THE NEW COLOR WAVELET BASED CODER

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Abstract. In this paper, we propose the novel color wavelet based CHC-RIOT (Color Homogenous Connected-Region Interested Ordered Transmission) coder. As it is developed based on two well-know wavelet based compressions, ZTE [3] and SPIHT [4] coders, the CHC-RIOT coder accommodates several properties such as scalability and progressive transmission. It also provides the multi-layer property by compressing the image into two layer bitstreams, the base layer and the enhancement layer bitstreams. Such that the base layer bitstream, a very high compressed bitstream, provides a proper quality of recognizable image while combining to the enhancement layer bitstream results in refining the reconstructed image.

1. Introduction

According to the developments of the recent data communications and image retrieval techniques, the distributions of the large size of digital images are tremendously increasing. Nevertheless, due to the size of an image contents and the limitation of the transmission bandwidth, the more efficient methodologies to either compress or transmit the image to the end user are reconsidered. In this paper, the concept of using multi-layer image compression is introduced. First, the image is highly compressed into a short bitstream "called the base layer" and used to represent a recognizable image (thumbnail).

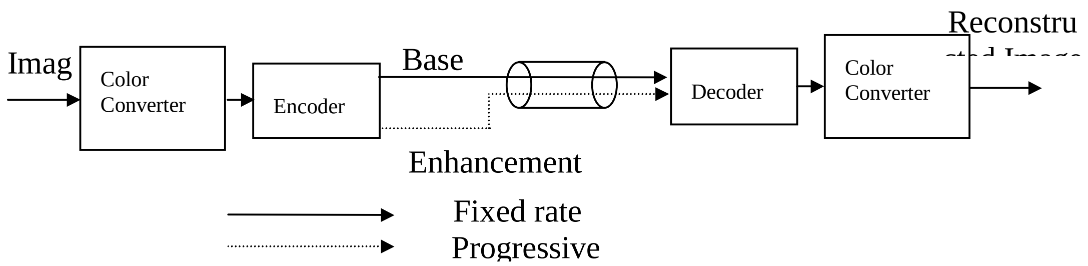


Figure 1. The structure of CHC-RIOT coder

The fidelity of the image can be progressively improved by using the rest of contents of the image that are compressed with in the former layer, "the enhancement layer". The advantages of the proposed method are very beneficial to several image processing applications, especially, the image retrieval aspect [5],[6]. This can be explained that, for example, the end user can easily view several thumbnails of the candidate images by requesting the "short" base layer bitstreams (rather than wastes for retrieving the whole images). On that occasion, he/she can further ask for refining only those of the images of interest.

In the next sections, the fundamental of the CHC-RIOT coder is explained. We show the evaluation results and the effects of the bit rates of the base layer and enhancement layer bitstreams to the visual quality of image in section 3. For the rest of the paper, we conclude the compression performance of the CHC-RIOT coder.

2. CHC-RIOT coder

The wavelet based CHC-RIOT coder is the color version of HC-RIOT (Homogenous Connected-Region Interested Ordered Transmission) coder [1],[2]. In Fig. 1, the structure of the CHC-RIOT coder is illustrated. It consists of three processes: (1) Color convertor, (2) Encoder and (3) Decoder. Same as in HC-RIOT coder, it compresses an image into two layer bitstreams: (i) base layer bitstream and (ii) enhancement layer bitstream.

In color converter, an image (RGB color space) is converted into YUV color space. It decorrelates the dependencies of RGB color components into luminance (Y) and chrominance (U and V) components. Since the chrominance components (U and V) are less sensitive to the human visual system (HVS) than the luminance component, the proposed system assigns the bit allocation ratio for luminance and chrominance as 4:2:0. After the color conversion, the YUV components are sent into the CHC-RIOT encoder which consists of two processes (Fig. 2): (1) Base layer encoder (using ZTE coder [3]) and (2) Enhancement layer encoder (using the modified SPIHT coder [4]). In the base layer encoder, YUV image is decomposed using Daubechies (9/7 wavelet based symmetric filter) into four levels. The YUV components are then separately coded obtaining three base layer bitstreams. The key development that is added to the base layer of CHC-RIOT is Wavelet Block Chain (WBC) [2]. The WBC identifies and labels homogenous block based regions of the image into edge, smooth or detail region. It improves perceptual coding as the encoder factors this classification information into its rate distortion criteria. In the enhancement layer encoder, the coefficients not processed by the base layer encoder are coded. In this case, each refinement pass simultaneously codes three components to produce the embedded bitstream providing a progressive transmission. The CHC-RIOT decoder is an inverse operation of the encoder [5],[6].

