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Improved Performance for "Color to Gray and Back" using Cosine, Haar and Slant Wavelet Transform with various Color *Spaces*

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Abstract: In this paper comparison of various Wavelet Transform with various color spaces using Image transforms alias DCT, Haar, And Slant for 'Color to Gray and Back'. Using Wavelet transform color information of the image is embedded into its gray scale version/equivalent. The aim of the paper is to provide better bandwidth and storage utilization instead of using the original color image for storage and transmission, gray (Gray scale version with embedded color information) can be used. Using three wavelet transforms and seven color spaces (YCbCr, YCgCb, YUV, YIQ, XYZ , YCC, Kekre's LUV And CMY) Twenty-Four variations of the algorithm for 'Color to Gray and Back' are being proposed. Among all considered image transforms and color spaces, Discreet Cosine Transform (DCT) gives better performance with YCbCr color space for 'Color to gray and Back'.

Keywords: - *Color Embedding, Color-to-Gray Conversion, Transforms, Color Space, Image Colorization, Information Hiding, Wavele .*

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I. INTRODUCTION

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 earlier researches, this has been done on various Wavelet Transform alias DCT, Haar, And Slant using RGB color spaces. Therefore. Further it has been extended using seven color spaces (YCbCr, YCgCb, YUV, YIQ, XYZ , YCC, Kekre's LUV And CMY).

The first step is to select the transform for which the wavelet need to be generated i.e. let's assume "4 x 4 Walsh transform as shown in Figure 1". The procedure of generating 16x16 Walsh wavelet transform from 4x4 Walsh transform is illustrated in Figure 2.

1	1	1	1
1	1	-1	-1
1	-1	-1	1
1	-1	1	-1

Figure 1: 4x4 Walsh Transform Matrix Figure

	1^{st} column of W4 Repeated N=4 times				2^{nd} column of W4 Repeated N=4 times				3^{rd} column of W4 Repeated N=4 times				4^{th} column of W4 Repeated N=4 times			
1 to 4 rows	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	-1	-1	-1	-1	-1	-1	-1	-1
	1	1	1	1	-1	-1	-1	-1	-1	-1	-1	-1	1	1	1	1
	1	1	1	1	-1	-1	-1	-1	1	1	1	1	-1	-1	-1	-1
5 to 8 rows	1	1	-1	-1	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	1	1	-1	-1	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	1	1	-1	-1	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	1	1	-1	-1
9 to 12 rows	1	-1	-1	1	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	1	-1	-1	1	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	1	-1	-1	1	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	1	-1	-1	1
13 to16rows	1	-1	1	-1	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	1	-1	1	-1	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	1	-1	1	-1	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	1	-1	1	-1

Figure 2: Generation of 16x16 Walsh wavelet transform from 4x4 Walsh transform

Wavelets for other transforms can also be generated using the same procedure.

The paper is organized as follows. Section II describes various color spaces. Section III presents Method to convert color-to-gray image. Section IV presents method to recover color image. Section V describes experimental results and finally the concluding remark are given in section VI.

II. COLOR SPACES

In this along with RGB eight other color space alice YCbCr, YCgCb, YUV, YIQ, XYZ , YCC, Kekre's LUV And CMY are also employed for 'Color-to-Gray and Back'

2.1 Kekre's LUV Color Space(K-LUV)

Kekre's LUV color space [4] is special form of Kekre Transform, where L is luminance and U andV are chromaticity value of color image. RGB to LUV conversion matrix is given in equation 1

$$\begin{bmatrix} L \\ U \\ V \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ -2 & 1 & 1 \\ 0 & -1 & 1 \end{bmatrix} * \begin{bmatrix} R \\ G \\ B \end{bmatrix} \text{---------(1)}$$

The LUV to RGB conversion matrix is given in equation 2.

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1 & -2 & 0 \\ 1 & 1 & -1 \\ 1 & 1 & 1 \end{bmatrix} * \begin{bmatrix} L \\ U \\ V \end{bmatrix} \text{---------(2)}$$

2.2 YCbCr Color Space

In YCbCr [4], Y is luminance and Cb and Cr are chromaticity value of color image. To get YCbCr components, convert RGB to YCbCr components. The RGB to YCbCr conversion matrix is given in equation 3.

$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 0.2989 & 0.5866 & 0.1145 \\ -0.1688 & -0.3312 & 0.5000 \\ 0.5000 & -0.4184 & -0.0816 \end{bmatrix} * \begin{bmatrix} R \\ G \\ B \end{bmatrix} \text{-------(3)}$$

The YCbCr to RGB conversion matrix is given in equation 4.

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.144 \\ -0.14713 & -0.22472 & 0.436 \\ 0.615 & -0.51498 & 0.0010 \end{bmatrix} * \begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} \text{------(4)}$$

2.3 YUV Color Space

The YUV color model [4] is used in PAL, NTSC, and SECAM composition color video standard. Where Y is luminance and U and V are chromaticity value of color image. To get YUV components, convert RGB to YUV components. The RGB to YUV conversion matrix is given in equation 5.

$$\begin{bmatrix} Y \\ U \\ V \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.144 \\ -0.14713 & -0.22472 & 0.436 \\ 0.615 & -0.51498 & 0.10001 \end{bmatrix} * \begin{bmatrix} R \\ G \\ B \end{bmatrix} \text{------(5)}$$

The YUV to RGB conversion matrix is given in equation 6.

