Study And Performance Analysis Of Image Compression Using Hybrid DWT-DCT Algorithm

Bhavya K B
Assistant professor Department of Electronics and Communication Engineering
Bangalore institute of technology,Bangalore,India

Image compression for decreasing the amount of data storage for faster data transfer. It is one of the active research topic in the era of data transmission through internet.The aim of an image/video compression technique is to reduce redundancy of the image data in order to transmit or store data in an efficient form. This results in the reduction of file size and allows more images to be stored in a given amount of disk or memory space. This research suggests a new image compression scheme with pruning proposal based on hybrid discrete cosine transformation (DCT) -discrete wavelet transformation (DWT). The effectiveness of the algorithm has been justified over some real images, and the performance of the algorithm has been compared with other common compression standards. Experimental results demonstrate that the Hybrid technique provides sufficient high compression ratios compared to other compression techniques. The performance of the Hybrid algorithm has been compared with standard algorithms in terms of the PSNR and the CR.

Keywords-image compression; DWT; DCT; JPEG; PSNR; MSE; compression ratio; image encoding

I.INTRODUCTION

Image compression is a key technology in transmission and storage of digital images because of vast data associated with them. Uncompressed data such as graphics, audio and video require considerable large storage capacity and transmission bandwidth.[1] Despite rapid growth in mass storage density and significant improvement in communication bandwidth, demand for data storage capacity and transmission bandwidth continues to outstrip the capabilities of existing technologies. Image data compression technique, concerned with the reduction of number of bits required to store and transmit image without appreciable loss of information. Image compression techniques are categorized into two main types depending on the redundancy removal way, namely Lossy and lossless compression [2,5,6]. Lossless compression such as Huffman coding, Arithmetic coding, Run Length coding, Entropy Encoding, and Lempel-Ziv algorithm allow the original image to be reconstructed exactly from the compressed image with low compression rate. On the other hand, lossy image compression that characterized by degrade image quality, can't be reconstructed exactly from the compressed image. Methods for lossy compression include: Fractal compression, Transform coding, Fourier-related transform, DCT (Discrete Cosine Transform) and Wavelet transform. In this research a new and very competent image compression scheme is presented based on Hybrid discrete wavelet transform and discrete cosine transform that results in high compression rate with no sacrifice in image quality. The performance of the hybrid

algorithm has been compared with some other common compression standards. Several quality measurement variables like peak signal to noise ratio (PSNR) and mean square error (MSE) have been estimated to determine how well an image is reproduced with respect to the reference image[8,9]. This article is structured as follows: Section II Illustrates the fundamentals of cosine transforms, Section III illustrates the fundamentals of wavelet transform , Section IV presents the Hybrid Compression Algorithm, Section V demonstrates the Experimental results and discussions. Finally, Section VI concludes the paper.

II .DISCRETE COSINE TRANSFORM

Discrete cosine transform (DCT) is one of the well-known transformations that expresses a sequence of finitely many data points in terms of a sum of cosine functions oscillating at different frequencies. The discrete cosine transform (DCT) helps separate the image into spectral sub-bands of differing importance with respect to the image's visual quality. The DCT is similar to the Discrete Fourier Transform where it transforms a signal or image from the spatial domain to the frequency domain. 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 ,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 where in some variants the input and/or output data are shifted by half a sample.

The equation of 1-D DCT is illustrated as

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

Where, $\alpha(u) = \begin{cases} \frac{1}{\sqrt{N}}, & u = 0 \\ \sqrt{\frac{2}{N}}, & u \neq 0 \end{cases}$

The equation of 2-D DCT is illustrated

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

where $\propto (u)$ & $\propto (v)$ are defined as shown in 1D case.