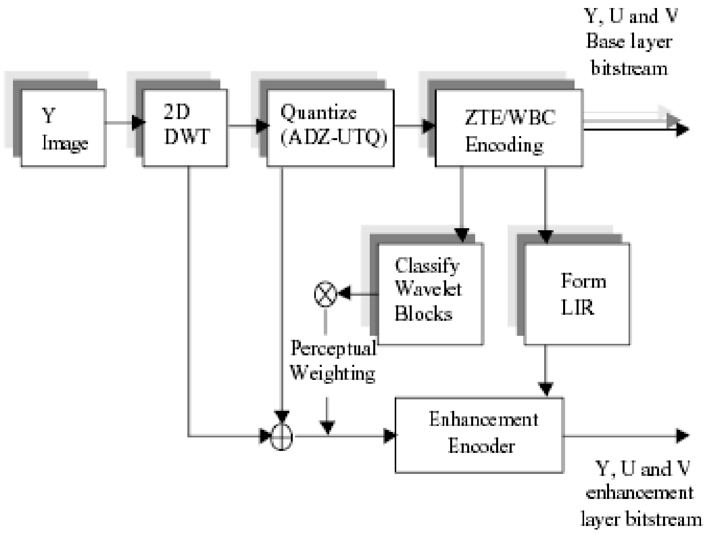


Figure 2. The CHC-RIOT encoder

3. Simulation results

In this section, the evaluations on the compression performance of the CHC-RIOT coder are discussed. Several results and discussions on the algorithm such as the evaluation of the CHC-RIOT base layer encoder and the CHC-RIOT enhancement layer encoder in terms of compression performance and visual quality are provided.

3.1 Evaluation of CHC-RIOT base layer encoder

The main objective of the CHC-RIOT base layer encoder is to generate the recognizable (very low resolution but still viewable) version of the image. The output of this encoder is used as the thumbnail. The base layer encoder is designed based on the ZTE coder [3] which has characteristics such as the optimized image quality can be obtained when the transmission rate is specified (especially at the very high compression environment).

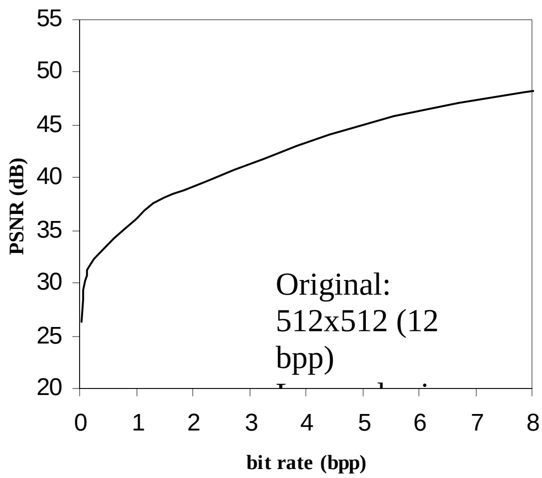


Figure 3. The compression performance of the CHC-RIOT base layer coder.

Compression performance of the base layer encoder

In Fig. 3, the compression performance of the proposed CHC-RIOT base layer encoder is shown. The base layer encoder is applied to the Lena image (size 512x512 pixels) representing in RGB format. Since the CHC-RIOT base layer encoder is designed to compress images in YUV format, preprocessing by a color converter is required. Note that the converter transforms the image from RGB (24 bpp., 8 bits per component) color format to YUV (4:2:0) color format (hence, each pixel is represented by 12 bpp.)

Based on the compression results (see Fig. 3), the primary characteristic of the base layer bitstream is conceived. Certainly, the image quality is improved along with the size of the bitstream. Especially at the very low bit rate (less than 0.5 bpp), the dramatic change is PSNR is recognized.

