A Constant Rate Block Based Image Compression Scheme for Video Display Link Applications

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***Abstract*—In this paper, we develop an embedded video compression scheme with a constant compression rate to reduce the communication bandwidth on video display links. The basic compression unit is a 2×4 pixel block and all blocks are coded independently to facilitate the function of partial frame update. The proposed embedded compression scheme features an ensemble of compression techniques. These techniques include various spatial domain predictions and vector quantization. The compression ratio of the luminance component is fixed at 2 and those of the two color components are 4. This leads to an overall 3 times constant rate compression. The compression efficiency of the proposed scheme is evaluated based on a set of test images. The achieved PSNR values range from 23.7dB to 38.86dB and the visual distortions are barely noticeable for display on hand held devices.**

I. INTRODUCTION

The display resolutions of 3C products are growing larger and larger nowadays. This results in a huge increase on the required data bandwidth along the display links. As shown in Fig. 1, an embedded image compression codec on the display link can alleviate the bandwidth problem without causing perceivable image distortions. Although many video/image compression schemes have been developed, they are not suitable for the target application, where a low complexity and real time scheme is required to minimize the hardware and power overheads. In addition, latest operation systems such as Android 5.0 support display partial update feature. This calls for a smaller coding unit, which can be decoded independently, in compression. Recent works on low complexity embedded image compression such as [1] does not guarantee a constant compression ratio. Those works [2-5] with rate control perform compression on either a frame or a line based. None of them support a block based constant rate approach. DSC (Display Stream Compression) [6] is the first public standard for compression on display link proposed by the organization VESA and supports constant compression rate of 2x and 3x. The prediction works on a group consisting of 3 consecutive pixels but requires reconstructed pixels from the previous line.

II. PROPOSED CONSTANT RATE BLOCK BASED IMAGE COMPRESSION SCHEME

The proposed system performs compression on a block-based manner with a block size of 2×4 and all blocks are compressed independently using no information other than the current block. Fig. 2 shows the flowchart of the proposed scheme. The image frame is first partitioned into blocks and then transformed to a Y-Cg-Co color space. These components are processed separately, each with a distinct compression rate. The compression rate for Y component is 2 and that of both color components is settled as 4. This leads to an overall compression rate of 3 for the proposed system.

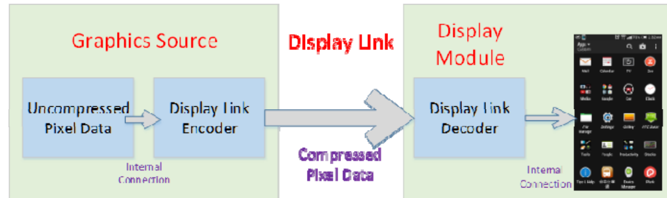


Fig. 1. Embedded image compression codec for display link

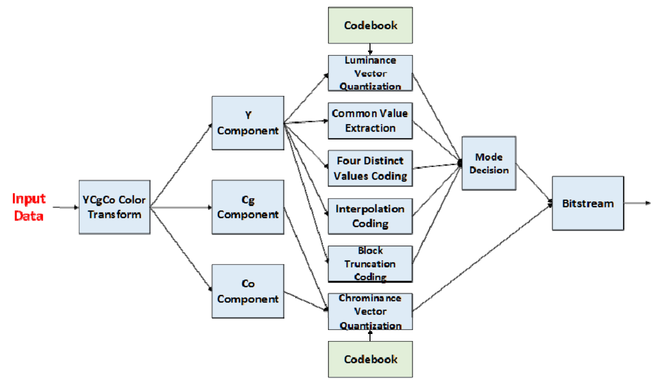


Fig. 2. Flowchart of the proposed embedded image compression scheme

The compression rate setting for the luminance component is less stringent than its two color counterparts. To cope with varying features on different coding blocks, an ensemble of coding tools is employed with each targeting a specific type of blocks. For the two color components (Cg and Co), vector quantization (VQ) is the only coding tool used due to its high compression efficiency. The mean of the block, however, is subtracted first before applying VQ for better efficiency. Separate codebooks are developed for each color component and the size of the codebook is 64. The mean value is recorded using a 6-bit scalar quantization index. VQ is also a coding option to the luminance component. As shown in Fig. 3, due to a larger bit budget allocation for the luminance, the VQ result is further refined by using integer DCT coding to reduce the VQ residuals. However, only 4 of the 8 DCT coefficients are quantized and coded.

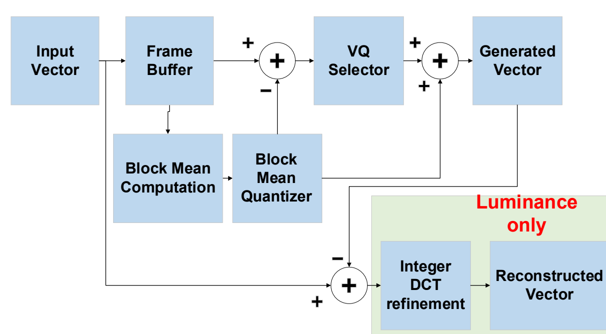


Fig. 3. Vector quantization and the residual refinement scheme

Besides vector quantization, 4 more coding options are available for the luminance component. In the common value extraction (CVE) scheme, each pixel is reconstructed by using the common value and the detailed part. In four distinct values coding (4DVC), pixels are classified into 4 groups each represented by a distinct value. In the interpolation based coding (IC) scheme, one half of the pixels in the block are coded directly with quantization, while the other half are reconstructed by either using interpolation or referencing the coded pixel values. In the block truncation coding (BTC) scheme, it quantizes all pixel values of the block into a reduced number of distinct values, while the mean and the standard deviation remain unchanged. Similar to luminance VQ, a DCT based refinement procedure is applied to the BTC result. The coding mode selection is based on the PSNR index defined as in Eq.(1). A variable length coding scheme is used to code the mode selection.

