Data Compression for Video-Conferencing using Half tone and Wavelet Transform

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***Abstract*—Overhead of data transmission over internet is increasing exponentially every day. Optimization of natural bandwidth is the basic motive by compressing image data to the maximum extend. For the same objective, combination of lossy half tone and lossless Wavelet Transform techniques is proposed so as to obtain low-bit rate video data transmission. Decimal values of bitmapped image are to be converted into either 1 or 0 in half toning process that incur pictorial loss and gives 8:1 compression ratio (CR) irrespective of image. Wavelet Transform is applied on half tone image for higher compression for various levels. An experimental result shows the higher CR, minimum Mean Square Error (MSE). Ten sample images of different people captured by Nikon camera are used for experimentation. All images are bitmap (.BMP) 512 X 512 in size. The proposed technique can be used for video conferencing, storage of movies and CCTV footage etc.**

Keywords-Half tone; Low-Bit rate; video data compression; Wavelet Tranform; Bandwidth optimization; Structural Similarity Index Measure (SSIM).

I. INTRODUCTION

From last two decades Wavelet Transform has found enormous application in different areas like speech, computer graphics, signal, image processing and in medical field for DNA, ECG, protein, blood pressure, and heart rate analysis. Wavelet Transform overcomes the limitations of Fourier Transform as it cannot detect local properties as in [1]. Hybrid Wavelet Transform using any two orthogonal transform can be used for higher image data compression with minimum loss using a set of complimentary wavelets, where comparison of DCT, DHT, DWT and Kekre transform is explained as in [2]. The combination of Wavelet Transform with Modified-Run-Length- Coding (MRLC) along with new quantization technique is proposed for ECG data compression. This proposed method improves data compression by 13 % as in [3].

Generation of Wavelet Transform from any orthogonal transforms by contraction and translation infinite set of functions can be generated. Experimental results of original image with reconstructed image using orthogonal transforms Walsh and DCT with respect to their Wavelets are compared. Walsh Wavelet and DCT Wavelet results are better than Walsh and DCT as in [4].

Wavelet Transform for high resolution satellite imageries with lifting scheme is proposed that reduces computational time and resources with appreciable results as in [5]. Considering main three factors of high embedding capacity, imperceptibility and robustness effective stenography is explained with Walsh Wavelet and DCT Wavelet proven that are prone to filtering, noise, cropping and compression of an image as in [6]. Spikes at different frequencies and amplitude using Wavelet Transform for Neural data compression from different channels are found to reconstruct unique signature and relate it some activities as in [7]. Various orthogonal Wavelet transforms of Walsh, Cosine, Hartley, Kekre are used for image data compression and proved better results as compared to respective normal forms. 70% to 90% is compressed by removing low energy coefficients in their respective Wavelet forms as in [8].

Section II explains about the half tone method and various half tone operators, Section III explains the Hybrid Algorithm of Half tone and Wavelet Transform, Section IV explains about experimental results and discussion. In section V paper conclusion and future scope is explained.

II. HALF TONING METHOD

A. *Neighbourhood Processing*

Half toning is the process in which intensity and pattern of dot varies to simulate different shades. Half tone dots are produced by superimposing mask over the image. Half toning is the error diffusion process that results into noisy image. Half toning templates shown in fig.1a to fig.1d are used to convert continuous tone image into half tone image. These templates are rotated on continues tone image as neighborhood processing.

For the same objective of high image data compression and low-bit-rate data transmission to optimize bandwidth for video conferencing, other techniques are used as hybrid technique with half tone technique. Half toning is the lossy technique and gives 8:1 CR. Two-fold hybrid techniques are used for higher compression ratio with half tone. Half tone with Kekre's Fast Codebook Generation (KFCG) vector quantization technique is presented by Kekre et al as in [9]. Lossy half tone with lossless Huffman coding technique is presented as in [10]. Lossy half tone with lossless Run-Length-Encoding technique is presented as in [11]. Importance of red plane from time complexity point of view is explained as in [12]. For reconstruction of image from half tone image Inverse half toning algorithm as in [13] is described. Some other half toning operators are proposed with performance analysis as in [14].

