IMAGE COMPRESSION ALGORITHMS USING 14- ADDITION TECHNIQUES

#1SYED RAHEEM – Assistant Professor, #2 JETYA BANOTHU –Assistant Professor,
Dept of ECE, KHADER MEMORIAL COLLEGE OF ENGINEERING & TECHNOLOGY,
DEVARAKONDA, NALGONDA, T.S., INDIA.

Abstract: Image compression is the application of Data compression on digital images. The discrete cosine transform (DCT) is a technique for converting a signal into elementary frequency components. It is widely used in image compression. Here we develop some simple functions to compute the DCT and to compress images. An image compression algorithm was comprehended using Matlab code, and modified to perform better when implemented in hardware description language. The IMAP block and IMAQ block of MATLAB was used to analyse and study the results of Image Compression using DCT and varying co-efficients for compression were developed to show the resulting image and error image from the original images. Image Compression is studied using 2-D discrete Cosine Transform. The original image is transformed in 8-by-8 blocks and then inverse transformed in 8-by-8 blocks to create the reconstructed image. The inverse DCT would be performed using the subset of DCT coefficients. The error image (the difference between the original and reconstructed image) would be displayed. Video processing systems such as HEVC requiring low energy consumption needed for the multimedia market has lead to extensive development in fast algorithms for the efficient approximation of 2-D DCT transforms. In this paper, we introduce a novel 8-point DCT approximation that requires only 14 addition operations and no multiplications. The proposed DCT approximation is a candidate for reconfigurable video standards such as HEVC. The proposed transform and several other DCT approximations are mapped to systole carray digital architectures and physically realized as digital prototype circuits using FPGA Spartan 3 and it are implemented by verilog language.

Keywords— Approximate DCT, low-complexity algorithms, image compression, HEVC, low power consumption.

I. INTRODUCTION

This A discrete cosine transform (DCT) expresses a sequence of finitely many data points in terms of a sum of cosine functions oscillating at different frequencies. DCTs are important to numerous applications in science and engineering ,from lossy compression of audio and images (where small high-frequency components can be discarded), to spectral methods for the numerical solution of partial differential equations. The use of cosine rather than sine functions is critical in these applications: for compression, it turns out that cosine functions are much more efficient (as explained below, fewer are needed to approximate a typical signal), whereas for differential equations the cosines express a particular choice of boundary conditions. In particular, a DCT is a Fourier-related transform similar to the discrete Fourier transform (DFT), but using only real numbers. DCTs are equivalent to DFTs of roughly twice the length, operating on real data with even symmetry (since the Fourier transform of a real and even function is real and even), where in some variants the input and/or output data are shifted by half a sample. There are eight standard DCT variants, of which four are common. The most common variant of discrete cosine transform is the type-II DCT, which is often called simply "the DCT"; its inverse, the type-III DCT, is correspondingly often called simply "the inverse DCT" or "the IDCT". Two related transforms are the

discrete sine transform (DST), which is equivalent to a DFT of real and odd functions, and the modified discrete cosine transform (MDCT), which is based on a DCT of overlapping data.

Data compression is the technique to reduce the redundancies in data representation in order to decrease data storage requirements and hence communication costs. Reducing the storage requirement is equivalent to increasing the capacity of the storage medium and hence communication bandwidth. Thus the development of efficient compression techniques will continue to be a design challenge for future communication systems and advanced multimedia applications. Data is represented as a combination of information and redundancy. Information is the portion of data that must be preserved permanently in its original form in order to correctly interpret the meaning or purpose of the data. Redundancy is that portion of data that can be removed when it is not needed or can be reinserted to interpret the data when needed. Most often, the redundancy is reinserted in order to generate the original data in its original form. A technique to reduce the redundancy of data is defined as Data compression. The redundancy in data representation is reduced such a way that it can be subsequently reinserted to recover the original data, which is called decompression of the data. Data compression can be

understood as a method that takes an input data D and generates a shorter representation of the data c(D) with less number of bits compared to that of D. The reverse process is called decompression, which takes the compressed data c(D) and generates or reconstructs the data D" as shown in Figure 1. Sometimes the compression (coding) and decompression (decoding) systems together are called a "CODEC".
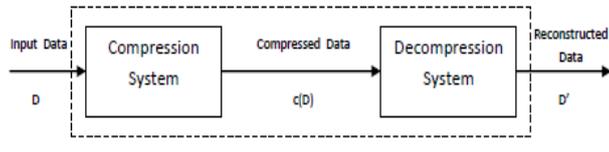

