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IMAGE AND VIDEO PROCESSING LABORATORY
(EC69211)

Mini Project: JPEG Compression

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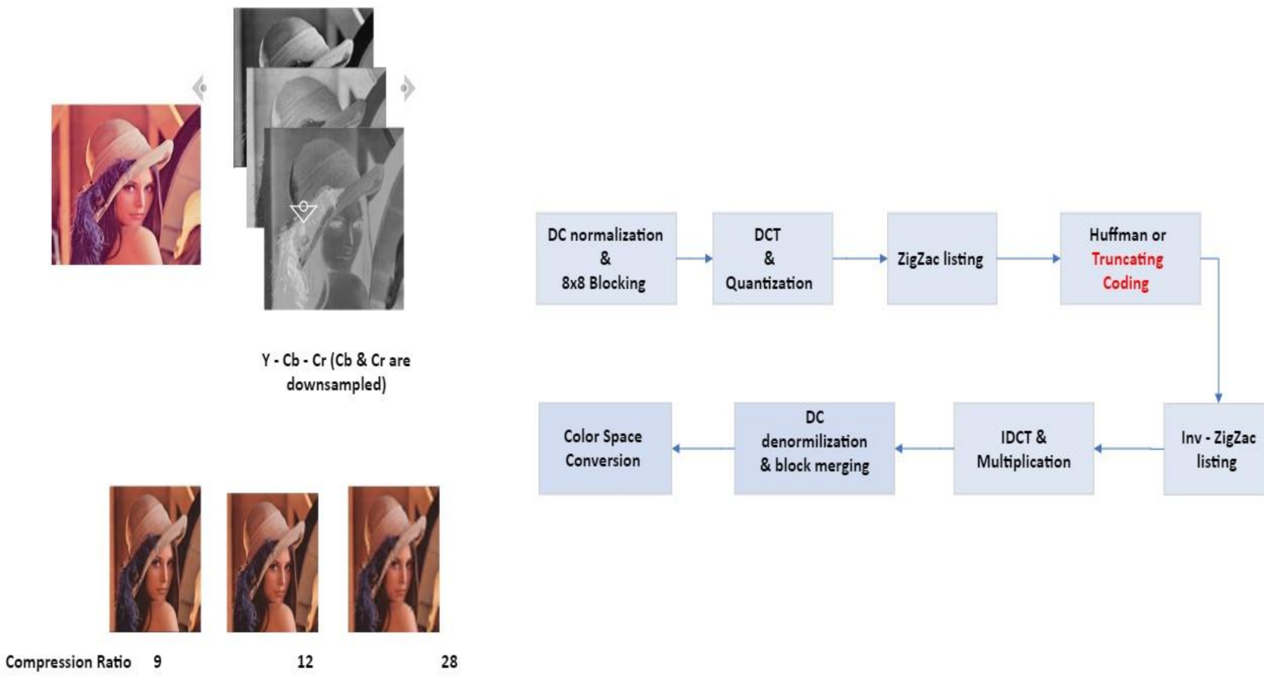
Mini Project

JPEG Compression

Pipeline



Introduction:

JPEG compression can be optimized by incorporating truncation—a targeted approach that removes a predetermined number of high-frequency DCT (Discrete Cosine Transform) coefficients. By introducing this additional step to the traditional JPEG pipeline, truncation aims to increase compression efficiency while preserving perceptual image quality. Below is a detailed breakdown of each step in this modified JPEG compression approach.

1. **Color Space Conversion (RGB to YCbCr):**

   Purpose: *As in standard JPEG compression, the RGB color space is converted to YCbCr to separate luminance (Y) and chrominance (Cb and Cr) components. This separation allows compression to prioritize luminance, leveraging the human eye's higher sensitivity to brightness over color, thus supporting efficient data reduction.*

2. **Chrominance Subsampling:**

   Purpose: *The chrominance components (Cb and Cr) undergo subsampling to reduce their spatial resolution. This approach capitalizes on the human visual system's lower sensitivity to color variations, enabling further data reduction without significant visual impact.*

3. **Block Division and Discrete Cosine Transform (DCT):**

   Purpose: *The image is divided into blocks (usually 8x8), and each block is transformed using the DCT, which converts spatial pixel values into frequency coefficients. This conversion highlights essential image features by concentrating image energy in the low-frequency components, preparing the data for the truncation process.*

4. **Quantization with Truncation:**

   Purpose: *Traditional quantization, which reduces the precision of DCT coefficients, is modified to include truncation, selectively removing a fixed number of high-frequency DCT coefficients. By setting these coefficients to zero or discarding them, truncation achieves additional data sparsity, reducing the amount of data needing encoding. This selective compression reduces data volume while retaining essential low-frequency components that most impact visual quality.*

5. **Zigzag Scanning and Run-Length Encoding:**

   Purpose: *The modified coefficients are ordered through zigzag scanning, a process that emphasizes low-frequency coefficients. Run-length encoding is then applied to capitalize on consecutive zeroes created by truncation, further compacting the data before the final entropy coding stage.*

