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A Review Paper on Image Compression Unit Using DCT

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ABSTRACT
The field of image and video compression has gone through rapid growth during the past thirty years, leading to various coding standards. The main goal of continuous efforts on image/video coding standardization is to achieve low bit rate for data storage and transmission, while maintaining acceptable distortion. In present every multimedia device is based on battery operated system. As we know power consumption is crucial part for those device. So there is need of fast and efficient algorithm and hardware unit for those multimedia devices. as we already know compression unit is the most important part for any multimedia device. So, in this paper, various developmental stages of image and video compression standards are reviewed, including JPE Gand JPEG 2000 image standards, MPEG-1, MPEG-2, MPEG-4, H.261, H.263, H.264/MPEG-4 AVC, and the latest international video standard HEVC as well as Chinese video coding standard AVS. Here we also did the complete comparative discussion between different compression unit in term of time complexity and quality.

1.INTRODUCTION

In present era, growing demand for multimedia wireless communication system. This communication system contains source of information like message, image's video's etc. These constitute the flow of large amount of data into network & thus affect the channel bandwidth and consequence of it is, power requirement is more for hand-held device, than we have need for low-power image/ video transmission.

The modern society has made itself into the global information age in which images and videos can be found everywhere in people's daily life. Nearly 1.42 million photos are uploaded to Flickr every day in average and over 2.6 million hours of video are uploaded to YouTube each month. Also the resolution of image and video grows dramatically from 100x100 in the 1960s to around 5000x3000 for image and 1980x1080 for video nowadays. However, the size of raw digital source data can be so tremendous that enormous resources are required for storage and transmission. For example, the size of a 150-minute color movie with 30 frames per second and 720x480 resolution is as large as 280 GB without compression, not to mention the situation when the movie needs to be transmitted through the Internet whose bandwidth can be lower than 10 Mbit/s. In light of this, digital image and video compression technology is a necessity even though computer power, storage, and the network bandwidth have increased significantly.

Image and video data compression refers to a process in which the amount of data for representing the input signal is reduced to a certain degree in order to achieve a higher efficiency in storage and transmission.

Compression can be achieved by reducing the redundancies inherent in image and video, including spatial, temporal, statistical and psycho visual redundancy In general, the effort of many image compression schemes is aimed at keeping the distortion of reconstructed image as low as possible for a given bit rate. However, in some applications such as portable multimedia devices, the best image quality are not always required Therefore, algorithm/architecture approaches for low power design. Which is based on the tradeoff between image quality and power consumption is clearly required. Therefore, image compression is necessary for that. Several developed image compression technologies are available The most popular technologies may be JPEG and JPEG 2000, which are published by Joint Photographic Experts Group. They are both standards for image compression, but they employed different technologies to achieve image compression Although JPEG 2000 have provided convenience for that, due to its high complexity based wavelet transform, this adds heavy burden on processors and bandwidth. Therefore, the area of image compression based on JPEG still plays important role. In JPEG standard, two compression processes were defined: lossy compression and lossless compression. The basic process, which is based on DCT, is lossy compression. High compression ratio could be achieved by lossy compression. Furthermore, the visual effect of the reconstruction image from the process of decode is similar with that of original image. Mean while, there are extending processing coding methods based the basic DCT sequence processing. They are applied widely compared with the basic encoder while extending encoder includes the basic sequence. DCT can decompose the image into different frequency components. Then, low-frequency components are kept while the high-frequency components are set as zeros to achieve compression. This procedure is achieved by quantization in JPEG encoder. In fact, it is the process that removes the information redundancies in original graphic source. Therefore, DCT is the fundamental for JPEG standard. Without that, the quantization is hardly to be achieved. DCT plays an important role in image compression especially in JPEG standard, which is based on block codec. In fact, there are four types of DCT. However, in image/video processing techniques, Type II DCT (which is known as DCT-II) is widely applied. In general, the simplest DCT block matrix is 8×8 in JPEG and H.263, which matrix could be 16×16 in MPEG. This means that an image would be divided into several 8×8 or 16×16 matrixes and each block was processed.

2. Literature Review

The field of image and video compression has experienced a rapid growth in recent years, various coding algorithms have been invented and improved. The development of international compression standards has accelerated the improvement of image and video coding applications. Several still image compression standards have been finalized like JPEG and JPEG 2000. Video compression standards includes MPEG-1, MPEG-2, MPEG-4 , H.261 , H.263, H.264/MPEG-4 AV, and the latest video coding standard HEVC . Fig. 1 summarizes the evolution of image/video coding standards by the International Telecommunication Union (Telegraphy section) (ITU-T) and the Internatio-nal Standards Organization (ISO) and their joint work from 1984.