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 0.7492 & -0.50901 & 1.1398 \\ -1.0836 & -0.22472 & -0.5876 \\ 0.97086 & 0.51498 & -0.000015 \end{bmatrix} * \begin{bmatrix} Y \\ U \\ V \end{bmatrix} \text{-------(6)}$$

2.4 YIQ Color Space

The YIQ color space [4] is derived from YUV color space and is optionally used by NTSC composite color video standard. The `I` stands for phase and `Q` for quadrature which is the modulation method used to transmit the color information. RGB to YIQ conversion matrix is given in equation 7.

$$\begin{bmatrix} Y \\ I \\ Q \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.144 \\ -0.595716 & -0.274453 & -0.32126 \\ 0.211456 & -0.522591 & 0.31135 \end{bmatrix} * \begin{bmatrix} R \\ G \\ B \end{bmatrix} \text{------(7)}$$

The YIQ to RGB conversion matrix is given in equation 8.

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1 & 0.9563 & 0.6210 \\ 1 & -0.2721 & -0.6474 \\ 1 & -1.107 & 1.7046 \end{bmatrix} * \begin{bmatrix} Y \\ I \\ Q \end{bmatrix} \text{---------(8)}$$

2.5 YCgCb Color Space

To get YCgCb [4] components, convert RGB to YCgCb components. The RGB to YCgCb conversion matrix is given in equation 9.

$$\begin{bmatrix} Y \\ Cg \\ Cb \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & -1 & 0 \\ 1 & 0 & -1 \end{bmatrix} * \begin{bmatrix} R \\ G \\ B \end{bmatrix} \text{--------(9)}$$

The YCgCb to RGB conversion matrix is given in equation 10.

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & -2 & 0 \\ 1 & 0 & -2 \end{bmatrix} * \begin{bmatrix} Y \\ Cg \\ Cb \end{bmatrix} \text{--------(10)}$$

2.6 XYZ Color Space

The RGB to XYZ [4] conversion matrix is given in equation 11.

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} .412453 & 0.357580 & 0.180423 \\ 0.212671 & 0.71160 & 0.072169 \\ 0.019334 & 0.119193 & 0.950227 \end{bmatrix} * \begin{bmatrix} R \\ G \\ B \end{bmatrix} \text{-------(11)}$$

The XYZ to RGB conversion matrix is given in equation 12.

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 3.240479 & -1.53750 & -0.498535 \\ -0.969256 & 1.875992 & 0.041556 \\ 0.055648 & -0.204043 & 1.057311 \end{bmatrix} * \begin{bmatrix} X \\ Y \\ Z \end{bmatrix} \text{------(12)}$$

2.7 CMY Color Space
The RGB to CMY conversion matrix is given in equation 13.

$$\begin{bmatrix} C \\ M \\ Y \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} - \begin{bmatrix} R \\ G \\ B \end{bmatrix} \text{-------(13)}$$

The CMY to RGB conversion matrix is given in equation 14.

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} - \begin{bmatrix} C \\ M \\ Y \end{bmatrix} \text{------(14)}$$

2.8 YCC Color Space
The RGB to YCC conversion matrix is given in equation 15.

$$\begin{bmatrix} R' \\ G' \\ B' \end{bmatrix} = \begin{bmatrix} 4.5 \\ 4.5 \\ 4.5 \end{bmatrix} * \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

$$\begin{bmatrix} Y \\ C1 \\ C2 \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.299 & -0.587 & 0.886 \\ 0.701 & -0.587 & -0.114 \end{bmatrix} * \begin{bmatrix} R' \\ G' \\ B' \end{bmatrix} \text{-----(15)}$$

The YCC to RGB conversion matrix is given in equation 16.

$$\begin{bmatrix} R' \\ G' \\ B' \end{bmatrix} = \begin{bmatrix} Y & + & C2 & & \\ Y & - & 0.0194C1 & - & 0.509C2 \\ Y & + & C1 & & \end{bmatrix}$$

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 4.5 \\ 4.5 \\ 4.5 \end{bmatrix} / \begin{bmatrix} R' \\ G' \\ B' \end{bmatrix} \text{---------(16)}$$

III. CONVERSION OF COLOR-TO-GRAY

The ‘Color to Gray and Back’ has two steps as Conversion of Color to Gray Image with color embedding into gray image & Recovery of Color image back as shown in Figure 4. Here the wavelet transform-based mapping method is elaborated as per the following steps.[1][2][3].

1) Image is converted into desired color space of size N x N i.e. K-LUV, YIQ, YUV, XYZ, YCbCr, CMY,YCC and YCgCb or kept in RGB.
2) Then, 1st-plane component of size NxN remain as it is and the size of 2nd-Plane and 3rd-plane is reduced to half i.e N/2.
3) Wavelet Transform i.e. DCT, Haar or Slant Wavelet Transform is applied to all the components of image.
4) First color component is divide it into four subbands as shown in Figure3 Low Pass [LL] , Vertical[LH] , Horizontal[HL], and diagonal [HH] subbands
5) LH to be replaced by second color component, HL to replace by third color component and HH by zero.
6) To obtain Gray image of size N x N inverse wavelet transform is applied.

