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Improved Performance for "Color to Gray and Back" using DCT-Walsh, DST-Walsh, Haar-Walsh, Hartley-Walsh, Slant-Wash, Kekre-Walsh Hybrid Wavelet Transform

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Abstract – *In this paper comparison of Discrete Cosine Transform-Walsh, Discrete Sine Transform-Walsh, Haar-Walsh, Hartley-Walsh, Slant-Wash, and Kekre-Walsh Hybrid Walsh Transforms using Normalization for 'Color to Gray and Back'. Using hybrid wavlet transform and normalization color information of the image is embedded into a gray scale image. The aim of this paper is to provide better bandwidth or storage utilization instead of original color image, gray image can be used. Among the proposed techniques, technique 2 for Discrete Cosine Transform – Walsh Hybrid Wavlet Transform gives the better performance in comparison to other Hybrid Wavlet Transform. The purpose is to achieve compression of 66.66% and to store and transmit gray image instead of color image and will be able to regenerate the color information afterwards from it.*

Keywords- *Color Embedding, Color-to-Gray Conversion, Transforms, Hybrid Wavelet Transforms, Normalization, Compression*

I. INTRODUCTION

Digital color image can be classified as 24 bit plane and gray image as 8 bit plane. Various devices resulted in development of color image but still there is in demand to convert color image as gray image which results in the lower of running cost, data quantity and maintain network traffic, etc.

Color image can be converted into gray image using a linear combination of RGB color element uniquely but still there is a problem in finding an RGB vector from a luminance value. Therefore, it is not possible theoretically to completely restore color image from a gray image. To solve this recently, colorization technique has been proposed which can restore color image from the gray image strongly depending on the color hints given by a user as initial condition subjectively [2]-[5].

Due to the increase in the size to database because of color image in a recent year. There is need to reduce the size of the data by enabling information of all individual plane in color image into a single plane of gray image which result into the reduce of bandwidth require to transmit the image over a network[6]-[12]. Resulted gray image can be printed using a conventional fax machine from a color image [7].Original color image can be retrieve from a gray image.

In this paper we have used three different techniques of color to gray using DCT-Walsh, DST-Walsh, Haar-Walsh, Hartley-Walsh, Slant-Wash, Kekre-Walsh Hybrid Wavelet Transform and normalization which results into recovered color image from the generated gray image which is almost similar to original color image. In technique 1 the color information in normalized form is hidden in LH and HL area of first component as in Figure 1. In technique 2 its hidden in HL and HH area of first component as in Figure1 and in technique 3 the color information in normalize form is hidden in LH and HH area of first component as in Figure 1. In the Second and Third component each pixel value is divided by 256 to minimize the error is known as normalization [14].

The paper has schema as follows. Section 2 describes hybrid wavelet transform generation. Section 3 presents the proposed system for "Color to Gray and Back". Section 4 describes experimental results and finally the concluding remarks and future work are given in section 5.