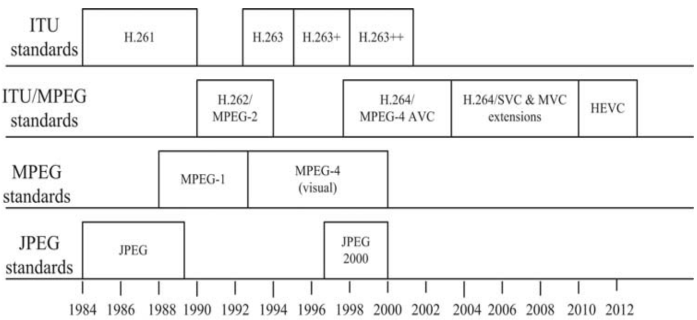


Fig. 1. History line of image/video coding standards by ITU-T and ISO/IEC committees

2.1 Image Compression Standard the develop-ment of image compression technologies provides a solution to the problem. The standardization process of image compression started from the mid-1980s, when ITU-T and ISO began to work together on establishing an international compression standard for continuous-tone still images, both grayscale and color, referred to as the Joint Photographic Experts Group (JPEG). At the turn of the millennium, the JPEG committee decided to figure out a new image compression standard, named JPEG 2000 standard, with the aim of providing greater flexibility and interchangeability than JPEG.

2.1.1 JPEG

In the mid-1980s, the members of ITU-T and ISO cooperated to establish a standard for compressing grayscale and color still images. This effort was known as JPEG, in which the word "joint" indicated the collaboration between ITU-T and ISO. After evaluating different coding schemes, a discrete cosine transform (DCT)-based coding algorithm was chosen as the baseline of JPEG in 1988. The JPEG group continued simulating and evaluating the algorithm, and made JPEG an international standard in 1992 [5]. The JPEG coding standardstill serves as the most widely used compression algorithm todays.

2.1.2 JPEG 2000

So much has changed since the introduction of JPEG in 1980s, and the market demand lead to the birth of a new standard JPEG 2000 to provide better quality and capability for market evolution that JPEG failed to cater for. So after issuing JPEG, ISO and ITU-T continued the work on the next image compression standard JPEG 2000 [15], which was approved in 2002 as an international standard. The target market of JPEG 2000 is assumed to be remote sensing, color fax, printing, scanning, digital photography, medical imagery, digital libraries/archives, Internet, e-commerce, etc. The detailed requirements for JPEG 2000 involve improving compression efficiency, lossy and lossless compression, multiple resolution representation, embedded bit-stream (progressive decoding and SNR scalability), tiling, region-of interest (ROI) coding, error resilience, random code stream access and processing, improved performance to multiple compression/decompression cycles and a more flexible file format The key technique of JPEG 2000 is the discrete wavelet transform (DWT). The merit of wavelet transform is that it provides not only high coding efficiency but also spatial and quality scalability features. Moreover, JPEG 2000 does notsuffer from the blocking artifacts since it does not involve 8x8block based transform. In terms of functionality, JPEG 2000 is indeed a great improvement over JPEG, providing better low bite rate compression performance, allowing larger image size, simplifying the decomposition architecture, etc. However there is no truly substantial improvement, especially at medium and high quality settings, although the new standard shows higher compression efficiency. Other than that, JPEG 2000 can be more complex than JPEG, so JPEG still serves as the most widely used image format given its low complexity and high lossy compression quality.

2.2 Discrete cosine transform (DCT)

is one of the major compression schemes. VLSI implementation of DCT operation requires fixed-point arithmetic since floating point arithmetic needs more area and consumes higher power. In order to satisfy the power, area and system performance constraints simultaneously, accurate bit-width selection is essential.

Like other transforms, the Discrete Cosine Transform (DCT) attempts to de-correlate the image data. After de-correlation each transform coefficient can be encoded independently without losing compression efficiency. This section describes the DCT and some of its important properties.

