

Hybrid DWT-DCT Algorithm for Digital Image Watermarking and Compression Applications

¹ A.Venkateswarlu, ² Dr.V.Siva Kumar Reddy, ³ Dr.N.Usha Rani

¹ Associate Professor & Head, Dept. of ECE, Adam's Engg. College, Paloncha, Khammam, Telangana, India

² Professor- Dept. of ECE, Principal & MRCET, Hyderabad, Telangana, India.

³ Professor & Head - Dept. of ECE, Vignan University, Guntur, Andhra Pradesh, India

Abstract: Digital image watermarking is process of adding some information in image in form of text, image and logo for the purpose of owner identification and security. This information may be in visible or in invisible form. So that anyone can be extracted that info when required for a particular purposes. The main obstacle in extraction process of watermark information is the different-2 attacks perform of watermarked image. These attacks degrade the watermark information embedded in watermarked image. Sometimes they affected so much as the watermark information will be destroyed. Digital image in their raw form require a more amount of storage capacity. Considering the important role played by digital imaging and video, it is necessary to develop a system that produces high degree of compression while preserving critical image information. There is various transformation techniques used for data compression. Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT) are the most commonly used transformation. DCT has high energy compaction property and requires less computational resources. On the other hand, DWT is multi resolution transformation. In this work, we propose a hybrid DWT-DCT algorithm for image compression and reconstruction taking benefit from the advantages of both algorithms. The algorithm performs the Discrete Cosine Transform (DCT) on the Discrete Wavelet Transform (DWT) coefficients. Simulations have been conducted on several natural, benchmarks, medical and endoscopic images.

The simulation results show that the proposed hybrid DWT-DCT algorithm performs much better than the standalone JPEG-based DCT, DWT, and WHT algorithms in terms of Peak Signal to Noise Ratio (PSNR). The new scheme reduces "false contouring" and "blocking artifacts" significantly. The rate distortion analysis shows that for a fixed level of distortion, the number of bits required to transmit the hybrid coefficients would be less than those required for other schemes Furthermore, the proposed algorithm is also compared with the some existing hybrid algorithms. The comparison results show that, the proposed hybrid algorithm has better performance and reconstruction quality.

I. Introduction

Study has shown that the 90% of total volume of data in internet access consists of image and video related data [1]. Image and video in their raw (uncompressed) form requires huge storage space. Such raw data needs large transmission bandwidth for the transmission over the network. Hence, lots of researches have been conducted in the field of data compression system. However, in this modern internet age, the demand for data transmission and the data storage are increasing. In this concern, data compression and reconstruction is the only option to relieve the network congestion. The compression technique reduces the size of data, which in turn requires less bandwidth and less transmission time and related cost. There are algorithms developed for the data compression such as: Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT), Walsh Hadamard Transform (WHT), etc. Study has shown that the 90% of total volume of data in internet access consists of image and video related data [1]. Image and video in their raw (uncompressed) form requires huge storage space. Such raw data needs large transmission bandwidth for the transmission over the network. Hence, lots of researches have been conducted in the field of data compression system. However, in this modern internet age, the demand for data transmission and the data storage are increasing. In this concern, data compression and reconstruction is the only option to relieve the network congestion. The compression technique reduces the size of data, which in turn requires less bandwidth and less transmission time and related cost. There are algorithms developed for the data compression such as: Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT), Walsh Hadamard Transform (WHT), etc.

1.1 Motivation and Objectives

Data compression is one of the major areas of the research in image and video processing applications. With the development of computer and internet technology, more multimedia-based information is being transmitted over the internet and wireless networks. The raw data to be transmitted consumes large bandwidth and requires huge storage space; as a result, it is desirable to represent the information in the data with

considerably fewer bits by the mean of data compression techniques. At a same time, the data compression technique must be able to reconstruct the data very close to original data. This can be achieved via an effective and efficient compression and decompression algorithms.

