International Journal of Advance Research in Science and Engineering
Volume No. 13, Issue No. 04, April 2024
www.ijarse.com
IJARSE
ISSN 2319 - 8354

Hybrid Techniques for Image Compression: A Comprehensive Review

***Swati Patil*[1], Pratibha Bhoite[2] , Ritu Rani[3]**

[1, 2,3]*Trinity College of Engineering & Research, Pune*
118swat@gmail.com

2pratibhachavan.tcoer@kjei.edu.in

3riturani.tcoer@kjei.edu.in

Abstract: With the increasing demand for high-quality image content across various applications, effective image compression techniques have become crucial for optimizing the storage and transmission resources. Hybrid compression techniques, which combine the strengths of different compression algorithms, have emerged as a promising approaches to achieving higher compression ratios while preserving image quality. This paper presents a comprehensive overview of hybrid techniques for image compression, highlighting the benefits and challenges associated with integrating multiple compression algorithms. This paper also discusses the potential applications of hybrid compression techniques in various domains such as medical imaging, remote sensing, and multimedia communication. Overall, this paper aims to provide insights into state-of-the-art hybrid techniques for image compression and to stimulate further research in this area. By combining the strengths of different compression algorithms, hybrid techniques offer a promising avenue for achieving efficient image compression without compromising image quality. Discussions of the knowledge of and issues about the ongoing hybrid compression technique development indicate the possibility of conducting further researches to improve the performance of image compression method.

Keywords: Image compression, Hybrid techniques, Lossy compression, Lossless com pression

Introduction

Image compression is the process of reducing the file size of an image while maintaining its visual quality. There are several techniques available for image compression, including lossless and lossy compression methods. However, in recent years, hybrid techniques have gained popularity for achieving higher compression ratios without significant loss of image quality.

Hybrid techniques for image compression combine elements of both lossless and lossy compression methods to optimize the compression process. By using a combination of these techniques, hybrid compression algorithms can achieve better compression ratios while preserving more visual details in the compressed image.

One of the advantages of hybrid techniques is that they can adapt to the characteristics of different types of images, allowing for more efficient compression. By incorporating both lossless and lossy compression methods, hybrid techniques can strike a balance between preserving image quality and reducing file size.

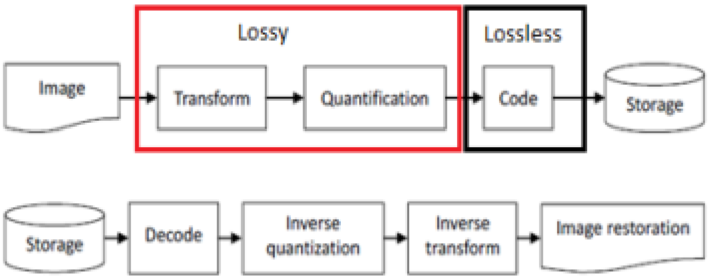

Fig. 1 Hybrid Compression Techniques

Overall, hybrid techniques for image compression offer a flexible and effective approach to achieve high-quality compression results. As the demand for efficient image compression continues to grow, hybrid techniques are likely to play an increasingly important role in the field of image processing.

2 Hybrid compression techniques

1. Transform-based methods: These techniques combine different transform methods such as Discrete Cosine Transform (DCT) and Wavelet Transform to achieve better compression efficiency. By taking advantage of the strengths of these different transforms, hybrid techniques can generate higher quality compressed images.

2. Prediction-based methods: These techniques use prediction models to reduce the redundancy in image data before applying traditional compression algorithms such as Huffman coding or Run-Length Encoding. By including predictive algorithms in the compression process, higher compression ratios can be achieved.

3. Neural network-based methods: With the recent advancements in deep learning, neural network-based compression techniques have become popular. These methods train a neural network to learn the optimal compression parameters for a given image dataset, resulting in highly efficient compression ratios.

4. Fractal-based methods: Fractal image compression techniques use fractal geometry to represent images as fractal patterns. By iteratively applying self-similarity transformations to image blocks, fractal compression can achieve high compression ratios while preserving image quality.

5. Hybrid lossless/lossy compression: This technique combines lossless and lossy compression methods to achieve higher compression ratios without sacrificing image quality. Lossless compression is used for preserving critical image details, while lossy compression is applied to non-essential image elements.

3 Related work

A research proposal by Jassim [1] aims at improving the performance of JPEG method by refining the lossy method. It is carried out by adding Five Modulus Method (FMM) before embarking process stages over JPEG. FMM uses the concept of each matrix block 8x8. Each pixel intensity is combined with -1,-2,1 or2 in the manner as follows: if pixel intensity is divided by 5 and equals 4, then pixel intensity is added with 1; if the result is 3, 2 is added; if the result is 2, 2 is subtracted; and if the result is 1, 1 is subtracted. In this way, all pixel intensities would be zero when divided by 5. The testing result indicates that, on average, the tested image compression ratio is better than that obtained through JPEG, whereas the quality of thereconstructed image is better when it is achieved through JPEG method. Other than adding FMM method [1], the improvement of hybrid compression performance is also made by combining several transformation methods (hybrid transformation). Of the combined transformation methods are transform coding technique and wavelet based [2-7].