0	**0**	**0**
0	**<u>X</u>**	**7**
3	**5**	**1**

Fig. 1a: Floyd-Steinberg

0	**0**	**0**
0	**<u>X</u>**	**1**
0	**1**	**3**

Fig. 1b. Small

0	**0**	**0**	**0**	**0**
0	**0**	**0**	**0**	**0**
0	**0**	**<u>X</u>**	**7**	**5**
3	**5**	**7**	**5**	**3**
1	**3**	**5**	**3**	**1**

Fig. 1c.: Jarvis

0	**0**	**0**	**0**	**0**
0	**0**	**0**	**0**	**0**
0	**0**	**<u>X</u>**	**1**	**9**
23	**7**	**5**	**3**	**11**
21	**19**	**17**	**15**	**13**

Fig. 1d.: South-East

Figure 1. Half tone operators: Fig.1a is Floyd-Steinberg half tone operator, Fig.1b is Small half tone operator, Fig.1c is Jarvis half tone operator, Fig.1d is South-East half tone operator

B. Quantization

As shown fig.2 color image is split into three primary R-G-B planes and it posses gray levels from 0-255, representing each pixel by 8-bit. After half tone technique, quantization process is used to convert gray level into bi-level with loss as either 0 or 1 as in [13].

III. HYBRID HALF TONE WITH WAVELET ALGORITHM

As shown in fig.2, on each plane of half tone image Haar Wavelet transform is applied. Fig.3 shows the working principle of Wavelet transform.

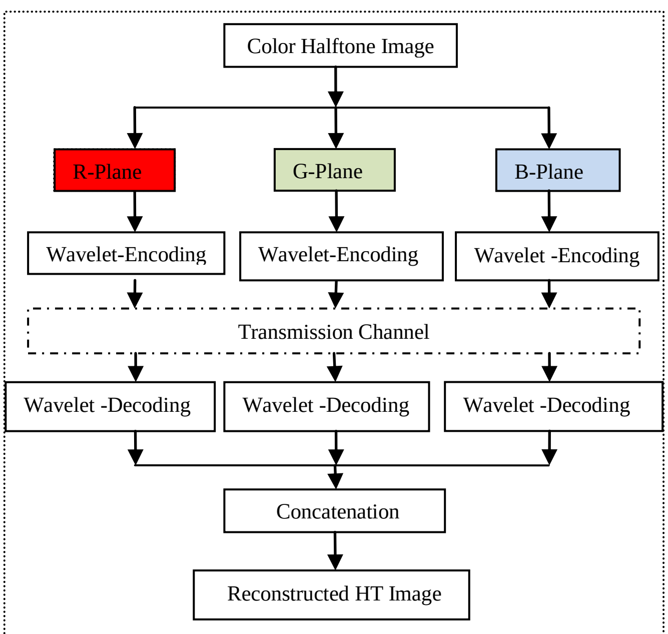

Figure 2. Block diagram of Half tone-Wavelet Transform

A. Algorithm

- Wavelet transform is applied on binary half tone image of size 512-by-512.
- In Wavelet transform alternate row and column is eliminated so as to reduce the overall NXN size of an image as is represented in fig.3 and sample result is shown in fig.4. b

$$Li=N/2^{i} \quad (1)$$

Where i =1, 2 … n

- Wavelet transform is applied on half tone image plane till to the desired level of compression. At each level of compression Wavelet transform extract features at different frequencies and location.
- Wavelet transform encoded data in its highest compressed form can be used for transmission on channel.
- At the receiving end inverse Wavelet transform is applied to decode image data so as to obtain half tone image.
- Inverse half toning algorithm is applied with concatenation of all the half tone planes to reconstruct of an image.

B. Compression Ratio (CR)

In first iteration of Wavelet transform image size of 512-by-512 in half tone form is converted into 256-by-256 as level-1 and referred as L1. At L1 Wavelet transform compresses data 50% to that of half tone image data as shown in fig. 3. Eq. (1) shows the decomposition of NXN size image into desired level Li. The Wavelet Transform is applied on low-low frequency component of L1, for further compression of 50% data is called as L2 and image size becomes 128-by-128 and henceforth L3 and L4 is achieved. The CR of original image to inverse image at L1 is 32. In the same way, L2 compresses original image data 128 times, L3 compresses 512 times and L4 compresses 2048 times.

