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JPEG IMAGE COMPRESSION AND DECOMPRESSION BY HUFFMAN CODING WITH IMAGE ENHANCEMENT

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ABSTRACT

This project focuses on implementing JPEG image compression and decompression using Huffman coding in Python, with an added step of image enhancement post decompression to improve visual quality. JPEG is a widely recognized lossy compression standard that combines Discrete Cosine Transform (DCT), quantization, and entropy coding to compress image files efficiently. The system leverages Huffman coding, a form of entropy encoding, to further compress the quantized image data by exploiting the statistical distribution of pixel values. In the decompression phase, Huffman decoding is first used to reconstruct the quantized data. An inverse DCT is then applied to recover the image in its spatial form. To enhance the decompressed image and address the quality loss introduced by compression, a post-processing image enhancement step is introduced. This includes techniques such as contrast adjustment, sharpening filters, and noise reduction, which help to improve the visual quality of the decompressed image. This project demonstrates efficient image size reduction while maintaining or improving visual quality, making it suitable for practical applications in image storage, transmission, and digital communication systems. Additionally, it serves as an educational tool for understanding not only image compression but also the role of high-boost filtering in image enhancement, highlighting its importance in modern image processing techniques.

I.INTRODUCTION

JPEG (Joint Photographic Experts Group) is a widely adopted standard for compressing digital images, balancing efficient data reduction with acceptable loss in visual quality. The compression process involves several stages, including color space conversion, discrete cosine transform (DCT), quantization, and entropy coding. Huffman coding, a form of entropy coding, plays a crucial role in this process by efficiently encoding the quantized DCT coefficients. However, the compression process can introduce artifacts such as

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blurring and blocking effects, which degrade image quality. To mitigate these effects, image enhancement techniques are employed post-decompression to restore and improve image quality.

1.1 OBJECTIVE AND SCOPE OF PROJECT

Objective

The primary objective of this project is to implement an efficient image compression and decompression technique for JPEG images using Huffman coding, integrated with image enhancement methods to preserve or improve image quality. Huffman coding, a lossless data compression algorithm, is used to reduce the size of image files without compromising data integrity, making storage and transmission more efficient. This project also focuses on applying image enhancement techniques post-decompression to counteract any visual degradation and improve perceptual image quality.

Scope

The scope includes evaluating performance through compression ratio and image quality metrics (PSNR, SSIM). This system is applicable in fields requiring efficient image storage and high-quality visual output.

1.2 PROBLEM STATEMENT

With the rapid growth of digital media, efficient storage and transmission of images have become critical. Uncompressed images consume significant memory and bandwidth, creating challenges in applications like web development, medical imaging, and multimedia. Traditional compression methods may degrade image quality, while lossless techniques often result in larger file sizes. This project addresses the need for an efficient, lossless compression method by implementing JPEG image compression and decompression using Huffman coding. To ensure visual quality post-decompression, image enhancement techniques are applied. The goal is to achieve optimal balance between compression efficiency and image quality for practical, real-world use cases. In today's digital age, the volume of image data generated, stored, and transmitted is growing exponentially. High-resolution images are essential in fields such as medical imaging, satellite communication, photography, and social media. However, uncompressed image files occupy substantial storage space and require high bandwidth for transmission, which can lead to inefficiencies and increased costs. While JPEG is a widely used image compression standard, its default methods often result in a trade-off between compression ratio and image quality.

II. LITERATURE SURVEY

The integration of Huffman coding in JPEG compression has been extensively studied. Huffman coding is a lossless data compression algorithm that assigns variable-length codes to input characters, with shorter codes assigned to more frequent characters. In the context of JPEG, Huffman coding is applied to the quantized DCT coefficients to

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achieve compression. Studies have shown that Huffman coding effectively reduces data size while maintaining image quality. However, the compression process can introduce artifacts that necessitate post-processing enhancement techniques.

Image enhancement techniques aim to improve the visual quality of images by enhancing features such as contrast, sharpness, and detail. Methods such as histogram equalization, unsharp masking, and edge enhancement have been widely used to enhance images. These techniques can be applied to JPEG decompressed images to mitigate artifacts and improve quality. Recent advancements have introduced adaptive methods, such as adaptive histogram equalization, which adjust enhancement parameters based on local image characteristics, leading to more effective enhancement.