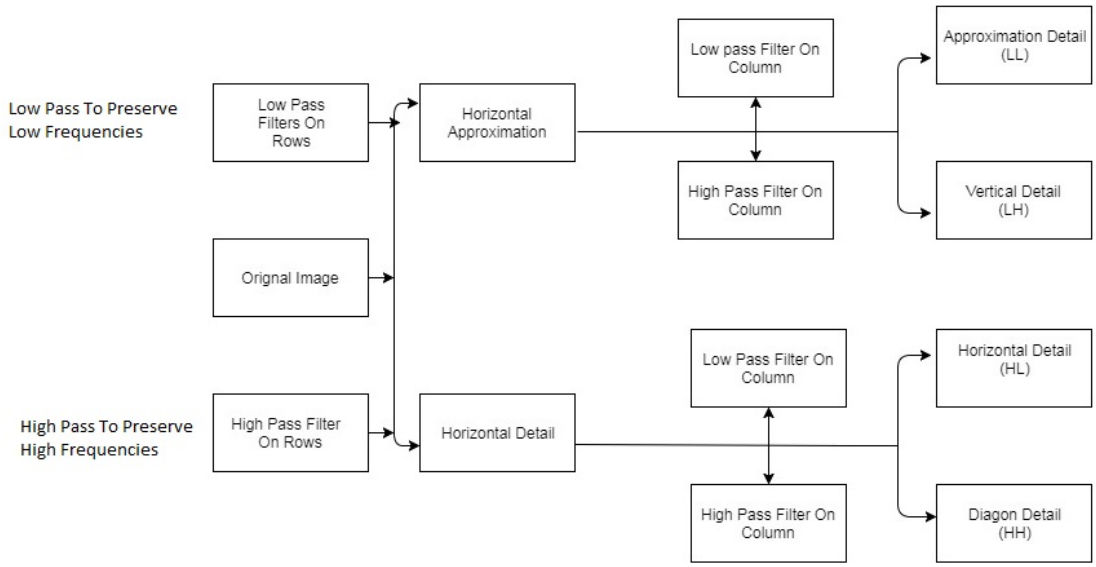

Figure 1: Subbands in transform domain

Hybrid Wavlet Transform

Kronecker product, denoted by ⊗, is an operation on two matrices of arbitrary size resulting in a block matrix. If A is an m × n matrix and B is a p × q matrix, then the Kronecker product A⊗ **B** is the mp × nq block matrix as shown in given equation:

$$A \otimes B = \begin{bmatrix} a11B & a12B & \cdots & a1nB \\ a21B & a22B & \cdots & a2nB \\ \vdots & \vdots & \vdots & \vdots \\ am1B & am2B & \cdots & amnB \end{bmatrix}$$

Hybrid wavlet transform is combining the trait traits of two different orthogonal transform which can be generated from matrices A and B of size pxq and qxp hwere N=p*q=pq. First 'q' number of rows of the hybrid wavlet transform is calculated using a Kronecker product of each element whereas the next q' rows of Kronecker product of Identify matrices.

$$C = \begin{bmatrix} c11 & c12 & \ldots & c1p \\ c21 & c22 & \ldots & c2p \\ \vdots & \vdots & \vdots & \vdots \\ cp1 & cp2 & \ldots & cpp \end{bmatrix} \begin{matrix} C1 \\ C2 \\ \vdots \\ CP \end{matrix}$$

$$D = \begin{bmatrix} d11 & d12 & \ldots & d1q \\ d21 & d22 & \ldots & d2q \\ \vdots & \vdots & \vdots & \vdots \\ dq1 & dq2 & \ldots & dqq \end{bmatrix}$$

Here first 'q' rows are calculated using Kronecker product of D and C of Hybrid Wavlet Transform matrix whereas next 'q' rows are calculated using identity matrix (I_q into Cp where p=2 to p) [1] as shown in given equation:

$$Iq \otimes Cp$$

II. PROPOSED METHOD

In this section, we have proposed three techniques of color to gray and recovered color method.

Color Embedding Algorithm

The color Embedding process is explain in Figure 2 is as shown below:

1. Firstly separate the color component of a color image into RGB plane.
2. Then, R-plane component of size NxN remain as it is and the size of G-Plane and B-plane is reduced to half i.e N/2.
3. Second and Third color component i.e G-plane and B-plane are normalized i.e pixel value is divided by 256 to minimize the embedding error.
4. To First color component i.e R-plane Hybrid Wavlet Transform is applied and divide it into four subbands as shown in Figure1 Low Pass[LL] , Vertical[LH] , Horizontal[HL], and diagonal [HH] subbands.
5. Technique 1: LH is replaced by normalized second color component, HL is replaced by normalized third color component.
   Technique 2: HL is replaced by normalized second color component, HH is replaced by normalized third color component.
   Technique 3: LH is replaced by normalized second color component, HH is replaced by normalized third color component.
6. To obtain Gray Image of size NxN inverse Hybrid transform is applied.

Color Extracting Algorithm

The color Extracting explain in Figure 3 is as below:

1. On Matted gray image of size NxN Hybrid Wavlet Transform is applied to obtain back four subbands.
2. Technique 1: Retrieve LH and HL component as second color component and third color component of size N/2 x N/2 and the the first color component of size NxN.
   Technique 2: Retrieve HL and HH component as second color component and third color component of size N/2 x N/2 and the the first color component of size NxN.
   Technique 3: Retrieve LH and HH component as second color component and third color component of size N/2 x N/2 and the the first color component of size NxN.
3. By multiply by 256 De-Normalize Second & Third Component i.e G-plane and B-plane.
4. Second & Third Component is resized to NxN size by making the size double.
5. On first color component i.e R-plane Inverse Hybrid Wavlet transform is applied.
6. Merge all the color component I.e R-plane , G-plane and B-plane to obtain Recovered Color Image .