2.2.1 The One-Dimensional DCT

The most common DCT definition of a 1-D sequence of length N is

$$C(u) = \alpha(u)\sum_{x=0}^{N-1} f(x)\cos\left[\frac{\pi(2x+1)u}{2N}\right], \qquad \text{..........(1)}$$

for u = 0,1,2,…,N −1. Similarly, the inverse transformation is defined as

$$f(x) = \sum_{u=0}^{N-1} \alpha(u)C(u)\cos\left[\frac{\pi(2x+1)u}{2N}\right], \qquad \text{........(2)}$$

for$x$ = 0,1,2,…,N −1. In both equations **(1)** and **(2)**α*(u)* is defined as

$$\alpha(u) = \begin{cases} \sqrt{\frac{1}{N}} & for \quad u = 0 \\ \sqrt{\frac{2}{N}} & for \quad u \neq 0. \end{cases}$$
..........(3)

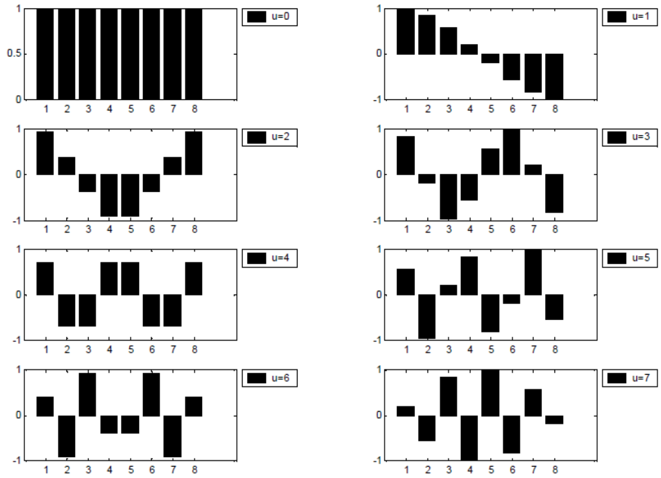
for $x = 0,1,2,\ldots,N-1$. In both equations **(1)** and **(2)** $\alpha(u)$ is defined as

$$u = 0, \; C(u=0) = \sqrt{\frac{1}{N}} \sum_{x=0}^{N-1} f(x)$$
.............(4)

It is clear from abovethat for Thus, the first transform coefficient is

$$\sum_{x=0}^{N-1} \cos\left[\frac{\pi(2x+1)u}{2N}\right]$$
..............................(5)

The average value of the sample sequence. In literature, this value is referred to as the DC Coefficient. All other transform coefficients are called the AC Coefficients4. To fix ideas, ignore the ( ) f x and ( ) u α component from above equation. The plot of N = 8 and varying values of u is shown in Figure 3. In accordance with our previous observation, the first the top-left waveform (u = 0) renders a constant (DC) value, whereas, all other waveforms (u = 1,2,…,7) give waveforms at progressively increasing frequencies These waveforms are called the cosine basis function. Note that these basis functions are orthogonal. Hence, multiplication of any waveform in Figure 3 with another waveform followed by a summation over all sample points yields a zero (scalar) value, whereas multiplication of any waveform in Figure 3 with itself followed by a summation yields a constant (scalar) value. Orthogonal waveforms are independent, that is, none of the basis functions can be represented as a combination of other basis functions



If the input sequence has more than N sample points then it can be divided into sub-sequences of length N and DCT can be applied to these chunks independently. Here, a very important point to note is that in each such computation the values of the basis function points will not change. Only the values of f (x) will change in each sub-sequence. This is a very important property, since it shows that the basic functions can be pre-computed offline and then multiplied with the sub-sequences. This reduces the number of mathematical operations (i.e., multiplications and additions) thereby rendering computation efficiency.

2.2.2 The Two-Dimensional DCT

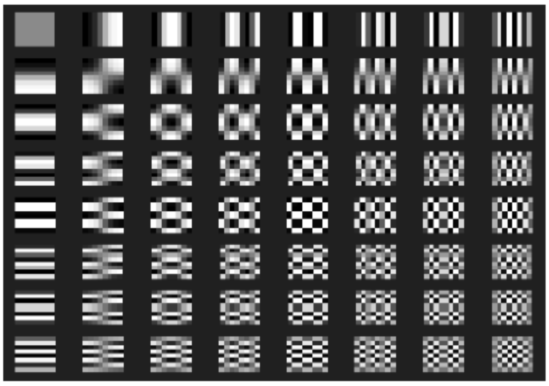
The objective of this document is to study the efficacy of DCT on images. This necessitates the extension of ideas presented in the last section to a two-dimensional space. The 2-D DCT is a direct extension of the 1-D case and is given by

$$C(u,v) = \alpha(u)\alpha(v) \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} f(x,y) \cos\left[\frac{\pi(2x+1)u}{2N}\right] \cos\left[\frac{\pi(2y+1)v}{2N}\right],$$

