INDIAN INSTITUTE OIF TECHNOLOGY KHARAGPUR

DEPARTMENT OF ELECTRONICS AND ELECTRICAL COMMUNICATION ENGINEERING

M-TECH FIRST YEAR

VISION AND INTELLIGENT SYSTEM (VIS)

EC69211 – Image and Video Processing Laboratory

MINI PROJECT

Submitted By: -

KARNA PATEL (22EC65R11)

ROHAN KUMAR (22EC65R27)

CONTENT:

PROBLEM STATEMENT:

1. Topic- JPEG Compression
2. Entire JPEG pipeline must be designed.
3. Code should be in Python/ C++.
4. Code should work for Coloured Images for all sizes i.e., variable height and width.

INTRODUCTION:

Process of converting an image file into another image file that occupies less storage space, without sacrificing its visual content. JPEG is one the most widely used Image compression technique in the world. The Discrete Cosine Transform (DCT), which separates spatial frequency information from the spatial amplitude samples, serves as the foundation for the JPEG algorithm. The visual information from the image that is least perceptually evident is then removed via quantization of these frequency components, which lowers the amount of data that needs to be saved. To create the compressed form, the redundant qualities of the quantized frequency samples are taken advantage of through quantization, run-length, and Huffman coding. Each of these processes is reversible to the extent that the compressed form may be used to approximate the original space-amplitude samples in an acceptable manner.

Types of Image Compressions:

1) Lossy Compression
2) Lossless Compression

Lossless Compression:

- Lossless Compression aims at reducing the bit rate of the compressed output without any distortion of the image.
- The bit-stream after decompression is identical to the original bit-stream.

Lossy Compression:

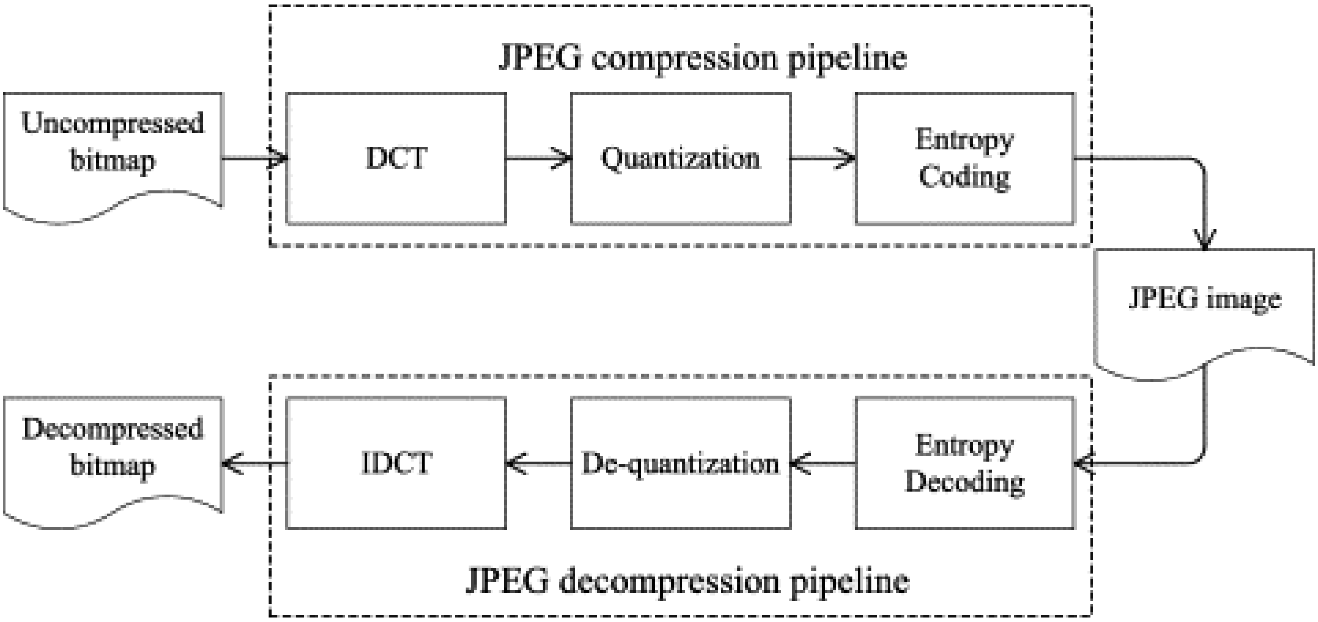
- Lossy compression technique is used in images where we can sacrifice some of the finer details in the image to save a little more bandwidth or storage space.
- Text or executable file compression cannot afford to be lossy.
- But certain picture content, particularly the higher frequencies, is frequently hardly perceptible to the human eye. Compression results from removing this superfluous data without suffering significantly from visual appeal loss.