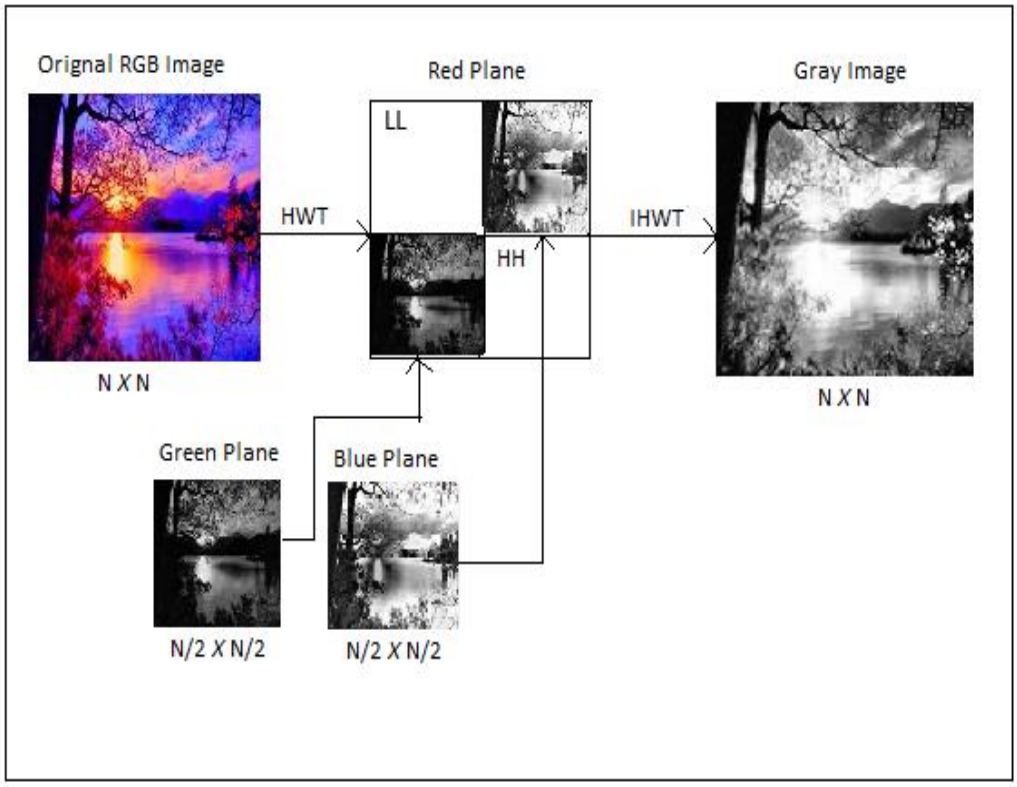

Figure 2: Generation of Gray Image from an Original Image using a transform

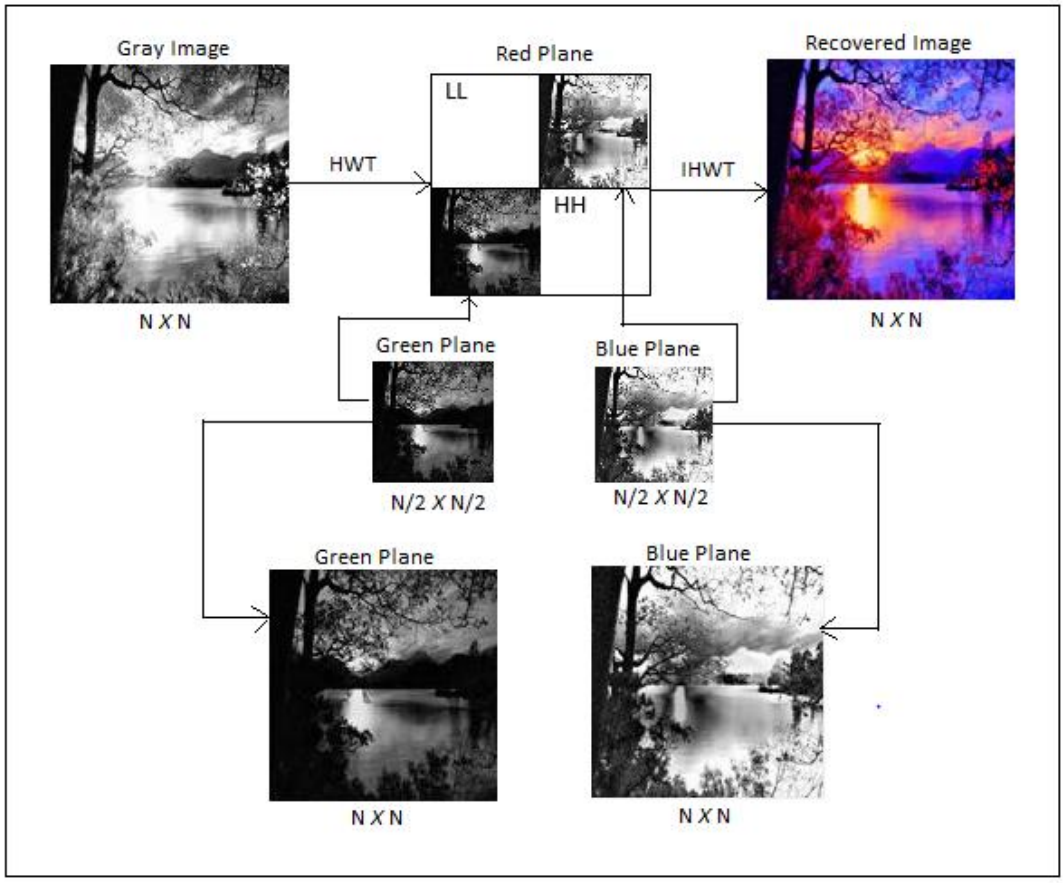

Figure 3: Generating a Recovered Image from Gray Image using a transform

III. RESULTS AND DISSCUSION

Experiment results shown in Figure 4 were noted on machine having Hardware and Software configuration.

1.Hardware Configuration

- Processor: Intel® Core™ i5-5200U CPU @2.20GHz
- RAM: 4.00GB
- System Type : 64 bit Operating System

2.Software Configuration:

- Operating System: Windows 7 Ultimate [64 bit].
- Software: Matlab 9.1.0.441655 (R2016b) [64 bit].

Using Mean Square Error (MSE) quality of 'Color to Gray and Back' is measured of original image with that of recovered image. In this experimental result is take for 16 different images of different granularity as shown in Figure 4 for DCT- Walsh HWT. It was observed that the gray images obtained from these techniques appears almost similar to the original gray image, which is due to the normalizing as it reduces the embedding error. Quality of the color image matters instead of matted gray image. Among all the hybrid wavelet transform tested it is observed from Table 1 and Figure 5 that for technique 1 DCT-Walsh HWT gives least MSE between Original Color Image and the Recovered Color Image. Among all the hybrid wavelet transform tested it is observed from Table2 and Figure 6 that for technique 2 DCT - Walsh HWT gives least