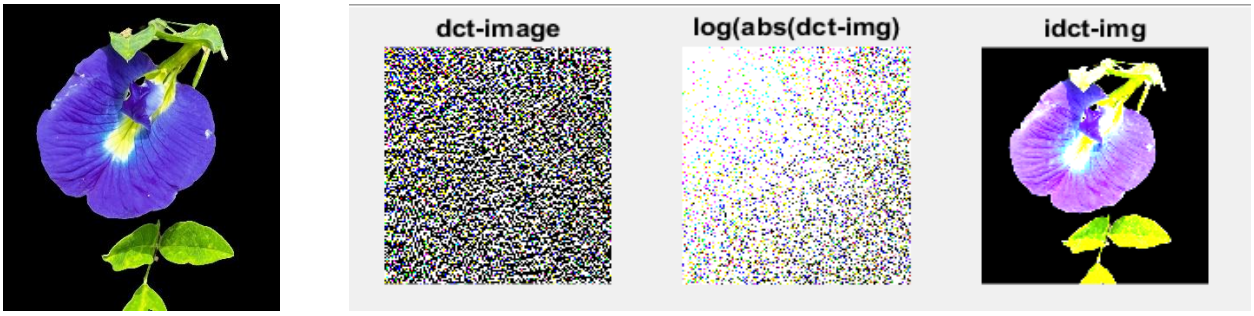

Figure 1:Illustration of DCT-IDCT a)input image b)Corresponding DCT and IDCT image.

III.DISCRETE WAVELET TRANSFORM

The Discrete Wavelet Transform (DWT), which is based on sub-band coding. In DWT, the signal to be analyzed is passed through filters with different cutoff frequencies at different scales. Wavelets can be realized by iteration of filters with rescaling. The resolution of the signal, which is the measure of the amount of detail information in the signal, is determined by the filtering operations, and the scale is determined by up-sampling and down-sampling. The DWT is computed by successive low-pass and high-pass filtering of the discrete time-domain signal. Images are treated as two dimensional signals, they change horizontally and vertically, thus 2D wavelet analysis must be used for images . 2D DWT for an image can be derived from a 1D DWT. 2D wavelet analysis uses the same 'mother wavelets' but requires an additional step at each level of decomposition. Any decomposition of a wavelet image a pair of waveforms: the low frequencies corresponding to the smooth parts of an image and the high frequencies corresponding to the detailed parts of an image. In 2D, the images are considered to be matrices with N rows and M columns. At every level of decomposition the horizontal data is filtered, and then the approximation and details produced from this are filtered on columns. At every level, four sub-images are obtained Figure 2 shows the four subband elements representing LL (Approximation),HL (Vertical), LH (Horizontal) and HH (Diagonal) respectively .

