JPEG Compression

Mini Project

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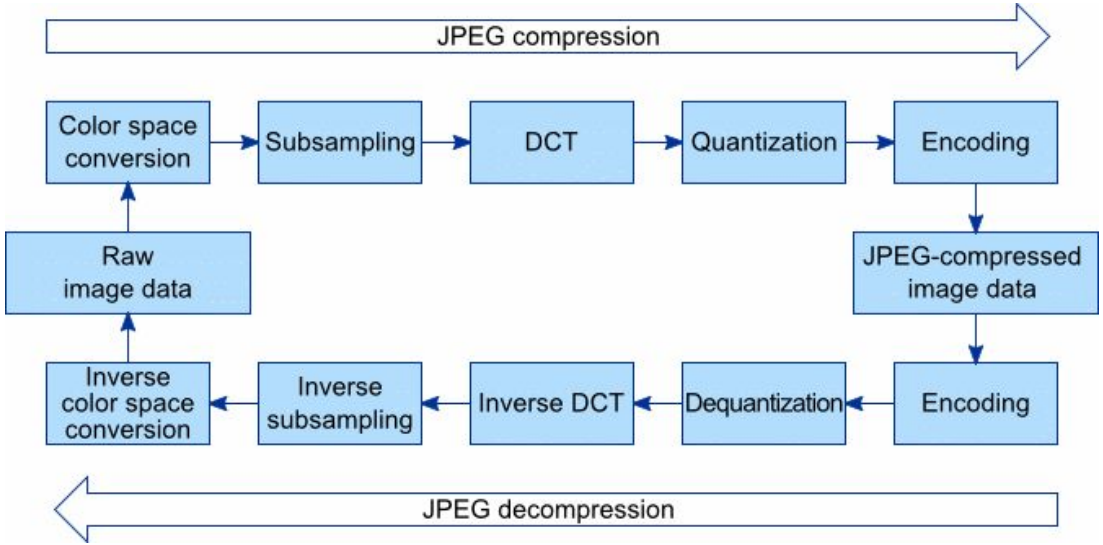
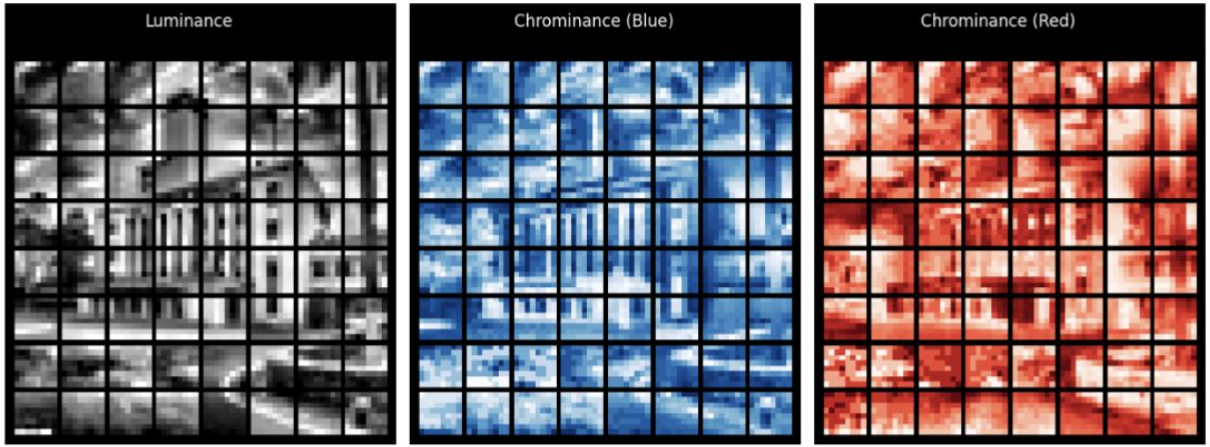
What is JPEG?

JPEG (Joint Photographic Experts Group) is a lossy image compression algorithm that results in significantly smaller file sizes with little to no perceptible impact on picture quality and resolution. It is based on the energy compaction property of DCT.