Figure. 1 Block Diagram of CODEC

If the reconstructed data D" is an exact replica of the original data D, the algorithm applied to compress D and decompress c(D) is lossless. On the other hand, the algorithms are lossy when D" is not an exact replica of D. Hence as far as the reversibility of the original data is concerned, the data compression algorithms can be broadly classified in two categories – lossless and lossy. Usually loseless data compression techniques are applied on text data or scientific data. Sometimes data compression is referred as coding, and the terms noiseless or noisy coding, usually refer to loseless and lossy compression techniques respectively. The term "noise" here is the "error of reconstruction" in the lossy compression techniques because the reconstructed data item is not identical to the original one. Data compression schemes could be static or dynamic. In static methods, the mapping from a set of messages (data or signal) to the corresponding set of compressed codes is always fixed. In dynamic methods, the mapping from the set of messages to the set of compressed codes changes over time. A dynamic method is called adaptive if the codes adapt to changes in ensemble characteristics over time. For example, if the probabilities of occurrences of the symbols from the source are not fixed over time, an adaptive formulation of the binary codewords of the symbols is suitable, so that the compressed file size can adaptively change for better compression efficiency. More recently, the wavelet transform has emerged as a cutting edge technology, within the field of image compression. Wavelet-based coding provides substantial improvements in picture quality at higher compression ratios.

II. DISCRETE COSINE TRANSFORM

The discrete cosine transform (DCT) helps separate the image into parts (or spectral sub-bands) of differing importance (with respect to the image's visual quality). The DCT is similar to the discrete Fourier transform: it transforms a signal or image from the spatial domain to the frequency domain (Fig 2)
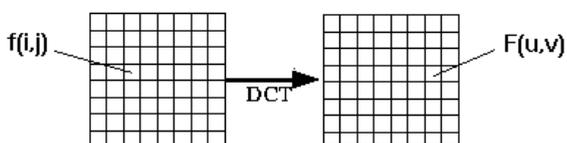

figure.2 Transformation of function into DCT

A discrete cosine transform (DCT) expresses a sequence of finitely many data points in terms of a sum of cosine functions oscillating at different frequencies. DCTs are important to numerous applications in science and engineering, from lossy compression of audio (e.g. MP3) and images (e.g. JPEG) (where small high-frequency components can be discarded), to spectral for the numerical solution of partial differential equations. The use of cosine rather than sine functions is critical in these applications: for compression, it turns out that cosine functions are much more efficient (as described below, fewer are needed to approximate a typical signal), whereas for differential equations the cosines express a particular choice of boundary conditions.

In particular, a DCT is a Fourier-related transform similar to the discrete Fourier transform (DFT), but using only real numbers. DCTs are equivalent to DFTs of roughly twice the length, operating on real data with even symmetry (since the Fourier transform of a real and even function is real and even), where in some variants the input and/or output data are shifted by half a sample. There are eight standard DCT variants, of which four are common.

The most common variant of discrete cosine transform is the type-II DCT, which is often called simply "the DCT"; its inverse, the type-III DCT, is correspondingly often called simply "the inverse DCT" or "the IDCT". Two related transforms are the discrete sine transforms (DST), which is equivalent to a DFT of real and odd functions, and the modified discrete cosine transforms (MDCT), which is based on a DCT of overlapping data.

III. RELATED WORK, ISSUES AND POSSIBLE SOLUTIONS

Apart of so many advantages of Discrete Wavelet Transform, Discrete wavelet transform donot justify wide replacement of DCT to avoid blocking artifacts. Discrete Cosine Transform is a technique for converting a signal into elementary frequency components, widely used in image compression. The rapid growth of digital imaging applications, including desktop publishing, multimedia, teleconferencing, and high-definition television (HDTV) has increased the need for effective and standardized image compression techniques. Among the emerging standards are JPEG, for compression of still images [Wallace 1991]; MPEG, for compression of motion vi deo [Puri 1992]; and CCITT H.261 (also known as Px64), for compression of video telephony and teleconferencing. There are many research papers that propose 1D Discrete cosine transform technique to modify an image so as to get the compressed data or image model. [1] shows a discrete wavelet technique to compress the images using wavelet theory in VHDL, Verilog. [2] shows FFT approach for data compression.that its histogram has a desired shape. [3] shows the lossless image compression algorithm using FPGA technology. [4] has shown an image compression algorithm using verilog with area, time and power constraints. [5] has shown a simple DCT technique to for converting signals into elementary frequency components using mathematica toolbox. [6] shows comparative analysis of various compression methods for medical images depicting lossless

