

Advanced Data Compression Techniques

Project: Implementation and Analysis of the JPEG Image Compression Pipeline Using DCT, Quantization, and Huffman Encoding

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Abstract:

One of the fundamental steps in the transmission and storage of digital images is still the JPEG image compression pipeline. The three main steps of the JPEG compression pipeline—Huffman Encoding, Quantization, and Discrete Cosine Transform (DCT)—are examined and put into practice in this project. In order to convert spatial pixel information into frequency components, the pipeline first applies the DCT to image blocks. Then, by decreasing the accuracy of less noticeable frequencies, quantization improves compression and efficiently eliminates unnecessary information. The quantized coefficients are then converted into compact variable-length codes for effective storage using Huffman encoding. This project highlights the advantages and disadvantages of each compression step by methodically going over each step and showing how JPEG achieves significant data reduction while keeping acceptable visual quality. The project offers useful insights into actual picture reduction procedures in addition to exploring the theoretical underpinnings of each step.

A comparison of compression ratios and reconstructed image quality is also included in the implementation. Visual results corroborate the pipeline's efficiency with little discernible degradation. Python and OpenCV are used in the system's implementation, enabling modular experimentation with every compression stage. All things considered, the project demonstrates JPEG's value as a workable and effective solution in contemporary multimedia systems.