Chroma Subsampling

Human eye is more sensitive to changes in luminance compared to chrominance and hence we can get away with subsampling the chroma channels in the (Y, Cb, Cr) image.

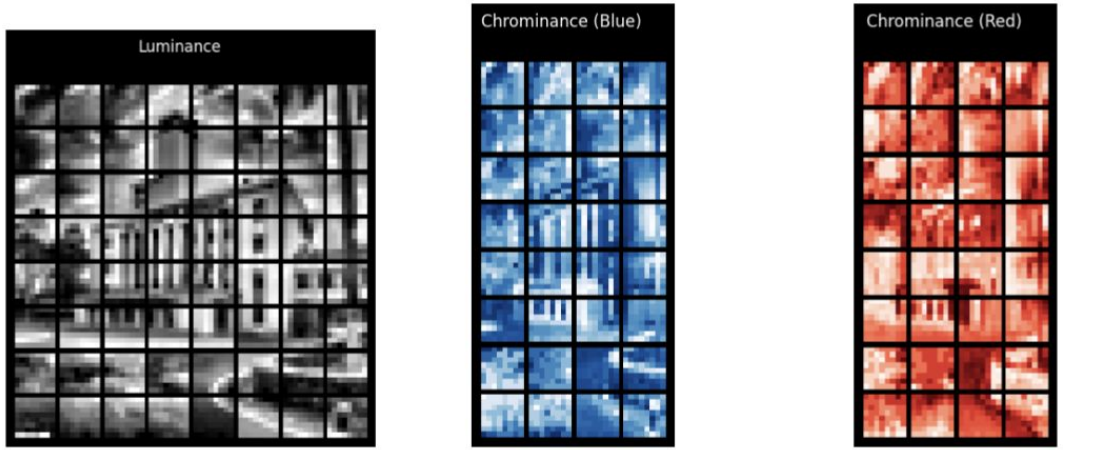


Luminance Chrominance(Blue) Chrominance(Red)

Example Image with '4:4:4' subsampling.

Chroma Subsampling

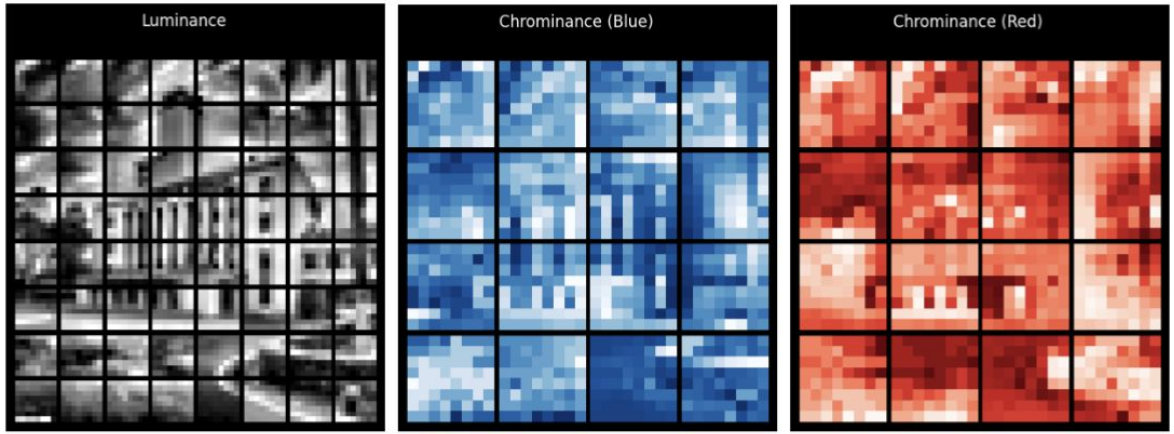
Human eye is more sensitive to changes in luminance compared to chrominance and hence we can get away with subsampling the chroma channels in the (Y, Cb, Cr) image.



Example Image with '4:2:2' subsampling.

