variety of techniques utilized on medical photographs are presented in Tables II-VII. The Huffman Coding method has a higher PSNR value than other approaches, but it has a lower compression ratio than those other methods. There is a higher value assigned to BPP in Huffman Coding. If we compare RLE to Huffman, we find that RLE has a greater compression ratio. Arithmetic Coding, on the other hand, has a lower compression ratio. The PSNR is lower when compared to both the Huffman Coding and the Arithmetic Coding options. It has been found that the MSE value is identical in both Huffman Coding and Arithmetic Coding [25]. In contrast to Huffman and RLE, Arithmetic Coding uses a less number of bits for each pixel utilized. The approach that has been suggested comes up with the highest possible compression ratio and PSNR values. Both MSE and BPP have values that are at a lower level than the other three methods.

#### IV. CONCLUSION

It was through the use of the new CNN with encoding technique that the most successful experimental results on animal identification were acquired. It is recommended that recommendation be made about the evaluation of the creation of an animal database using the CNN with encoding approach. Through the use of this method, it is possible to determine the overall outcomes by determining the independent counts of test images and training images. The purpose of this article review of machine learning is to improve the accuracy of the classification of scene photographs, as demonstrated by our interpretation.

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