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Introspection of Fractal Image Compression for a Multimedia Application

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***Abstract*-- Fractal image compression is the self-similar approach of digital image compression which is an essential feature of an image as it allows us to use the graphical object in our application. It may be of lossy or lossless nature. Lossless compression includes the image formats such as GIF,PNG or raw image whereas lossy compression includes the image formats such as JPG. In this have review the several aspects of digital image compression with respect to compression techniques such as Canonical Huffman Coding, Multi-level compression, semantic analysis, region of attention network, single value decomposition, volumetric image compression, Context tree ,sparse codes, Content-Oriented Learned Image Compression, Pixel based methods, Genertic algorithms and deep learning approach with medical image compression. Each technique has it's own merits and demerits which keeps the method reserves for a specific multimedia application.**

***Keywords*- Image, Fractal, Digital, Pixel, region of attention, compression, PSNR**

I. INTRODUCTION

The method of picture compression reduces the size of image files. The two most common ways that image compression operates are by either deleting information from the image in the form of bytes or by rewriting the image file using an image compression method to use less storage space. One efficient technique to make sure an image loads quickly when a user interacts with a website or application is to compress it. It's a crucial component of image optimization.

Uncompressed images take longer to load than compressed ones. This is important because SEO, conversion rates, the user's digital experience, and other important metrics are greatly influenced by the speed at which webpages and applications load. One of the main ways that developers optimize websites is to improve web performance.

Typically, image compression is used in conjunction with other strategies for enhancing web performance. A content delivery network (CDN) caches content to speed up its delivery to end users. Web servers are prevented from becoming overloaded thanks to load balancing.

Lazy loading is a technique that can speed up a website's most important content. However, in general, image compression is frequently one of the most rapid methods for improving page performance.

1.1. Fractal Image Compression

Fractal compression is a lossy compression method for digital images, based on fractals. The method is best suited for textures and natural images, relying on the fact that parts of an image often resemble other parts of the same image. Fractal algorithms convert these parts into mathematical data called "fractal codes" which are used to recreate the encoded image.

1.1.1. Key Aspects of Fractal Image Compression

1.1.1.1. Encoding Efficiency: Traditional fractal encoding is time-consuming; however, methods like domain classification significantly reduce search times by limiting comparisons to similar classes of blocks.

1.1.1.2. Decompression Techniques: Innovations in decompression, such as non-affine contraction mappings, aim to improve image quality post-compression, demonstrating the versatility of fractal.

1.1.1.3. Lossless Compression and Security: New algorithms integrate fractal coding with encryption techniques, enhancing data security while maintaining high compression ratios.

1.1.1.4. Applications and Adaptability: Fractal compression is beneficial for various applications, including military data processing and archiving, due to its ability to adapt compression levels based on image resolution.

1.2. Lossy Image Compression

Lossy Image compression reduces the size of an image with the relative decline in it's quality features. Without keeping every pixel, lossy image compression keeps only the most important information about the image. Lossy compression algorithms come in a variety of forms, each of which is outlined in greater detail below. However, each of them reduces the size of the image file by removing data from it.

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Most of the time; people don't need to see an image in all of its dimensions and resolution. The largest screen resolution for desktop computers is 1680 x 1050 pixels, while the smallest screen resolution for mobile devices is 360 x 800 pixels. It is extremely uncommon for an image to occupy the entire screen, even at those dimensions.) "Lossy" image compression is a common method for reducing an image's quality and size in a way that doesn't bother the average viewer.

1.2.1. Joint Photographic Expert Group

Joint Photographic Experts Group-named file format is probably the most widely used method of image compression. Files can typically be compressed to a ratio of 10:1 with minimal quality loss. JPEG 2000 and JPEG XR are two more recent versions of JPEG, but many browsers do not support these formats.

1.2.2. High Efficiency Image Format

A type of container file for compressed images is known as the High Efficiency Image Format (HEIF). This method of compressing images is sometimes referred to as HEIC files.

1.2.3. Web Picture Format

Web P is also used for lossy image compression, but it also supports lossless compression. WebP was initially created by Google to take the place of the JPEG, PNG, and GIF file formats.

1.3. Lossless Image Compression

Lossy Image compression reduces the size of an image without the affecting it's quality features. So lossless image compression preserves the quality of an image. Mathematical algorithms are used in lossless" image compression to rewrite an image file without removing any information. A lossless-compressed image should have a much smaller file size, but it should look almost exactly like the original. Although lossless compression can reduce image file sizes by as much as 40%, it is still not as effective as lossy compression for optimizing images for the web and reducing file sizes. The requirements of the end users should be carefully considered by website developers.

1.3.1. Graphical Interchange file

Graphical interchange file format which is frequently used in web applications.GIF files are animated by nature.