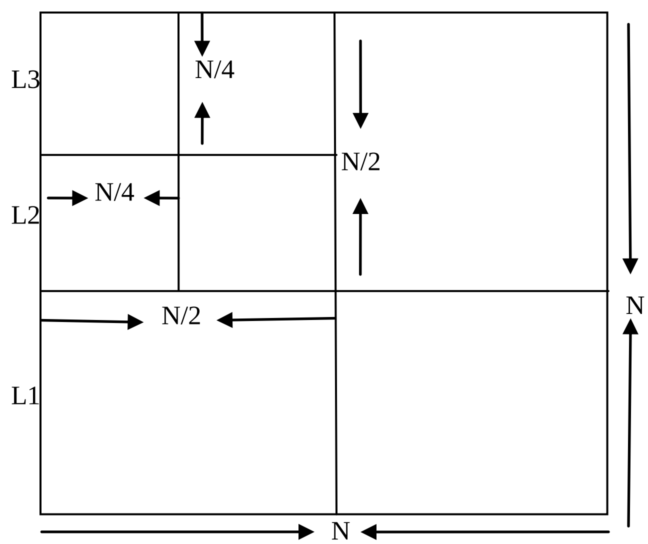

Figure 3. Wavelet Transform Pyramid

IV. RESULTS AND DISCUSSION

Combination of Half tone with Wavelet Transform is used to achieve higher CR on different ten 512-by-512 in size bitmapped images, for low bit-rate image data compression in Video-Conferencing. Mean-Square-Error (MSE) and Structural Similarity Index Measure (SSIM) are used between original image and inverse image.

Table-I, III, V and Table-VII shows the MSE between original images and inverse image for different half tone operators at L1, L2, L3 and L4. As well as Table-II, IV, VI and Table-VIII shows the SSIM between original image and inverse images for different half tone operators at L1, L2, L3 and L4. Fig. 5, 7, 9 and 11 shows the graphical representation of MSE between original images and inverse image for different half tone operators at L1, L2, L3 and L4. As well as fig. 6, 8, 10 and 12 shows the SSIM between original image and inverse images for different half tone operators at L1, L2, L3 and L4.

Fig. 13 shows the reconstructed images from different half tone operators and Wavelet Transform at levels from L1 to L4. Reconstructed image quality of Small operator is almost same to that of standard Floyd-Steinberg and Jarvis operators. As well as it gives same MSE and SSIM with reduced computational complexity [11].

Whereas South-East operator gives higher MSE and negligible poor in image quality as compared to standard operators. Fig. 13 shows the MSE increases and image quality decreases from L1 to L4. As shown in fig.3, in each level only Low-Low frequency component is used to take inverse Wavelet transform. Remaining Low-High, High-Low and High-High components are considered as matrix of zeros of the same size in the respective level.

TABLE I. MSE- BETWEEN INVERSE AND ORIGINAL IMAGE USING DIFFERENT HALF TONE OPERATORS WAVELET TRANSFORM AT-L1

S.N.	Image	Flyod	Jarvis	Small	South-East
1	Aditi	117.8627	215.8853	249.986	360.656
2	KekreHB	318.1064	264.8021	391.9745	447.651
3	Sanjay	285.8108	377.4874	398.578	621.227
4	Anita	263.2586	452.0141	506.7903	903.042
5	Tandle	142.0714	342.3254	389.9147	777.652
6	Pallavi	130.8618	187.4659	171.0308	633.804
7	More	172.1179	297.9908	316.0038	625.25
8	Shruti	108.5584	177.0217	173.92	646.386
9	Ravi	302.4952	224.187	287.0564	625.001
10	Ajay	214.7108	195.7814	275.4807	577.054
	Average	205.5854	273.49611	316.07352	621.772