MSE between Original Color Image and the Recovered Color Image. And similarly among all the hybrid wavelet transform tested it is observed from Table3 and Figure6 that for technique 3 DCT – Walsh HWT gives least MSE between Original Color Image and the Recovered Color Image. From all the techniques we can observe from Figure8 that for DCT – Walsh HWT we get the best results for the technique 2.

Figure 4: Images Used for an Experiment

Table 1: MSE of Original Color w.r.t. Recovered Color Image (Method 1)

	Hybrid Wavlet Transform					
	DCT - Walsh HWT	**DST - Walsh HWT**	**Harsh - Walsh HWT**	**Hartely - Walsh HWT**	**Slant - Walsh HWT**	**Kekre - Walsh HWT**
Img1	52.19	103.98	83.58	245.23	216.74	211.88
Img2	59.39	89.70	78.64	179.91	175.53	163.22
Img3	28.13	159.68	36.42	79.35	66.49	70.46
Img4	48.32	134.76	55.16	101.11	85.74	92.55
Img5	45.76	168.68	60.65	155.67	127.52	128.36
Img6	55.65	205.54	69.54	161.00	139.28	135.55
Img7	408.17	514.93	471.88	710.12	725.51	693.73
Img8	60.30	204.09	74.03	153.22	140.74	134.29
Img9	45.08	219.86	60.28	145.55	136.09	131.78
Img10	236.94	357.14	270.80	422.03	402.46	405.96
Img11	139.87	198.73	166.84	314.81	294.90	297.73
Img12	28.43	31.91	29.89	36.65	36.81	36.38
Img13	351.25	422.82	395.40	499.21	493.57	479.31
Img14	36.89	147.07	47.65	47.65	122.02	124.97
Img15	76.90	245.06	98.97	190.88	176.11	168.81
Img16	84.02	281.21	96.61	164.97	159.40	155.35
Avg	**109.83**	**217.82**	**131.02**	**225.46**	**218.68**	**214.40**