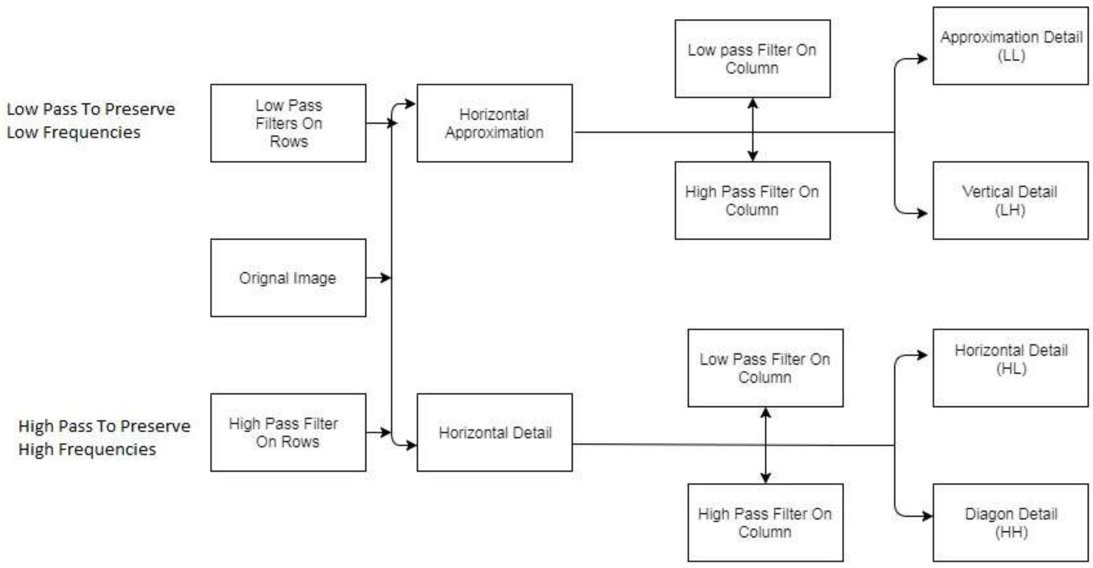


Figure 3 : Subbands in transform domain

IV. RECOVERED COLOR IMAGE

One nice feature of the proposed embedding method is the ability to recover the color from the Gray image (gray scale version with embedded color information) as shown in Figure 5. For that, reverse all steps in the Color-to-gray mapping. [1][2][3].

1) On gray image of size NxN, Wavelet Transform is applied to obtain back four subbands.
2) Retrieve LH and HL component as second color component and third color component of size N/2 x N/2.
3) On all three color component inverse Transform is applied.
4) Second color component and third color component are resized to N x N.
5) To obtain Recovered Color Image all three components are merged.
6) If not in RGB, convert recovered color image to RGB color space.