Hybrid compression uses this hybrid transform combined with quantization and coding techniques like entropy coding [2], Huffman coding [3-4], or arithmetic coding [6], [7].The testing result indicates that hybrid transform is going to improve hybrid compression performance if it is combined with Huffman coding instead of arithmetic or entropy coding.

Some researchers have also examined the performances of hybrid transform to obtain the best possible compression performance. One such combination of the examined hybrid transform is Discrete Wavelet Transform. If it uses filter Db4 and LWT [8], it can maintain the quality of tested image (average PSNR=36.67dB). Examination of the performances of hybrid wavelet transform: Discrete Hartley Transform(DHT)- Discrete Cosine Transform(DCT), DCT-DHT, Discrete Walsh Transform(DWaT)-DCT, DCT-DWaT, DHT-DWaT, DWaT-DHT, Discrete Kekre Transform(DKT)-DCT, DCT-DKT [9] indicates that the use of hybrid transformation produces the best result if it is compared to single orthogonal transformation. Examination of hybrid transform using the combination of Discrete Walsh Transform(DWaT) and other: DCT, Discrete Sine Transform (DST), DKT, Real-DFT(Discrete Fourier Transform), Slant, DWT [10] produces the same result as well. DWT is used to represent global properties ofa picture. DCT, Walsh, DST, Slant and Real-DFT are used independently to describe local properties of an image. The best performance of compression is obtained through a combination of DWT and DCT.

Examination of the performance of hybrid transform uses a combination of Haar transformation and nonsinusoidal transformations like Walsh, Kekre, and Slant to contribute to global features of a picture. They are however selected as local components by Kekre et al. [11]. The testing result indicates that the best compression is obtained through a combination of Haar-Slant. If Haar transformation is coupled with DCT, DST, Haar-Hartley and Real-DFT [12], then the best hybrid transform is obtained through a combination of Haar-DCT of RMSE 9.77.

Several researchers have also tested the performance of hybrid transform using a combination of DCT, acting as base transformation, and DWT, Kekre, DKT, DWT, DHT, Walsh, Haar, Sine, or Slant [13-17]. The testing result [13-15] indicates that the performance of hybrid compression can be increased using an improved hybrid transformation of DCT-Kekre. The proposed method [14] is even capable of maintaining a relatively good quality of the image (PSNR=63.4 dB, MSE=0.2). The testing result of hybrid transform, when applied to different color spaces [16], [17], indicates that DCT-Haar performance is capable of maintaining the quality of a picture.

Hybrid compression improvement not only develops hybrid transform that uses a combination of coding transform and wavelet-based method. A study by Afrose et al. [18] proposes a joint of 3 transformation methods: Singular Value Decomposition (SVD), Discrete Wavelet Transform (DWT) and Discrete Cosine Transform (DCT). Having used these three methods, the hybrid transform is then combined with Quantization factor and entropy encoding. The testing result indicates that the proposed method is capable of improving the quality of the reconstructed image of 20.61 dB in the average PSNR and 0.033 inthe average MSE.

The development of hybrid compression includes KFCG (Kekre's Fast Codebook Generation) and KMCG (Kekre's Median Codebook Generation) [19] quantization method refinements as well. The performance of KFCG and KMCG quantization method is faster than that of LBG (Linde Buzu Gray) algorithm. The testing result indicates that combination of KFCG quantization and Hybrid Wavelet transformation produces the least distortion and a relatively good image quality as is reflected in theStructural Similarity Index (SSIM) of 0.974 nearly reaching 1, which shows the relatively good performanceof compression method.

4 Challenges and considerations

1. Complexity: Hybrid techniques often involve combining multiple compression algorithms, which can make the overall compression process more complex and computationally intensive.

2. Trade-off between quality and compression ratio: Achieving a balance between image quality and compression ratio can be challenging with hybrid techniques, as different compression algorithms may prioritize one over the other.

3. Compatibility: Hybrid techniques may require compatibility between different compression algorithms, which can be difficult to achieve and may limit the range of codecs that can be used together.

4. Implementation: Implementing hybrid techniques can be more challenging than using a single compression algorithm, as it requires integrating multiple algorithms and ensuring they work together effectively.

5. Optimization: It can be difficult to optimize hybrid techniques for different types of images and content, as the performance of the compression algorithm may vary depending on the characteristics of the image.

