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New Half tone Operators for High Data Compression in Video-Conferencing

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Abstract—Optimization of bandwidth is major challenge in networking field for transmission of data in application like video conferencing. To compress such a huge video data, combination of lossy half tone and lossless Run-Length-Encoding (RLE) technique is proposed so as to obtain low-bit rate video data transmission. Half tone is the binary image, in which long strings of 1's and 0's are present, on it RLE is applied. An experimental result shows the higher compression ratio (CR), minimum Root Mean Square Error (RMSE) and high Peak Signal-to-Noise Ratio (PSNR) with acceptable image quality. Objective of the paper is that, this technique can be used for video conferencing. In video conferencing person's face is the object and usually background is constant where RLE effectively gives higher CR for long string of data. Ten sample images of different people captured by Nikon camera are used for experimentation. All images are bitmap (.BMP) 256 X 256 in size. The same technique can be used for storage of movies, CCTV footage etc.

Keywords: half toning; Run-Length-Encoding; Low-Bit rate; video data compression

1. Introduction

In the coming years of time, there will be massive usage of audio, video data transmission and the major challenge is the optimum use of natural available bandwidth. For that purpose it is essential to compress such data to the maximum extend for bandwidth optimization. In this paper a combination of half toning a lossy and Run-Length-Encoding (RLE) lossless techniques are used where higher data compression is achieved and can reduce bandwidth costs significantly. This hybrid technique can be used for low-bit rate video data transmission for video conferencing. Video degradation, loss location, loss pattern due to packet loss is explained in [1].

RLE is the well known data compression technique used in many applications. For accurate identification of objects in the image RLE is used in robotic vision system [2]. Modified RLE with quantization and wavelet is used for data compression of Electrocardiogram (ECG) [3]. Adaptive DCT is used for data compression. The data DCT coefficients are compressed by RLE with Huffman coding technique and are used for image compression [4]. Reversible integer wavelet transform and RLE is used for representation and selective bit scrambling in telemedicine network [5]. For a standalone system-on-chip the volume of data, scan power consumption and test application time is reduced. To achieve the same approach of alternating variable run-length (AVR) codes as in [6]. Other compression techniques are used with half tone technique for higher CR. Half tone with Kekre's Fast Codebook Generation (KFCG) vector quantization technique is presented by Kekre et al as in [7]. Half tone with Huffman coding technique is presented in [8]. Significance of red plane is explained in [9]. Inverse half toning algorithm for reconstruction of image is explained in [10].

2. Half toning

Half toning is the process of breaking continuous tone image into dots of different sizes. Half toning process in which intensity and pattern of dot varies to simulate different shades. Different half toning methods are presented in [11]. As shown in Fig. 1 different half toning masks are used for experimentation [12]. Half toning dots are produced by superimposing mask over the image. Half toning is the error diffusion process that results into noisy image. The sample color image represented by 24-bit is shown in Fig. 3.a. This image is split into three primary Red, Green and Blue planes. Each plane is 8-bit plane and appears like a gray image. Human eye can discern near

0	0	0
0	X	7
3	5	1

(a)

0	0	0
0	X	1
0	1	3

(b)

0	0	0	0	0
0	0	0	0	0
0	0	X	1	9
23	7	5	3	11
21	19	17	15	13

(c)

0	0	0	0	0
0	0	0	0	0
0	0	X	7	5
3	5	7	5	3
1	3	5	3	1

(d)

Fig. 1: Half tone operator (a) Flyod-Steinberge (b) Small (c) South-East (d) Jarvis

