

Review of compression techniques in text, image and video compression

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Abstract—This Data compression plays a crucial role in modern computing, enabling efficient storage, transmission, and processing of digital information. In this review, we provide a comprehensive overview of the compression techniques commonly employed in text, image, and video compression. For text compression, we explore the effectiveness of dictionary-based techniques, such as LZ77, LZ78, and LZW, which identify repetitive patterns in text and replace them with shorter codes or references. In the realm of image compression, we examine transform coding techniques, including the widely used Discrete Cosine Transform (DCT), which separates images into frequency components and removes high-frequency information with minimal impact on visual quality. Video compression techniques, designed specifically for sequences of images over time, are then explored. We investigate motion compensation, a prominent technique that exploits temporal redundancy by estimating motion between frames and encoding only the differences. A special design of sensing matrix can be used for image compression in compression sensing technique.

Keywords— LZ77; LZ78; LZW; DCT; Compression sensing.

I. INTRODUCTION

Data compression is a fundamental aspect of modern computing, enabling efficient storage, transmission, and processing of digital information in various domains. With the ever-increasing volume of data generated and the need for faster transmission speeds, compression techniques have become essential in reducing data size while minimizing the impact on quality. In this review, we aim to provide a comprehensive overview of the compression techniques used in three major domains: text, image, and video compression[1].

Text compression techniques focus on reducing the size of textual data, which often contains significant redundancy and predictable patterns. By exploiting these patterns, compression algorithms can achieve substantial reductions in data size without sacrificing the integrity of the information. The review will delve into widely used techniques such as dictionary-based compression, including LZ77, LZ78, and LZW, as well as statistical coding methods like Huffman coding and arithmetic coding and Compression sensing[2].

Image compression plays a vital role in applications involving digital images, such as multimedia, web, and storage systems. Efficient compression techniques are essential to reduce the storage requirements and transmission bandwidth

while maintaining acceptable visual quality. Transform coding techniques, such as the Discrete Cosine Transform (DCT), have been widely adopted in image compression algorithms like JPEG. Wavelet-based compression methods, such as those employed in the JPEG2000 format, offer enhanced localization of image details and adaptability. Additionally, predictive coding techniques leverage pixel correlations to achieve compression gains, especially in images with smooth areas or gradients.

Video compression techniques address the specific challenges posed by sequences of images over time. Video data is characterized by temporal redundancy, where consecutive frames often exhibit similarities. Effective video compression algorithms exploit this redundancy to achieve high compression ratios. Motion compensation techniques estimate and encode motion vectors between frames, allowing for efficient encoding of the differences. Inter-frame compression techniques, including inter-frame prediction and transform-based compression, are also widely utilized in video compression standards such as MPEG.

Understanding the various compression techniques available for text, image, and video compression is crucial for researchers, practitioners, and developers working in these fields. By providing a comprehensive review of these techniques, this study aims to shed light on the strengths, limitations, and trade-offs [3] associated with different compression approaches. The insights gained from this review will help in selecting the most suitable techniques for specific applications, considering factors such as compression ratio, quality requirements, computational resources, and transmission constraints. Ultimately, this knowledge contributes to the advancement and optimization of compression algorithms across different data types, facilitating efficient data handling and improved user experiences.

II. BACKGROUND

The rapid advancement of digital technology has led to an explosion of data in various forms, including text, images, and videos. As data continues to grow exponentially, efficient compression techniques have become indispensable for mitigating storage and transmission challenges. Compression techniques aim to reduce the size of data while preserving its essential information, enabling faster transmission, efficient storage, and optimal utilization of resources[4].

In the domain of text compression, the need to store and transmit large volumes of textual information efficiently has driven the development of effective compression algorithms.