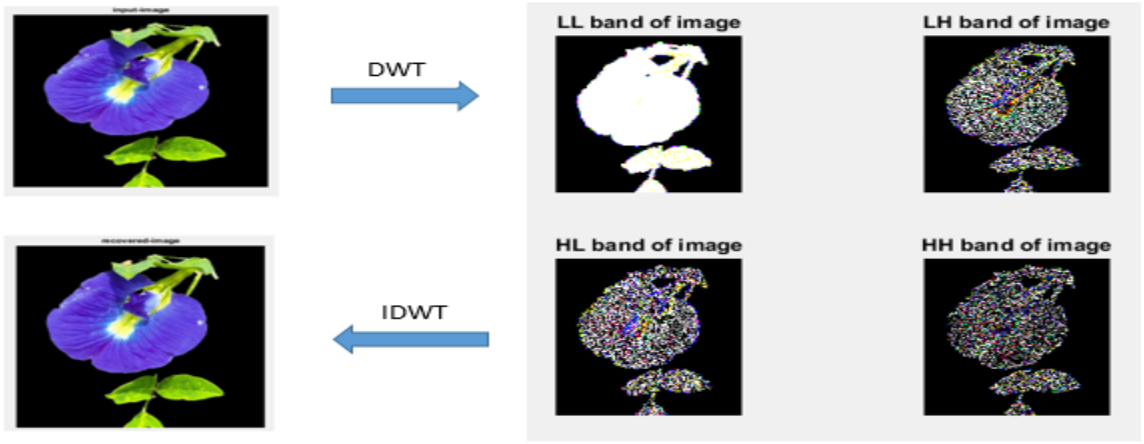

Figure 2:Illustration of DWT-IDWT

IV.HYBRID COMPRESSION ALGORITHM

The Hybrid transform algorithm uses the properties of both the DWT and DCT techniques. Hybrid transform algorithm provides a better compression. The input image is taken and preprossed first converted into 32*32 blocks. Each block is transformed individually. The 32*32 block is converted into 16*16 after one level DWT and discarding all the LH1, HH1, and HL1 coefficients except the LL1. The second level of the 2 dimensional DWT is applied on the conserved LL1 coefficients. And this yield is an 8*8 block after discarding all the coefficients and preserving only LL2 (i.e. LH2, HH2, and HL2). After that, the DCT is applied on this block(LL2). The reconstruction can be performed by the reverse process i.e. first the IDCT is performed which yields an 8*8 block. Then, on the obtained block the first level IDWT is done, first level IDWT gives a 16*16 blocks ,later second level of IDWT is applied which gives the 32*32 block .Post processing blocks results in the recovered image which is same as original input image in quality but reduced in storage size. Similarly multilevel decomposition can be done which results is more and more compression.Figure3 shows the hybrid 3 level algorithm ,where DWT is applied thrice followed by DCT ,reverse will be the reconstruction process.

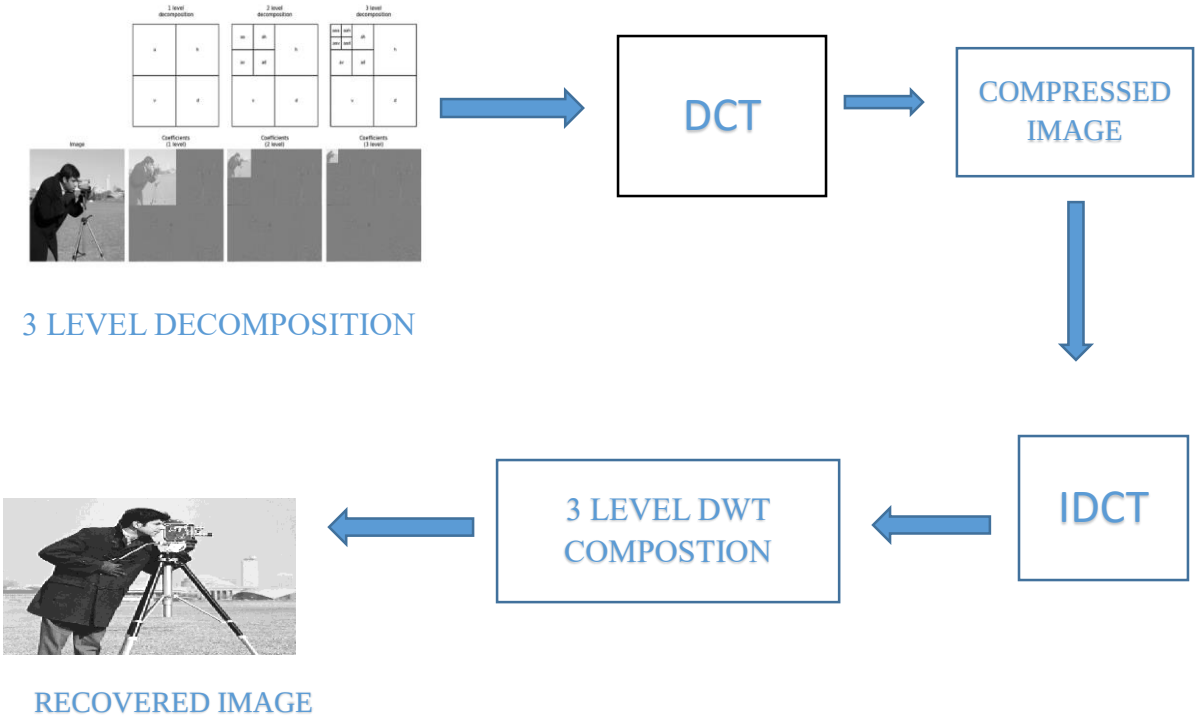

Figure 3:Flow diagram for hybrid DWT-DCT algorithm

V. EXPERIMENTAL RESULTS AND DISCUSSION

In this research, performance analysis of an efficient hybrid compression technique based on discrete wavelet transform (DWT) and discrete cosine transform (DCT) Carried out. .A set of colored test images (jpeg format) are taken to justify the effectiveness of the algorithm. Figure. 4 shows a test image and resulting compressed images using DCT , DWT and the hybrid multi level DWT-DCT compression methods.[12]