6. Complexity of compression process: Hybrid techniques often involve a combination of lossless and lossy compression algorithms, which can make the overall compression process more complex and may require more storage and processing power.

7. Compatibility with existing standards: Hybrid techniques may not always be compatible with existing image compression standards, which can limit their usefulness in certain applications.

Overall, while hybrid techniques can offer improved compression performance compared to single algorithms, they also come with a set of challenges and considerations that need to be carefully addressed in order to achieve optimal results.

5 Conclusion:

The improvement of image compression technique to get an optimal compression ratio and best quality of the image can be made by combining lossy and lossless compression technique known as a hybrid compression technique. This combination aims at optimizing the advantages of each compression method.

An analytical review of the journals has revealed classifications of the development of hybrid compression technique, as are shown in Table 1

Table 1. Classifications of the development of hybrid compression technique

Classification	Proposed Method	Paper
Hybrid Transformation	FMM	[1]
Hybrid Transformation	Combination of coding transform and wavelet-based, quantization, coding	[2]-[7]
Hybrid Transformation	Combination of coding transform and wavelet-based	[8]-[17]
Hybrid Transformation	SVD, DWT, DCT	[18]
Hybrid Transformation	Hybrid Wavelet, quantization (KFCG, KMCG)	[19]

In conclusion, hybrid techniques offer promising avenues for improving image compression performance beyond the capabilities of traditional methods. By combining different compression approaches, hybrid techniques can achieve higher compression ratios while maintaining satisfactory image quality. However, addressing the challenges and advancing the state-of-the-art in hybrid compression require interdisciplinary research efforts and collaboration among researchers from academia and industry.

6 Applications and Future Directions

There are several potential areas for improvement and future research directions in hybrid compression techniques. These areas aim to address existing challenges, explore new opportunities, and advance the state-of-the-art in image compression.

Deep Learning-based Compression: Further exploration of deep learning techniques for hybrid compression, including the development of novel neural network architectures, optimization algorithms, and training strategies tailored for efficient image representation and reconstruction. Investigation of unsupervised learning approaches, self-supervised learning, and reinforcement learning techniques for learning adaptive compression representations directly from data.

Adaptive and Context-aware Compression: Research on advanced content-aware compression techniques that leverage contextual information, semantic segmentation, and object detection to optimize compression strategies based on image content and structure. Exploration of perceptual optimization methods, including psychovisual models, attention mechanisms, and human perception-inspired algorithms for enhancing image quality preservation and perceptual fidelity.

Robust and Error-resilient Compression: Development of robust compression algorithms resilient to various types of errors, including transmission errors, packet loss, channel noise, and compression-induced artifacts.Investigation of error concealment techniques, error prediction models, and joint source-channel coding approaches for improving error recovery and resilience in compressed image transmission and storage.

Hybrid Compression for Emerging Applications:

Exploration of hybrid compression techniques tailored for emerging applications and technologies, such as virtual reality (VR), augmented reality (AR), light field imaging, hyperspectral imaging, and quantum imaging. Research on compression methods optimized for specific application requirements, including high-resolution content, low-latency encoding, interactive streaming, and immersive user experiences.

Efficient Hardware Implementation:

Optimization of hybrid compression algorithms and architectures for efficient hardware implementation on embedded systems, FPGA (Field-Programmable Gate Array) platforms, GPU (Graphics Processing Unit) accelerators, and specialized processors. Investigation of hardware-friendly compression techniques, algorithmic optimizations, and parallel processing strategies to achieve real-time performance, low-power operation, and scalability in hardware implementations.

Standardization and Interoperability:

Standardization efforts to establish guidelines, interoperability frameworks, and compression standards for hybrid compression techniques, ensuring compatibility and seamless integration with existing compression formats and systems.Collaboration with standardization organizations, industry consortia, and regulatory bodies to promote the adoption, dissemination, and widespread deployment of hybrid compression solutions across diverse applications and environments.

Objective Quality Assessment and Evaluation:

Advancements in objective quality assessment metrics, benchmark datasets, and evaluation methodologies tailored for hybrid compression techniques. Development of comprehensive evaluation frameworks for assessing compression performance, image quality preservation, perceptual fidelity, computational efficiency, and robustness across different compression algorithms, parameters, and application scenarios.

References

1.Signal & Image Processing : An International Journal (SIPIJ) Vol.4, No.2, April 2013 DOI :10.5121/sipij.2013.4203 31 IMAGE COMPRESSION BY EMBEDDING FIVE MODULUS METHOD INTO JPEG Firas A. Jassim Management Information Systems Department, Irbid National University, Irbid 2600, Jordan Firasajil@yahoo.com

2.A Hybrid Compression Method for Integral Images Using Discrete Wavelet Transform and Discrete Cosine Transform E. Elharar, Adrian Stern, Ofer Hadar, Member, IEEE, and Bahram Javidi, Fellow, IEEE

3.Emy Setyaningsih1 , Agus Harjoko2 1Department of Computer Systems, Institut Sains & Teknologi AKPRIND, Yogyakarta, Indonesia 1,2Department of Computer Science and Electronics, Universitas Gadjah Mada, Yogyakarta, Indonesia

4.R.G. .Baraniuk, "Image Compression using an Efficient", Journal on Today's Ideas – Tomorrow's Technologies (JOTITT), vol/issue: 1(1), pp. 45–50, 2013.