II. Literature Survey

Image/Video is digitally represented in a set of pixel. Generally the neighboring pixels are correlated to each other and are redundant in nature. The redundancy unnecessarily occupies storage space which in turn increases the transmission cost and the bandwidth of the system.

Hence, it is necessary to reduce the redundancy of an image/video. The reduction in redundancy can be achieved by means of data compression techniques. The main idea behind the compression technique is to use orthonormal transformation making the pixel value smaller than the original. The transformation of the data also makes the coefficients of the transformed matrix uncorrelated to each other. There are various methods of transformations being used for data compression as follows:

- i. Karhunen-Loeve Transform (KLT)
- ii. Discrete Fourier Transform (DFT)
- iii. Discrete Sine Transform (DST)
- iv. Walsh Hadamard Transform (WHT)
- v. Discrete Cosine Transform (DCT)
- vi. Discrete Wavelet Transform (DWT)

2.1 Karhunen-Loeve Transform: Among the above transformation techniques, KLT is the optimal transformation technique which always results exactly uncorrelated transformed coefficients. Moreover, KLT has the minimum mean square error as compared to other transformation techniques. It also has high energy compaction property i.e. it keeps as much energy as possible in few coefficients. However, one of the drawback of KLT is it is non separable transformation thus; it requires large computational resources as compared to other transformation techniques.

2.2 Discrete Cosine Transform (DCT)

A DCT represents the input data points in the form of a sum of cosine functions that are oscillating at different frequencies and magnitudes. There are mainly two types of DCT: one dimensional (1-D) DCT and two dimensional (2-D) DCT. Since an image is represented as a two dimensional matrix, for this research work, 2-D DCT is considered. The 2-D DCT for an input sequence can be defined as follows:

$$D_{DCT}(i, j) = \frac{1}{\sqrt{2N}} B(i) B(j) \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} M(x, y) \cos \left[\frac{2x+1}{2N} i\pi \right] \cos \left[\frac{2y+1}{2N} j\pi \right]$$

where,

$$B(u) = \begin{cases} \frac{1}{\sqrt{2}} & \text{if } u = 0 \\ 1 & \text{if } u > 0 \end{cases}$$

In the DCT compression, almost all of the information is concentrated in a small number of the low frequency coefficients. These low frequency coefficients are also known as DC components and the rest of the components are AC components. The DCT coefficients are then quantized using a 8*8 quantization table, Q, as described in the Joint Photographic Expert Group (JPEG) standard.

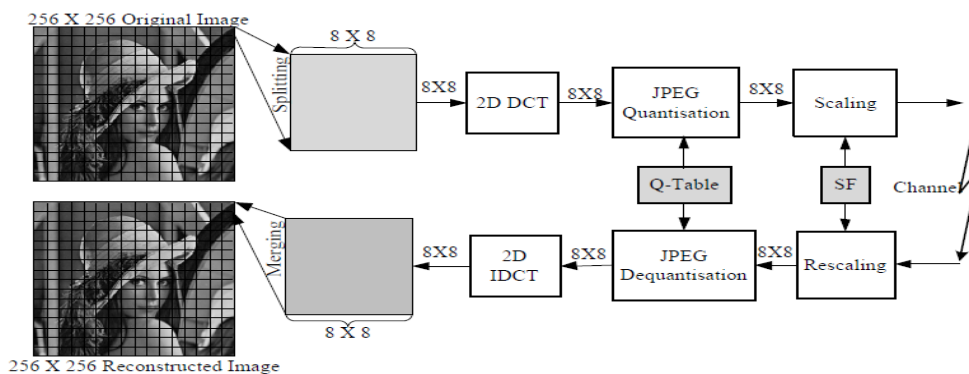


Figure 2.1. Block diagram of JPEG-based DCT

2.3 Discrete Wavelet Transform (DWT)

The DWT represents an image as a sum of wavelet functions, known as wavelets, with different location and scale [8]. It represents the data into a set of high pass (detail) and low pass (approximate) coefficients. The input data is passed through set of low pass and high pass filters.

