Colorization Based Compression Using Mean Shift Segmentation and Sparse Recovery Algorithm

Savita Deshmukh
Department of Electronics and Communication Engineering
Medi-caps Institute of Technology and Management, , Indore, M.P., India

Vibha Tiwari
Department of Electronics and Communication Engineering
Medi-caps Institute of Technology and Management, , Indore, M.P., India

Abstract- In this paper, the colorization-based coding problem has been solved using smooth L_0 (SL0) and L_1 norm (OMP) minimization sparse recovery algorithms. In colorization-based coding method at the encoder, only few representative pixels (RP) for the chrominance values are sent along with luminance part of image to the decoder where the chrominance values for all the pixels are reconstructed by colorization method. The major issue in colorization-based coding method is to select or extract the RP well so as to reconstruct chrominance information of all the pixels, which is required for the reconstruction of good quality color image. Colorization matrix is constructed using mean-shift segmentation of luminance part of the image which is used in extracting RP set by applying OMP and SL0 algorithm. The size of transmitted image is reduced because of reduced number of RP set. The quality of reconstructed image has been evaluated using MSE, PSNR and SSIM parameters.

Keywords – Colorization, compressive sensing, image compression, image reconstruction.

I. INTRODUCTION

Image processing technology enables the reconstruction of still image and video, as well as the realistic automatic synthesis of such still image and video with computer graphics in accordance with users need. In the image processing the term colorization is an important part, basically the term colorization is used to add color in black and white or gray image which is introduced by Wilson Markle to describe the computer-assisted process. There are several methods for the colorization process in which we take a similar color image for reference image, and conveying its colors value to the gray image or black and white image. A new approach to colorization a black and white image is introduced which is based on the compression technique [1][4]. The main task of colorization process is to extract representative pixel (RP) at the transmitter end and maintains the color information for these RP values and also maintain the quality of reconstructed color image and compression rate. In the colorization based compression technique, compression rate of reconstructed color image is good, due to this we can transmit the image with minimum band width and taking the minimum transmission time, this is the main advantage of using the colorization based compression technique.

In this paper we formulated the minimum number of RP selection with smooth L_0 (SL0) and L_1 norm (OMP) optimization method and the selection of the RP is minimum with respect to the given colorization matrix. Using OMP and SL0 the difference between the original color image and the reconstructed color image becomes minimum. By using this method there is no need to repeatedly extract RP. The optimization problem is also called as a variation approach, and the variation approach in image processing can be used in the colorization based coding method.

The main function of colorization based coding method is the extraction of the representative pixels. Basically the term colorization is used to describe any technique for adding color to monochrome image or movie. In many colorization techniques a user typically needs to state many color scribbles on the image to achieve a appropriate result as method proposed by Huang et al. [1] and Levin et al.[2]. Initially color image is converted to YcbCr color space i.e. into luminance (Y) and Chrominance (Cb & Cr) parts. The colorization method adopted by Levin et al. [2] extracts RP set denoted by vector x. The color vector (u) is computed from known RP set vector x at decoder using,

$$u = A^{-1} x \qquad (1)$$

where A is RP extraction matrix. The RP set is chosen so as to minimize the difference between original and reconstructed image. The process of choosing RP set is performed in iterations till minimum difference is obtained. In each iteration A is constructed which increases computation time. In [4], the redundant RP set are reduced and the only required ones are extracted iteratively. However, extracting RP set iteratively with proposed methods it is not assured that using the extracted RP set, color image can be constructed faithfully. To simplify the algorithm optimization techniques may be adopted. It is known that if x is sparse then it is possible to formulate the problem as,

$$|\mathbf{x}|_0,\ \text{s.t. } \mathbf{b} = A\mathbf{x} \qquad (2)$$

However, since the solution of eq (2) is NP hard, therefore L1 minimization technique may be applied given as,

$$|\mathbf{x}|_1,\ \text{s.t. } \mathbf{b} = A\mathbf{x} \qquad (3)$$

The solution of eq (3) can be obtained if A follows restricted isometric property (RIP) [19]. In this paper L1 minimization technique is implemented using orthogonal matching pursuit (OMP) [18] and smooth L0 (SL0) [17] norm is also used.