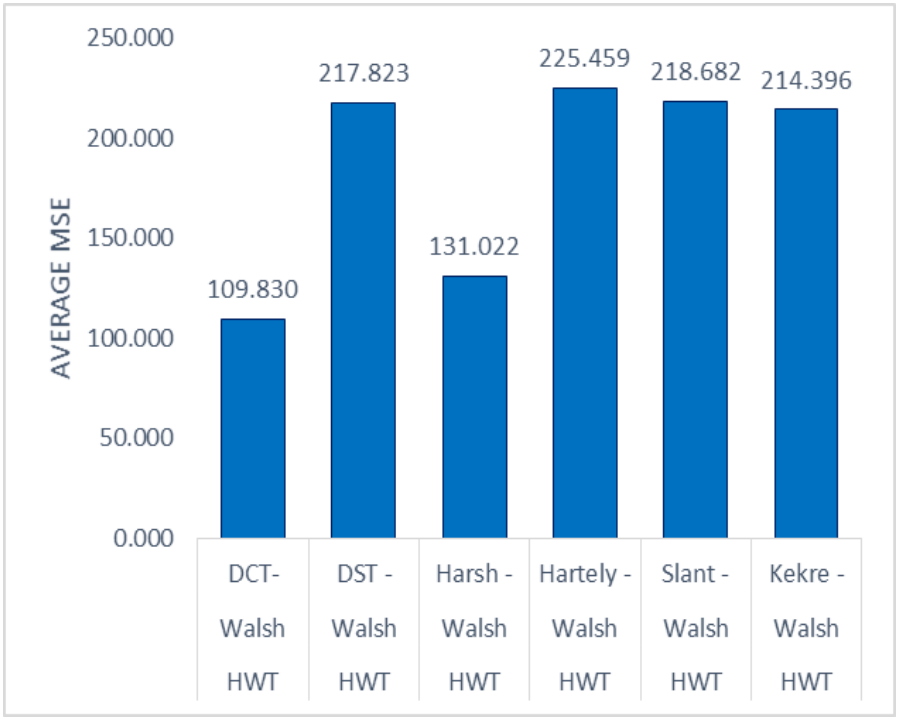

Figure 5: Average MSE of Original Color w.r.t Recovered Color (Method 1)

Table 2: MSE of Original Color w.r.t. Recovered Color Image (Method 2)

	Hybrid Wavlet Transform					
	DCT-Walsh HWT	**DST-Walsh HWT**	**Harsh-Walsh HWT**	**Hartely-Walsh HWT**	**Slant-Walsh HWT**	**Kekre - Walsh HWT**
Img1	44.81	69.81	65.39	195.08	188.01	172.65
Img2	54.93	69.48	66.63	143.12	142.15	127.79
Img3	26.28	94.62	31.29	62.77	59.67	57.50
Img4	44.74	89.29	48.57	77.75	71.55	71.96
Img5	43.01	108.45	52.01	118.67	107.55	102.83
Img6	47.59	127.88	53.80	103.35	90.99	95.97
Img7	339.14	392.71	378.71	570.36	600.11	560.90
Img8	50.12	126.72	55.14	96.12	90.77	89.19
Img9	38.26	130.13	46.43	103.88	99.32	93.25
Img10	214.05	278.73	234.92	347.45	349.13	341.21
Img11	126.01	153.52	144.86	268.19	261.85	254.21
Img12	27.31	29.03	28.37	33.05	34.56	33.58
Img13	305.11	351.19	342.09	442.62	441.13	417.82
Img14	28.73	88.18	35.72	107.36	95.97	94.04
Img15	64.18	153.94	74.60	130.74	114.41	123.18
Img15	70.71	175.88	77.25	111.90	113.10	104.67
Avg	**95.31**	**152.47**	**108.49**	**182.02**	**178.77**	**171.30**