Figure 4. (a).Original image: Aditi

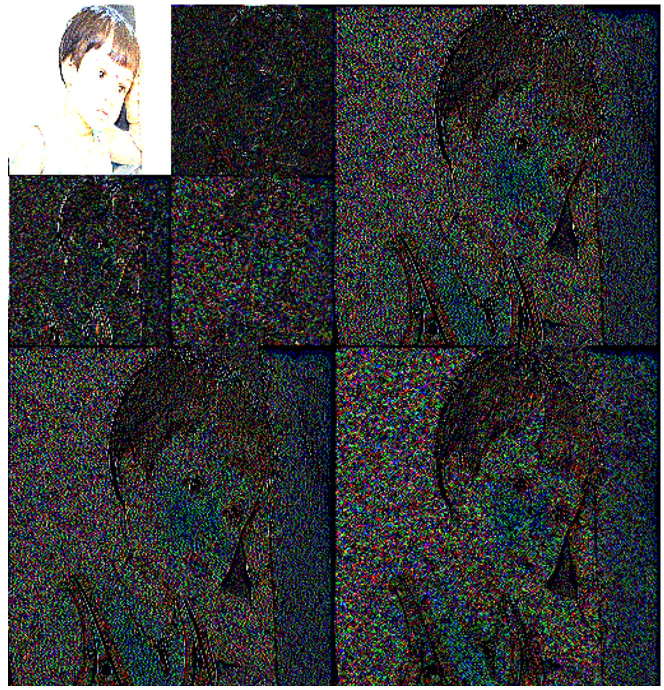

Figure 4. (b). Aditi: Wavelet Transform (L3) image using Jarvis half tone

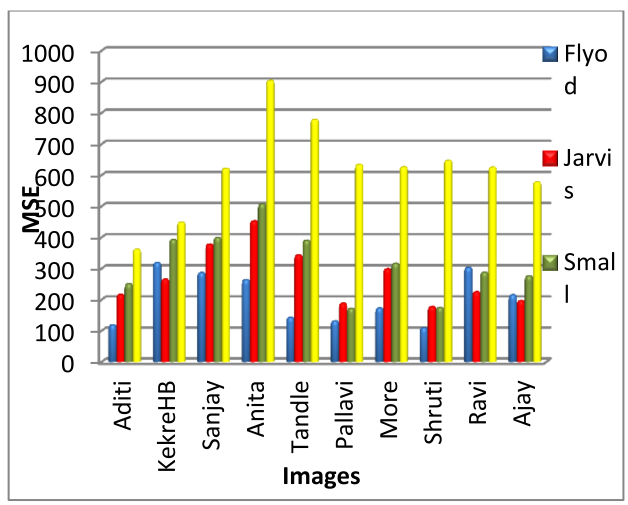

Figure 5. MSE between inverse and original images using different half tone operator and Wavelet Transorm at L1

TABLE II. SSIM- BETWEEN INVERSE AND ORIGINAL IMAGE USING DIFFERENT HALF TONE OPERATORS WAVELET TRANSFORM AT-L1

S.N	Image	Flyod	Jarvis	Small	South-East
1	Aditi	0.9911	0.9906	0.9911	0.9936
2	KekreHB	0.966	0.9931	0.9798	0.999
3	Sanjay	0.9957	0.9964	0.9968	0.9982
4	Anita	0.9893	0.9909	0.9909	0.9939
5	Tandle	0.9841	0.983	0.9842	0.9872
6	Pallavi	0.998	0.9995	0.9996	1
7	More	0.9936	0.9929	0.9936	0.9955
8	Shruti	0.9958	0.9975	0.9978	0.9996
9	Ravi	0.9821	0.9975	0.9989	0.9992
10	Ajay	0.9769	0.9948	0.9946	0.9969
	Average	0.98726	0.99362	0.99273	0.99631

TABLE III. MSE- BETWEEN INVERSE AND ORIGINAL IMAGE USING DIFFERENT HALF TONE OPERATORS WAVELET TRANSFORM AT-L2

S.N.	Image	Flyod	Jarvis	Small	South-East
1	Aditi	117.9284	215.8858	249.9898	360.688
2	KekreHB	318.1064	264.8021	391.9745	447.651
3	Sanjay	285.8108	377.4875	398.578	621.227
4	Anita	263.2586	452.0141	506.7903	903.045
5	Tandle	142.0714	342.3254	389.9147	777.652
6	Pallavi	130.8618	187.4659	171.0308	633.804
7	More	172.1183	297.991	316.0038	625.25
8	Shruti	108.5584	177.0218	173.9202	646.386
9	Ravi	302.4952	224.187	287.0564	625.001
10	Ajay	214.7103	195.7814	275.4808	577.054
	Average	205.592	273.4962	316.07393	621.776

