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Review of Artifacts In JPEG Compression And Reduction

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***Abstract*— In recent years, the development of social networking and multimedia devices has grown fast which requires wide bandwidth and more storage space. The other approach is to use the available bandwidth and storage space efficiently as it is not feasible to change devices often. On social networking sites large volume of data and images are collected and stored daily. Compression is a key technique to solve the issue. JPEG compression gives good and clear results but the decompression technique usually results in artifacts in images. In this paper types of artifact and reduction techniques are discussed.**

***Index Terms*— JPEG compression; artifact; artifact reduction; post-processing; lossy compression; lossless compression**

I. Introduction

Generally, compression techniques represent the image in fewer bits representing the original image. The main objective of image compression is to reduce irrelevant information and redundancy of the image so that the image can be transmitted in an efficient form. Compression can be classified into lossless and lossy compression techniques. Original images can be reconstructed from the com-pressed data in Lossless compression whereas Lossy compression will not be able to reconstruct the exact original image but it usually trans-form an image into another domain, quantize and encode its coefficients however this technique does not give the results as original image which leads to information loss [1].

Figure shows a baseline JPEG Encoder. This baseline uses an encoding scheme based on Discrete Cosine Transform (DCT) to achieve compression. A DCT algorithm achieves higher degree of compression with minimal loss of information. The JPEG compression technique is divided into five functional steps.

- RGB to YCC color space conversion
- Spatial sub-sampling of the chrominance channels in YCC space
- Transformation of a blocked representation of the YCC spatial image data to a frequency domain representation using DCT.
- Quantization
- Encoding

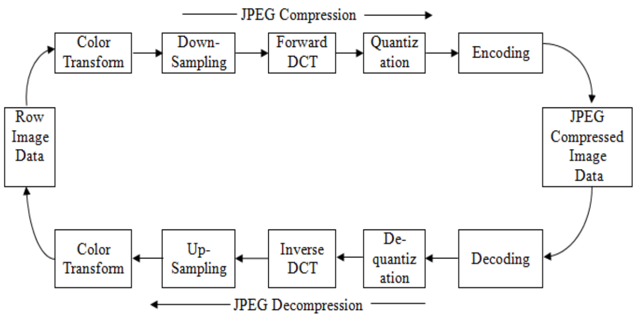

Fig. 1: JPEG Encoder and Decoder

Each eight-bit sample is level shifted by subtracting $2^{8-1=7}$ = 128 before being DCT coded. This is known as DC level shifting. The 64 DCT coefficients are then uniformly quantized according to the step size given in the application-specific quantization matrix. After quantization, the DC (commonly referred to as (0, 0)) coefficient and the 63 AC coefficients are coded separately. The DC coefficients are DPCM coded with prediction of the DC coefficient from the previous block $DIFF = DC_i - DC_{i-1}$. This separate treatment from the AC coefficients is to exploit the correlation between the DC values of adjacent blocks and to code them more efficiently as they typically contain the largest portion of the image energy. The 63 AC coefficients starting from coefficient AC (1, 0) are run length coded following a zigzag scan.

1. Run Length Coding

Entropy coding of the JPEG encoder is accomplished in two stages. In first stage, quantized DCT coefficients are translated into an intermediate set of symbols. In the second stage, each symbol is represented by variable length codes. For the JPEG standard a symbol is structured in two parts:

1) Variable length code (VLC) referred to as symbol-1,
2) Binary representation of the amplitude referred as symbol-2.

2. Coding of DC Coefficients

Instead of assigning individual variable length codewords (e.g. Huffman code) to each DIFF, the DIFF values are categorized based on the magnitude range called CAT. The CAT table consist of a category and it's corresponding variable length coded values. Table shows the categories for the range of amplitudes in the baseline JPEG. There are 11 categories for nonzero coefficients for the DCT coefficient values of range -2047 to 2047. Category starts from 1 as

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category zero is not used for symbols; it is used for defining the end of block (EOB) code [5].

Category	Values
1	-1,1
2	-3,-2,2,3
3	-7,-6,-5,-4,4,5,6,7
4	-15,……,-8,8,……,15
5	-31,……,-16,16,……,31
6	-63,……,-32,32,……,63
7	-127,……,-64,64,……,127
8	-255,……,-128,128,……,255
9	-511,……,-256,256,……,512
10	-1023,……,-512,512,……,1023
11	-2047,……,-1024,1024,……,2047

I: CAT Table

3. Coding of AC coefficients

During zig-zag scan a two dimensional symbol is assigned to each nonzero AC coefficient. A two-dimensional event is of (RUN, CAT), sometimes called (RUN, SIZE) where CAT is a amplitude category of a nonzero coefficient in the zigzag order, and RUN is the number of zeros preceding this nonzero coefficient in baseline encoder. The maximum length of run is limited to 15. But encoding of run greater than 15 can also be done by a special symbol (15, 0), which is a run length of 15 zero coefficients followed by a coefficient of zero amplitude. Hence it can be explained as the extension symbol with 16 zero coefficients as it is greater than the maximum length. There can be up to three consecutive (15, 0) symbols before the terminating symbol-1 followed by a single symbol-2 [4].