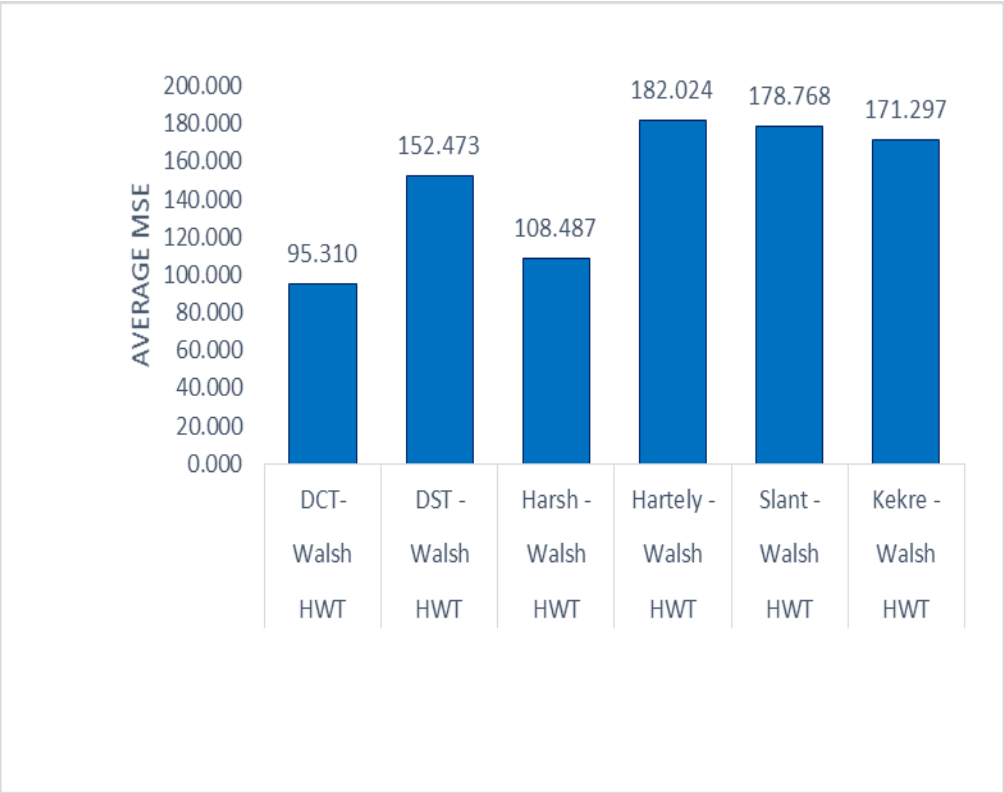

Figure 6: Average MSE of Original Color w.r.t Recovered Color (Method 2)

Table 3: MSE of Original Color w.r.t. Recovered Color Image (Method 3)

	Hybrid Wavlet Transform					
	DCT-Walsh HWT	**DST-Walsh HWT**	**Harsh-Walsh HWT**	**Hartely-Walsh HWT**	**Slant-Walsh HWT**	**Kekre-Walsh HWT**
Img1	40.25	68.40	56.13	56.13	146.63	138.14
Img2	50.84	67.22	61.27	61.27	135.44	117.61
Img3	26.08	94.47	30.41	30.41	56.38	54.11
Img4	44.49	88.47	48.72	48.72	76.92	76.61
Img5	42.02	105.90	49.37	49.37	94.05	90.52
Img6	53.42	134.80	63.16	63.16	128.44	109.80
Img7	373.74	429.75	414.88	414.88	656.28	608.61
Img8	58.74	134.82	69.53	69.53	133.96	121.89
Img9	42.19	136.46	51.26	51.26	113.63	103.47
Img10	223.71	285.42	244.41	244.41	357.06	350.03
Img11	122.38	154.44	135.00	135.00	207.50	203.29
Img12	27.81	29.59	28.60	28.60	34.25	33.76
Img13	315.02	342.31	335.52	335.52	450.77	428.76
Img14	31.32	89.51	37.38	37.38	72.90	73.42
Img15	64.00	153.76	77.85	77.85	146.47	125.41
Img16	77.31	182.96	85.19	85.19	135.57	137.94
Avg	**99.58**	**156.14**	**111.79**	**111.79**	**184.14**	**173.33**