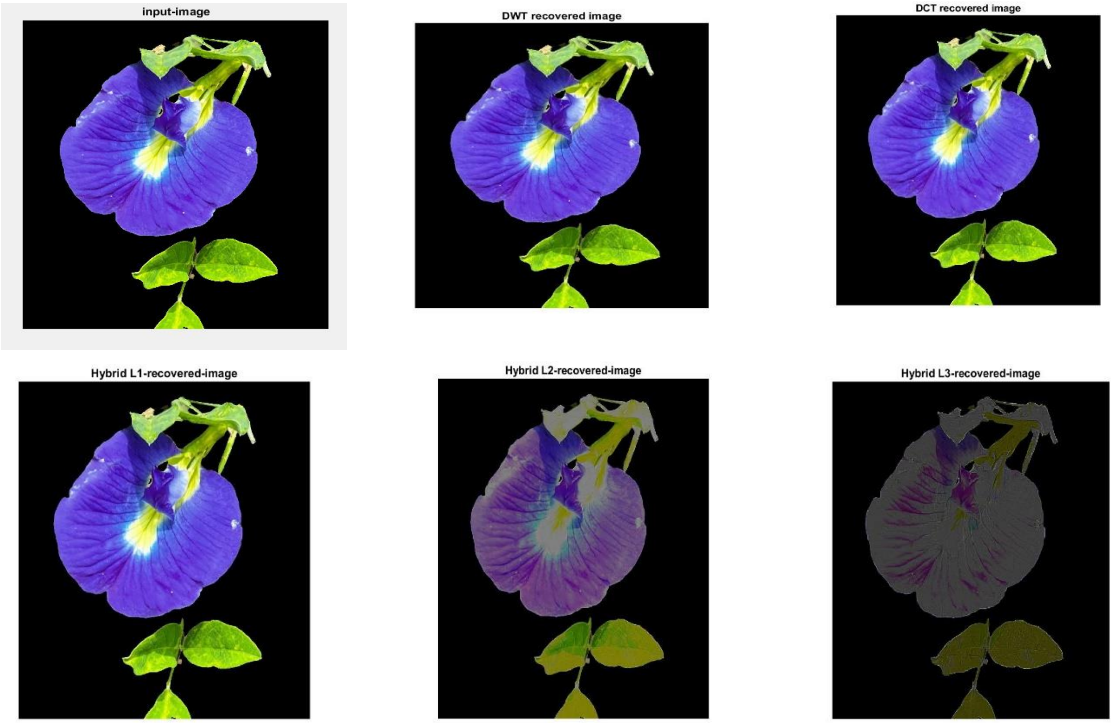

Figure 4. A real image and corresponding compressed images with DCT, DWT and Multilevel Hybrid DWT-DCT algorithm

.

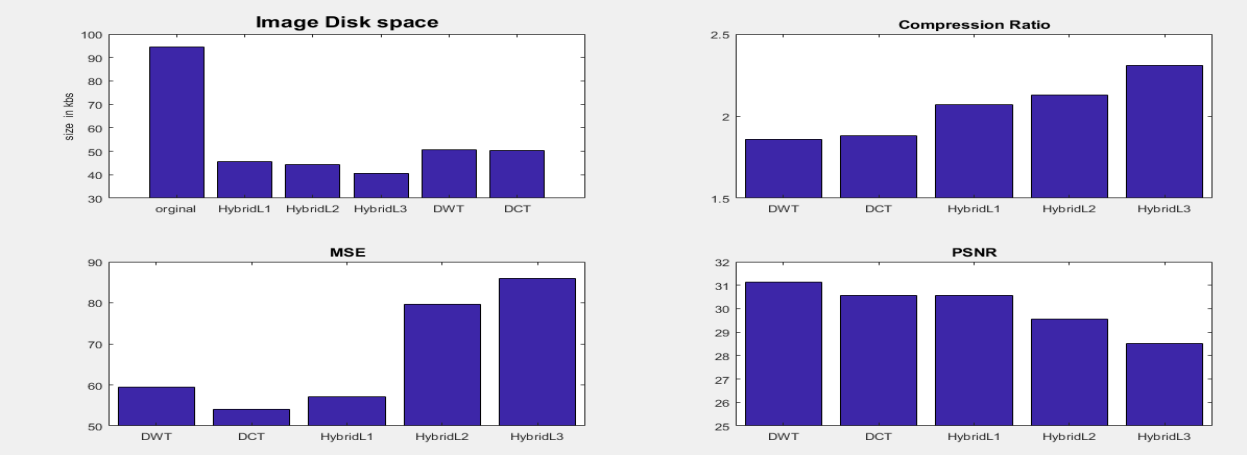

Figure 5. Graphical representation of result.