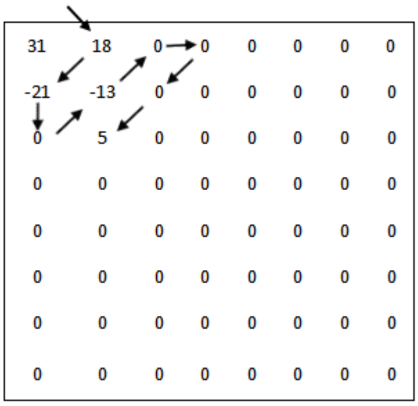

Fig. 3: Quantized DCT coefficients of a luminance block

4. Entropy coding

Two entropy coding methods namely Huffman coding and arithmetic coding are used for coding of the magnitude categories or run length events as per the JPEG standard. In Huffman coding a table named Huffman tables is used, and the type of Huffman table is determined by the entropy table. Whereas Arithmetic coding methods use arithmetic coding conditioning tables, which may also be determined by the entropy table specification. As AC and DC coefficient are encoded separately, there can be up to four different Huffman and arithmetic coding tables for each DC and AC coefficient. Default values are not specified for Huffman tables, so that the applications may choose tables appropriately as per the requirement. Default tables values are defined for the arithmetic coding conditioning. Huffman coding is used in Baseline sequential coding and extended DCT-based and lossless processes may use either Huffman or arithmetic coding. [2, 5].

5. Post-processing of JPEG

Post processing techniques basically used with image restoration and image enhancement technique. Image processing procedures needed for fully automated and quantative analysis (registration, segmentation, visualization) require images with the signal to noise ratio and the least artifacts in order to improve their performances. Digital image and video are mostly coded using discrete cosine transform(DCT) and discrete wavelet transform(DWT). When we have to transfer the data at low-bit rate these coding techniques have many visual distortions and imperfections called artifact occur. There are always some confusion between noise and artifact. According to my study difference is that noise may obscure features in an image, while artifacts appear to be features but are not. If the 'problem' is structured, it is probably an artifact, whereas if it is random, it is probably noise. Noise can be understood as a degradation of the image due to random occurrences which have no relation to the true object. Noise is randomly scattered throughout the image but most noticeable in the darker and shadow areas [4].

II. ARTIFACT

During the conversion to jpeg process, resultant image have jagged edges. Hence Artifacts are sometimes also called jaggies, most commonly seen on diagonal lines and in areas of colour. It is caused by processing of the image when the image is compressed to jpeg from the native file, in camera or in post processing. Artifact is part of the contents of an image that does not have a counterpart in the physical object being imaged.

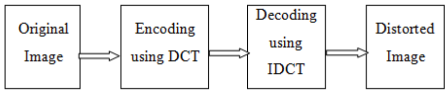

Fig. 4: Image processing model for communication

Artifacts are nothing but the visible distortion that occurs at the different stages of the communication process i.e. the displayed image may differ from the original image to it's final recipient. According to their occurrence image and video artifacts are divided into four types that are: due to capture, processing, delivery and display. Basically image artifacts are result of lossy compression. In image compression some data are discards that may be too complex to store in the available data-rate, the result of discarded data is compression artifact. The greatest technical limitation in the image and video process is the available bandwidth which affects the Compression ratio. If compression ratio is increases, the artifact will become more visible.

A. Types of Artifact

Several types of artifact occurs in JPEG-compressed images while performing block based coding for quantization.

1. Ringing Artifact

A course quantization of high frequency components result in Ringing artifacts in an image. Ringing artifact appears as a ringing effect or sharp oscillations near a strong and sharptransition in a signal. Ringing effect are produced in all coding schemes that involve quantization in the frequency domain. Ringing artifacts occurs often when DWT encoder is used. When images are compressed with non-block based encoder, the ringing effect can spread out further in images.Rringing artifacts are more noticeable artifact in wavelet coding like blocking artifact that is more visible in DCT coding. Ringing is less visible in JPEG compression. It is more visible at the low bit rates. Ringing issues are used for real time processing application.