The combination of Huffman coding for compression and image enhancement techniques has been explored in various studies. For instance, research has demonstrated that applying enhancement techniques to JPEG decompressed images can significantly improve visual quality without substantial increases in data size. These studies highlight the importance of considering both compression and enhancement in image processing workflows to achieve optimal results.

III. EXISTING CONFIGURATION

Existing systems that utilize JPEG compression with Huffman coding typically follow a standardized process. The image is first converted from RGB to YCbCr color space to separate luminance and chrominance components. The image is then divided into 8x8 blocks, and the DCT is applied to each block to transform spatial domain data into frequency domain coefficients. Quantization is performed on the DCT coefficients to reduce precision, followed by the application of Huffman coding to the quantized coefficients for compression. This process results in a compressed image file that can be stored or transmitted efficiently.

Upon decompression, the inverse processes are applied: Huffman decoding, inverse quantization, and inverse DCT. The decompressed image may exhibit artifacts such as blurring and blocking effects due to the lossy nature of JPEG compression and quantization. To address these issues, image enhancement techniques are applied to the decompressed image. These techniques aim to restore lost details and improve visual quality, often through methods that enhance contrast, sharpness, and edge definition.

IV. PROPOSED CONFIGURATION

The proposed configuration aims to enhance the existing JPEG compression and decompression process by integrating advanced image enhancement techniques. After the decompression stage, where Huffman decoding, inverse quantization,

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and inverse DCT are applied, an enhancement module is introduced. This module employs adaptive enhancement techniques, such as adaptive histogram equalization, to improve image quality. Adaptive histogram equalization adjusts the contrast of the image based on local regions, enhancing details without over-amplifying noise. Additionally, edge enhancement techniques are applied to improve the sharpness of edges and fine details in the image.

Furthermore, machine learning algorithms are explored to optimize the enhancement process. By training models on a dataset of compressed and decompressed image pairs, the system can learn to predict and correct artifacts introduced during compression. This approach aims to provide a more tailored enhancement, improving image quality based on the specific characteristics of the compressed image.