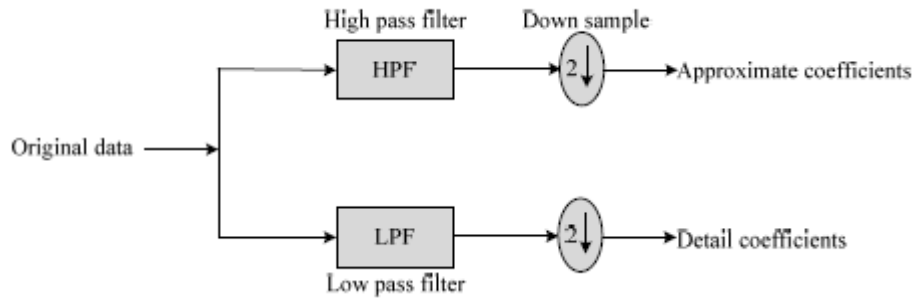


Figure 2.2 Block diagram of 1-D forward DWT

In case of 2-D DWT, the input data is passed through set of both low pass and high pass filter in two directions, both rows and columns. The outputs are then down sampled by 2 in each direction as in case of 1-D DWT. The complete process is illustrated in Figure 2.3. As shown in Figure 2.2, output is obtained in set of four coefficients LL, HL, LH and HH. The first alphabet represents the transform in row where as the second alphabet represents transform in column. The alphabet L means low pass signal and H means high pass signal. LH signal is a low pass signal in row and a high pass in column. Hence, LH signal contain horizontal elements. Similarly, HL and HH contains vertical and diagonal elements, respectively.