2. Blocking Artifact

Images are often coded using BDCT or DWT. When block based DCT coding technique is used, blocking artifacts are most noticeable artifacts. IN BDCT or DWT each image is divided into N*N blocks. BDCT is used widely in image/video compression standards such JPEG, MPEG-1, MPEG-2, MPEG-4, H.263 due to its high compression, low computational complexity and easy implementation. The N*N, the blocks are independently DCT transformed, quantized, coded and then transmitted. Horizontal and vertical borders appear in the image, when the correlation between the two adjacency blocks are disturbed which leads to the blocking artifact. This is the most visible degradation of the block transform coding. Blocking artifacts are appearing in the images and videos at the block edges especially at curves and corners. Blocking artifacts in image can be eliminated by saving them using a lossless file format. The images that are created by ray-tracing programs have blockiness on the terrain.

The blocking artifact is further divided into 3 categories such as:

- *Staircase noise.*
- *Grid noise.*
- *Corner outliers.*

Staircase noise: Generally this noise appears on the block edges which lead to degradation such that the block bands looks like the edge. This especially happens with diagonal edges, these get a staircase like character.

Grid noise: When higher bit rate applications are used in decompressed data, this noise occurs.

Corner outliers: This typically occurs at the corner points of blocks, where the corner point is either much larger or much smaller than neighboring pixels [6].

3. Blur Artifact

When high frequencies are absent in the low bit rate video it results in blurring artifact. Blurring means that the image is not smoother like original. Blurring is produced due to the increased thickness of edges. Blur and ringing are artifacts are resulted from frequency domain quantization of coefficients. The main difference between these two effects is that they appear on horizontal and vertical. Blurring effect can be decreased by increasing the viewing distance. Other difference in blurring and ringing artifact is that the correlation between adjacent pixels in same row/column for LH (HL) orientation will increase in blurring but the correlation is reduced between adjacent pixel in the same row or column for LH (HL) orientation in ringing.

4. Colour Distortion

As human eyes are sensitive to brightness not as sensitive to colour, much of the colour (chrominance) information is lost, while luminance is retained. The process of of splitting an image is called "chroma subsampling". In Chroma-subsampling a colour image is split into two image.

1. Brightness image (Y image)
2. Two colour images (C_b C_r image)

The brightness (luma or Y) image is stored at the original resolution, whereas the two colour (chroma or C_b C_r) images are stored at a lower resolution. The compressed images look slightly different from the original one but it retains the image information, with less brilliant colour.

5. Texture Deviation

Texture deviation is another type of distortion in image which is caused by the loss of fidelity in mid-frequency components. This distortion appears as granular noise in image in transform coding. This distortion is less visible to the human Visual system. However, in segmentation-or model based coding texture deviation often manifests itself as an over smoothing of texture patterns that can be visually annoying.

Artifacts results in information loss but they can be sometimes used intentionally as a visual style, known as *glitch art*. Glitch art is made either by "capturing" an image of a glitch as it randomly happens, or more often by design when an artist manipulates digital technology to induce a glitch to happen. There are many approaches to making these glitches happen on demand, ranging from physical changes to the hardware to direct alternations of the digital files themselves.[3,7] Some of them are listed below.

- *Datamoshing*
- *Circuit bending*
- *3D model glitching*

III. Artifact Reduction

A highly compressed image leads to a range of artifacts. Post-processing technique is used to remove these compression artifacts. This technique is implemented at the decoder end to reduce the compression artifacts and to improve the overall image quality for a given bit rate without increasing the bit rate or modifying the coding procedure. The Post-processing algorithm has distorted image as an input. To process that image optimally the algorithm needs the parameter that was used in the encoding process, the block

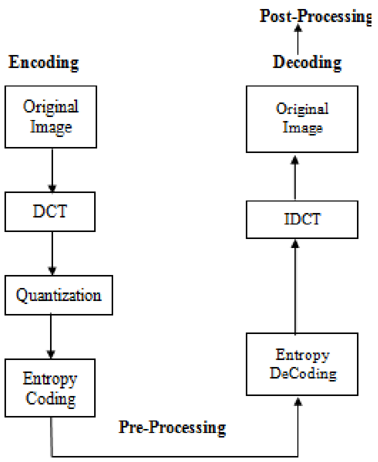

Fig 5: Process of Transform Coding

size & quantization parameter (JPEG quality). If the parameters are exactly identical, complete retrieval of original image is possible. The output of decoder is original image recovered from the distorted image [4, 6].

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