TABLE IV. SSIM- BETWEEN INVERSE AND ORIGINAL IMAGE USING DIFFERENT HALF TONE OPERATORS WAVELET TRANSFORM AT-L2

S.N.	Image	**Flyod**	**Jarvis**	**Small**	**South-East**
1	Aditi	0.9911	0.9906	0.9911	0.9937
2	KekreHB	0.966	0.9931	0.9798	0.999
3	Sanjay	0.9957	0.9964	0.9968	0.9982
4	Anita	0.9893	0.9909	0.9909	0.9939
5	Tandle	0.9841	0.983	0.9842	0.9872
6	Pallavi	0.998	0.9995	0.9996	1
7	More	0.9936	0.9929	0.9936	0.9955
8	Shruti	0.9958	0.9975	0.9978	0.9996
9	Ravi	0.9821	0.9975	0.9989	0.9992
10	Ajay	0.9769	0.9948	0.9946	0.9969
	Average	0.98726	0.99362	0.99273	0.99632

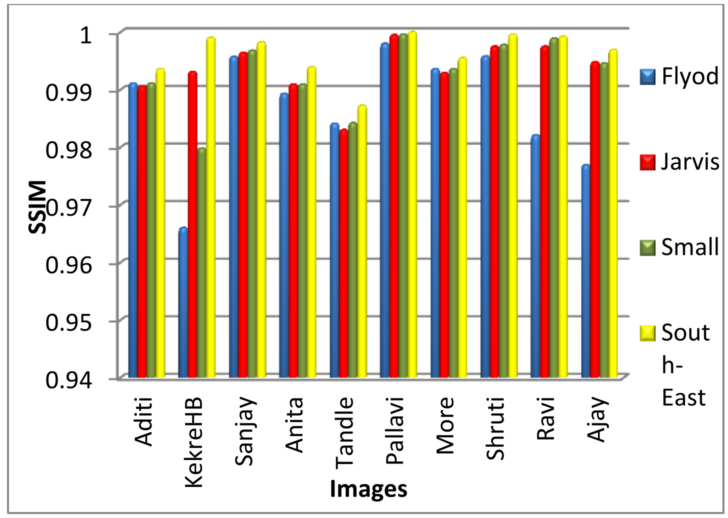

Figure 6. SSIM between inverse and original images using different half tone operator and Wavelet Transorm at L1

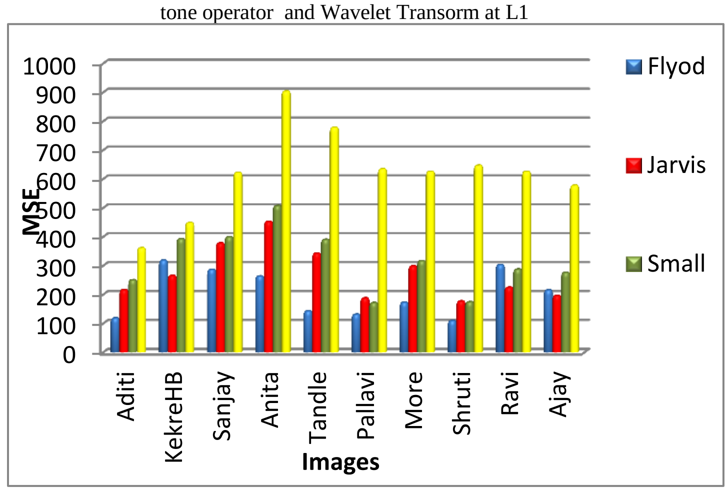

Figure 7. MSE between inverse and original images using different half tone operator and Wavelet Transorm at L2