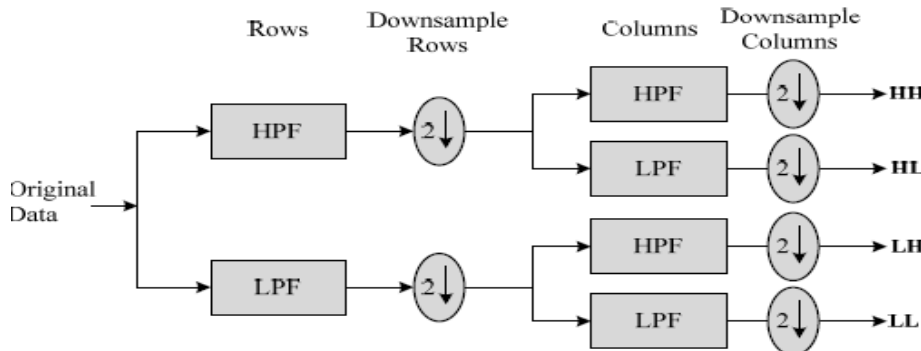


Figure 2.3 Block diagram of 2-D forward DWT

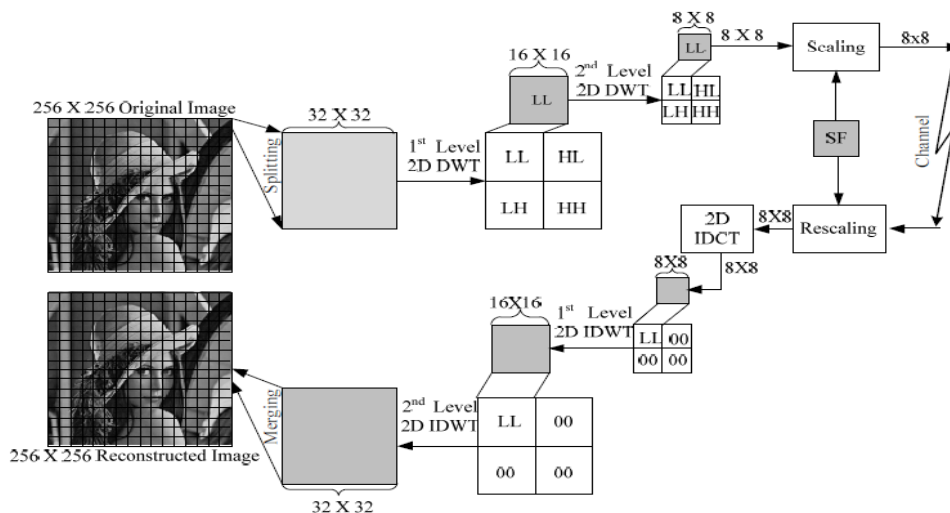


Figure 2.4. Block diagram of the DWT decomposition

III. Proposed Hybrid DWT-DCT Algorithm

3.0 Introduction

For the lower compression ratio, the DCT algorithm shows higher energy compaction characteristics and requires less computational complexity as compared to other compression methods: DFT, DST, WHT, and DWT. However, it introduces the blocking artifacts and the false contouring effect at the higher compression ratio. Furthermore it is not a multi-resolution technique. On the other hand, DWT is multi-resolution compression method i.e. an image can be obtained in different resolutions by discarding the detail coefficients and taking only the approximate coefficient. But, the energy compaction characteristic of DWT is less as compared to DCT and requires more computational processor. Hence, multiple transform can be implemented in order to compensate the drawback of each other. In this research work, a hybrid DWT-DCT algorithm has been proposed.

Hybrid DWT-DCT algorithm

3.1 The process of data compression

Given consideration of the type of application, the original image/frame of size 265×265 (or any resolution, provided divisible by 32) is first divided into blocks of size 32×32 . Each block 32×32 is then decomposed using the 2-D DWT. The high-frequency coefficients HL, LH, and HH are discarded. At this level, seventy five percent of data are compressed. The low frequency coefficients (LL) are passed to the next stage. The passed LL components are further decomposed using 2-D DWT. The compression level can be adjusted by applying various DWT sub sampling methods.

The concepts of DWT sub sampling is pictorially explained in Figure 3.1. Figure 3.1-

(a) shows the fully sampled DWT sub sampling, (b) shows the quarterly sampled DWT sub sampling and (c) shows the half sampled DWT sub sampling.

Fully sampled DWT sub sampling: In this method of DWT sub sampling, all the LL, HL, LH, and HH coefficients are taken into consideration.

Quarterly sampled DWT sub sampling: In this method of DWT sub sampling, all the HH coefficients are discarded.

Half sampled DWT sampling: Similarly, by the half sampled DWT sub sampling, means taking odd and even coefficients from either HL, or HL set and discarding the HH coefficients.

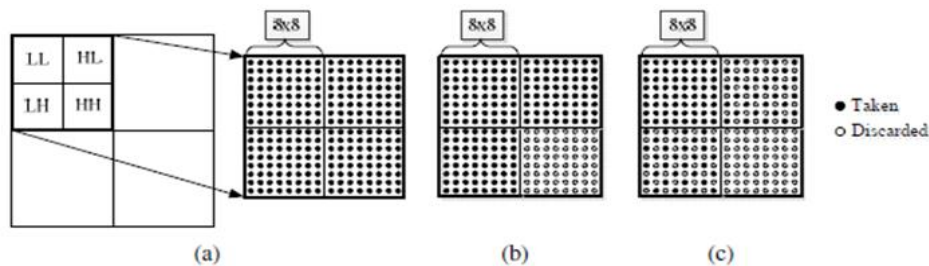


Figure 3.1. Sub-sampling of the DWT coefficients: (a) fully sampled; (b) quarterly sampled; (c) half sampled

After the DWT sub sampling, the 8-point DCT is applied to these DWT coefficients. To achieve further compression, a JPEG-like quantization is performed. In this stage, most of the higher frequency components are rounded to zero. The quantized coefficients are further scaled using scalar quantity known as scaling factor (SF). The entire hybrid DWT-DCT compression process is illustrated in Figure 3.2.