5.International Research Journal of Engineering and Technology (IRJET) ISSN: 2395 -0056 Volume: 03 Issue: 05 | May-2016 www.irjet.net p-ISSN: 2395-0072 © 2016, IRJET | Impact Factor value: 4.45 | ISO 9001:2008 Certified Journal | Page 2758 Video Compression Using Hybrid DCT-DWT Algorithm Mr.S.V.Phakade1 ,Harish Patil2 , Shaileshkumar Nikam3 , Sidhappa kitture4

6.C.S. Raju, and D.V.R.K. Reddy, "On Compression Characteristics of White Band and Narrow Band Images using Hybrid DCT and DWT" 2nd International Conference on Electronics and Communication Systems (ICECS 2015), IEEE, pp. 827–830, 2015.

7.P.V.M. Vijayabhaskar, and N.R. Raajan, "Comparison of Wavelet Filters in Image Coding using Hybrid Compression Technique", International Conference on Emerging Trends in VLSI, Embedded System, NanoElectronics and Telecommunication System (ICEVENT), IEEE, pp. 1–5, 2013.

8.S.P. Banu, and Y. Venkataramani, "An Efficient Hybrid Image Compression Scheme Based on Correlation of Pixels for Storage and Transmission of Images", International Journal of Computer Applications, vol/issue:18(3),pp. 6–9, 2011.

9.B.A. Geeta, and G. Sonal, "Review of Comparison Between Single Orthogonal Transform and Hybrid Transforms for Storing Color Information in Grey Scale Image" International Journal of Emerging Technology and Advanced Engineering (IJETAE), vol/issue: 2(11), pp. 768–771, 2012.

10.H.B. Kekre, et al., "Image Compression Based on Hybrid Wavelet Transform Generated using Orthogonal Component Transforms of Different Sizes", International Journal of Soft Computing and Engineering (IJSCE), vol/issue: 3(3), pp. 53–57, 2013.

11.H.B. Kekre, et al., "Color Image Compression using Hybrid Wavelet Transform with Haar as Base Transform",International Journal of Scientific and Research Publications, vol/issue: 4(6), pp. 1–13, 2014.

12.H.B. Kekre, et al., "Performance Comparison of Hybrid Haar Wavelet Transform with Various Local Transforms in Image Compression using Different Error Metrics", International Journal of Image Processing (IJIP), vol/issue: 8(4), pp.186–203, 2014.

13.S.D. Thepade, and S. Erandole, "Effect of Tiling in Image Compression using Wavelet Transform & Hybrid Wavelet Transform for Cosine", IEEE International Conference on Emerging Trends in Computing, Communication and Nanotechnology (ICECCN 2013), pp. 753–758. 2013.

14.T. Deepa, and H. Girisha, "Image Compression using Hybrid Wavelet Transform and Their Performance Comparison", International Journal Of Modern Engineering Research (IJMER), vol/issue: 4(6), pp. 6–12, 2014.

15. H.B. Kekre, et al., "Performance Superiority of Hybrid DKT-DCT Wavelet Compared To DKT, DCT Individual Transforms and Their Wavelets in Image Compression", 5th International Conference - Confluence The Next Generation Information Technology Summit (Confluence), IEEE, pp. 619–624, 2014.

16.S.D. Thepade, and S. Erandole, "Improved Image Compression using Row & Column Cosine Hybrid Wavelet Transform with Various Color Spaces", International Conference for Convergence for Technology-2014, IEEE, pp. 1–6, 2014.

17.S.D, Thepade, and J.H. Dewan, "Image Compression using Hybrid Wavelet Transform with Varying Proportions of Cosine, Haar, Walsh and Kekre Transforms with Assorted Color Spaces", International Conference on Control, Instrumentation, Communication and Computational Technologies (ICCICCT), IEEE, pp. 1500–1508, 2014.

18.S. Afrose, et al., "A Hybrid SVD-DWT-DCT Based Method for Image Compression and Quality Measurement of The Compressed Image", International Conference on Electrical Engineering and Information Communication Technology (ICEEICT), Bangladesh:IEEE, pp. 1–4, 2015.

19.H.B. Kekre HB, et al., "Color Image Compression using Vector Quantization and Hybrid Wavelet Transform", Procedia Computer Science, vol/issue: 89, pp. 778–784, 2016.