ALGORITHM:

- Divide the image into non-overlapping 8 x 8 blocks andcompute the discrete cosine transform (DCT) of each block. This produces a set of 64 “DCT coefficients” per block.

- Quantize these DCT coefficients, i.e., divide by some number and round off to nearest integer (that’s why it is lossy). Many coefficients now become 0 and need not bestored.

- Now run a lossless compression algorithm (typicallyHuffman encoding) on the entire set of integers.



JPEG COMPRESSION AND DCOMPRESSION PIPELINE

Discrete Cosine Transform

- It expresses a signal as a linear combination of cosine bases (as opposed to the complex exponentials as in the Fourier transform). The coefficients of this linear combination are called DCT coefficients.

- It is real-valued unlike the Fourier transform which has complex terms.

- Discovered by Ahmed, Natarajan and Rao in 1974.

1-D 8 Point DCT

$$F(u) = \frac{C(u)}{2} \sum_{x=0}^{7} f(x) \cos \frac{(2x+1)u\pi}{16}$$

2-D 8×8 Point DCT

$$F(u,v) = \frac{C(u)C(v)}{4} \sum_{x=0}^{7} \sum_{y=0}^{7} f(x,y) \cos \frac{(2x+1)u\pi}{16} \cos \frac{(2y+1)v\pi}{16}$$

Where u, v = 0,1,…,7.

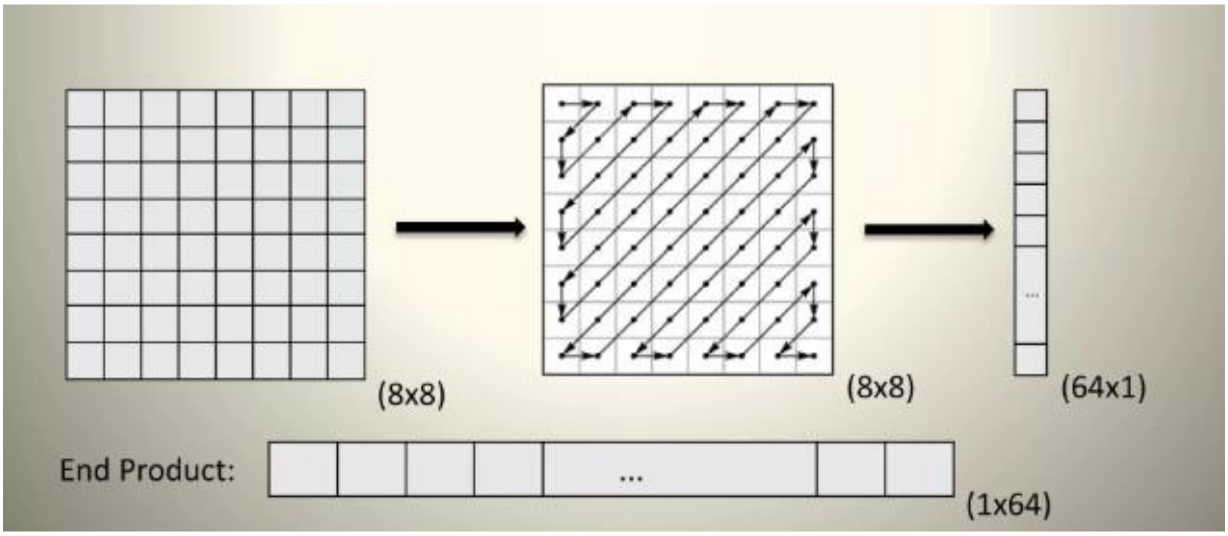
$$C(u) = \begin{cases} \frac{1}{\sqrt{2}} & \text{U=0} \\ 1 & \text{else} \end{cases}$$