$$PSNR_{RGB} = 10\log_{10}\left(\frac{3\times MAX_I^2}{MSE_R + MSE_G + MSE_B}\right) \quad (1)$$

III. EXPERIMENTAL RESULTS AND EVALUATIONS

In order to evaluate the performance of the proposed scheme, eight test images (numbering from upper left to lower right) are selected to test the compression quality. The selected images are as shown in Fig. 4. Some of them are artificial images and some are natural scenes. Fig. 5 illustrate the compression result of image 2, including the distribution of coding mode selection and the resultant PSNR value. Since there's still no constant rate compression standard currently available, the classic JPEG compression scheme is chosen here for performance comparison. JPEG is working on blocks of size 8×8 block size, which is 8 times the block size adopted in the proposed system. This gives the JPEG scheme many advantages in terms of coding flexibility and bit allocation. The JPEG scheme, however, is not a constant rate compression scheme. Its quantization factor is adjusted manually to achieve an average compression rate close to 3. Fig. 6 shows the comparison result. Although the JPEG scheme excels in some high resolution images (4,5 and 6), the proposed one performs comparably in images 2,3, and 4 and even outperforms the JPEG scheme in image 8 with a text image. The achieved PSNR values range from 23.7dB to 38.86dB and the visual distortions are barely noticeable for display on hand held devices.

In conclusion, a block based constant rate (a compression factor of 3) image codec is developed. It can greatly alleviate the data bandwidth problem associated with the display link

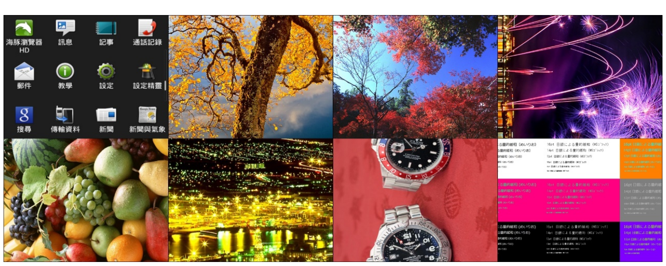
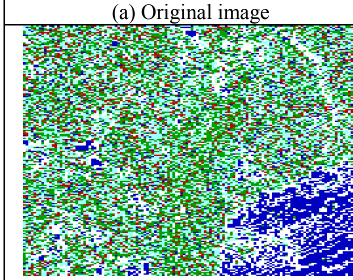


Fig. 4. 8 image test sets

(a) Original image (b) Reconstructed image



(c) mode selection

mode	percentage
CVE	18.2%
VQ	9.6%
4DVC	27.9%
BTC	14.7%
IC	29.6%
PSNR	25.3dB

Fig. 5 illustration of image 2 compression result

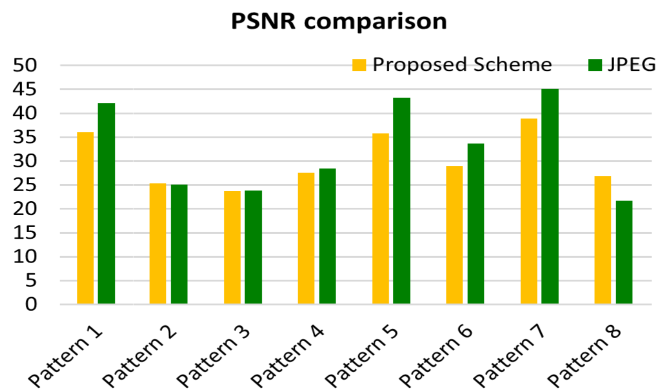


Fig. 6 PSNR comparison of the proposed scheme against JPEG scheme

and the compressed image quality is generally satisfactory for smaller display devices such as mobile phones.

REFERENCES

[1] R. K. Senapati, U. C. Pati, K. K. Mahapatra," Reduced memory, low complexity embedded image compression algorithm using hierarchical listless discrete Tchebichef transform," IET Image Processing, vol. 8 , issue 4, 2014, pp. 213-38

[2] Jianmin Jiang " A Low-Cost Content-Adaptive and Rate-Controllable Near-Lossless Image Codec in DPCM Domain," *IEEE Trans. on Image Processing*, vol. 9, no. 4, pp.543-554, Apr. 2000.

[3] Tsung-Han Tsai , Yu-Hsuan Lee, and Yu-Yu Lee, " Design and Analysis of High-Throughput Lossless Image Compression Engine Using VLSI-Oriented FELICS Algorithm" *IEEE Trans. on VLSI*, vol. 18, no. 1, pp. 39-52, Jan. 2010.

[4] Tsung-Han Tsai , Yu-Hsuan Lee, "a 6.4Gbit/s Embedded Compression Codec for Memory Efficient Applications on Advanced HD Specifications," *IEEE Transactions on Circuits and Systems for Video Technology*, vol. 20, iss. 10 , pp. 1277 – 1291, 2010.

[5] Yin-Tsung Hwang, Ming-Wei Lyu, Chen-Cheng Lin, "A Low Complexity Embedded Compression Codec Design with Rate Control for High Definition Video," IEEE Transactions on Circuits and Systems for Video Technology, vol. 25, issue 4, 2015, pp. 674-687

[6] VESA Display Stream Compression white paper http://www.vesa.org/wp-content/uploads/2014/04/VESA_DSC-ETP200.pdf