for $u,v = 0,1,2,\ldots,N-1$ and $\alpha(u)$ and $\alpha(v)$ are defined above. The inverse transform isdefined as

$$f(x,y) = \sum_{u=0}^{N-1} \sum_{v=0}^{N-1} \alpha(u)\alpha(v) C(u,v) \cos\left[\frac{\pi(2x+1)u}{2N}\right] \cos\left[\frac{\pi(2y+1)v}{2N}\right],$$

for$x,y = 0,1,2,\ldots,N-1$. The 2-D basis functions can be generated by multiplying the horizontally oriented 1-D basis functions (shown in Figure 3) with vertically oriented set of the same functions. The basis functions for $N = 8$ are shown in. Again, it can be noted that the basic functions exhibit a progressive increase in frequency both in the vertical and horizontal direction. The top left basis function of results from multiplication of the DC component in below Figure with its transpose. Hence, this function assumes a constant value and is referred to as the DC coefficient.



2.2 The Standard Cosine Transforms:

Notice especially that the denominator inthe cosines (which is N -1 or N) agrees with the distance between \centers." Thisdistance is an integer, measuring from meshpoint to meshpoint or from midpoint tomidpoint. We also give the diagonal matrix D that makes D^{-1}AD symmetric andmakes the eigenvectors orthogonal:

DCT-1

Centers $j = 0$ and $N-1$
Components $\cos jk\frac{\pi}{N-1}$
$D_1 = \mathrm{diag}\left(\sqrt{2}, 1, \ldots, 1, \sqrt{2}\right)$

$$A_1 = \begin{bmatrix} 2 & -2 & & & \\ -1 & 2 & -1 & & \\ & \cdot & \cdot & \cdot & \\ \cdot & & -1 & 2 & -1 \\ & & & -2 & 2 \end{bmatrix}$$

DCT-2

Centers $j = -\frac{1}{2}$ and $N-\frac{1}{2}$
Components $\cos\left(j+\frac{1}{2}\right)k\frac{\pi}{N}$
$D_2 = I$

$$A_2 = \begin{bmatrix} 1 & -1 & & & \\ -1 & 2 & -1 & & \\ & \cdot & \cdot & \cdot & \\ & & -1 & 2 & -1 \\ & & & -1 & 1 \end{bmatrix}$$

DCT-3

Centers $j = 0$ and N
Components $\cos j\left(k+\frac{1}{2}\right)\frac{\pi}{N}$
$D_3 = \mathrm{diag}(\sqrt{2}, 1, \ldots, 1)$

$$A_3 = \begin{bmatrix} 2 & -2 & & & \\ -1 & 2 & -1 & & \\ & \cdot & \cdot & \cdot & \\ & & -1 & 2 & -1 \\ & & & -1 & 2 \end{bmatrix}$$

DCT-4

Centers $j = -\frac{1}{2}$ and $N-\frac{1}{2}$
Components $\cos\left(j+\frac{1}{2}\right)\left(k+\frac{1}{2}\right)\frac{\pi}{N}$
$D_4 = I$

$$A_4 = \begin{bmatrix} 1 & -1 & & & \\ -1 & 2 & -1 & & \\ & \cdot & \cdot & \cdot & \\ & & -1 & 2 & -1 \\ & & & -1 & 3 \end{bmatrix}$$

These are generally full matrices of the form Toeplitz plus near-Hankel." Particular tridiagonal matrices (not centered dierences) were noticed by Kitajima, Rao, Hou, and Jain. We hope that the pattern of Second dierences with dierentcent-erings will bring all eight matrices into a common structure. Perhaps each matrix deserves a quick comment.

3. Research Gaps:

Error Resilient feature of Image Compression is not fully utilized in terms of

- Optimized hardware
- Power requirement
- Coefficient aware design
- Optimization in JPEG architecture

To introduce an Error resilient DCT architecture to compete the existing architecture. Design, Implement & Validate DCT architecture on different standards using an appropriate image processing parameter.

5. Conclusion

In this paper, an overview of existing image and video compression standards is presented. As for image coding standards, JPEG and JPEG 2000 are introduced.DCT plays an important role in image compression especially in JPEG standard, which is based on block code. However, in some applications such as portable multimedia devices, the best image quality are not always required Therefore, algorithm/architecture approaches for low power design. which is based on the tradeoff between image quality and power consumption is clearly required.

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