The contribution of this paper is that we formulated the RP selection problem with an $L1$ minimization optimization problem. The selection of the RP is minimum with respect to the given colorization matrix. The error difference between the original color image and the reconstructed color image becomes least with respect to the L2 norm error. By the L1 minimization the number of pixels in the RP set is also minimized The best set of RP is obtained by a single minimization step and does not need any refinement, In additional this method is RP reduction methods. The optimization problem is also called as a variational approach, and the variational approach in image processing can be used in the colorization based coding method. This paper is extension of method proposed by Lee et al. [19]. In [18], RP set is computed along with its position using OMP, however in this paper only optimized RP set is computed using OMP and SL0 algorithm. This reduces the size approximately to half. The reconstructed color image quality is measured using PSNR, SSIM and MSE values.

A. RP Extraction method-

In colorization based compression method propose an iterative sparse coding method for the extraction of the RP (representative pixel) set. The selection of RP set can be formulated into sparse recovery optimization problem [11]. The suitable RP values are obtained by solving the L_0 minimization problem and L_1 norm (OMP) minimization sparse recovery algorithms chose RP values at encoder such that it reduces the number of non-zero components from colorization matrix. The solution can be obtained only if colorization matrix satisfies the restricted isometric property (RIP) [12]. So, for to satisfy RIP it is multiplied by a random Gaussian matrix. In, [16] colorization based coding is a technique which compresses a color image using the colorization method. Observations show that this method collect optimal set of RP and optimal colorization matrix. The main issue in colorization based coding is to extract a good RP(representative pixel) set from the original color image with this RP set color image is reconstructed at the decoder end. Experimental results show that this method provides better reconstruction color image and compression rate.

Colorization of an image is done by dividing it into regions and then assigning a color to each region. Segmentation of image is performed with two objectives. The first objective is to decompose the image into parts for further analysis and the second objective is to perform a change of representation in image. Due to some worthy properties in mean shift segmentation [12], there are two different parameter one is photometric distance and the other is spatial distance. Therefore, using these segmentation we can generate segmented regions of different photometric and spatial characteristics. In multi-scale Segmentation to create the colorization matrix, we use multi-scale mean shift segmentation. A multi-scale mean shift segmentation method is executed at different scales. This scale is decided by using kernels with different bandwidths. With smaller bandwidth a kernel segments the image into smaller segments. While with larger bandwidth a kernel segments the image into larger segments.

In proposed method we are using multi value mean shift segmentation method for segmenting the image with using 20 different spatial and range resolution combination. This means that we performed the mean-shift segmentation with 20 different spatial and range resolutions. The parameters *hs* and *hr* control the spatial and the range resolutions, respectively, and large values of *hs* and *hr* result in large scaled segmented regions. The parameters *(hs , hr)* used in each scale are as follows: Scale 1: (40,80), Scale 2: (38, 76), Scale 3: (36, 72), Scale 4: (34, 68), Scale 5: (32, 64), Scale 6: (30, 60), Scale 7: (28, 56), Scale 8: (26, 52), Scale 9: (24, 48), Scale 10: (22, 44), Scale 11: (20, 40), Scale 12: (18, 36), Scale 13: (16, 32), Scale 14: (14, 28), Scale 15: (12, 24), Scale 16: (10, 20), Scale 17: (8, 16), Scale 18: (6, 12), Scale 19: (4, 8), Scale 20: (2, 4).

To reduce the size of color information, sparse recovery algorithms SL0 and OMP are used [17].The main idea of SL0 is to use a "smooth" measure of the L0 norm. SL0 algorithm may result in significantly better reconstruction capabilities in terms of phase transition while retaining the same required computation time as existing SL0 algorithms. L1 optimization problem can be solved by linear programming such as the Basis Pursuit (BP) or Orthogonal Matching Pursuit (OMP) [6] [7].

B. Overall system diagram-

The color image is converted into YCbCr space with luminance (Y) and Chrominance (Cb & Cr) channels. The luminance channel is segmented using multi-scale-mean-shift segmentation technique. The segmented image is transformed using wavelet daubechies (db10) coefficients. The colorization matrix is constructed using these segments. SL0 and OMP algorithms are used to extract RP set using colorization matrix and transformed color channels. From encoder, luminance and RP sets are sent to the decoder.