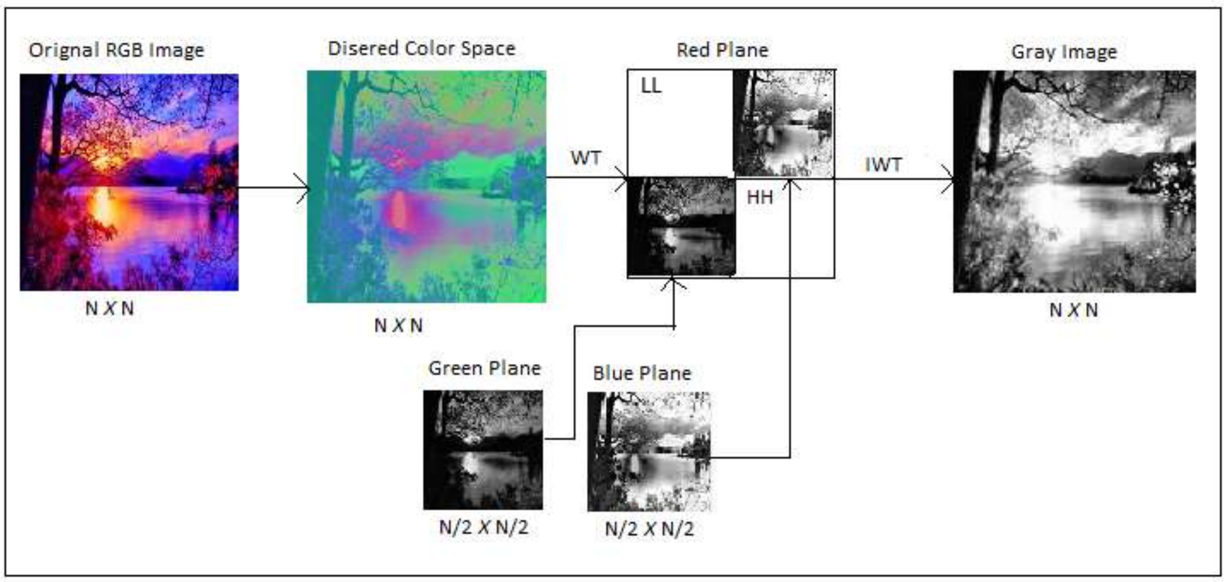


Figure 4: Generation of Gray Image from an Original Image using a transform

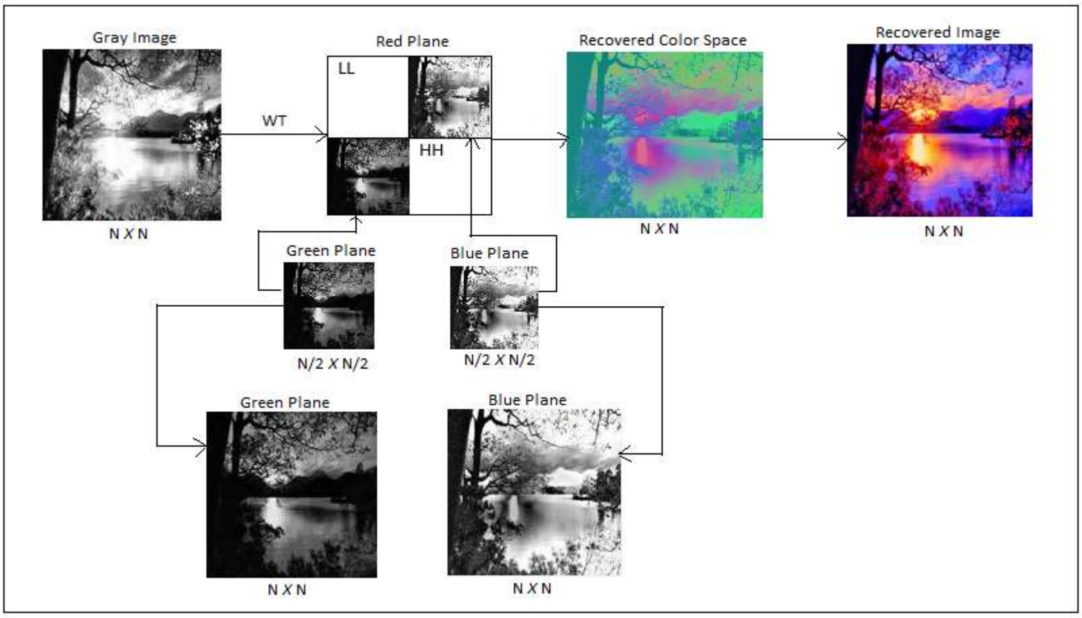


Figure 5 : Generating a Recovered Image from Gray Image using a transfo

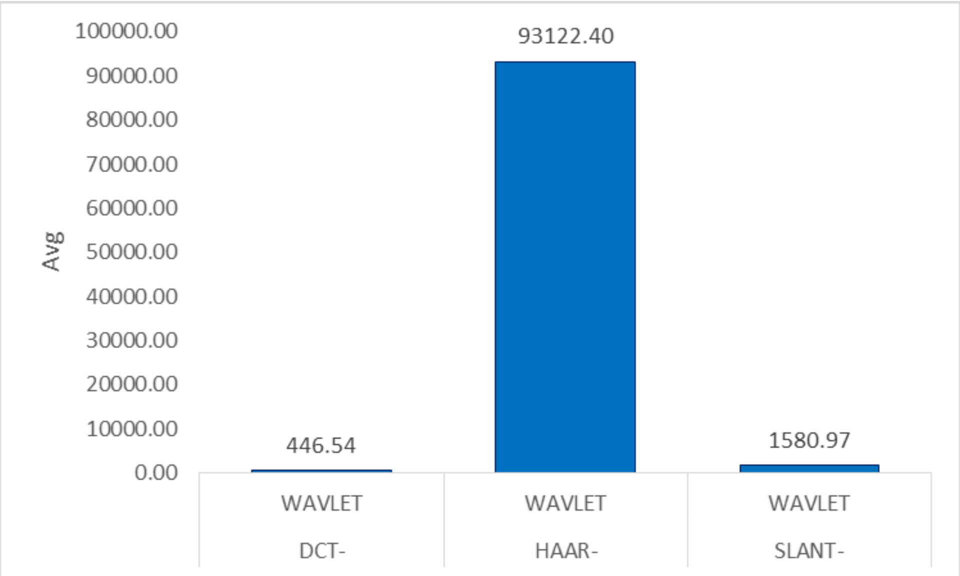
V. FIGURES AND TABLES

Using Mean Squared Error (MSE) quality of 'Color to Gray and Back' is measured of original color image with that of recovered color image, also the difference between original gray image and gray image (where color information is embedded) gives an important insight through user acceptance of the methodology. Result in this experiment are taken on 16 different images as show in Figure 6 of different category as shown in Table 1. It is observed in YCbCr color space shows the least MSE between Original Color Image and the Recovered Color Image for the Wavelet Transforms (DCT, Haar, Slant). It is observed that DCT wavelet transform gives least MSE between Original Color Image and the Recovered Color Image in all of the color space of the image. Among all considered wavelet transforms, DCT wavelet transform gives best results. And it is observed that Haar wavelet transform gives least MSE between Original Gray Image and the Matted Gray Image in all the color space of the image. Among all considered wavelet transforms, less distortion in Gray Scale image after information embedding is observed for Haar wavelet transform. The quality of the matted gray is not an issue, just the quality of the recovered color image matters. This can be observed that when DCT wavelet transform is applied on YCbCr color space the recovered color image is of best quality as compared to other wavelet transforms and color spaces.