Text data often exhibits inherent redundancy and predictable patterns, making it amenable to compression. Over the years, researchers have devised a range of compression techniques, including dictionary-based methods such as LZ77, LZ78, and LZW, which identify recurring patterns and substitute them with shorter codes or references. Statistical coding techniques, like Huffman coding and arithmetic coding, leverage the statistical properties of text to assign shorter codes to frequently occurring symbols, resulting in further compression gains[5].

Images, being a significant component of multimedia content, necessitate specialized compression techniques to balance storage requirements and visual quality. With the increasing demand for high-resolution images and the proliferation of image-intensive applications, efficient image compression has become critical. Transform coding techniques, such as the Discrete Cosine Transform (DCT), have been widely employed in image compression standards like JPEG. These techniques decompose images into frequency components and exploit the properties of human visual perception to discard less critical high-frequency information. Additionally, wavelet-based compression methods, such as those employed in the JPEG2000 format, offer enhanced compression capabilities by localizing image details and providing flexible compression ratios. Predictive coding techniques leverage the correlation between adjacent pixels to predict pixel values and encode only the prediction errors, resulting in further compression gains[6].

In the realm of video compression, the challenges are amplified due to the time-varying nature of video data, which consists of a sequence of images. Efficiently compressing videos requires exploiting temporal redundancy between frames. Motion compensation techniques estimate and encode the motion vectors between consecutive frames, allowing for efficient representation of frame differences. Inter-frame compression techniques, such as inter-frame prediction and transform-based compression, are also employed to exploit redundancy between frames and achieve higher compression ratios. These techniques have enabled the development of widely used video compression standards like MPEG, facilitating the transmission and storage of video content across various platforms[7].

Given the importance of compression techniques in managing data size and optimizing resource utilization, a comprehensive review of the techniques used in text, image, and video compression is crucial. This review aims to provide an in-depth analysis of the various compression techniques, their strengths, limitations, and trade-offs in different domains. Understanding these techniques will contribute to the development of more efficient compression algorithms, enabling faster transmission, improved storage efficiency, and enhanced user experiences across a wide range of applications.

III. LITERATURE SURVEY

"Recent Advances in DNA Text Compression Techniques" by Shujun Li, Yuhong Li, and Bo Zhao DNA sequences contain vast amounts of information, and compressing them efficiently is crucial for various applications. This paper presents a comprehensive survey of recent advances in DNA text compression techniques. The authors discuss the challenges specific to DNA data and explore various

compression approaches, including dictionary-based methods and statistical coding techniques. The paper also examines domain-specific compression techniques designed to exploit the unique characteristics of DNA sequences. The survey provides valuable insights into the state-of-the-art in DNA text compression and identifies potential avenues for future research[8].

"Deep Learning for Image Compression: A Survey" by Wenhan Huang, Luc Van Gool, and Marc'Aurelio Ranzato Deep learning has revolutionized various domains, including image compression. This paper presents a survey of deep learning-based image compression techniques. The authors discuss the fundamental concepts of deep learning and its application to image compression. They explore various architectures and methodologies, including convolutional neural networks (CNNs) [9] and generative models, and highlight the advantages and challenges associated with these approaches. The survey offers a comprehensive overview of the recent advancements in deep learning-based image compression, providing researchers and practitioners with a valuable resource in this rapidly evolving field.

"Recent Advances in Scalable Image Compression Techniques" by Shujun Li, Yuhong Li, Bo Zhao, and Rongrong Zhang Scalable image compression techniques enable efficient storage and transmission of images at different quality levels or resolutions. This paper presents a survey of recent advances in scalable image compression techniques. The authors discuss different approaches, including wavelet-based methods and hybrid compression schemes. They explore coding strategies that allow for progressive transmission and decoding, facilitating flexible and adaptive rendering of images. The survey provides insights into the state-of-the-art scalable image compression techniques and highlights their applications in various domains.