1.3.2. Portable Network Graphics

Portable network graphics removes the background of an image .So it is frequently used for logo files and trademarks in a web application.

1.3.3. Bitmap images

Bitmap image files are configured on bitmaps and generated on any painting software. These images which are less appropriate for a web application.

1.3.4. Raw Images

RAW images are not at all compressed. Photos taken with digital cameras in RAW format should be compressed and converted before being used on a website (Saudagar et.al,2020), Under some circumstances where the website is specifically designed to display extremely high-quality image, these images can be used without any alteration.

1.4. Image Compression Methods

To reduce file sizes, both lossy and lossless compression employ a variety of image compression algorithms—an algorithm is a set of rules for a computer to follow.Some image compression methods are as follows:

1.4.1. Transform Coding

A lossy image compression method known as transform coding frequently makes use of the discrete cosine transform (DCT) to mathematically represent a file with less information. Transform coding is the foundation of JPEG.

1.4.2. Arithmetic Coding

Another type of lossless compression algorithm is arithmetic coding. Digital images, like any other digital file, are represented by a string of characters at lower computational levels. In an image file, arithmetic coding encodes commonly used characters with fewer bits and less frequently used characters with more bits. Overall, the result is fewer bits than the initial string of characters.

1.4.3. Run Length Coding

The lossless compression technique known as run-length encoding (RLE) encodes repeated pixels. For instance, instead of writing out all eight white pixels (shuo et.al, 2024). It records the number of pixels (like 8W) when there are eight white pixels in a row.

1.4.4. Lempel Ziv Welch

Based on the older compression algorithms LZ77 and LZ78, the Lempel–Ziv–Welch algorithm is a lossless compression technique.

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1.4.5. Huffman Coding

Compared to arithmetic encoding, Huffman coding typically does not significantly reduce file size but preserves the quality features. In this method we allocate variable length codes to input string characters.

1.4.6. Flat-Deflat Method

Based on LZ77 compression and Huffman coding, flat-deflate is a lossless compression algorithm.

II. LITERATURE REVIEW

2.1 RESEARCH PROBLEM(S)

S.NO.	Author(s)	Paper Title	Research Gap	Result and Discussion
1.	Li, Sijia, Wang, Zhuwen and Mou, Dan(2025)	Fractal Analysis of Volcanic Rock Image Based on Difference Box-Counting Dimension and Gray-Level Co-Occurrence Matrix: A Case Study in the Liaohe Basin, China	Strategy to minimize the iterative steps is missing which may affect the computational performance.	This method offers dependable technical assistance, a data base for geological analyses linked to volcanic rocks, and a significant improvement in recognition accuracy when compared to single-feature recognition techniques
2.	Zhang, Hong gang et.al.(2025)	Optimisation of gradation based on fractal dimension for large-size graded crushed stone	No measurement parameter has found to reduce the count of iterative steps in terms of entropy encoding with respect to time.	This paper evaluates the fractal dimension, a crucial factor in comprehending the material's grading and its effects on performance, is computed in the study.
3.	Qi,Yongjun, et.al.(2025)	Investigation of Image Compression Based on Semantic Network and Deep Residual Variational Auto-Encoder	Study to optimize Entropy Encoding with respect to time is missing which may increases the time complexity .	The proposed mechanism can effectively enhances the compression ratio of an image.
4.	Rajan et.al.(2023)	An Improved Image Compression Algorithm using 2D DWT and PCA with Canonical Huffman Coding	Exploiting Canonical Huffman Coding for high compression	The contemporary learning offers the usage of canonical Huffman coding (CHC) to work as entropycoder, who necessitates lesser decoding period likened to binary Huffman codes. For graphics compression, discrete wavelet transform (DWT) and CHC through principal component analysis (PCA) were pooled.
5.	Zhang, et.al. (2023)	Image Compression Network Structure Based on Multiscale Region of Interest Attention Network	Enhancement of Multi level color Image compression	In modern times, computer age is typically associated with storage capacity and performance. Compression of digital images has become an essential aspect of their transmission and storage. Due to