Figure 6: Images Used for an Experiment

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

	DCT-WAVLET	HAAR-WAVLET	SLANT-WAVLET
Img1	15.33	9929.50	72.84
Img2	13.57	9796.70	92.68
Img3	6.08	2454.20	35.36
Img4	12.55	5657.00	28.16
Img5	12.07	6466.20	63.86
Img6	13.12	2827.40	74.85
Img7	128.56	7774.20	307.19
Img8	12.66	6435.40	82.41
Img9	10.62	4336.00	76.30
Img10	60.79	8783.20	140.50
Img11	32.19	4405.00	159.46
Img12	6.95	7298.50	26.94
Img13	74.25	4237.40	202.48
Img14	9.80	4468.60	46.08
Img15	19.35	3729.20	87.42
Img16	18.64	4523.90	84.45
AVG	446.54	93122.40	1580.97

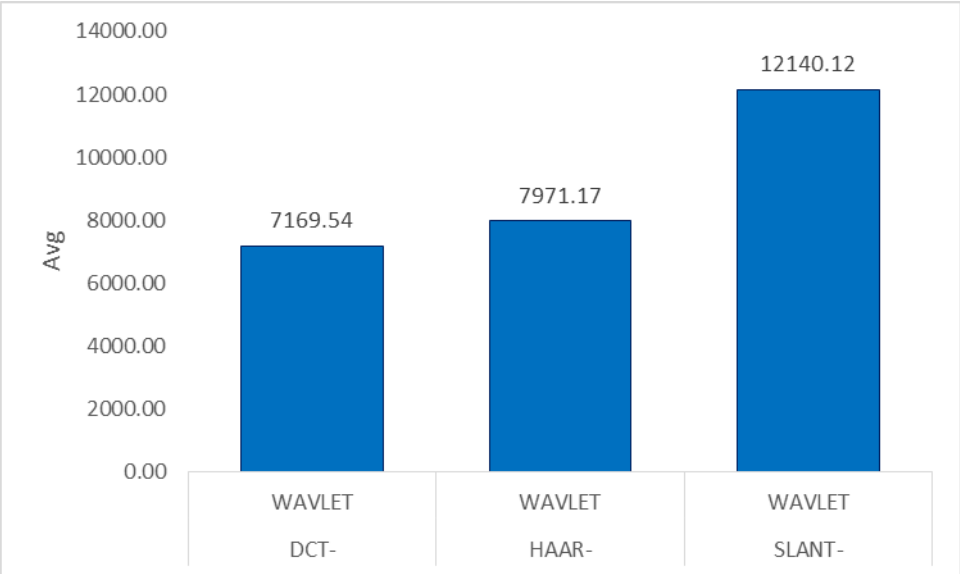


Average MSE of Original Color w.r.t Recovered Color (YCbCr)

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

	DCT-WAVLET	HAAR-WAVLET	SLANT-WAVLET
Img1	531.28	566.77	766.94
Img2	208.00	257.97	561.85
Img3	89.75	114.05	239.98
Img4	551.04	560.38	610.70

Img5	707.30	743.29	960.62
Img6	189.27	228.34	458.67
Img7	878.85	979.35	1489.90
Img8	332.77	380.67	675.34
Img9	504.41	545.51	794.64
Img10	1025.40	1095.70	1475.20
Img11	209.27	286.55	762.52
Img12	825.86	840.07	935.39
Img13	340.96	488.27	930.12
Img14	279.84	297.27	432.24
Img15	378.20	427.36	648.34
Img16	117.34	159.62	397.66
Avg	7169.54	7971.17	12140.12

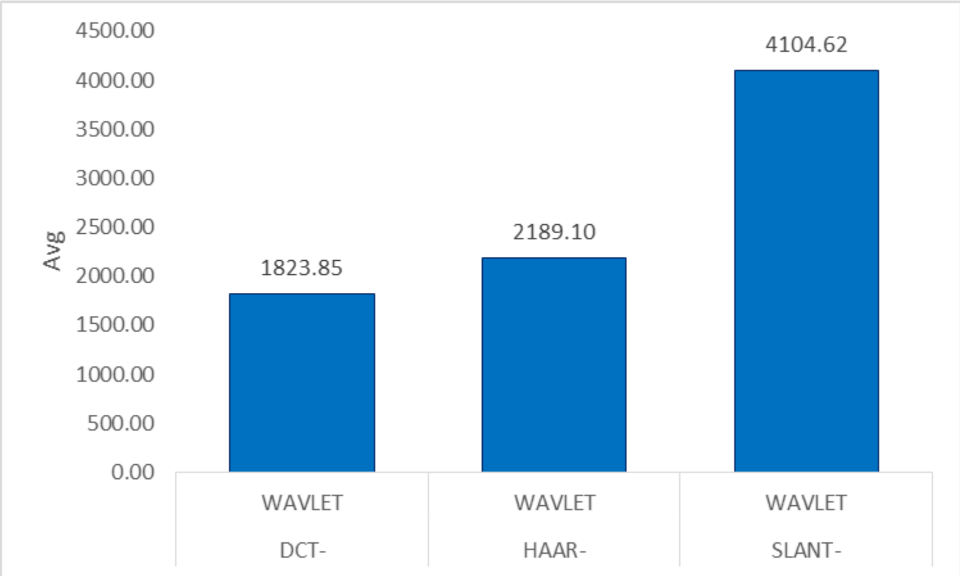


Average MSE of Original Color w.r.t Recovered Color (YCgCr)