Quantization

- The DCT coefficients are floating point numbers and storing them in a file will produce no compression. So, they need to bequantized.
- The human eye is not sensitive to changes in the higher frequency content. So, we can have cruder quantization for the higher frequency coefficients and a finer one for the lower frequency coefficients.
- Quantization is performed by dividing the DCT coefficients by a quantization matrix and rounding off to the nearest integer.
- This is the lossy part of JPEG.

Zig-Zag Ordering

- The quantized DCT coefficients are now read in zigzag ordering.
- This ordering ensures that the low frequency components are chosen initially and then high frequency components are chosen.
- It ensures that if needed low and high frequency components can be separated.

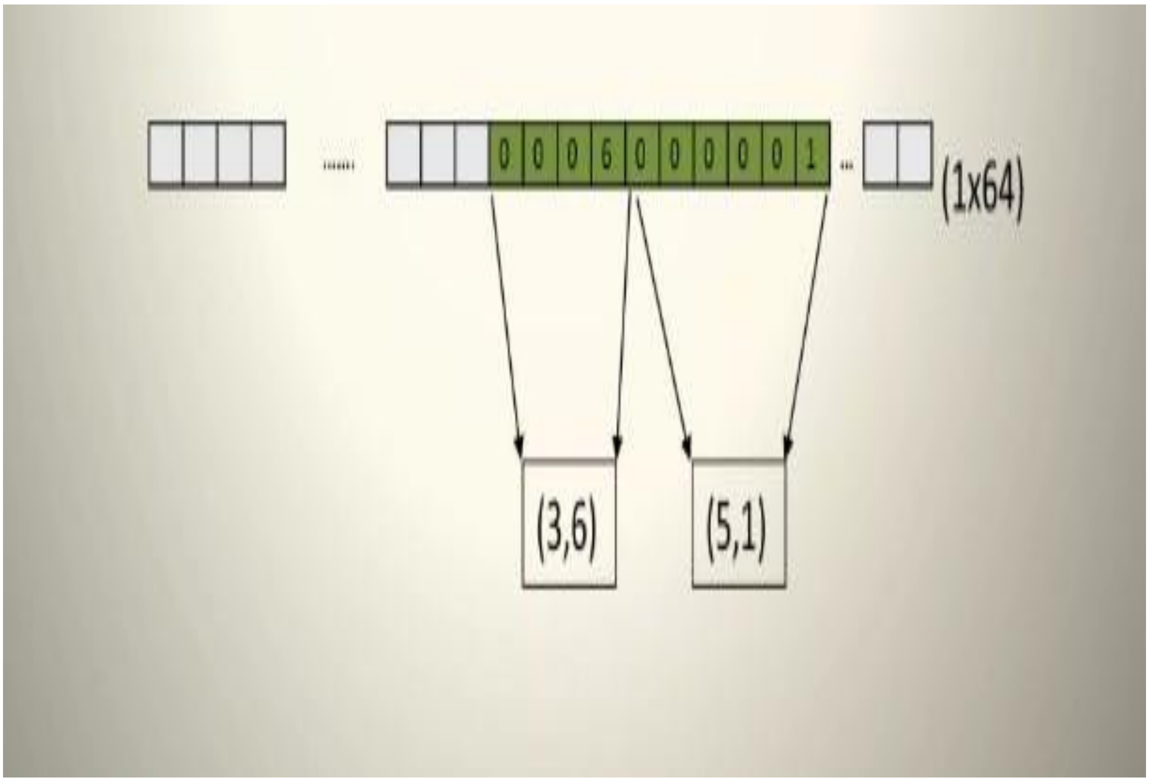


ZIG_ZAG PATTERN REPRESENTATION

Run- length encoding

- Under this coding scheme, all the elements from each 8*8 block that we got after zigzag algorithm is written in the format (Size, Value).