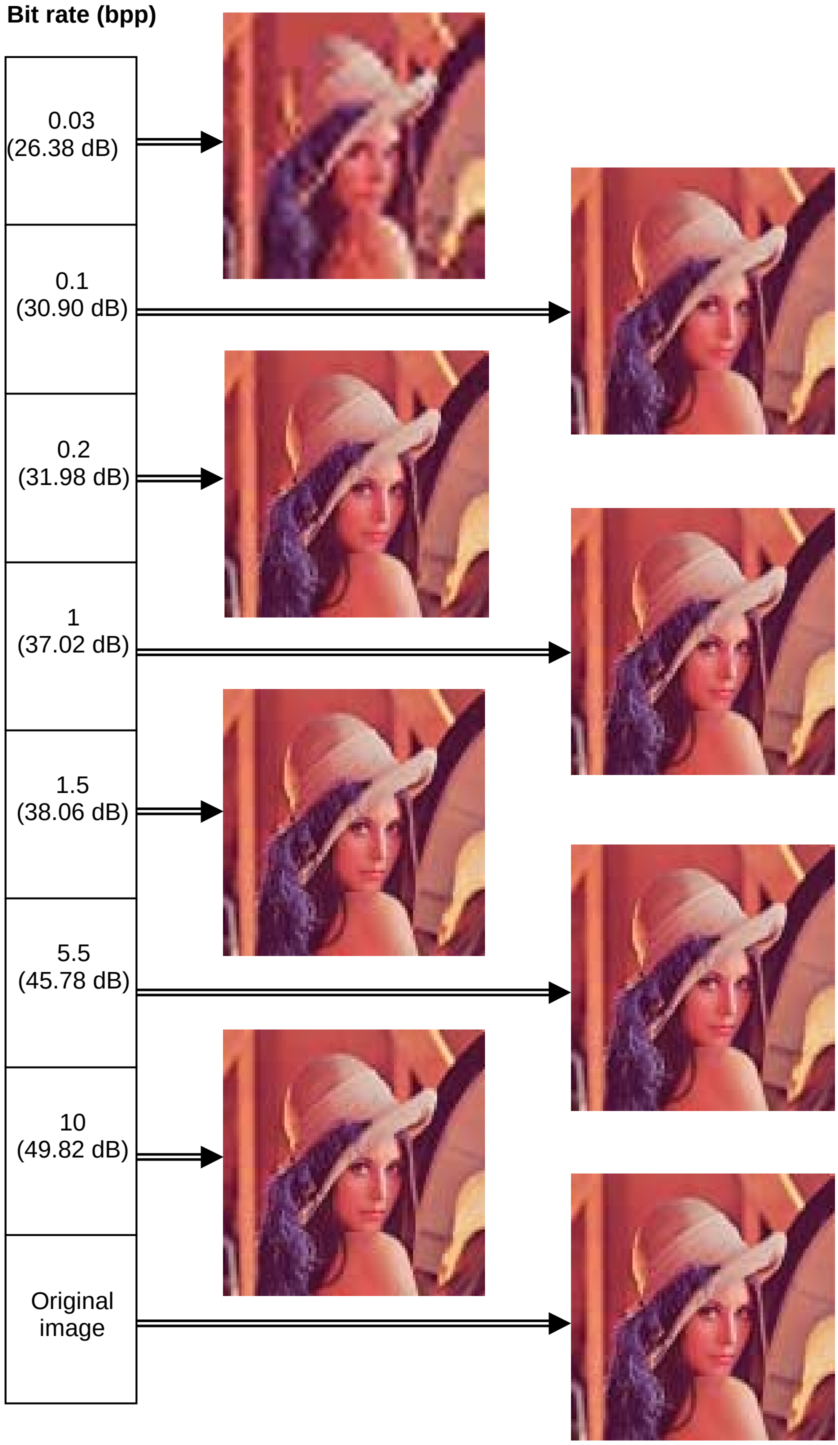
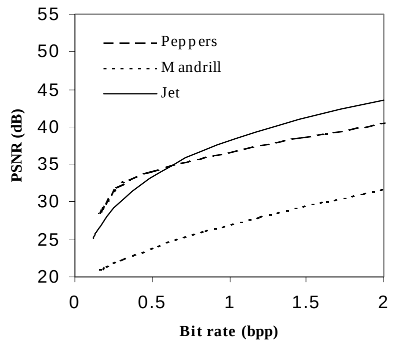