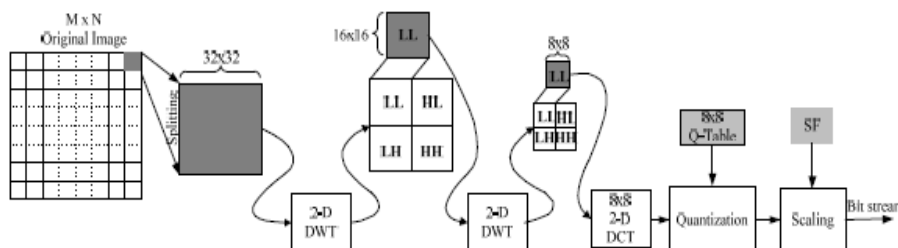


Figure 3.2. Block diagram of the proposed hybrid DWT-DCT algorithm: Compression

The process of data reconstruction

The bit stream after the SF is the compressed data of interest. It is rescaled by same SF for the reconstruction procedure. Furthermore, the output rescaled data are dequantized by using the same JPEG quantization table used for the compression procedure. The dequantized data are passed through 2-D inverse DCT. The data obtained after inverse 2-D DCT is then passed through the 2-D inverse DWT at first level. During the 2-D inverse DWT, zero values are padded in place of the detail coefficients. Finally, the output from first level 2-D DWT passed through the 2-D inverse DWT in second level and hence the final image is reconstructed. The entire reconstruction procedure is illustrated in Figure 3.3.

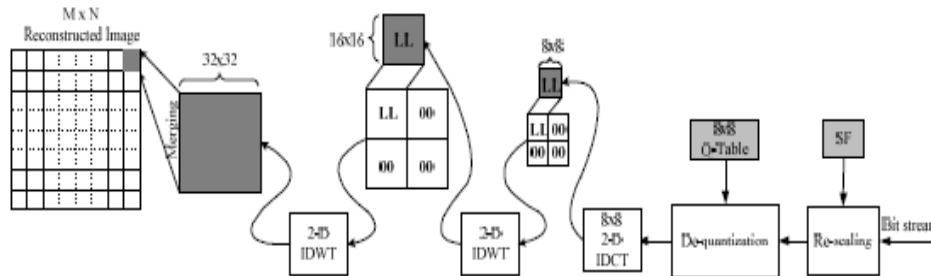


Figure 3.3. Block diagram of the proposed hybrid DWT-DCT algorithm: Reconstruction

A standard image ‘Lena’ of size 256*256 is taken as example to illustrate the effectiveness of the proposed hybrid algorithm. The image is transformed and reconstructed using proposed hybrid and stand alone DCT, DWT, and FWHT algorithm as well in order to verify the results. The image is compressed at compression ratio (CR) of around 96% for all of the three algorithms.

In Figure 3.4, (a) is the original image, (b) is the reconstructed image using DCT, (c) is the reconstructed image using DWT (d) is the reconstructed image using WHT, and (e) is the reconstructed image using proposed hybrid algorithm. When the image is reconstructed using standalone DCT, the PSNR of this image is 28.66dB. Some blocking artifacts and the contouring effect (around the wall) can be observed in such image. For the image reconstructed using DWT, and FWHT, the PSNR is 25.49 dB, and 25 dB respectively. The visual quality of the reconstructed image using DWT and WHT are also worst as compared to others. However, the PSNR for the image that is reconstructed using proposed hybrid algorithm is 30.01 dB, which is quite high than other algorithms. It can also be observed that the image is free from blocking artifacts and the false contouring effect.