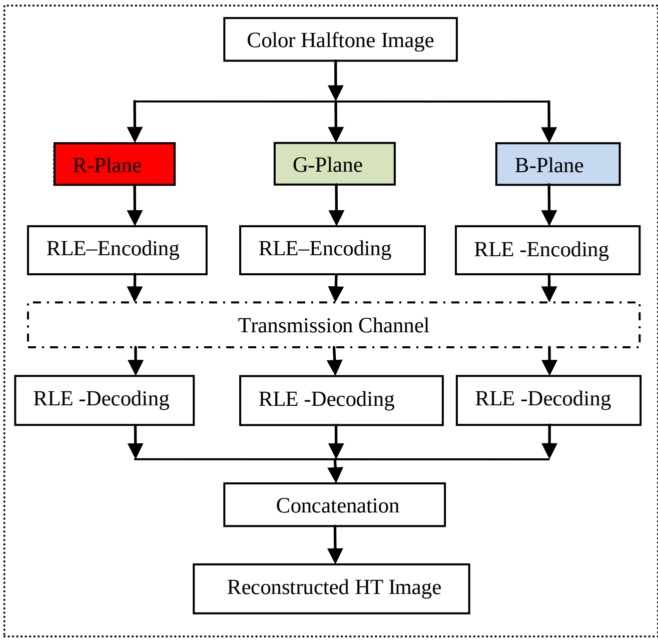


Fig. 2: Block diagram: Half tone and Run-Length-Encoding /Decoding

about 200 different shades, hence in 8-bit plane i.e. 28 means 256 gray shades are used. Half toning process converts this range of grey shades into only two shades using quantization technique. Those are represented as logical state 1 and 0 and forms binary image. In this way half toning process converts representation of 8-bits/pixel into 1-bit/pixel, hence gives compression ratio 8:1 for all bitmap images. Applying RLE on such half tone image compresses data further and requires less than a bit per pixel.

3. Run-length-encoding and decoding algorithm

Halftone image is in the binary form. There is the alternate stream of binary value 1 and 0. For further compression of halftone image data, we have applied Run-Length-Encoding and Decoding algorithm. The block diagram as shown in Fig. 2 describes the flow of algorithm.

3.1 Run-Length-Encoding

- Color half tone image split into primary Red, Green and blue planes and individual plane is treated for RLE.
- Consider the first value of the binary stream as the symbol. Compare this symbol with the remaining binary stream, when the symbol changes, store the count and only the start symbol.
- Repeat this procedure for the remaining binary stream.
- The encoding procedure results a conversion from 2-D matrix to 1-D. That the image is in the most compressed form and is used for transmission.

3.2 Run-Length-Decoding

- For reconstruction of image write the first value of the binary stream as the symbol.
- Repeat the symbol for next value of count.
- Complement the state of symbol for next value of count.
- To generate 2-D binary image from 1-D encoded form break the row at 256 and continue for second line.
- Repeat the decoding procedure for the remaining stream of count to obtain 2-D binary image 256 by 256 inverted binary halftone image.
- Concatenation of the primary planes results into color half tone image.

4. Discussion

4.1 Half toning templates

Fig. 1a and Fig.1d shows the standard Floyd-Steinberg [13] and Jarvis [14] half tone templates; these require four and twelve tap, effectively three and ten tap operation respectively. Our proposed half tone operators shown in Fig. 1c and Fig. 1b shows the South-East (SE) and Small half tone templates require twelve and three tap, effectively eleven and one tap operation [12]. Half toning noise is present in high frequencies. To obtain inverse continuous image from half tone image separable Finite Impulse Response (FIR) low-pass filter is used that blurs the edges and destroy fine details in the original image [15, 16].

4.2 Measuring parameters

Table-1 through Table-4 are the experimental results for different half tone templates, in which CR between half tone image and RLE 1-D vector as well as original image to RLE 1-D vector, image quality measuring parameter Root Mean Square Error (RMSE) and Peak Signal to noise Ratio (PSNR) are used. The abbreviation used in Table-1 RLE-HT to indicate CR between Run-Length-Encoded vector to half tone image. In Table-II RLE-ORG stands for measuring CR between RLE image and original image. Data type for original, half tone and RLE is double. Fig. 3a is the original bitmap (.bmp) image. Fig. 3b is the color half tone image using Floyd-Steinberg template. Fig. 3c to Fig. 3f are the inverse images from half tone images using different templates. SE half tone template gives comparatively higher RMSE but very good compression ratio with marginally higher in computational computations.Table-1 shows the comparative results of CR for different half toning operators between RLE coded image and half tone image. Floyd-Steinberg gives less compression ratio but the image quality is best among all templates. Fig. 4a and Fig. 4b are the graphical representations for set of images to the CR of RLE coded images to half tone images, RLE coded images to original images respectively. Fig. 4c shows the graph for RMSE between original image and inverse image for different templates. Fig. 4d shows the graph for PSNR between original image and inverse image for different templates.

All the ten sample images are captured by Nikon camera. The camera specifications are 14.1 Mega-Pixel resolutions, 21-X zoom. Laptop configuration is Intel core, duo CPU, P8600 @ 2.40 GHz, 789 MHz, 2.92 GB of RAM. Experimentation is performed in MATLAB 2008b.