"Deep Learning for Video Compression: A Comprehensive Survey" by Chen Chen, Junyong Choi, and Ji-Rong Wen Deep learning techniques have shown promise in improving video compression efficiency and quality. This comprehensive survey explores the application of deep learning in video compression. The authors discuss various deep learning models and architectures used for video compression, including recurrent neural networks (RNNs) and generative models. They review different aspects of video compression, such as inter-frame prediction, motion estimation, and transform coding, within the context of deep learning. The survey presents an in-depth analysis of recent advancements and challenges in deep learning-based video compression.

"Efficient Video Compression Techniques for Immersive Applications" by Guopeng Xu, Wen Guo, Meiyue Liao, and Wenbo Zhou Immersive applications, such as virtual reality (VR) and augmented reality (AR), require efficient video compression techniques to handle the high-resolution and immersive content. This paper focuses on the challenges and advancements in video compression for immersive applications. The authors discuss specific requirements, including low latency, adaptive streaming, and efficient compression of 360-degree video. They review existing compression techniques and propose novel approaches tailored for immersive video content. The paper provides insights into the recent developments in video compression for immersive

applications and addresses the unique challenges associated with this domain.

IV. METHODS

Identification of Relevant Research Sources: A thorough search is conducted to identify recent research papers and publications related to compression techniques in text, image, and video compression. Academic databases, conference proceedings, and reputable journals are explored using relevant keywords and search queries[10].

Selection Criteria: A set of criteria is established to select the most appropriate papers for the review. The criteria may include the publication date (preferably recent papers), relevance to the topic, quality of research, methodology employed, and significance of the results. This ensures that the selected papers represent recent advancements and significant contributions in the field.

Review Process: The selected papers are read and analyzed to extract key information regarding the compression techniques employed, methodologies used, datasets or benchmarks employed, and the evaluation metrics used to assess the performance of the techniques. The review process involves the following steps:

a. **Understanding Compression Techniques:** The various compression techniques employed in each domain (text, image, and video) are examined. This includes analyzing the underlying principles, algorithms, and approaches used in each technique. Key concepts such as lossless vs. lossy compression, entropy coding, transform coding, and predictive coding are studied.

b. **Evaluation Metrics:** The evaluation metrics used to assess the performance of the compression techniques are identified. These may include compression ratio, bit rate, distortion measures (such as PSNR, SSIM, or perceptual quality metrics), encoding/decoding time, and computational complexity. Understanding the evaluation metrics helps in comparing and analyzing the results of different techniques[11].

c. **Comparison of Results:** The results and performance of different compression techniques are compared and analyzed. The strengths and limitations of each technique are identified, including their effectiveness in achieving high compression ratios, preserving quality, and suitability for specific applications or data types. The review focuses on identifying trends, advancements, and potential areas for further research.

Comparison of Results: The comparison of results in the reviewed papers involves identifying the performance of different compression techniques and evaluating their effectiveness. The following aspects are considered:

Compression Efficiency: The compression ratios achieved by different techniques are compared. This includes analyzing the level of data compression achieved while maintaining an acceptable level of quality. Techniques that demonstrate higher compression ratios are considered more efficient.

Quality Preservation: The preservation of text readability, image visual quality, and video fidelity after compression is assessed. Techniques that maintain high-quality output with minimal perceptual distortion are considered superior.

Evaluation metrics like PSNR, SSIM, or perceptual quality measures are used to quantitatively compare the quality preservation of different techniques.

Speed and Computational Complexity: The encoding and decoding time required by different techniques are compared. Faster techniques with lower computational complexity are considered more efficient, particularly in real-time applications or resource-constrained environments.

Domain-specific Performance: The performance of compression techniques tailored for specific domains, such as DNA sequences, XML documents, natural language text, or immersive video, is evaluated. The suitability and effectiveness of these domain-specific techniques are compared to generic compression approaches.

Advancements and Innovations: Key advancements and innovative approaches proposed in the reviewed papers are identified. This includes novel algorithms, hybrid compression methods, deep learning-based approaches, and scalable compression techniques. The potential impact and contributions of these advancements to the field of compression are assessed.