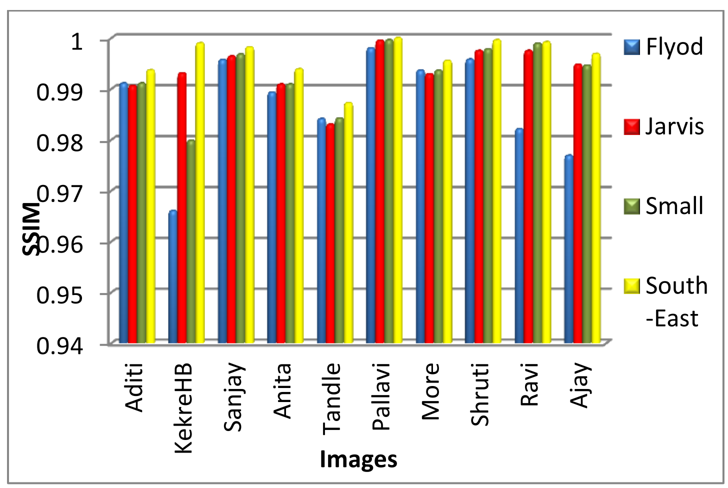

Figure 8. SSIM between inverse and original images using different half tone operator and Wavelet Transorm at L2

TABLE V. MSE- BETWEEN INVERSE AND ORIGINAL IMAGE USING DIFFERENT HALF TONE OPERATORS WAVELET TRANSFORM AT-L3

S.N.	Image	Flyod	Jarvis	Small	South-East
1	Aditi	134.267	220.2996	227.7553	370.799
2	KekreHB	368.0072	224.9916	403.7703	435.893
3	Sanjay	312.8477	345.6988	330.1543	461.705
4	Anita	203.2026	264.9968	302.8949	542.179
5	Tandle	121.0674	228.9125	226.9721	412.069
6	Pallavi	163.8037	187.3523	169.3533	381.113
7	More	171.3309	257.8598	236.361	428.801
8	Shruti	155.6485	194.6737	175.9346	375.641
9	Ravi	194.6619	190.1707	207.5549	436.251
10	Ajay	121.9036	184.7462	195.4543	420.552
	Average	194.6741	229.9702	247.6205	426.5

TABLE VI. SSIM- BETWEEN INVERSE AND ORIGINAL IMAGE USING DIFFERENT HALF TONE OPERATORS WAVELET TRANSFORM AT-L3

S.N.	Image	**Flyod**	**Jarvis**	**Small**	**South-East**
1	Aditi		0.9905	0.991	0.9935
2	KekreHB	0.9583	0.9998	0.972	1
3	Sanjay	0.9927	0.9964	0.9968	0.9982
4	Anita	0.9873	0.9908	0.9868	0.9938
5	Tandle	0.984	0.9831	0.9841	0.9873
6	Pallavi	0.9968	0.9995	0.9996	1
7	More	0.9935	0.9929	0.9935	0.9955
8	Shruti	0.9909	0.9974	0.9978	0.9989
9	Ravi	0.9879	0.9963	0.999	0.9995
10	Ajay	0.988	0.9947	0.9917	0.9969
	Average	0.9866	0.99414	0.99123	0.9964

Image data can be compressed to the higher level of Wavelet Transform say 16X16 and 8X8, but the image reconstruction quality degrades a lot.

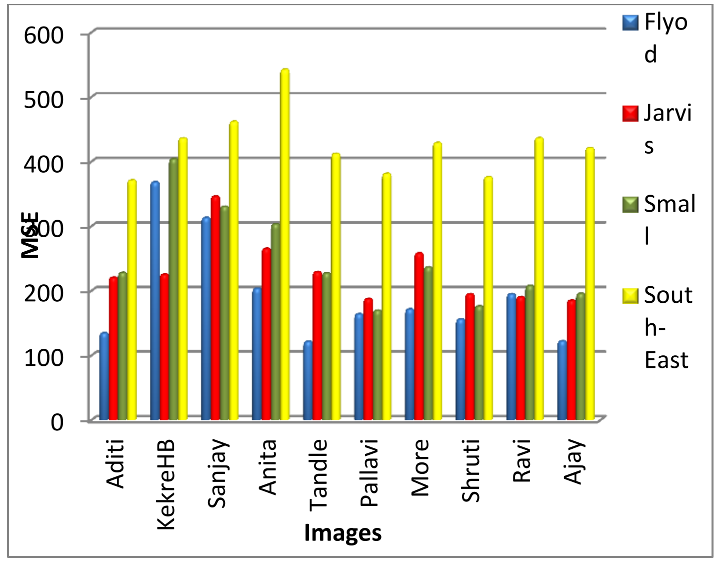

Figure 9. MSE between inverse and original images using different half tone operator and Wavelet Transorm at L3