5. Conclusion and future scope

For low-bit rate video data transmission image data is compressed using combination of half tone and RLE on ten different 256 by 256 bitmap images. Additional advantage is that no need to send array of symbol location, only array of count is required in RLE that results higher CR. Future scope to this paper is parallel processing of R-G-B planes to compensate the time. During experimentation for some images, it is observed that green and blue plane gives same CR and RMSE. Another scope is to predict the run length encoded 1-D vector for green and blue planes. On an average all operators gives CR between RLE-HT around 2 and RLE-ORG from 13 to 18, RMSE 15 to 17 where as SE operator gives little-bit higher RMSE and more than double CR as compared to other operators. The most economical from computational complexity point of view is the Small operator that gives almost same image quality, higher CR and almost same RMSE as compared to standard operator. Computational complexity of Small operator is around three times less as compared to Jarvis and SE operator. On an average SE operator compresses half tone image 4.5

times and original image 37 times results best among all operators. This hybrid compression technique can be used for video data transmission with low-bit rate for video conferencing and for storage of CCTV footage and the same is under process. Limitation is the real time processing for each frame in the stream of images so that smooth video conferencing can be achieved.

a) *b)* *c)* *d)*

e) *f)* *g)* *h)*

Fig. 3: Result Images: (a) Original image: Shruti (b) Flyod-Steinberge half tone image (c) Flyod-Steinberge half tone invrse image (d) Jarvis half tone inverse image (e) Small half tone image (f) South-East half tone inverse image

Table1: CR BETWEEN RLE AND HALF TONE

1		**Flyod-Steinberge**	**Jarvis**	**Small**	**South-East**
S.N	***Image***	***RLE-HT***	***RLE-HT***	***RLE-HT***	***RLE-HT***
1	Shruti	1.92	2.26	2.47	4.93
2	KekreHB	1.32	1.73	2.17	4.29
3	Sanjay	1.65	2.17	2.5	4.7
4	Anita	1.73	1.75	2	2.29
5	Tandle	2.05	2.48	2.62	5.17
6	Pallavi	2.03	2.31	2.49	5.49
7	More	1.78	2.22	2.48	4.78
8	Aditi	1.69	2.19	2.42	4.56
9	Ravi	1.49	1.73	2.21	4.34
10	Ajay	1.57	1.82	2.16	4.6
	Average	**1.723**	**2.066**	**2.352**	**4.515**

Table2: CR BETWEEN RLE AND ORIGINAL IMAGE

2		**Flyod-Steinberge**	**Jarvis**	**Small**	**South-East**
S.N	***Image***	***RLE-ORG***	***RLE-ORG***	***RLE-ORG***	***RLE-ORG***
1	Shruti	15.31	18.08	19.7	39.41
2	KekreHB	10.54	13.79	17.35	43.25
3	Sanjay	13.19	17.36	19.95	37.6
4	Anita	13.82	13.99	16.04	18.31
5	Tandle	16.35	19.79	20.98	41.36
6	Pallavi	16.18	18.48	19.89	43.87
7	More	14.19	17.73	19.81	38.25

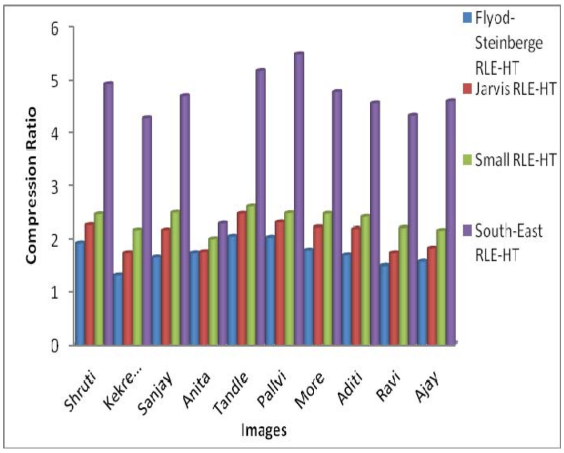
8	Aditi	13.47	17.46	19.42	36.44
9	Ravi	11.89	13.84	17.64	34.66
10	Ajay	12.51	14.51	17.27	36.77
	Average	**13.745**	**16.503**	**18.805**	**36.992**