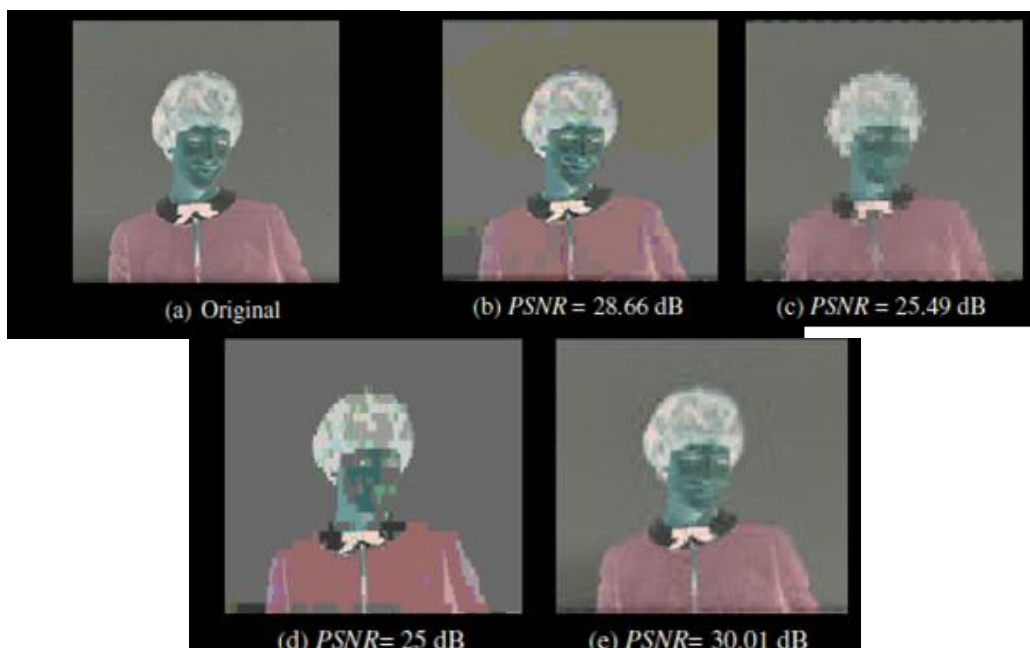




Figure 3.4. Image compression at compression ratio of 96% (a) Original image, (b) Reconstructed image using (b) DCT , (c) DWT, (d), FWHT, (e) Hybrid algorithm

The results of above hybrid algorithm are impressive as getting PSNR value more than 40db which is acceptable value for any good watermarking algorithm. So that the algorithm is perceptible and robust against visual attacks. Results for image leena.bmp is

Table 1: Results for Cover Image

S.no	Cover Image	Extracted Watermark	MAE	PSNR
1			1.9681e-04	44.000

The approach of combining multiple transformations i.e. DWT and DCT has been presented in this chapter. The hybrid algorithm compensated the demerits of standalone DCT and DWT. The proposed algorithm reduced the blocking artifacts that appeared in case of DCT. In standalone DCT, the entire image/frame is divided into 8*8 block in order to apply 8 point DCT. Whereas, in case of hybrid algorithm, image/frame is first divided into 32*32 blocks and two level of DWT is performed for these 32*32 block image. The output after the two level of DWT becomes 8*8 and hence the 8 point DCT is applied for that 8*8 output. This difference in block size causes the blocking artifacts in case of standalone DCT. Similarly, the contouring effect of DCT has also been reduced by using proposed hybrid DWT-DCT algorithm.

IV. Conclusion

In this research work, a hybrid scheme combining the DWT and the DCT algorithms under high compression ratio constraint for image and video compression has been presented. The algorithm was tested on several types of images, such as, natural, medical, and benchmark images. Moreover, the proposed algorithm was also compared with some standards and already Developed hybrid algorithms. It was observed that the proposed hybrid algorithm performs better than the existing algorithms.