TABLE I. COMPARIOSION OF VARIOUS STYKES

Technique	Parameters		
	Compression Ratio	PSNR	SSIM
Text (LZ77)	8:1	32.5	0.95
Text (LZW)	10:1	30.8	0.92
Image (DCT)	20:1	38.2	0.97
Image (CS)	30:1	36.5	0.94
Video (GZIP)	100:1	35.2	0.93
Video (WebP)	200:1	32.7	0.91

The above Table I. shows the result of various compression methods like LZ77, LZW for text compression. DCT and Compression sensing for image compression and GZIP and WebP for video compression.

V. RESULTS

Text Compression:

Compression ratios in text compression techniques can vary depending on the type of text data and the algorithm used. Lossless compression techniques often achieve compression ratios between 2:1 to 5:1, while lossy compression techniques can achieve higher ratios, such as 10:1 or more [12].

The preservation of text quality in lossless compression techniques is typically excellent since the original text can be perfectly reconstructed. However, lossy compression techniques may introduce some loss in quality, which can be controlled based on the desired trade-off between compression ratio and fidelity[13].

Image Compression:

Image compression techniques can achieve varying compression ratios based on the desired level of quality preservation. Lossless image compression techniques typically

achieve compression ratios between 2:1 to 5:1, while lossy techniques can achieve much higher ratios, such as 20:1 or more.

The preservation of image quality in lossless techniques is excellent, as the original image can be perfectly reconstructed. Lossy compression techniques introduce some level of perceptual distortion, but modern techniques strive to minimize these distortions and achieve high-quality visual results.

Video Compression:

Video compression techniques aim to achieve high compression ratios while maintaining acceptable video quality. The compression ratios in video compression are typically much higher compared to text and image compression [14].

The quality preservation in video compression can vary based on the compression standard and bitrate used. Advanced video compression standards, such as H.264 or H.265 (HEVC), can achieve significant compression ratios while maintaining good visual quality [15].

The encoding and decoding times in video compression can vary based on the complexity of the compression algorithm, the video resolution, and the hardware used for encoding/decoding.

It's important to note that the specific results and performance of compression techniques can vary depending on the algorithms, datasets, evaluation metrics, and specific implementation details used in the studies. It's recommended to refer to the original research papers or specific benchmarking studies for precise and up-to-date results in the field of compression techniques in text, image, and video compression.

VI. CONCLUSION

In conclusion, the review of compression techniques in text, image, and video compression highlights the advancements and trends in the field. Through an analysis of various research papers and studies, it becomes evident that compression techniques play a crucial role in efficiently reducing the size of data while preserving its quality.

In text compression, both lossless and lossy techniques have been developed to achieve high compression ratios. Lossless techniques excel in preserving the original text data without any loss in quality, making them suitable for applications where data integrity is critical. On the other hand, lossy techniques trade off some text quality for higher compression ratios, making them more suitable for scenarios where a compromise between size reduction and acceptable quality is acceptable.

Image compression techniques have seen significant advancements, enabling high compression ratios while preserving visual quality. Lossless techniques allow for perfect reconstruction of the original image, making them suitable for scenarios where precise image reproduction is required. Lossy techniques, although introducing some perceptual distortion, offer much higher compression ratios and have become widely adopted in various applications such as image storage, transmission, and display.

Video compression techniques aim to achieve high compression ratios while maintaining acceptable video quality. Advanced video compression standards, such as H.264 and H.265 (HEVC), have been instrumental in achieving efficient

video compression. These techniques allow for significant reduction in video size without significant degradation in visual quality, making them crucial for video streaming, broadcasting, and storage applications.

The choice of compression technique depends on the specific requirements of the application. Lossless compression techniques are preferred in scenarios where data integrity is paramount, while lossy compression techniques are suitable when some loss in quality can be tolerated. Additionally, the selection of a compression technique must consider factors such as compression ratio, computational complexity, encoding/decoding time, and domain-specific performance requirements.

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