- Here size represents the number of zeros the non-zero value is preceded before any other non-zero value.



Example of RUN LENGTH CODING

Huffman encoding

- **Input:** a set of non-zero quantized DCT coefficients from allthe different blocks of the image (values lying between - 1024 to +1024).

- **Output:** a set of encoded coefficients with length (in termsof number of bits) less than that of the original set.

- **Principles behind Huffman encoding:**

- Encode the more frequently occurring coefficients with fewer bits. Encode the rarely occurring coefficients with more bits. This will reduce the average bit-length.

- Ensure that the encoding for no coefficient is a strict prefixof the encoding of any other coefficient. This is called a “prefix-free code”.

SIZE	Value	Code
0	0	---
1	-1,1	0,1
2	-3, -2, 2,3	00,01,10,11
3	-7,..., -4, 4,..., 7	000,..., 011, 100,...111
4	-15,..., -8, 8,..., 15	0000,..., 0111, 1000,..., 1111
.		.
.		.
11	-2047,..., -1024, 1024,... 2047	...

Table 1: Huffman Table for DC components *Value* field

The look-up table for generating code words for *Size* is as given below:-

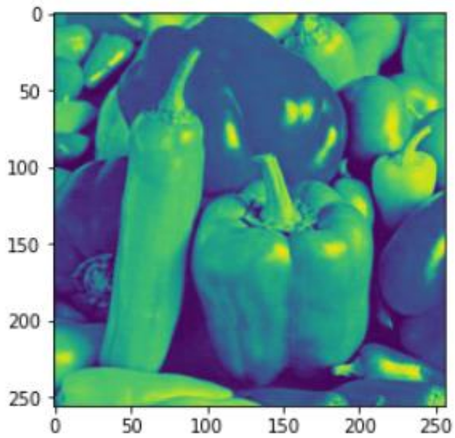
SIZE	Code Length	Code
0	2	00
1	3	010
2	3	011
3	3	100
4	3	101
5	3	110
6	4	1110
7	5	11110
8	6	111110
9	7	1111110
10	8	11111110
11	9	111111110

Table 2: Huffman Table for DC components *Size* field

Then during decompression, this Huffman code is decoded and all the process is applied in reverse order to get the compressed image back.

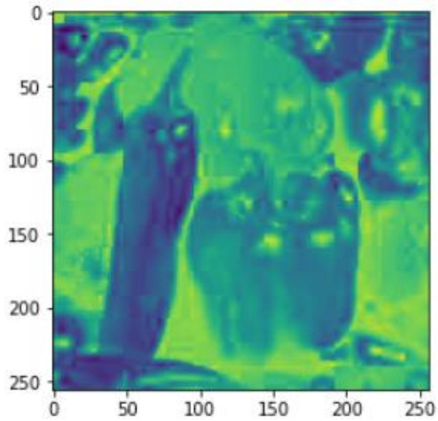
OUTPUT:

Original Image



Quantized Luminance

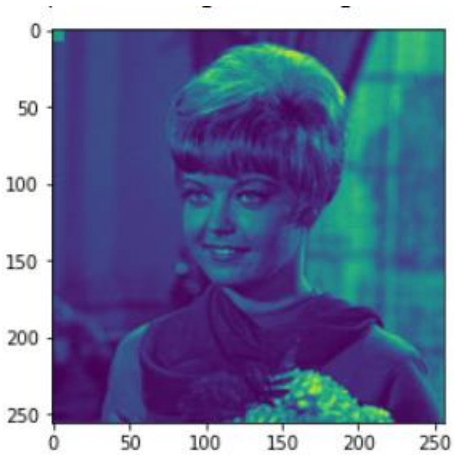
Component



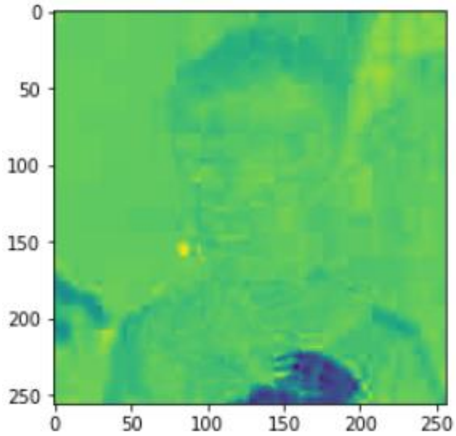
Quantized Chrominance

Component

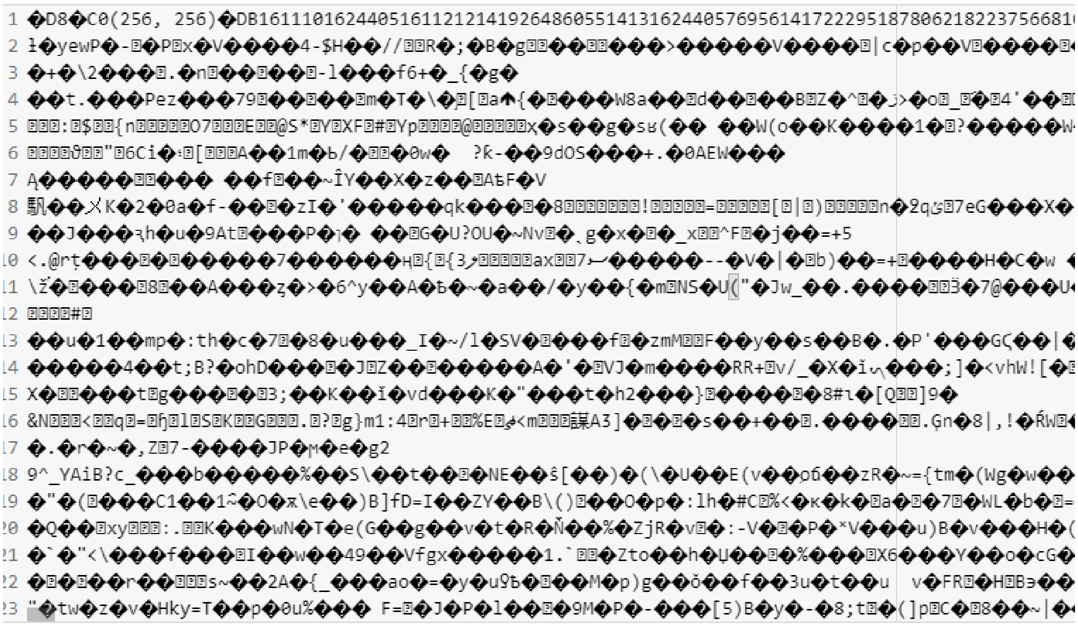
Original Image



Quantized Luminance Component



Quantized Chrominance Component



Compressed File in Bytes Form

ANALYSIS AND DISCUSSION:

- JPEG file compression technique is a type of lossy Image compression technique.
- Considering the fact that Image is compressed substantially, the quality of the output image is still impressive.
- It plays with the visual limitations of the Human eye and removes non-important part of the Image.
- Down-sampling the Cb and Cr component, the quantization and the Huffman encoding of Run-Length code helps in substantially reducing the file size without losing the quality.

CONCLUSION:

- JPEG compression algorithm can be applied on any Greyscale or Coloured Image.
- It will work with up to 24 BIT images.
- Suitable for many applications like Satellite Imaging, Medical Imaging, General Mobile Photography etc.
- Note that JPEG is not a good algorithm for compressing images with substantial high frequency components like text Images.