and lossy image compression. [7] shows Fourier analysis and Image processing technique. [8] shows Image compression Implementation using Fast Fourier Transform. [9] depicts a comparative study of Image Compression using Curvelet, Ridgilet and Wavelet Transform Techniques. JPEG is primarily a lossy method of compression.JPEG was designed specifically to discard information that the human eye cannot easily see. Slight changes in color are not perceived well by the human eye, while slight changes in intensity (light and dark) are. Therefore JPEG's lossy encoding tends to be more frugal with the gray-scale part of an image and to be more frivolous with the color .DCT separates images into parts of different frequencies where less important frequencies are discarded through quantization and important frequencies are used to retrieve the image during decompression.

IV. PROBLEM FORMULATION

Wavelet based techniques for image compression have been increasingly used for image compression. The wavelet uses subband coding to selectively extract different subbands from the given image.These subbands can then be quantized with different quantizers to give better compression.The wavelet filters are specifically designed to satisfy certain constraints called the smoothness constraints. The wavelet filters are designed so that the coefficients in each subband are almost uncorrelated from the coefficients in other subbands [3]. The wavelet transform achieves better energy compaction than the DCT and hence can help in providing better compression for the same Peak Signal to Noise Ratio (PSNR). A lot of research has been done on the performance comparison of the DWT and DCT for image compression which is less than 1 dB. This proposed work is to analyse the image compression algorithm using 2-dimension DCT. According to the DCT properties, a DC is transformed to discrete delta-function at zero frequency. Hence, the transform image contains only the DC component. To transformed an image into 8 x 8 subsets by applying DCT in 2 dimension. Also, a subset of DCT co-efficients have been prepared in order to perform inverse DCT to get the reconstructed image. The work to be done is to perform the inverse transform of the transformed image and also to generate the error image in order to give the results in terms of MSE (Mean Square Error), as MSE increases, the image quality degrades and as the MSE would decrease, image quality would be enhanced with the help of changing the co-efficients for DCT Blocks.

V. WORK METHODOLOGY

Image compression is a technique used to reduce the storage and transmission costs. The existing techniques used for compressing image files are broadly classified into two categories, namely lossless and lossy compression techniques. In lossy compression techniques, the original digital image is usually transformed through an invertible linear transform into another domain, where it is highly de-correlated by the transform. This de-correlation concentrates the important image information into a more compact form.

The transformed coefficients are then quantized yielding bit-streams containing long stretches of zeros. Such bit-streams can be coded efficiently to remove the redundancy and store it into a compressed file. The decompression reverses this process to produce the recovered image. The 2-D discrete cosine transform (DCT) is an invertible linear transform and is widely used in many practical image compression systems because of its compression performance and computational efficiency [10-12]. DCT converts data (image pixels) into sets of frequencies. The first frequencies in the set are the most meaningful; the latter, the least. The least meaningful frequencies can be stripped away based on allowable resolution loss. DCT-based image compression relies on two techniques to reduce data required to represent the image. The first is quantization of the image"s DCT coefficients; the second is entropy coding of the quantized coefficients [13]. Quantization is the process of reducing the number of possible values of a quantity, thereby reducing the number of bits needed to represent it. Quantization is a lossy process and implies in a reduction of the color information associated with each pixel in the image. Entropy coding is a technique for representing the quantized coefficients as compactly as possible.
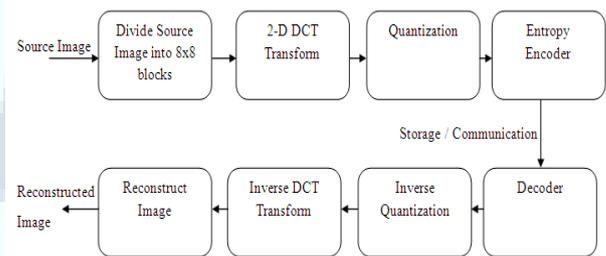

figure.3: Block Diagram For Compression/

Decompression Algorithm In this paper, a simple entropy encoder algorithm will be proposed and implemented. It works on quantized coefficients of the discrete cosine transform. The basic idea of the new approach is to divide the image into 8x8 blocks and then extract the consecutive non-zero coefficients preceding the zero coefficients in each block. In contrast to the Run_Length decoder, the output of this encoder consists of the number of the nono-zero coefficients followed by the coefficients themselves for each block. The decompression process can be performed systematically and the number of zero coefficients can be computed by subtracting the number of non-zero coefficients from 64 for each block.