Quality Measure of Image compression:

1].Compression Ratio

Normally the Quality of an image compression scheme can be measured in terms of Compression efficiency: Compression efficiency is measured through compression ratio (CR). The CR can be defined as the ratio of number of zeros of the current decomposition to the number of coefficients.

$$CR = \frac{n_1}{n_2}$$

where n_1 and n_2 denote the number of information carrying units (bits) in the original image and the compressed image.

2].Peak Signal to Noise Ratio(PSNR).

This ratio is used as a quality measurement between the original and a compressed image. The higher the PSNR, the better the quality of the compressed, or reconstructed image

$$PSNR = 10 * \log_{10}\left(\frac{R^2}{MSE}\right)$$

R is the maximum fluctuation in the input image data type.

3].Mean Square Error(MSE)

The MSE represents the cumulative squared error between the compressed and the original image. The lower the value of MSE, the lower the error.

$$MSE = \frac{1}{m * n}\sum_{x=0}^{N-1}\sum_{y=0}^{M-1}[f(x,y) - f'(x,y)]^2$$

The experimental results with the Hybrid compression method have been arranged in the Table 1 shows the comparison between DWT, DCT and the Hybrid compression method. Experimental results demonstrate that the Hybrid compression technique gives better performance compared to other standard compression techniques.

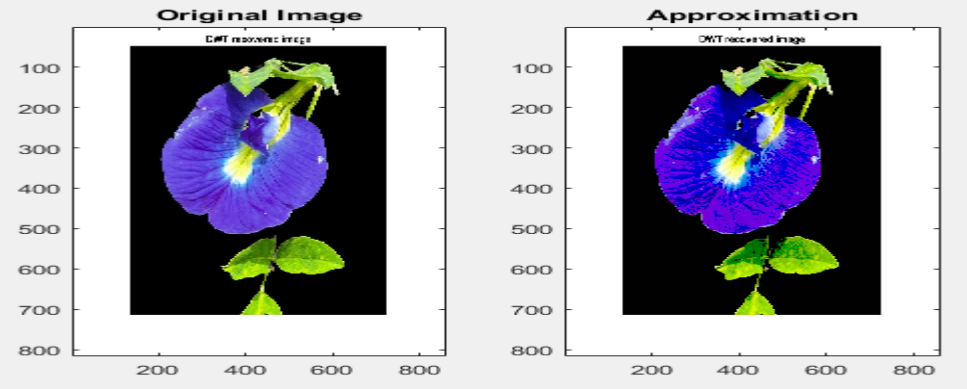

Figure 6:Evaluation metrics approximation

Table 1. COMPARISON BETWEEN DWT ,DCT AND MULTI LEVEL HYBRID COMPRESSION ALGORITHM.

Compression Techniques	File sizes	CR	MSE	PSNR (dB)
Original Image(jpeg)	94.5kb	-	-	-
DWT	50.8kb	1.86	59.49	31.135
DCT	50.2kb	1.88	54.06	30.559
1 level Hybrid DWT-DCT (Proposed Method)	45.5kb	2.07	57.20	30.552
2 level Hybrid DWT-DCT	44.3kb	2.13	79.59	29.558
3 level Hybrid DWT-DCT	40.7kb	2.31	85.92	28.510

6. CONCLUSIONS

A new image compression scheme based on Hybrid discrete wavelet transform and discrete cosine transform is studied in this research which provides sufficient high compression ratios with no appreciable degradation of image quality. The effectiveness and robustness of this approach has been justified using a set of real images. The images are taken with a iphone camera . To demonstrate the performance of the hybrid method, a comparison between the hybrid technique and other common compression techniques has been revealed. From the experimental results it is evident that, the hybrid compression technique gives better performance compared to other traditional techniques. Wavelets are better suited to time-limited data and wavelet based compression technique maintains better image quality by reducing errors.DCT reduces the spatial and spectral redundancy between the neighboring pixels. Combining both algorithm a better compression technique with highly improved compression quality images are obtained .The future direction of this research is to implement a Hybrid compression technique for Ultra HD images , 4K,8K high resolution Images\videos and HEVC codec.