Chroma Subsampling

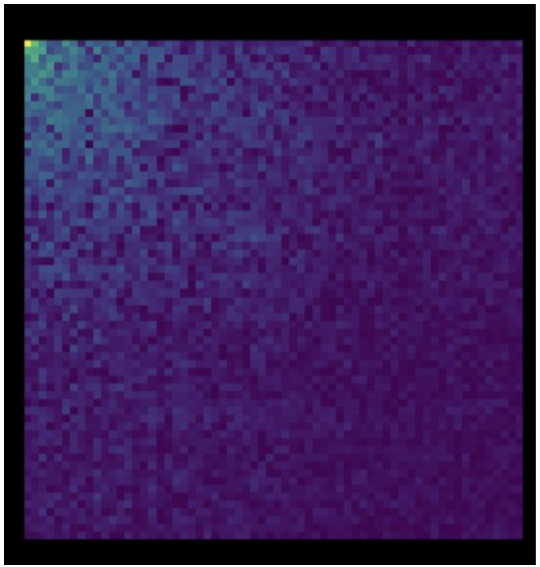
Human eye is more sensitive to changes in luminance compared to chrominance and hence we can get away with subsampling the chroma channels in the (Y, Cb, Cr) image.



Example Image with '4:2:0' subsampling.

Discrete Cosine Transform

The discrete cosine transformation has the property of energy compaction, this leads most of the values away from the origin to be close to zero.



DCT of a 64x64 Image

Discrete Cosine Transform

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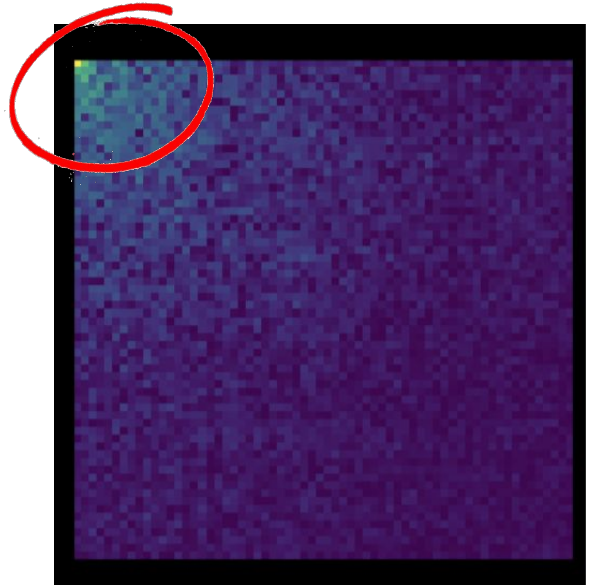


DCT of a 64x64 Image

Quantization

The human eye is not very good at perceiving high-frequency elements in an image. We can get away with removing some of this high-frequency information without affecting the perceived quality of the image.

$$\begin{bmatrix} 16 & 11 & 10 & 16 & 24 & 40 & 51 & 61 \\ 12 & 12 & 14 & 19 & 26 & 58 & 60 & 55 \\ 14 & 13 & 16 & 24 & 40 & 57 & 69 & 56 \\ 14 & 17 & 22 & 29 & 51 & 87 & 80 & 62 \\ 18 & 22 & 37 & 56 & 68 & 109 & 103 & 77 \\ 24 & 35 & 55 & 64 & 81 & 104 & 113 & 92 \\ 49 & 64 & 78 & 87 & 103 & 121 & 120 & 101 \\ 72 & 92 & 95 & 98 & 112 & 100 & 103 & 99 \end{bmatrix}$$