				storage and bandwidth constraints, it has become highly indispensible to compress images before to transmission and storage
6.	Garg et.al.(2022)	A Multilevel Enhanced Color Image Compression Algorithm using SVD & DCT, International Journal on Recent and Innovation Trends in Computing and Communication	Image Compression based on Semantic Analysis	The methodology of reducing the size of an image with quality reduction can reduce the bandwidth required for image transmission. This approach is considered to diminish the bandwidth necessary for graphical compression which is of great importance to diminish the acquired memory of a device which in turn may increase the network efficiency
7.	Xue et.al.(2022)	aiWave: Volumetric Image Compression with 3D Trained Affine Wavelet-like Transform	Issues with Compressing Image using single value decomposition	The red, green, and blue (RGB) channel colors are extracted using singular value decomposition (SVD) in this image compression technique. The development of a variety of multimedia computer services and applications, including those for storage and telecommunications, necessitates image compression.
8.	Miyamoto et.al.(2022)	Context Tree Based Lossy Compression and it's Applications to CSI Representation,	Image Compression associated with region of Interest attention network	Most of the contemporary schemes using region of interest for compressing the images with remote sensing data works on the basic grading of images and unable to locate the valued objective locals of an image which resulted in the form of less and insufficient proportion of image compression.
9.	Gani et.al.(2022)	Image Compression using Singular Value Decomposition by extracting Red, Green and Blue Channels	Quality Retrieval for Image Compression	Image compression intended to reduce the size of an image without losing it's characteristics and features. Genearlly images are compressed using high order of parametric elements which is not sufficient for proper reduction of image size as it complex when we deals with large size images.
10.	Lather	Sensitivity of Sparse codes to	Performance of Volumetric	Medical imaging is one of the critical

	et.al.(2022)	Image Distortions, Neural Computations	Image Compression	components for compression as it requires to observer the image components quite deeply in 3D space with pixel volume.
11.	Meinget.al.(2022)	Content-Oriented Learned Image Compression	Deal with Content-Oriented Learned Image Compression	a GAN-based architecture is created to demonstrate our scheme's efficacy. Experiments unequivocally demonstrate our method's superiority in terms of visual quality and other metrics. The efficacy of this approach actually shows that current encoders and decoders are sufficiently "smart" to recognize distinct image regions.
12.	Pan et.al.(2021)	Photoacoustic Reconstruction using Sparsity in Curvelet Frame: Image versus Data Domain	Lossy Compression based on Context Tree	Wireless communication plays an important role in transmission media and it is highly required that the time variant channel state information should be transmitted in an effective manner.
13.	Xu,Y.(2020)	High-Quality Image Compression Algorithm Design Based on Unsupervised Learning	Learning based Lossy Image Compression	Trained lossy approach of image compression works on joint optimization of falsehood ratio performance
14.	Dmitry et.al.(2020)	Image Compression as a Variation Calculus Task	Image Compression in the form of variational calculus task	We obtain an enhanced technique for compressing digital videos and the capacity to regulate the relative importance of the compression ratio and the quality of the image that has been decoded. The high-frequency portion of the image spectrum was optimized. For wide-format video images in video communication systems, the suggested approach is advised due to the increase in compression ratio while maintaining image quality.
15.	Wang et.al.(2019)	An End-to-End Deep learning Image Compression Framework Based on Semantic Analysis	Sensitivity Issues with Sparse Codes	The evolution of sparse codes is considered as a concept of graphical representation of outer layer of an image component which applied unsupervised learning mechanism for exploration.
16.	Kumar	An Efficient Technique for	Views specification for	A new approach of viewing has presented

	et.al..(2019)	Image Compression and Quality Retrieval Using Matrix Completion	human centered multiple Image Coding	in this paper which enhances the viewing experiences with multiple description coding using three description lattice vector quantization.
17.	Li et.al.(2019)	Learning Content-Weighted Deep Image Compression	Issues with Photoacoustic Rebuilding in Curvlet Frame	A novel wedge-restriction of the Curvelet transform has implemented to accomplish this, making it possible to construct such a basis (Pan et.al.,2021). A variational framework is used to formulate both of the recovery issues.

III. Conclusion

The projected solutions for mentioned research problems discussed in AIS has achieved following improvements in their respective domains:

- High Image Compression rate with 2D DWT and PCA.
- Optimality of MSE and PSNR for color images using DCT and SVD.
- Implementation of Proper mechanism for semantic analysis with deep learning framework.
- Optimized compression of Images with single value decomposition through RGB channels.
- Avoidance of falsehood associated with region of code using network structure of Image Compression.
- Implementation of single value decomposition based matrix completion for quality parameters.
- Implementation of affine wavelet mechanism for volumetric image compression.
- Quality addition in context oriented lossy compression using CSI vector mechanism.
- Implementation of encryption decryption scheme for lossy compression.
- Sensitivity issues of sparse codes have propely demonstrated and resolved.
- Different views for human centered multiple Image Coding have identified using predictive coding.

IV. Scope For Further Work

Some of the primary research gaps identified during the study that may offer scope for further research in near future are as follows:

- Most of the Image compression algorithms have projected for images with moderate resolution. It may be applied on HD Images.
- Some image compression algorithms that are discussed are generally applied on 2D images. For better exploration these algorithms may also be tested on 3D images.
- The projected algorithm may also be tested on datasets of medical images like MRI and CT scan images.

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