VI. LOSSLESS AND LOSSY IMAGE COMPRESSION

When hearing that image data are reduced, one could expect that automatically also the image quality will be reduced. A loss of information is, however, totally avoided in lossless compression, where image data are reduced while image information is totally preserved. It uses the predictive encoding which uses the gray level of each pixel to predict the gray value of its right neighbor. Only the small deviation from this prediction is stored. This is a first step of lossless data reduction. Its effect is to change the statistics of the

image signal drastically. Statistical encoding is another important approach to lossless data reduction. Statistical encoding can be especially successful if the gray level statistics of the images has already been changed by predictive coding. The overall result is redundancy reduction, that is reduction of the reiteration of the same bit patterns in the data. Of course, when reading the reduced image data, these processes can be performed in reverse order without any error and thus the original image is recovered. Lossless compression is therefore also called reversible compression. Lossy data compression has of course a strong negative connotation and sometimes it is doubted quite emotionally that it is at all applicable in medical imaging. In transform encoding one performs for each image run a mathematical transformation that is similar to the Fourier transform thus separating image information on gradual spatial variation of brightness (regions of essentially constant brightness) from information with faster variation of brightness at edges of the image (compare: the grouping by the editor of news according to the classes of contents). In the next step, the information on slower changes is transmitted essentially lossless (compare: careful reading of highly relevant pages in the newspaper), but information on faster local changes is communicated with lower accuracy (compare: looking only at the large headings on the less relevant pages). In image data reduction, this second step is called quantization. Since this quantization step cannot be reversed when decompressing the data, the overall compression is „lossy" or „irreversible".

VII. JPEG

The DCT is used in JPEG image compression, MJPEG, MPEG, DV, and Theora video compression. There, the two-dimensional DCT-II of N x N blocks are computed and the results are quantized and entropy coded. In this case, N is typically 8 and the DCT-II formula is applied to each row and column of the block. The result is an 8×8 transform coefficient array in which the (0,0) element (top-left) is the DC (zero-frequency) component and entries with increasing vertical and horizontal index values represent higher vertical and horizontal spatial frequencies. It incorporated the last advances in the image compression to provide a unified optimized tool to accomplish both lossless and lossy compression and decomposition using the same algorithm and the bit stream syntax. The systems architecture is not only optimized for compression efficiency at even very low bit-rates, it is also optimized for scalability and interoperability in the networks and noisy mobile environments. The JPEG standard will be effective in wide application areas such as internet, digital photography, digital library, image archival, compound documents, image databases, colour reprography (photocopying, printing, scanning, facsimile), graphics, medical imagery, mobile multimedia communication, 3G cellular telephony, client-server networking, e-commerce, etc.

VIII. QUANTIZATION

DCT-based image compression relies on two techniques to reduce the data required to represent the image. The first is quantization of the image's DCT coefficients; the second is

entropy coding of the quantized coefficients. Quantization is the process of reducing the number of possible values of a quantity, thereby reducing the number of bits needed to represent it. Entropy coding is a technique for representing the quantized data as compactly as possible. I have developed functions to quantize images and to calculate the level of compression provided by different degrees of quantization.

VIII. DIGITAL ARCHITECTURE AND REALISATION

In this section we propose architectures for the detailed 1-Dand 2-D approximate 8-point DCT. This section explores the hardware utilization of the discussed algorithms while providing a comparison with the proposed novel DCT approximation algorithm and its fast algorithm realization. Our objective here is to offer digital realizations together with measured or simulated metrics of hardware resources so that better decisions on the choice of a particular fast algorithm and its implementation can be reached.
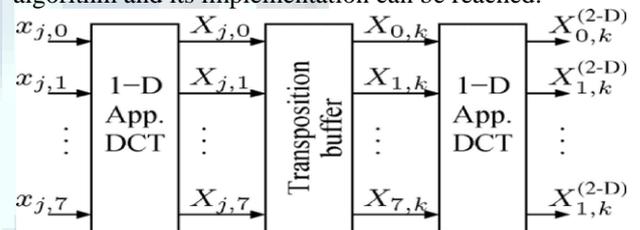