V. RESULTS

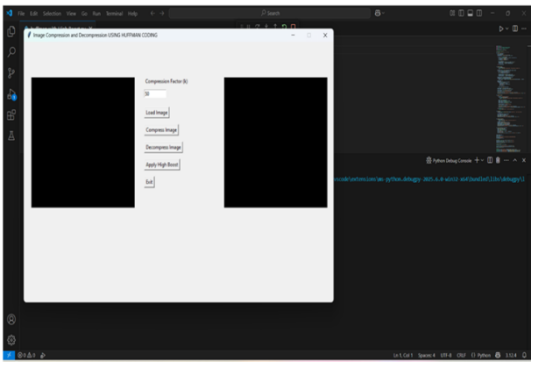

Fig No-5.1

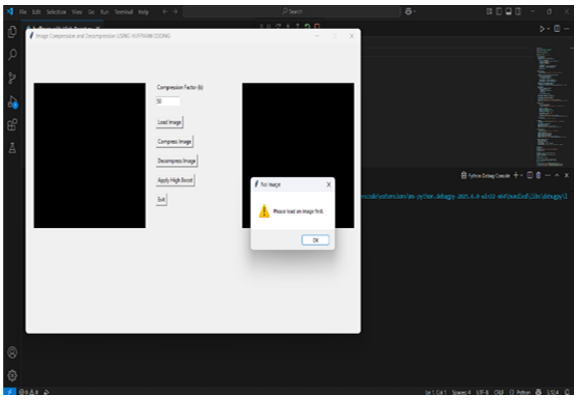

Fig No-5.2

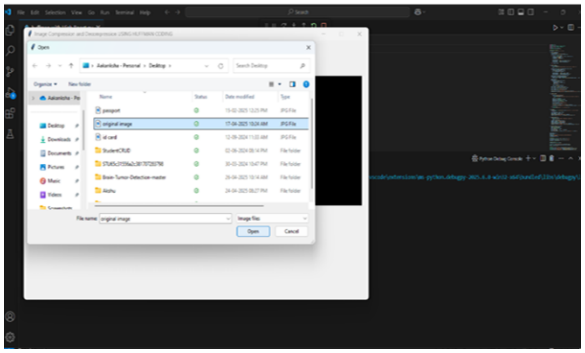

Fig No-5.3

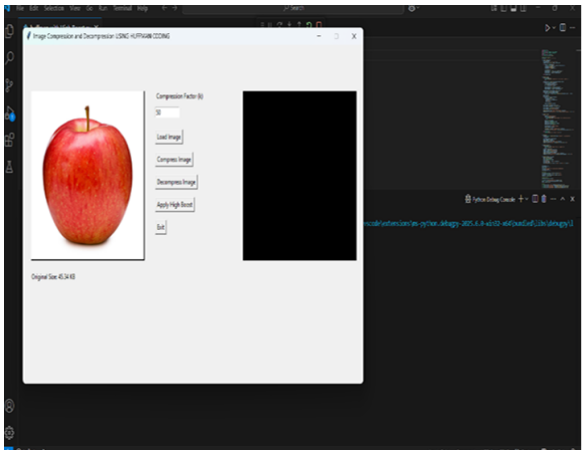

Fig No-5.4

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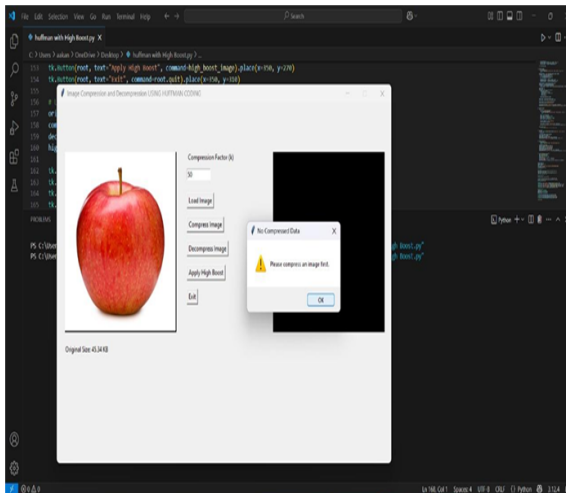

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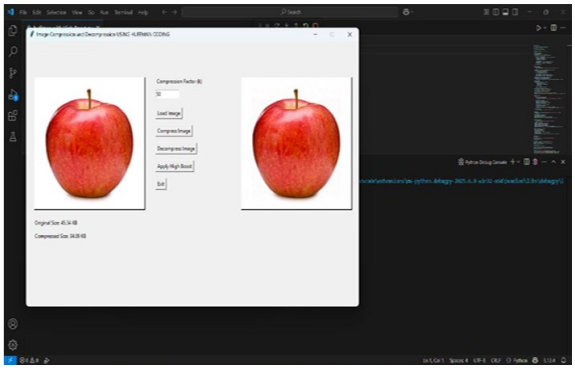

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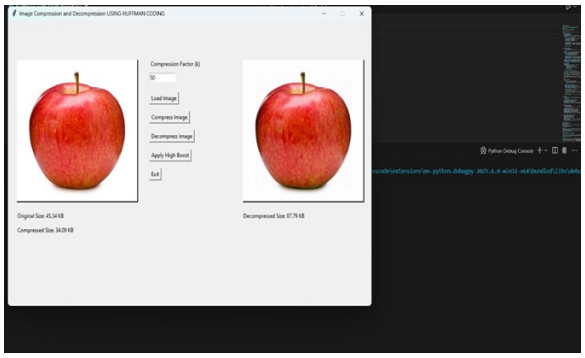

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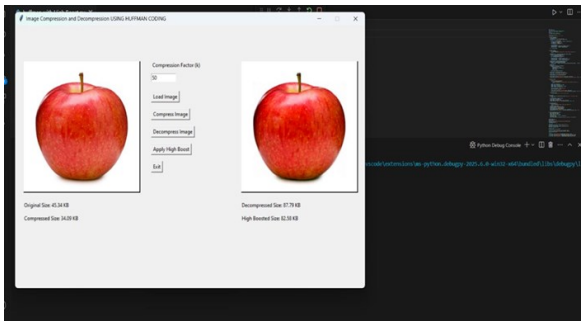

Fig No-5.8

CONCLUSION

JPEG compression with Huffman coding remains a fundamental method for image compression, balancing efficiency and quality. However, the introduction of artifacts during compression necessitates the application of image enhancement techniques to restore and improve visual quality. By integrating advanced enhancement methods and exploring machine learning approaches, the proposed configuration aims to optimize the quality of JPEG compressed images, ensuring that they meet the visual standards required for various applications.

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