REFERENCES

[1] T. Sheltami, M. Musaddiq and E. Shakshuki, "Data Compression Techniques in Wireless Sensor Networks," Futur. Gener. Comput. Syst., vol. 64, pp. 151–162, 2016.

[2] W. Z. Wahba and A. Y. A. Maghari, "Lossless Image Compression Techniques: Comparative Study," Int. Res. J. Eng. Technol., vol. 3, no. 2, pp. 1–9, 2016.

[3] M. Mozammel Hoque Chowdhury and Amina Khatun, Image Compression Using Discrete Wavelet Transform, lJCSI International Journal of Computer Science Issues, Vol. 9, Issue 4, No I, PP, 327- 330, July 2012.

[4] Mohammed Abo-Zahhad, Sabah M. Ahmed and Nabil Sabor, Wavelet Threshold Based ECG Data Compression Technique Using Immune Optimization Algorithm, International Journal of Signal Processing, Image Processing and Pattern Recognition Vol. 8, No. 2 (2015), pp. 347-360.

[5] Pratik Chavada, Narendra Patel, and Kanu Patel, Region of Interest Based Image Compression, International Journal of Innovative Research in Computer and Communication Engineering, Vol. 2, Issue 1, PP2747-2754, January 2014.

[6] M. J. Weinberger, G. Seroussi and G. Sapiro, 'The LOCO-I loss less image compression algorithm: Principles and standardization into JPEG-LS", IEEE Trans. on Image Processing, Vol. 2, pp. 1309-1324, Aug. 2000.

[7] Othman Khalifa, "Wavelet Coding Design for Image Data Compression", The International Arab Journal of Information Technology, Vol. 6, No. 2, pp. 118-127, April 2009

[8] J. Uthayakumar, T. Vengattaraman and P. Dhavachelvan, "A Survey on Data Compression Techniques: From the Perspective of Data Quality, Coding Schemes, Data Type and Applications," J. King Saud Univ. Inf. Sci., 2018.

[9] A. Mr, S. Subramanian and S. Mr, "Comparing PSNR of Different Image Transforms (DCT, DFT, DWT, DHT, DTT)," 2018.

[10] Nashar Luthfi Sugara, T. W. Purboyo and A. L. Prasasti, "Comparative Analysis of Image Compression Using Huffman and DCT Method on JPG Image," J. Eng. Appl. Sci., vol. 13, pp. 4447-4452, 2018.

[11] G. Suseela and Y. A. V. Phamila, "Energy Efficient Image Coding Techniques for Low Power Sensor Nodes: A Review," Ain Shams Eng. J., vol. 9, no. 4, pp. 2961–2972, 2018.

[12] A. H. M. J. I. Barbhuiya, T. A. Laskar and K. Hemachandran, "An Approach for Color Image Compression of JPEG and PNG Images Using DCT and DWT," Proc. of the International Conference on Computational Intelligence and Communication Networks (CICN), pp. 129–133, 2014.

[13] A. J. Maan, "Analysis and Comparison of Algorithms for Lossless Data Compression," Int. J. Inf. Comput. Technol., vol. 3, no. 3, pp. 139–146, 2013.

[14] A. M. G. Hnesh and H. Demirel, "DWT-DCT-SVD Based Hybrid Lossy Image Compression Technique," Proc. of the International Conference on Image Processing, Applications and Systems (IPAS), pp. 1–5, 2016.

[15] R. Kher and Y. Patel, "Medical Image Compression Framework Based on Compressive Sensing, DCT and DWT," Biology, Engineering and Medicine, vol. 2, no. 2, pp. 1–4, 2017.

[16] S. Sharma and S. Kaur, "Image Compression Using Hybrid of DWT, DCT and Huffman Coding," Int. J. Sci. Emerg. Technol. with Latest Trends, vol. 5, no. 1, pp. 19–23, 2013.

[17] O. Ghorbel, "DCT & DWT Image Compression Algorithms in Wireless Sensor Networks: Comparative Study and Performance Analysis," Int. J. Wirel. Mob. Networks, 2013.

[18] A. Katharotiya, S. Patel and M. Goyani, "Comparative Analysis between DCT and DWT Techniques of Image Compression," J. Inf. Eng. Appl., vol. 1, no. 2, pp. 9–17, 2011