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

	DCT-WAVLET	**HAAR-WAVLET**	**SLANT-WAVLET**
Img1	56.08	89.19	273.50
Img2	60.83	81.38	208.85
Img3	29.31	38.01	81.96
Img4	51.17	58.60	100.73
Img5	47.31	62.66	151.88
Img6	57.44	72.21	160.51
Img7	435.36	505.80	870.07
Img8	61.66	76.31	163.13
Img9	45.94	62.13	158.75
Img10	245.22	281.91	470.79
Img11	144.39	172.05	339.70
Img12	28.80	30.41	39.98

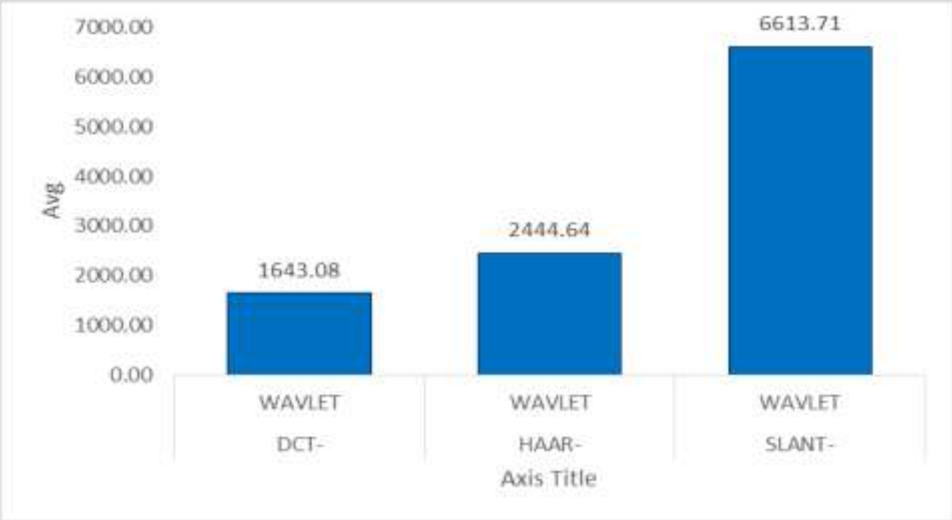
Img13	357.55	407.88	566.70
Img14	38.93	50.60	143.54
Img15	78.58	101.20	200.14
Img16	85.27	98.75	174.38
AVG	1823.85	2189.10	4104.62



Average MSE of Original Color w.r.t Recovered Color (CMY)

Table 4: MSE of Original Color w.r.t. Recovered Color Image (LUV)

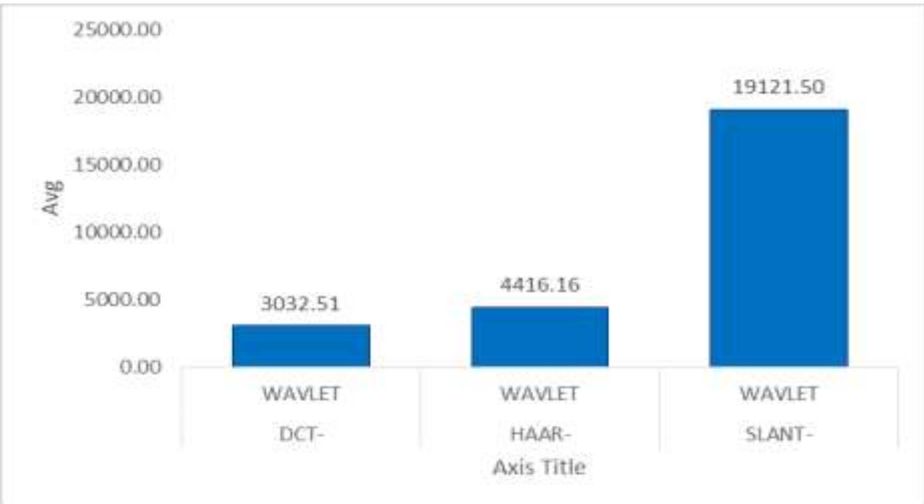
	DCT-WAVLET	**HAAR-WAVLET**	**SLANT-WAVLET**
Img1	54.79	90.27	290.44
Img2	51.00	100.96	404.85
Img3	24.07	48.38	174.30
Img4	47.99	57.33	107.65
Img5	42.26	78.25	295.58
Img6	49.97	89.04	319.38
Img7	417.90	518.40	1029.00
Img8	51.81	99.70	394.38
Img9	39.32	80.43	329.55
Img10	229.90	300.12	679.70
Img11	127.42	204.70	680.67
Img12	25.26	39.47	134.79
Img13	299.10	446.40	888.25
Img14	36.81	54.24	189.21
Img15	71.24	120.39	341.37
Img16	74.27	116.55	354.59
AVG	1643.08	2444.64	6613.71