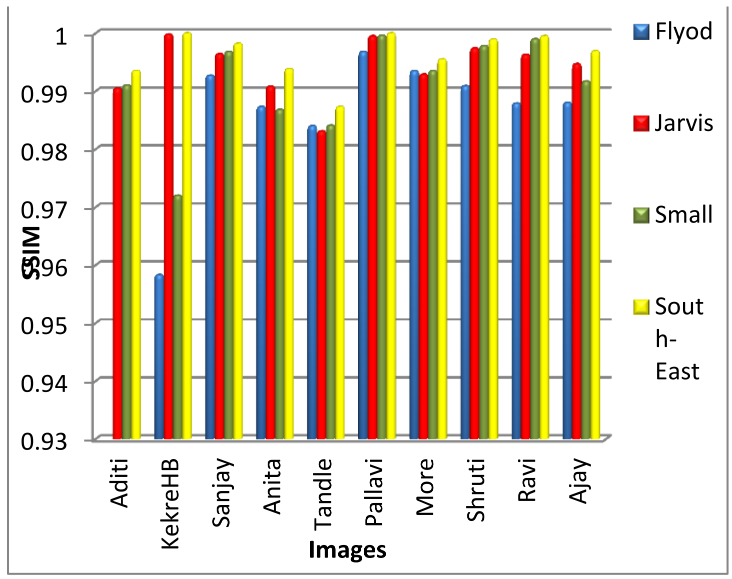

Figure 10. SSIM between inverse and original images using different half tone operator and Wavelet Transorm at L3

TABLE VII. MSE- BETWEEN INVERSE AND ORIGINAL IMAGE USING DIFFERENT HALF TONE OPERATORS WAVELET TRANSFORM AT-L4

		Flyod	Jarvis	Small	South-East
1	Aditi	190.86	240.092	225.3853	345.85
2	KekreHB	595.84	510.291	586.0695	360.28
3	Sanjay	703.25	458.67	489.1887	541.14
4	Anita	380	254.844	259.2035	378.81
5	Tandle	231.56	204.578	197.7312	308.28
6	Pallavi	232.66	199.918	184.2595	310.61
7	More	275.28	243.013	241.0863	342.42
8	Shruti	231.27	203.948	186.0357	300.9
9	Ravi	978.47	235.499	480.6849	325.47
10	Ajay	525.64	178.201	252.2813	311.26
	Average	434.48	272.905	310.1926	352.5

TABLE VIII. SSIM- BETWEEN INVERSE AND ORIGINAL IMAGE USING DIFFERENT HALF TONE OPERATORS WAVELET TRANSFORM AT-L4

		Flyod	Jarvis	Small	South-East
1	Aditi	0.991	0.9903	0.9908	0.9933
2	KekreHB	0.9409	0.9553	0.9487	0.9842
3	Sanjay	0.992	0.9962	0.9966	0.9981
4	Anita	0.9759	0.9907	0.9847	0.9938
5	Tandle	0.984	0.9831	0.984	0.9873
6	Pallavi	0.9954	0.9994	0.9996	1
7	More	0.9936	0.9929	0.9935	0.9955
8	Shruti	0.9877	0.9974	0.9978	0.9989
9	Ravi	0.9573	0.9941	0.9759	1
10	Ajay	0.9605	0.9947	0.9825	0.9977
	Average	0.97783	0.98941	0.98541	0.99488