At decoder, luminance channel is decompressed. The decompressed luminance channel is multi-scale-mean shift segmented and transformed to construct the colorization matrix again. The received RP set along with colorization matrix isi used to reconstruct the color channel. After inverse transforming color channel, color image is reconstructed using decompressed luminance channel. The block diagram of encoder and decoder is shown in Fig 1.

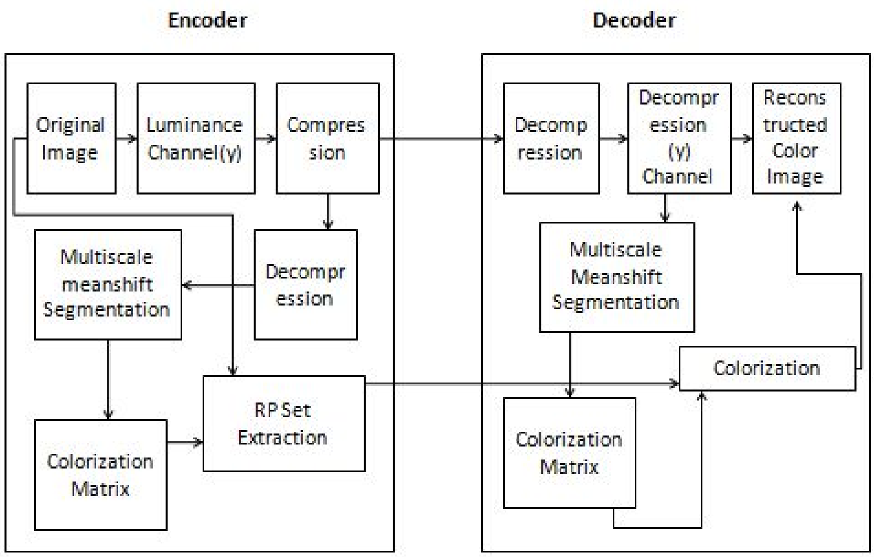

Fig. 1. Block diagram for the encoder and Decoder

IV. EXPERIMENT AND RESULTS

In this section, we present the experiments performed on original color image of pepper, butterfly and cap each of size 256x256 using Matlab software. In this experiment at the encoder end original color image is converted in its luminance and chrominance channels. For further process the luminance part is segmented with Multi-scale mean-shift segmentation method. Same procedure is applied at the decoder end for constructing the colorization matrix, at the decoder the RP set from encoder and colorization matrix are used to reconstruct the color image. The original color images and reconstructed color images are shown in the Fig. 2, 3 and 4. Table-1 represent the quality of reconstructed color images based on PSNR, SSIM and MSE parameters.

.

(a) (b) (c)

Fig.2 . Experimental results with the 256×256 "Pep" image. (a) Original. (b) SL0. (c) OMP.

(a) (b) (c)

Fig. 3. Experimental results with the 256×256 "cap" image. (a) Original. (b) SL0. (c) OMP.

(a) (b) (c)

Fig. 4. Experimental results with the 256×256 "butterfly" image. (a) Original.(b) SL0. (c) OMP.

Table -1 Experiment Result

IMAGE	METHODE	PSNR	SSIM(Cb)	SSIM(Cr)	MSE (Cb)	MSE(Cr)	FILE SIZE (KB)
CAP	OMP	31.3786	0.8121	0.9704	0.0089	0.00005	0.4121
	SLO	31.3825	0.8125	0.9705	0.0089	0.00005	0.4121
BUTTERFL Y	OMP	32.9995	0.8666	0.8605	0.0031	0.0019	0.3750
	SLO	33.0255	0.8680	0.8606	0.0031	0.0019	0.3750
PEP	OMP	29.6195	0.9068	0.7001	0.0025	0.080	0.3652
	SLO	29.6204	0.9071	0.6999	0.0025	0.080	0.3652

IV.CONCLUSION

In this paper, we formulate the colorization-based coding problem into an optimization problem. The extraction of RP sets is done using sparse recovery algorithms SL0 and OMP. In colorization-based coding method, at the encoder we have chosen few representative pixels (RP) for the chrominance values and the RP set and compressed luminance information are sent to the decoder, and at the decoder end, the chrominance values for all the pixels are reconstructed by using colorization method. Experimental results show that the proposed method exceeds other colorization based coding methods to a large extent in quantitative as well as qualitative measures and gives comparative results even when lesser size image is transmitted. The memory requirement of the method increases with increase in segment size and hence the colorization matrix size. So better segmentation technique may be used in future which may be reduce colorization matrix size at the same time extracts optimal RP set.