6. **Huffman Coding Adapted for Truncation**

   Purpose: *Huffman coding is adjusted to accommodate the increased number of zero-valued coefficients from truncation. This modification ensures that the encoding process efficiently represents the sparse coefficient set, leveraging the statistical properties introduced by truncation for better compression.*

7. **Entropy Coding with Truncation**

   Purpose: *Entropy coding, often combined with Huffman coding, is applied to the truncated coefficient set to optimize representation. This step uses the statistical frequency of symbols in the truncated data, achieving a highly compressed output that retains visually relevant information.*

8. **Decoding Adapted for Truncated Data:**

   Purpose: *Decoding is modified to handle the truncated coefficient set, reconstructing the image from the compressed data. While some high-frequency details are irretrievably lost, the decoding process aims to preserve overall image quality and ensure that the visual fidelity remains acceptable.*

Conclusion:

By incorporating truncation into JPEG compression, this approach strategically removes high-frequency DCT coefficients, introducing greater data sparsity and enabling higher compression ratios. The method depends on a fine balance between removing insignificant high-frequency data and maintaining the image's perceptual quality. With careful tuning, truncation within the JPEG pipeline can provide enhanced compression efficiency while minimally impacting visual fidelity, making it valuable for applications prioritizing high compression ratios.

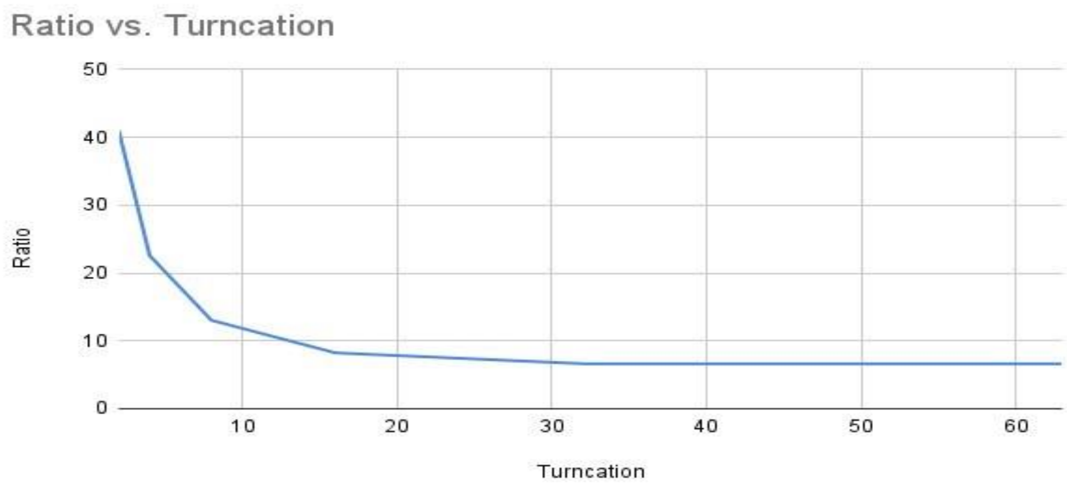
Inputs and Outputs:

Input 1:

Compression Ratio: 8.3

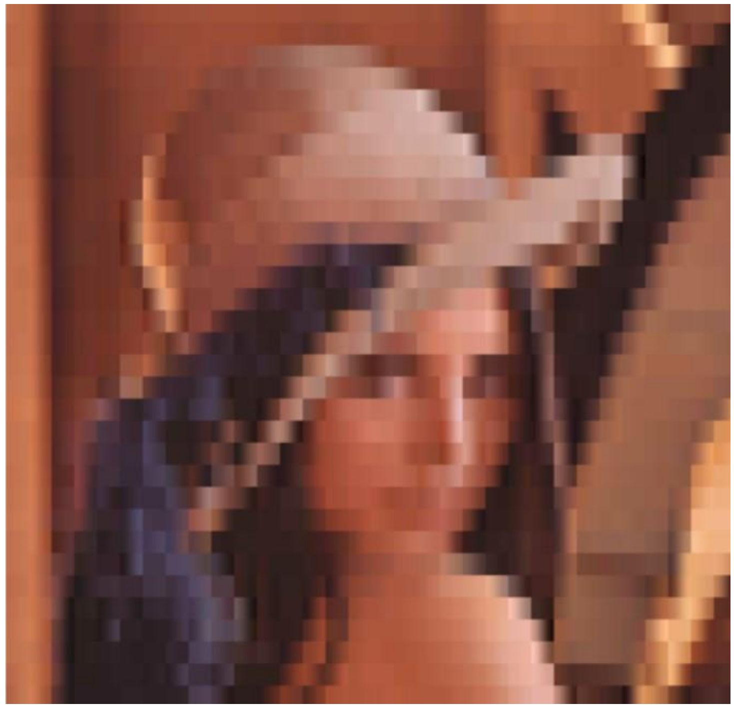
Compression Ratio: 39

Compression Ratio: 41

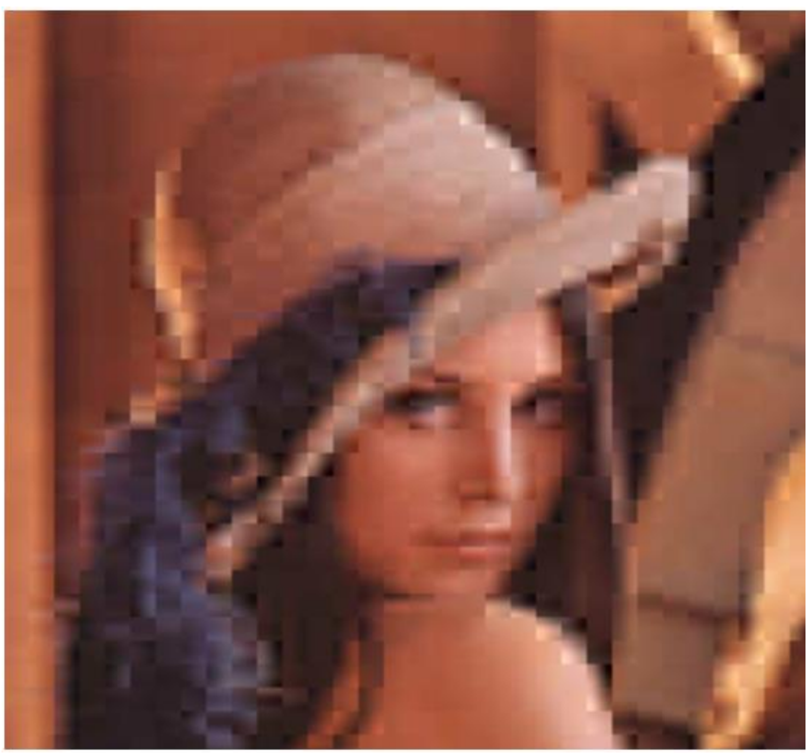

Ratio vs. Turncation
Ratio
Turncation
0
10
20
30
40
50
10
20
30
40
50
60

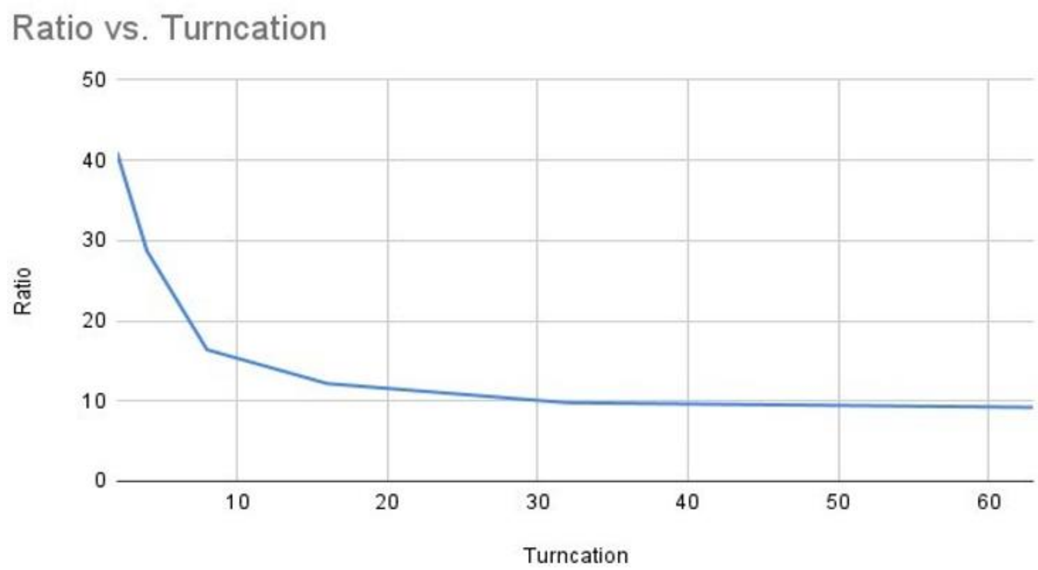
Input 2:

Compression Ratio: 41



Compression Ratio: 28.7





Discussion

1. *JPEG compression technique is a lossy compression. Lossy compression means that after the image is compressed in JPEG format, it loses certain actual contents of the image.*
2. *The loss in the JPEG standard is mainly in the quantization stage. This is because we use the floor functions for each DCT coefficient. While reverting, all these values are pushed to zero.*
3. *Only 8-bit images are supported in JPEG format. Modern high-resolution digital cameras support 10, 12, 14, or 16-bit images.*
4. *The quality of the Image is reduced after JPEG compression owing to the loss of the actual content of the image.*
5. *JPEG image compression is not suitable for images with sharp edges and lines. JPEG image format is not capable of handling animated graphic images.*
6. *This is mainly a DCT-driven algorithm, The major energy density in the spectrum is contained in the centre of the plot, with diminishing gradients in a radial direction*
7. *In chroma subsampling, the luminance and chrominance matrices are subdivided. The chrominance parameters are not easily observable by the human eye.*
8. *Thus, there is heavy down sampling in this domain. This causes loss in quality.*

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