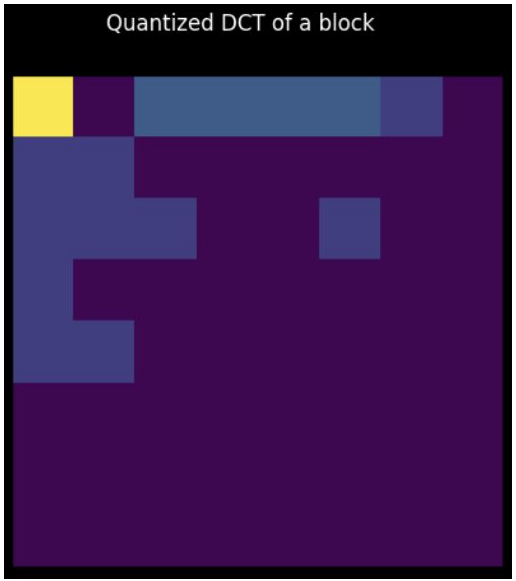
Luminance Table

$$\begin{bmatrix} 17 & 18 & 24 & 47 & 99 & 99 & 99 & 99 \\ 18 & 21 & 26 & 66 & 99 & 99 & 99 & 99 \\ 24 & 26 & 56 & 99 & 99 & 99 & 99 & 99 \\ 47 & 66 & 99 & 99 & 99 & 99 & 99 & 99 \\ 99 & 99 & 99 & 99 & 99 & 99 & 99 & 99 \\ 99 & 99 & 99 & 99 & 99 & 99 & 99 & 99 \\ 99 & 99 & 99 & 99 & 99 & 99 & 99 & 99 \\ 99 & 99 & 99 & 99 & 99 & 99 & 99 & 99 \end{bmatrix}$$

Chrominance Table

Quantization

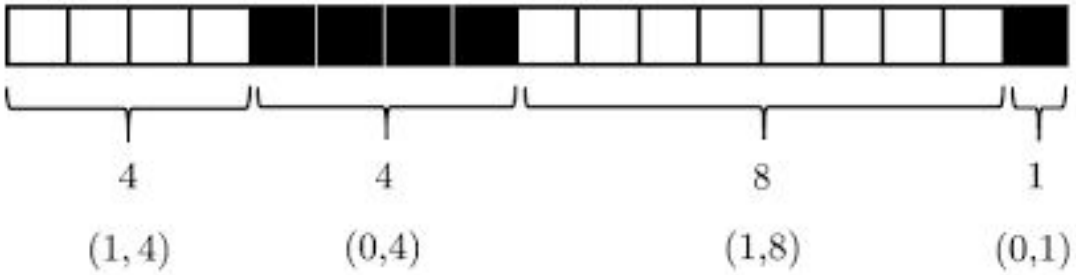
The human eye is not very good at perceiving high-frequency elements in an image. We can get away with removing some of this high-frequency information without affecting the perceived quality of the image.



Quantized DCT of a 8x8 block

Entropy Encoding

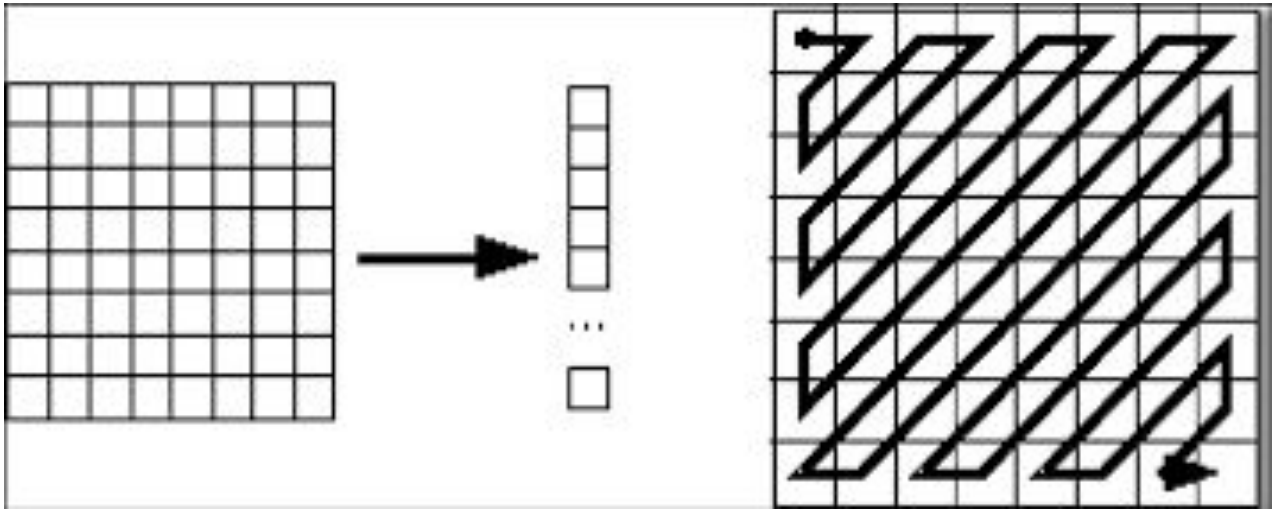
Now, we perform Differential Coding on DC components and Run Length Encoding on AC components. This step is lossless.