REFERENCES

[1] B. Corona, M. Nakano, H. Pérez, “Adaptive Watermarking Algorithm for Binary Image Watermarks”, *Lecture Notes in Computer Science, Springer, pp. 207-215, 2004.*

[2] A. A. Reddy and B. N. Chatterji, "A new wavelet based logo-watermarking scheme," Pattern Recognition Letters, vol. 26, pp. 1019-1027, 2005.

[3] P. S. Huang, C. S. Chiang, C. P. Chang, and T. M. Tu, "Robust spatial watermarking technique for colour images via direct saturation adjustment," Vision, Image and Signal Processing, IEE Proceedings -, vol. 152, pp. 561-574, 2005.

[4] F. Gonzalez and J. Hernandez, " A tutorial on Digital Watermarking ", In IEEE annual Carnahan conference on security technology, Spain, 1999.

[5] D. Kunder, "Multi-resolution Digital Watermarking Algorithms and Implications for Multimedia Signals", Ph.D. thesis, university of Toronto, Canada, 2001.

[6] J. Eggers, J. Su and B. Girod," Robustness of a Blind Image Watermarking Scheme", Proc. IEEE Int. Conf. on Image Proc., Vancouver, 2000.

[7] Barni M., Bartolini F., Piva A., Multichannel watermarking of color images, IEEE Transaction on Circuits and Systems of Video Technology 12(3) (2002) 142-156.

[8] Kundur D., Hatzinakos D., Towards robust logo watermarking using multiresolution image fusion, IEEE Transcations on Multimedia 6 (2004) 185-197.

[9] C.S. Lu, H.Y.M Liao, “Multipurpose watermarking for image authentication and protection,” *IEEE Transaction on Image Processing*, vol. 10, pp. 1579-1592, Oct. 2001.

[10] L. Ghouti, A. Bouridane, M.K. Ibrahim, and S. Boussakta, “Digital image watermarking using balanced multiwavelets”, *IEEE Trans. Signal Process*., 2006, Vol. 54, No. 4, pp. 1519-1536.

[11] P. Tay and J. Havlicek, "Image Watermarking Using Wavelets", in *Proceedings of the 2002 IEEE*, pp. II.258 – II.261, 2002.

[12] P. Kumswat, Ki. Attakitmongcol and A. Striaew, "A New Approach for Optimization in Image Watermarking by Using Genetic Algorithms", *IEEE Transactions on Signal Processing*, Vol. 53, No. 12, pp. 4707-4719, December, 2005.

[13] H. Daren, L. Jifuen,H. Jiwu, and L. Hongmei, "A DWT-Based Image Watermarking Algorithm", in *Proceedings of the IEEE International Conference on Multimedia and Expo*, pp. 429-432, 2001.

[14] C. Hsu and J. Wu, "Multi-resolution Watermarking for Digital Images", *IEEE Transactions on Circuits and Systems- II*, Vol. 45, No. 8, pp. 1097-1101, August 1998.

[15] R. Mehul, "Discrete Wavelet Transform Based Multiple Watermarking Scheme", in *Proceedings of the 2003 IEEE TENCON*, pp. 935-938, 2003.

[16] Sukho Lee, Sang-Wook Park, Paul Oh, and Moon Gi Kang, "Colorization-Based Compression Using Optimization", VOL. 22, NO. , JULY 2013.

[17] Guan Gui,Qun Wan, Wei Peng, " Fast Compressed Sensing-Based Sparse Multipath Channel Estimation with Smooth L0 Algorithm ", ", CMC, April 2011.

[18] Lichao Su., Jian Chen , Xiaozhen Fu," Images reconstruction method using SL0 algorithm for compressed sensing based on single layer wavelet transformation", ICSAI, May 2012.

[19] Xiaoming Liu, Jun Liu, Zhilin Feng, " Colorization Using Segmentation with Random Walk ", CAIP '09,2009.