Table3: RMSE BETWEEN RLE AND HALF TONE IMAGE USING DIFFERENT HALFTONE OPERATOR

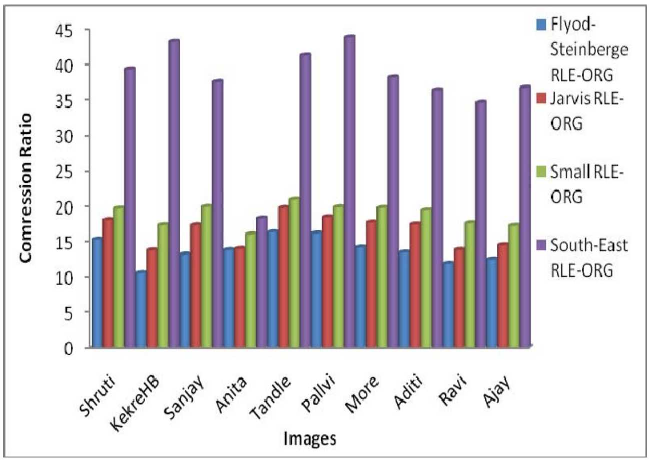
3		**Flyod-Steinberge**	**Jarvis**	**Small**	**South-East**
S.N	***Image***	***RMSE***	***RMSE***	***RMSE***	***RMSE***
1	Shruti	12.44	16.88	14.2	23.66
2	KekreHB	19.94	16.48	19.95	23.99
3	Sanjay	23.3	22.83	22.67	25.37
4	Anita	13.93	17.41	17.57	28.8
5	Tandle	13.07	17.56	17.57	26.99
6	Pallavi	12.88	16.3	12.88	24.43
7	More	13.56	16.73	15.56	23.46
8	Aditi	12.46	17.5	16.3	23.23
9	Ravi	21.71	14.76	14.97	22.4
10	Ajay	14.65	15.49	14.32	22.15
	Average	**15.794**	**17.194**	**16.599**	**24.448**

Table4: PSNR BETWEEN RLE AND HALF TONE IMAGE USING DIFFERENT HALFTONE OPERATOR

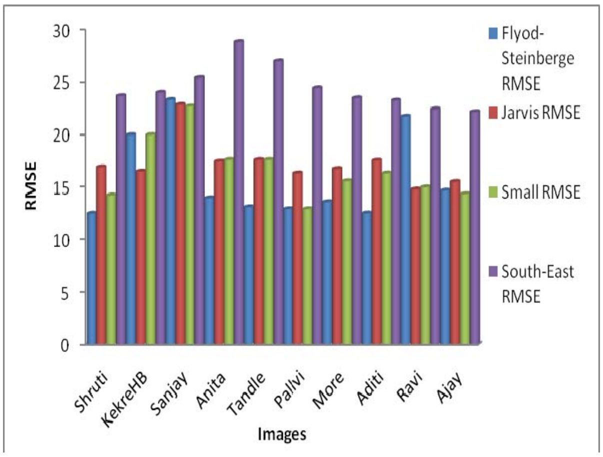
4		**Flyod-Steinberge**	**Jarvis**	**Small**	**South-East**
S.N	***Image***	***PSNR***	***PSNR***	***PSNR***	***PSNR***
1	Shruti	21.894	23.96	23.0457	27.4796
2	KekreHB	25.997	24.338	25.9971	27.5974
3	Sanjay	27.346	27.167	27.109	28.0838
4	Anita	22.878	24.814	24.8932	29.1852
5	Tandle	22.324	24.891	24.8911	28.625
6	Pallavi	22.194	24.243	22.1943	27.7552
7	More	22.645	24.469	23.8374	27.4039
8	Aditi	21.905	24.857	24.243	27.3197
9	Ravi	26.733	23.381	23.5041	27.0021
10	Ajay	23.315	23.799	23.1166	26.9069
	Average	**23.723**	**24.592**	**24.28315**	**27.7359**



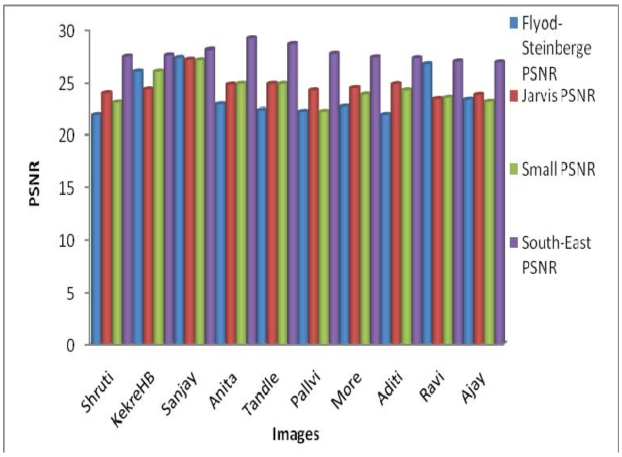
(a)



(b)



(c)



(d)

Fig. 4: Graphical representation: (a) CR between RLE and half tone image using different half tone operator (b) CR between RLE and original image using different half tone operator (c) RMSE between inverse and original image using different half tone operator (d) PSNR between inverse and original image using different half tone operator

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