Average MSE of Original Color w.r.t Recovered Color (LUV)

Table 5: MSE of Original Color w.r.t. Recovered Color Image (XYZ)

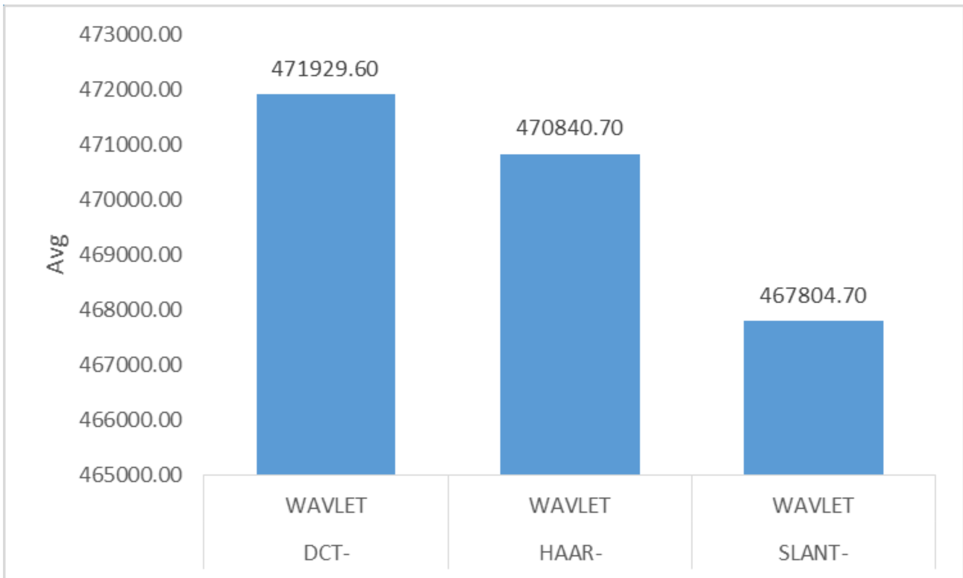
	DCT-WAVLET	HAAR-WAVLET	SLANT-WAVLET
Img1	92.17	178.81	1002.40
Img2	119.19	206.49	1245.80
Img3	57.45	101.45	509.00
Img4	74.56	94.28	306.13
Img5	77.93	145.25	809.72
Img6	103.15	180.00	958.82
Img7	659.18	873.25	3124.20
Img8	114.41	199.56	1123.50
Img9	88.15	168.56	1010.20
Img10	352.12	463.10	1630.60
Img11	258.58	414.27	2023.90
Img12	45.87	66.49	304.49
Img13	643.73	754.08	2330.10
Img14	61.64	110.55	632.54
Img15	137.74	240.58	1080.90
Img16	146.66	219.43	1029.20
AVG	3032.51	4416.16	19121.50



Average MSE of Original Color w.r.t Recovered Color (XYZ)

Table 6: MSE of Original Color w.r.t. Recovered Color Image (YCC)

	DCT-WAVLET	HAAR-WAVLET	SLANT-WAVLET
Img1	6759.60	6711.10	6537.30
Img2	5164.00	5112.30	4863.40
Img3	42761.00	42699.00	42633.00
Img4	13602.00	13593.00	13548.00
Img5	33921.00	33856.00	33704.00
Img6	40541.00	40444.00	40312.00
Img7	18721.00	18662.00	18111.00
Img8	62172.00	62092.00	61892.00
Img9	43059.00	42956.00	42788.00
Img10	20754.00	20710.00	20493.00
Img11	21825.00	21743.00	21364.00
Img12	9374.00	9324.30	9302.00
Img13	16025.00	15897.00	15637.00
Img14	21447.00	21422.00	21308.00
Img15	44668.00	44600.00	44437.00
Img16	71136.00	71019.00	70875.00
AVG	471929.60	470840.70	467804.70