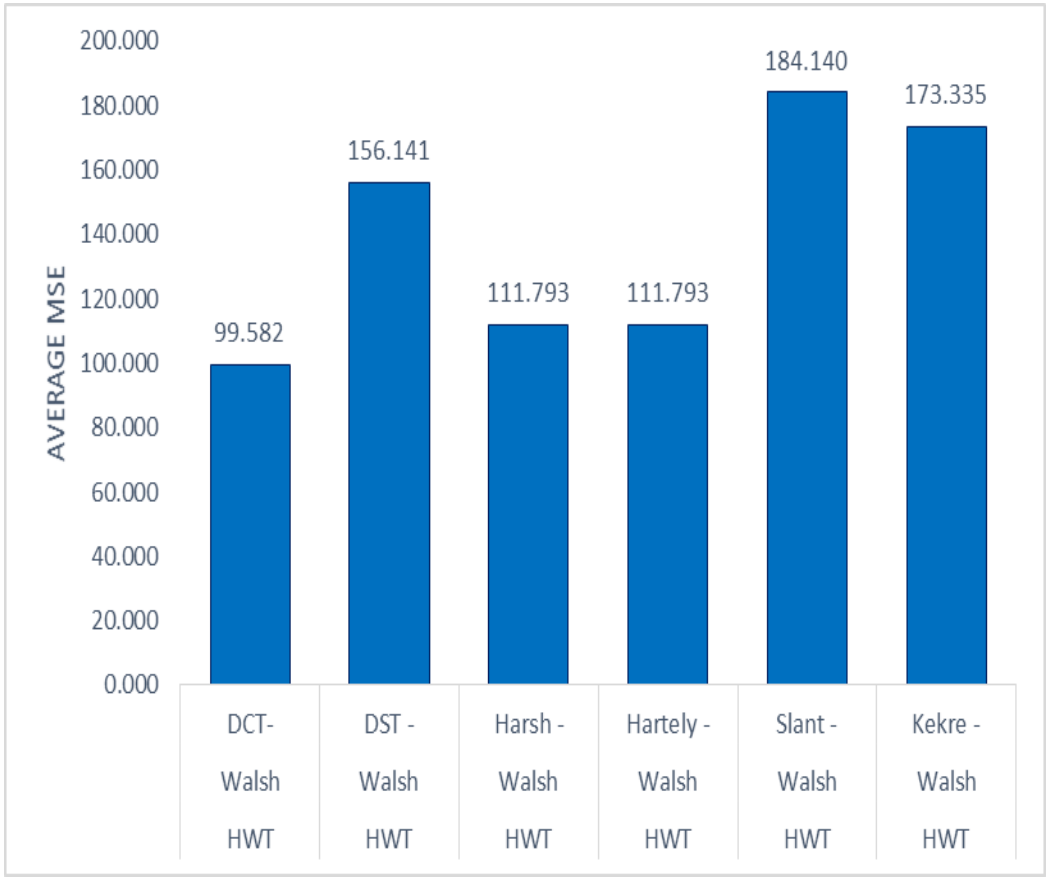

Figure 7: Average MSE of Original Color w.r.t Recovered Color (Method 3)