After this we can use Huffman coding to further compress these RLE blocks.

Entropy Encoding

These blocks are then parsed in a zig-zag fashion. It is easy to see that the latter values of this list would be values close to zero.



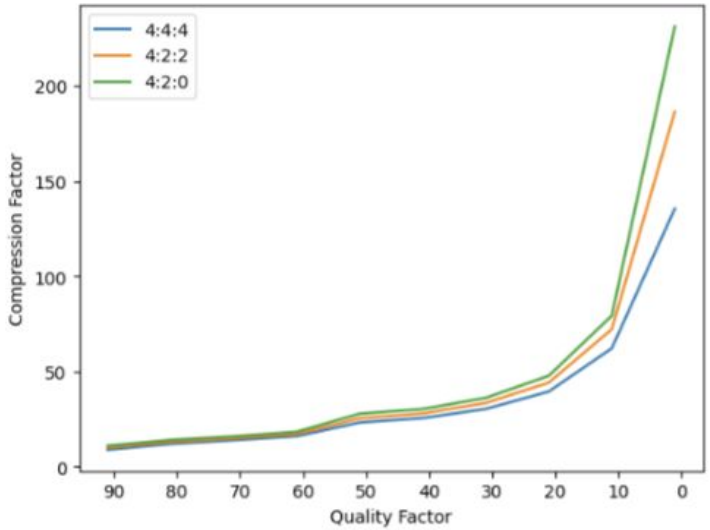
Results

(a) Original Image

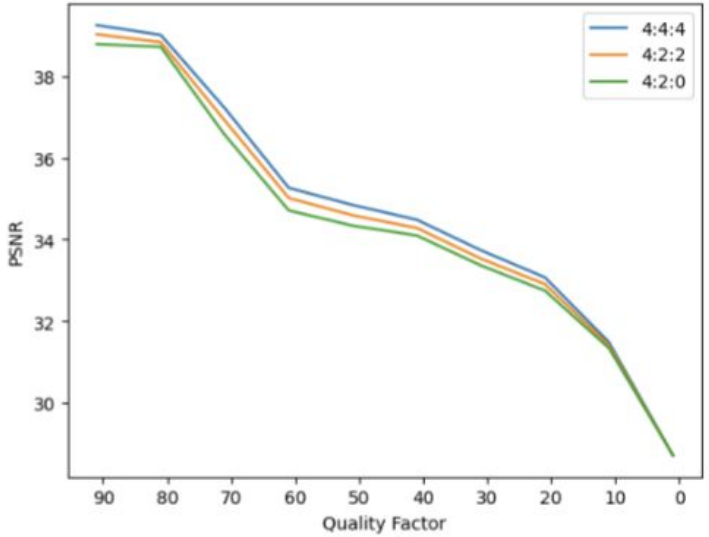
(b) Our Compressed Image

Figure 1: Our Compression Results

Results



(a) Compression vs. Quality Factor



(b) PSNR vs. Quality Factor

Figure 2: Analysis by varying Quality Factor.