Fig.4.Two-dimensional approximate DCT

This is propose digital computer architectures that are custom designed for the real-time implementation of the fast algorithm. The proposed architectures employs two parallel realizations of DCT approximation blocks, as shown in Fig.4. The 1-D approximate DCT blocks (Fig.4) implement a particular fast algorithm chosen from the collection described earlier in the paper. The first instantiation of the DCT block furnishes a row-wise transform computation of the input image, while the second implementation furnishes a column-wise transformation of the intermediate result. The row- and column-wise transforms can be any of the DCT approximations detailed in the paper. In other words, there is no restriction for both row- and column-wise transforms to be the same. However, for simplicity, It adopted identical transforms for both steps.
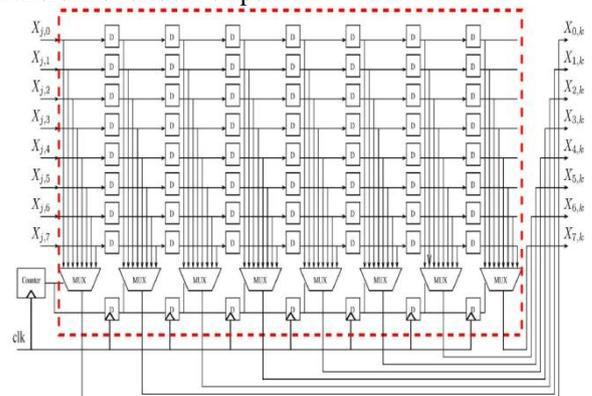

Fig.5. Proposed transposition buffer block

Between the approximate DCT blocks a real-time row-parallel transposition buffer circuit is required. Such block

ensures data ordering for converting the row-transformed data from the first DCT approximation circuit to a transposed format as required by the column transform circuit. The transposition buffer block is detailed in Fig. 5.The circuitry sections associated to the constituent matrices of the discussed factorizations are emphasized in the figures in bold or dashed boxes.

IX. CONCLUSION

In this paper, we proposed a novel low-power 8-point DCT approximation that require only 14 addition operations to computations and hardware implementation for the proposed transform and several other prominent approximate DCT methods, including the designs by Bouguezel-Ahmad-Swamy. We obtained that all considered approximate transforms perform very close to the ideal DCT. However, the modified CB-2011approximation and the proposed transform possess lower computational complexity and are faste than all other approximations under consideration. Interms of image compression, the proposed transform could outperform the modified CB- 2011algorithm. Hence the new proposed transform is the best approximation for the DCT interms of computational complexity and speed among the approximate transform examined. Introduced implementations address both1-D and 2-Dapproximate DCT. All the approximations were digitally implemented using both Xilinx FPGA tools and CMOS45nm ASIC technology. The speeds of operation were much greater using the CMOS technology for the same function word size. Therefore, the proposed architectures are suitable for image and video processing, being candidates for improvements in several standards including the HEVC.

REFERENCES

[1] H.-Y. Lin and W.-Z. Chang, "High dynamic range imaging for stereoscopic scene representation," in *Proc. 16th IEEE Int. Conf. ImageProcess. (ICIP)*, Nov. 2009, pp. 4305–4308.

[2] M. Rezaei, S. Wenger, and M. Gabbouj, "Video rate control for streaming and local recording optimized for mobile
devices," in *Proc.IEEE 16th Int. Symp. Personal, Indoor Mobile Radio Communications (PIMRC)*, Sept. 2005, vol. 4, pp. 2284–2288.

[3] H. Zheng and J. Boyce, "Packet coding schemes for MPEG video overinternet and wireless networks," in *Proc. IEEE Wireless Commun. NetworkingConf. (WCNC)*, 2000, vol. 1, pp. 191–195.

[4] E.Magli and D. Taubman, "Image compression practices and standards for geospatial information systems," in *Proc. IEEE Int. Geoscience and Remote Sensing Symposium (IGARSS)*, Jul. 2003, vol. 1, pp. 654–656.

[5] M. Bramberger, J. Brunner, B. Rinner, and H. Schwabach, "Real-time video analysis on an embedded smart camera for traffic surveillance," in *Proc. 10th IEEE Real-Time and Embedded Technology and Applications Symp.*, May 2004, pp. 174–181.

[6] S. Marsi, G. Impoco, S. C. A. Ukovich, and G. Ramponi, "Video enhancement and dynamic range control of HDR sequences for automotive applications," *Advances in Signal Processing*, vol. 2007, no. 80971, pp. 1–9, June 2007.

[7] I. F. Akyildiz, T.Melodia, andK.R.Chowdhury, "Asurvey onwireless multimedia sensor networks," *Computer Telecommun. Network.*, vol. 51, no. 4, pp. 921–960, Mar. 2007.