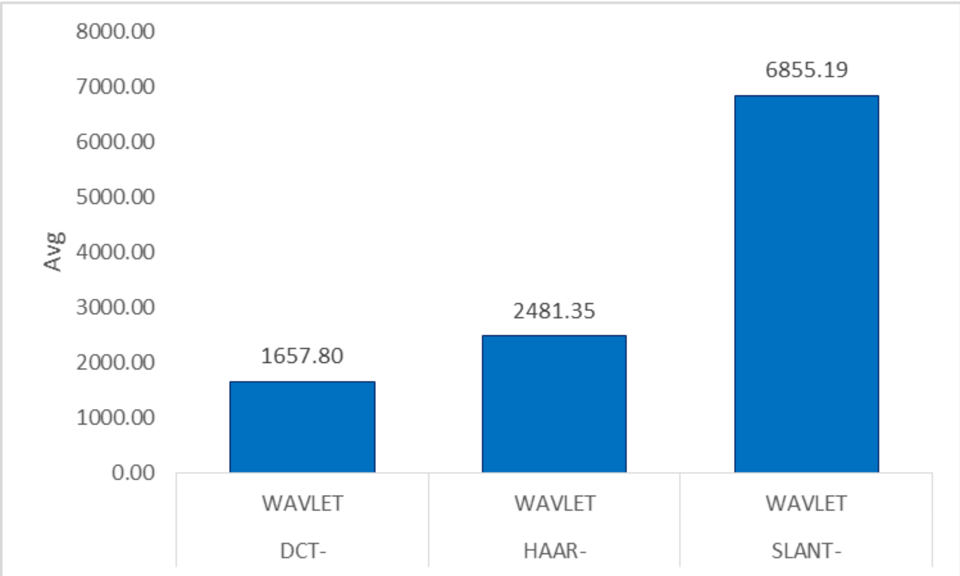


Average MSE of Original Color w.r.t Recovered Color (YCC)

Table 7: MSE of Original Color w.r.t. Recovered Color Image (YIQ)

	DCT-WAVLET	HAAR-WAVLET	SLANT-WAVLET
Img1	55.39	94.60	335.07
Img2	51.60	104.98	434.35
Img3	24.17	49.05	177.68
Img4	48.14	58.60	117.84
Img5	44.09	77.53	288.18

Img6	50.24	90.69	333.26
Img7	424.63	544.86	1222.20
Img8	51.77	98.03	377.34
Img9	40.00	83.09	351.90
Img10	232.18	294.48	612.87
Img11	127.83	206.75	693.12
Img12	25.48	38.00	119.09
Img13	299.32	446.91	891.52
Img14	36.93	54.74	194.35
Img15	71.68	122.40	354.00
Img16	74.37	116.65	352.42
Avg	1657.80	2481.35	6855.19

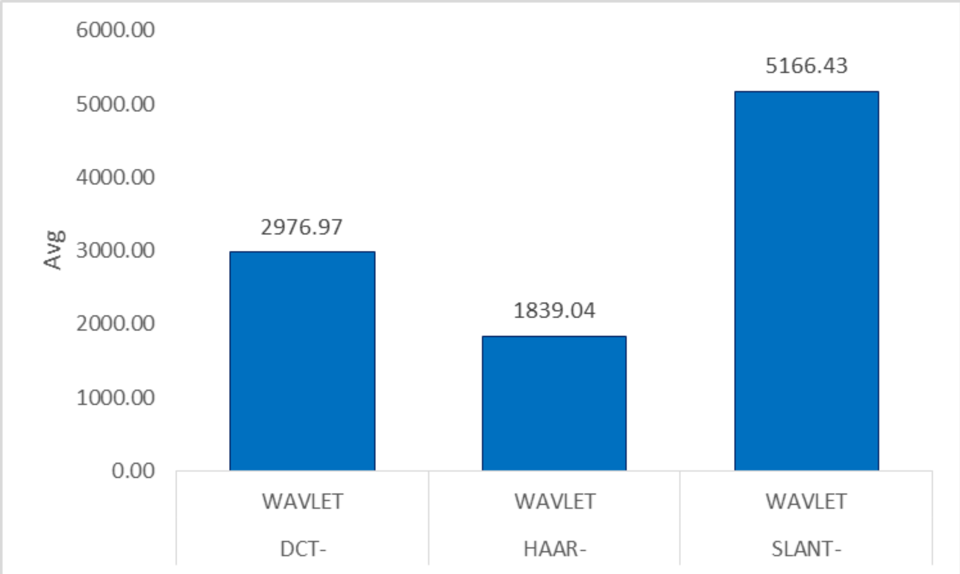


Average MSE of Original Color w.r.t Recovered Color (YIQ)

Table 8: MSE of Original Color w.r.t. Recovered Color Image (YUV)

	DCT-WAVLET	**HAAR-WAVLET**	**SLANT-WAVLET**
Img1	80.35	114.94	322.90
Img2	63.12	114.94	322.90
Img3	149.29	114.94	322.90
Img4	81.99	114.94	322.90
Img5	126.23	114.94	322.90
Img6	161.48	114.94	322.90
Img7	475.39	114.94	322.90
Img8	240.08	114.94	322.90
Img9	171.66	114.94	322.90
Img10	265.00	114.94	322.90
Img11	194.72	114.94	322.90
Img12	60.45	114.94	322.90
Img13	342.14	114.94	322.90

Img14	85.95	114.94	322.90
Img15	192.45	114.94	322.90
Img16	286.68	114.94	322.90
Avg	2976.97	1839.04	5166.43



Average MSE of Original Color w.r.t Recovered Color (YUV)

Table 9: 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

VI. CONCLUSION

In this paper we have proposed method to convert image to gray embedding color information into it and method 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. The proposed method is based on wavelet transforms i.e DCT, Haar and Slant wavelet transform with color spaces alias YCbCr, YCgCb, YUV, YIQ, XYZ , YCC, Kekre's LUV And CMY. The YCbCr color space is proved to be better with DCT wavelet transform 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 wavelet 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 hybrid wavelet transforms for 'Color-to-Gray and Back'.

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