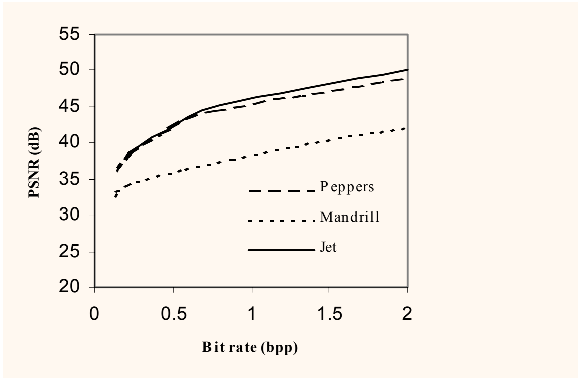
Figure 4 The reconstructed images based on several base layer bitstreams.
(Numbers in the left column are in bpp.)

Visual quality of the base layer encoder

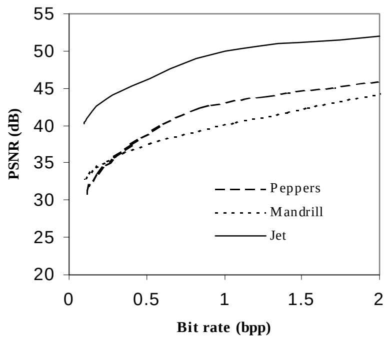
In Fig. 4, the set of reconstructed images based on several sizes of the CHC-RIOT base layer bitstreams are shown. For the bit rate less than 0.1 bpp, obviously the reconstructed images have unacceptable perceptual quality. On the other hand, above the bit rate of 0.2 bpp, the subjective corruption of the images is almost unnoticeable. Based on these results, we consider the bit rate at 0.2 bpp. to be the size of the base layer bitstream since it uses small number of bits while providing the acceptable image quality.



a) The Y component of the test images



b) The U component of the test images



c) The V component of the test images

Figure 5. The compression performance of each Y, U and V component of Lena image.

3.2 Evaluation of CHC-RIOT enhancement layer encoder

In this subsection, the evaluation of CHC-RIOT enhancement layer encoder is provided. Basically, the evaluation is performed by analyzing the effects on each Y, U and V components coded in the CHC-RIOT enhancement layer bitstream. In the simulations, we use three types of the (512x512 pixels) images (Mandrill, Peppers and Jet images), where the size of Y, U and V components (based on the sampling format 4:2:0) are 512x512, 256x256 and 256x256 pixels, respectively. Note that the simulation is performed under the condition of the base layer compression rate is 0.2 bpp (default).

Comparing the results of the compression performances in PSNR among Y, U and V components (shown in Fig. 5), obviously the U and V components are less significant than the Y component. Though the images are coded at the very low bit rates, the PSNRs of both U and V components are still high, for example at 0.3 bpp the PSNRs of the reconstructed Jet image are approximately 40 and 44 dB, respectively. On the other hand, since most of the image content (activity) corresponds to the Y component, its PSNR is relatively sensitive to the bit rate. Consequently, we can conclude that the overall PSNR of the reconstructed image (coded by the CHC-RIOT coder) significantly depends on the compression performance in Y component. Moreover, since the proposed CHC-RIOT coder is designed based on the bit plane coding, as the bit rate is increased (especially at the very low bit rates), the PSNRs of all components improve dramatically. However, the slopes of the PSNRs decline when the bit rate is approximately greater than 1 bpp. This is because most of the MSBs (most significant bits), which dominantly influence the PSNR of the reconstructed image, are coded at the early stage of the compressed bitstream. Consequently, the rest of the bitstream is occupied by the insignificant bits, which have less effect on the image visual quality (the PSNR).

4. Conclusion

In this paper, we propose the color wavelet-based compression method, the CHC-RIOT coder. Based on the multi-layer property of the proposed algorithm, it provides not only an excellent high compression performance but also the base layer, a high compressed bitstream, produces the high quality image thus providing the fast transmission of recognizable image (thumbnail). Then, the rest of the information (enhancement layer) is delivered when the fine reconstructed image is required. Based on the multi-layer bitstream, it gains several advantages for some applications such as retrieval system.

References

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