[8] A. Madanayake, R. J. Cintra, D. Onen, V. S. Dimitrov, N. Rajapaksha, L. T. Bruton, and A. Edirisuriya, "A row parallel 8 8 2-D DCT architecture using algebraic integer-based exact computation," *IEEE Trans. Circuits Syst. Video Technol.*, vol. 22, no. 6, pp. 915–929, Jun. 2012.

[9] N. Ahmed, T. Natarajan, and K. R. Rao, "Discrete cosine transform," *IEEE Trans. Comput.*, vol. C-23, no. 1, pp. 90–93, Jan. 1974.

[10] K. R. Rao and P. Yip, *Discrete Cosine Transform: Algorithms, Advantages, Applications*. San Diego, CA, USA: Academic, 1990.

[11] V. Britanak, P. Yip, and K. R. Rao, *Discrete Cosine and Sine Transforms*. New York, NY, USA: Academic, 2007.

[12] V. Bhaskaran and K. Konstantinides, *Image and Video Compression Standards*. Norwell, MA, USA: Kluwer, 1997.

[13] J. Liang and T. D. Tran, "Fast multiplierless approximation of the DCT with the lifting scheme," *IEEE Trans. Signal Process.*, vol. 49, no. 12, pp. 3032–3044, Dec. 2001.

[14] T. I. Haweel, "A new square wave transform based on the DCT," *Signal Process.*, vol. 81, no. 11, pp. 2309–2319, Nov. 2001.

[15] K. Lengwehasatit and A. Ortega, "Scalable variable complexity approximate forward DCT," *IEEE Trans. Circuit Syst. Video Technol.*, vol. 14, no. 11, pp. 1236–1248, Nov. 2004.

[16] R. J. Clarke, "Relation between the Karhunen-Loève and cosine transforms," in *IEE Proceedings F Communications, Radar and Signal Processing*, Nov. 1981, vol. 128, no. 6, pp. 359–360.

[17] W. B. Pennebaker and J. L.Mitchell, *JPEG Still Image Data Compression Standard*. New York, NY, USA: Van Nostrand Reinhold, 1992.

[18] N. Roma and L. Sousa, "Efficient hybrid DCT-domain algorithm for video spatial downscaling," *EURASIP J. Adv. .Signal Process.*, vol. 2007, no. 2, pp. 30–30, 2007.

[19] International Organisation for Standardisation,, "Generic coding of moving pictures and associated audio information—Part 2: Video," 1994, ISO, ISO/IEC JTC1/SC29/WG11—Coding of Moving Pictures and Audio.

[20] International Telecommunication Union,, ITU-T Recommendation H.261 Version 1: Video Codec for Audiovisual Services at kbits ITU-T, Tech. Rep., 1990.

[21] International Telecommunication Union,, ITU-T Recommendation H.263 Version 1: Video Coding for low bit Rate Communication ITU-T, Tech. Rep., 1995.

[22] H. L. P. A. Madanayake, R. J. Cintra, D. Onen, V. S. Dimitrov, and L. T. Bruton, "Algebraic integer based 8 8 2-D DCT architecture for digital video processing," in *Proc. ISCAS*, May 2011, pp. 1247–1250.

[23] International Telecommunication Union,, ITU-T Recommendarion H.264 Version 1: Advanced Video Coding for Generic Audio-Visual Services ITU-T, Tech. Rep., 2003.

[24] T.Wiegand, G. J. Sullivan, G. Bjontegaard, and A. Luthra, "Overview of the H.264/AVC video coding standard," *IEEE Trans. Circuits Syst. Video Technol.*, vol. 13, no. 7, pp. 560–576, Jul. 2003.

[25] M. T. Pourazad, C. Doutre, M. Azimi, and P. Nasiopoulos, "HEVC: The new gold standard for video compression: How does HEVC compare with H.264/AVC?," *IEEE Consumer Electron. Mag.*, vol. 1, no. 3, pp. 36–46, Jul. 2012.

AUTHOR'S PROFILE:

[1]. SYED RAHEEM, Completed his M.Tech Degree From JNTU, HYDERABAD presently working as Assistant Professor, Dept of ECE, KHADEER MEMORIAL COLLEGE OF ENGINEERING & TECHNOLOGY, DEVARAKONDA, NALGONDA, T.S., INDIA.

[2]. **JETYA BANOTHU**, Completed his M.Tech Degree From JNTU, HYDERABAD presently working as Assistant Professor, Dept of ECE, KHADER MEMORIAL COLLEGE OF ENGINEERING & TECHNOLOGY, DEVARAKONDA, NALGONDA, T.S., INDIA.