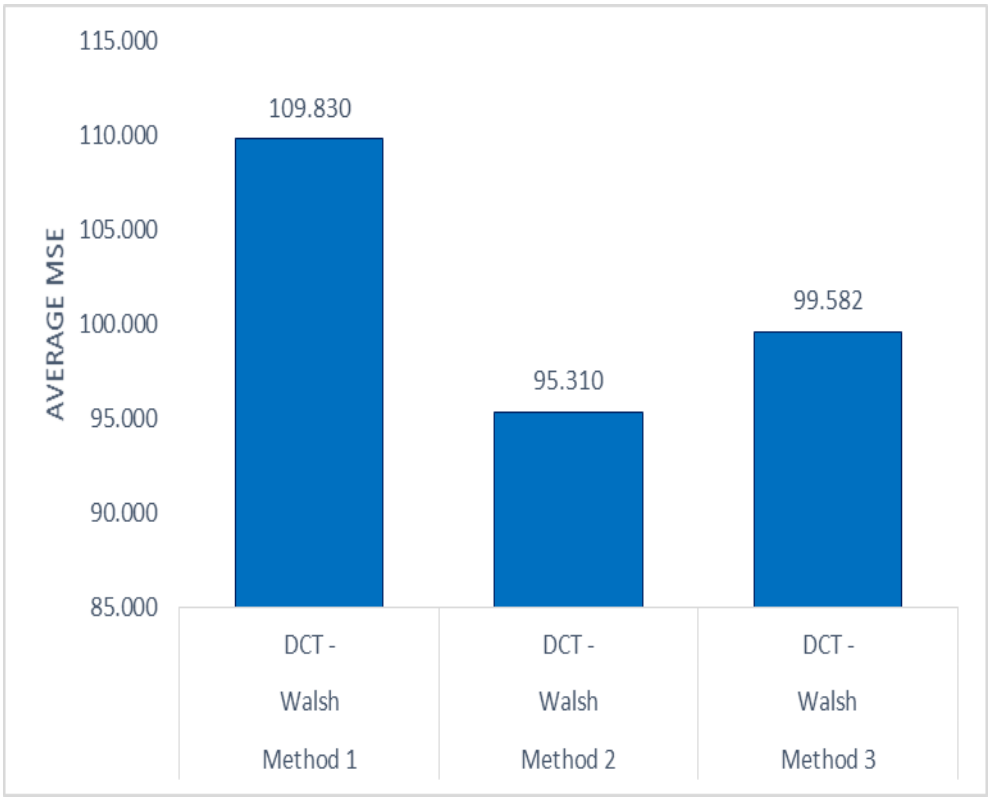

Figure 8 :Average MSE comparision for Orignal Color W.r.t Recovered Color Image for the best results of all the techniques.

Table 4: Comparison of Color Image, Load on Network (Gray Image) and Recovered Image

	Comparison of Color Image ,Load on Network(Gray Image) and Recovered Image		
	Original Image	**Gray Image**	**Recovered Image**
Img 1	11.9KB	6.03KB	10.61KB
Img 2	9.71KB	6.83KB	8.16KB
Img 3	10.70KB	1.07KB	8.77KB
Img 4	13.01KB	1.47KB	9.24KB
Img 5	14.79KB	11.68KB	12.30KB
Img 6	12.55KB	1.82KB	10.20KB
Img 7	26.27KB	6.15KB	17.31KB
Img 8	8.98KB	1.11KB	7.32KB
Img 9	14.41KB	1.12KB	11.95KB
Img 10	18.99KB	6.41KB	14.14KB
Img 11	15.47KB	12.04KB	11.72KB
Img 12	9.72KB	2.73KB	8.12KB
Img 13	16.45KB	3.38KB	11.90KB
Img 14	8.65KB	4.00KB	7.20KB
Img 15	11.02KB	1.31KB	8.75KB
Img 16	12.42KB	1.07KB	9.57KB

IV. CONCLUSION AND FUTURE WORK

In this paper we have proposed three technique to convert color image into gray image with color information embedding into it in two different regions and technique of retrieving color information from gray image. These allows us to achieve 66.66% compression and to store and send gray image instead of color image by embedding the color information into a gray image which is almost similar to an
original image. Based on DCT-Walsh, DST-Walsh, Haar-Walsh, Hartley-Walsh, Slant-Walsh and Kekre-Walsh HWT using Normalization approach DCT-Walsh HWT proved to be the best among all the transforms used in all three techniques. But among all the techniques, technique 2 using DCT-Walsh HWT gives the best results for "Color-to-Gray and Back". Even it is observed that the image named as img 10 as shown in Figure4 gave the maximum MSE for all the transform which shows that as granularity i.e. frequent changes in the intensity of a color of an image increases MSE of an image increases, so as smooth as the image will be there will be least MSE. Even it is concluded that while transferring the images on the various social media the compression of an image take place only on the image having a large size and due to this compression data of an image is being lost that is permanent in nature and with the proposed technique we can observe from Table [4] that the load on a network has been reduced by doing C2G on original image while transmitting and the recovered image is almost similar to an original colored image and the data loss is very less. Our next research step could be to test HWT with other color specious for "Color-to-Gray and Back".

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