References

- [1]. P. N. Topiwala, Wavelet image and video compression. Kluwer Academic, 1998.
- [2]. B. Furht, Ed., Encyclopedia of Multimedia. Springer, 2006.
- [3]. R. K. Rao and P. Yip, Discrete Cosine Transform: Algorithms, Advantages and Applications. NY: Academic, 1990.
- [4]. W. B. Pennebaker and J. L. Mitchell, JPEG Still Image Data Compression Standard, 3rd ed. New York: Springer, 1993.
- [5]. G. Joy and Z. Xiang, "Reducing false contours in quantized color images," Computer and Graphics, Elsevier, vol. 20, no. 2, pp. 231–242, 1996.
- [6]. L. Chen, VLSI Design of Wavelet Transform: Analysis, Architecture and Design Examples. Imp. College press, 2007.
- [7]. R. A. DeVore, B. Jawerth, and B. J. Lucier, "Image compression through wavelet transform coding," IEEE Transactions on Information Theory, vol. 38, no. 2, pp. 719–746, 1992.
- [8]. G. Strang and T. Nguyen, Wavelets and Filter Banks. Cambridge Press, 1996.
- [9]. J. M. Shapiro, "Embedded image coding using zerotrees of wavelet coefficients," IEEE Transactions on Signal Processing, vol. 41, no. 12, pp. 3445–3462, 1993.
- [10]. A. Said and W. A. Pearlman, "A new, fast, and efficient image codec based on set partitioning in hierarchical trees," IEEE Transactions on Circuits and Systems for Video Technology, vol. 6, no. 3, pp. 243–250, 1996.
- [11]. ISO/IEC JTC1/SC29/WG1 N871 R, "Embedded, independent block-based coding of subband data," July 1998.
- [12]. ISO/IEC JTC1/SC29/WG1 N1020 R, "EBCOT: Embedded block coding with optimized truncation," Oct. 1998.
- [13]. A. Said and W. Pearlman, "Low-complexity waveform coding via alphabet and sample-set partitioning in visual communications and image processing," in Proc. SPIE, 1997, pp. 25–37.
- [14]. S.-T. Hsiang and J. W. Woods, "Embedded image coding using zeroblocks of subband/wavelet coefficients and context modeling," in Proc. ISCAS 2000 Geneva Circuits and Systems, vol. 3, 2000, pp. 662–665.
- [15]. R. Costantini, J. Bracamonte, G. Ramponi, J. L. Nagel, M. Ansoorge, and F. Pellandini, "Low complexity video coder based on discrete Walsh Hadamard transform," in Proc. European signal processing conference, 2002, pp. 1217–1220.
- [16]. Parthiban V, Ganesan R, "Hybrid Watermarking Scheme for Digital Images" Journal of Computer Applications ISSN: 0974 – 1925, Volume-5, Issue EICA2012-1, February 10, 2012
- [17]. Md. Maklachur Rahman, "A DWT, DCT and SVD based watermarking technique to protect the image piracy", International Journal of Managing Public Sector Information and Communication Technologies (IJMP ICT) Vol. 4, No. 2, June 2013
- [18]. Lalit Kumar Saini, Vishal Shrivastava, "A New Hybrid DWT-DCT Algorithm for Digital Image Watermarking", International Journal of Advance Engineering and Research Development (IJAERD), Volume 1, Issue 5, May 2014



Mr.A.VENKATESWARLU is presently pursuing Ph.D (Part-time) from Vignan University, Guntur; A.P. and Associate Professor & Head, Department of ECE, Adam's Engineering College, Paloncha. He received his B.Tech Degree in Electronics and Communication Engineering from JNT University, Hyderabad, and M.Tech Degree in Digital Systems and Computer Electronics from JNT University, Ananathapur. He had 2 Publications in International Conferences and also he had Professional Bodies member like, Member of IEEE, Member of ISTE.



Dr.V.Siva Kumar Reddy he had more than 20 years of experience at various levels of Academic and Administrative Positions. He is presently working as Professor & Principal, Department of ECE, MallaReddy College of Engg. & Tech., Medchal, Hyderabad. Research areas are Architectures for Signal Processing & Image/Video Coding and Video communications he had more than 75 Publications in various reputed International/National Journals and Conferences and also he had Professional Bodies member like Fellow of IETE, Member of IEEE, Member of ISTE.



Dr.N.Usha Rani she has more than 20 years of experience at various levels of Academic and Administrative Positions. She is presently working as Professor & Head, Department of ECE, Vignan University, Guntur. Research areas are Image/Video processing and video communications. She has more than 45 Publications in various reputed International/National Journals and Conferences. She has Professional Bodies member like Member of IEEE, and Member of ISTE.