Results

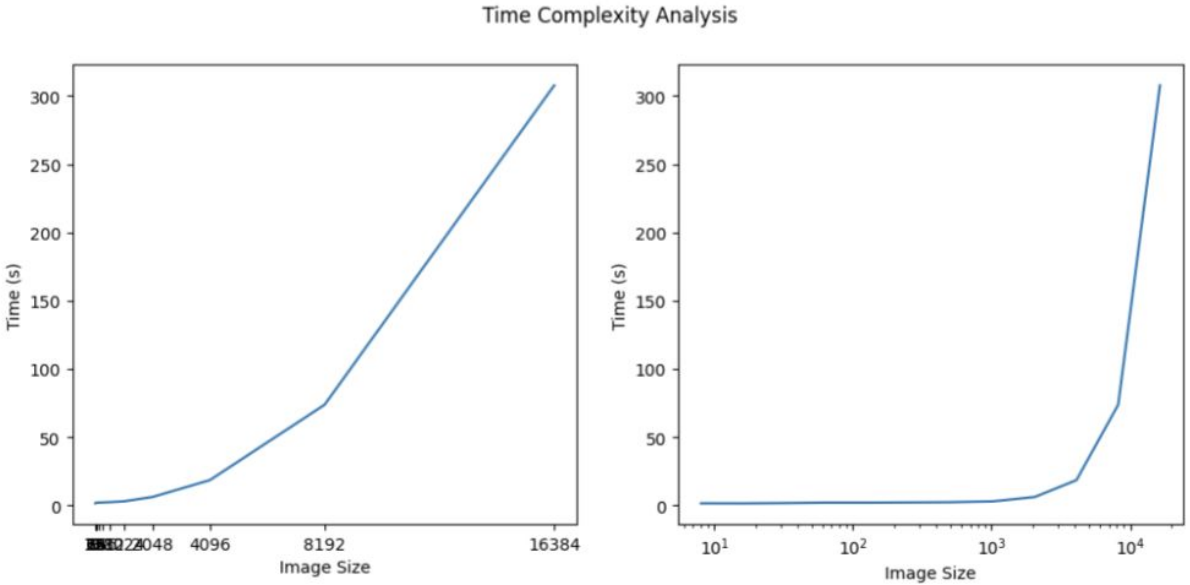


Figure 3: Time Complexity Analysis

Results

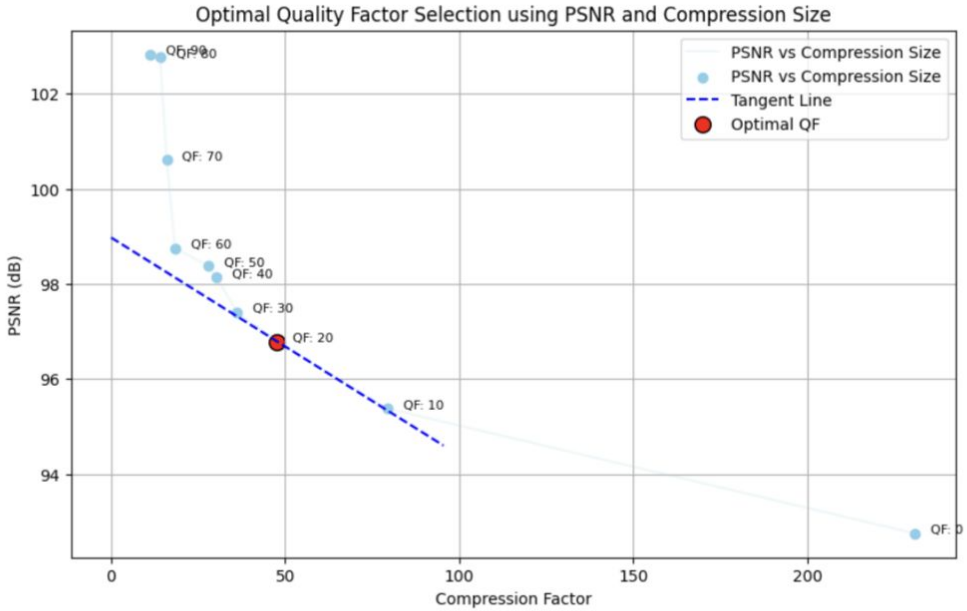


Figure 4: Optimal Quality Factor

$$\text{PSNR} = 10 \log_{10} \left(\frac{255^2}{\frac{1}{M \times N} \sum_{i=1}^{M} \sum_{j=1}^{N} [\text{compressed}(i,j) - \text{original}(i,j)]^2} \right)$$

This selection is inspired by the Elbow Method while selecting optimal number of clusters using silhouette score for the KMeans Algorithm.

Thanks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