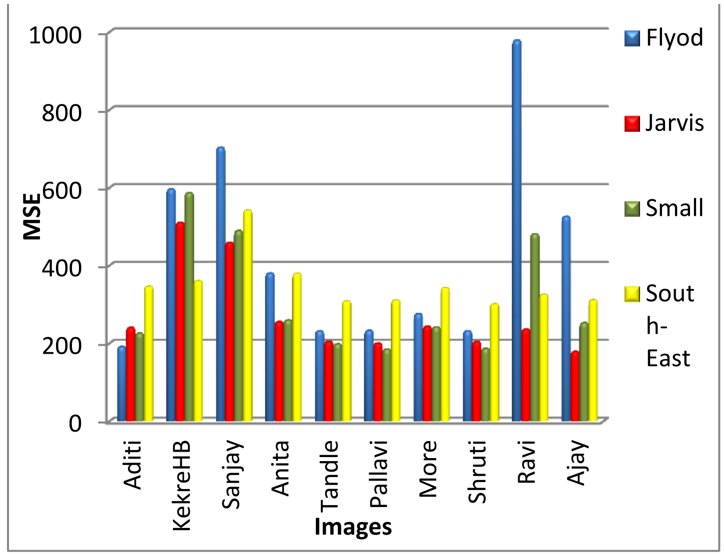

Figure 11. MSE between inverse and original images using different half tone operator and Wavelet Transorm at L4

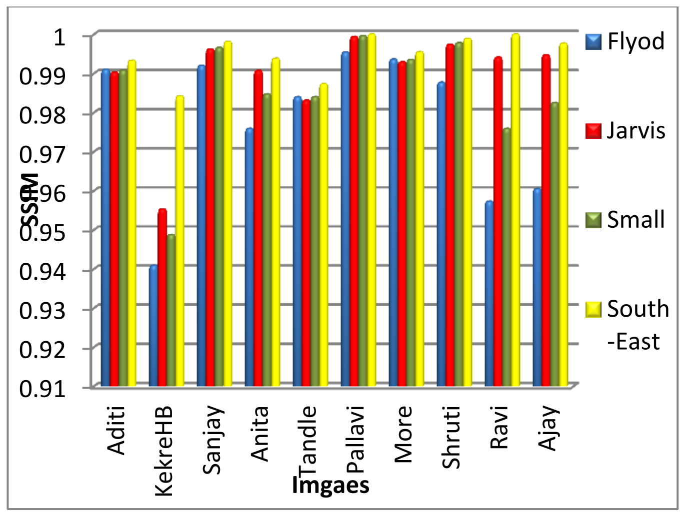

Figure 12. SSIM between inverse and original images using different half tone operator and Wavelet Transorm at L4

Size	Floyd-Steinberg	Jarvis	Small	South-East
32X 32 L4	 a. MSE=190.8560	 b. MSE=240.0915	 c. MSE=225.3853	 d. MSE= 345.8487
64X 64 L3	 e. MSE=134.2670	 f. MSE=220.2996	 g. MSE=227.7553	 h. MSE=370.7987
128 X12 8 L2	 i. MSE=117.9284	 j. MSE=215.8858	 k. MSE=249.9898	 l. MSE=360.688
256 X25 6 L1	 m. MSE=117.8627	 n. MSE= 215.8853	 o. MSE=249.986	 p. MSE=360.656

Figure 13. Reconstructed images using different half tone operators and Wavelet Transform at different levels from L1 to L4:

(1) CR=32 for L1, (2) CR=128 for L2, (3) CR=512 for L3, (4) CR=2048 for L4

V. CONCLUSION

For low-bit rate video data transmission image data is compressed using combination of half tone and Wavelet Transform on ten different 512 by 512 bitmap images. Wavelet Transform is applied at different levels that converts image from 512 by 512 to 256 by 256 as level L1, 128 by 128 as L2, 64 by 64 as L3 and 32 by 32 as L4.

Below this level reconstructed image quality degrades. Future scope to this paper is to convert Wavelet Transform domain image into desired number of non-overlapping blocks. Calculate energy of all the blocks and can eliminate the some lowest energy blocks based on threshold. Elimination of such non-overlapping blocks will increase the CR. In real-time processing, proposed algorithm takes more processing time as compared to the frame rate that required for smooth video-conferencing. As well as to develop an algorithm to preserve the features of Low-High, High-Low and High-High components of Wavelet transform domain image and can be added to Low-Low frequency component of Wavelet transform.

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