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Lossless Colour Image Compression Using RCT Technique and Hierarchical Prediction

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Abstract- Image compression is the process of reducing the amount of data required to represent an image. Digital images are usually compressed by lossy compression method or lossless compression method. In existing system digital images are encoded by lossy compression due to its large memory and bandwidth requirements. This project presents a new lossless colour image compression algorithm, based on the RCT technique and hierarchical prediction. For the lossless compression of an RGB image, it is first de-correlated by a reversible colour transform and then Y component is encoded by a conventional lossless gray scale image compression method. For encoding the chrominance images, a hierarchical scheme is developed. It enables the use of upper, left, and lower pixels for the pixel prediction, whereas the conventional raster scan prediction methods use upper and left pixels. The proposed method also increases the Signal to Noise ratio and compression ratio compared with JPEG 2000. The tools used for this project is MATLAB.

Index Terms- Chrominance image, Compression ratio, Hierarchical prediction, JPEG 2000, Lossless colour image compression, Luminance image, Peak signal to noise ratio, RCT technique

1 Introduction

A digital image is a numeric representation of a two dimensional image. Image processing is the field of signal processing where both the input and output signals are images. Image processing is very important subject and finds applications in fields such as photography, satellite imaging, medical imaging and image compression. However, as computers have become more powerful, as a result of which processing shifted to digital domain. DIP overcomes traditional analog problems such as noise, distortion during processing. The digital image is composed of finite number of element, each of which has particular location and value. Pixel is a term most widely used to denote the elements of the digital images. It allows a much wider range of algorithms to be applied to the input data and can avoid problems such as built of noise and signal distortion during processing.

Images have considerably higher storage requirement than text. Audio and video require more demanding properties for data storage. An image stored in an uncompressed file format, such as the popular BMP format, can be huge. The huge amount of storage space is not only the consideration but also the data transmission rate for communication of continues media are also significantly large. Image data compression becomes still more important because of the fact that the transfer of uncompressed graphical data requires far more bandwidth and data transfer rate.

Lossless compression is used in cases where it is important that the original and the decompressed data be identical. Most lossless compression programs do two things in sequence: the first step generates a statistical model for the input data, and the second step uses this model to map input data to bit sequences in such a way that portable data will produce shorter output than improbable data.

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There are different methods of lossless compression which uses different compression algorithms. Some of which are Adaptive coding, Adaptive Huffman coding, DEFLATE, Entropy encoding, Fibonacci coding and so on. Among a variety of algorithms, the most widely used ones maybe Lossless JPEG [1], JPEG-LS [2], LOCO-I [3], CALIC [4], JPEG2000 [5] (lossless mode) and JPEG XR [6]. For the compression of color images, the color components are first decorrelated by a color transform, and each of the transformed components is independently compressed by the above referenced methods. For example, the RGB to $Y C_b C_r$ transform [7] may be the most frequently used one for the lossy compression of color image and video. However, in the case of lossless compression, most color transforms cannot be used due to their uninvertibility with integer arithmetic. Hence an invertible version of color transform, the reversible color transform (RCT) was defined and used in JPEG2000 [5]. There has also been much research for finding better RCTs [8]–[10], among which we adopt a transform proposed in [9] because it approximates the conventional $Y C_b C_r$ transform very well.

2 PROPOSED SYSTEM DESCRIPTION

The proposed system develops a hierarchical prediction scheme, while most of existing prediction methods in lossless compression are based on the raster scan prediction method. But the raster scan prediction method is sometimes inefficient in the high frequency region. The “hierarchical” prediction for the compression was already proposed, but only pixel interpolation is used. To be specific, this method use lower row pixels as well as the upper and left pixels for the prediction of a pixel to be encoded. For the compression of colour images, the RGB is first transformed to YC_uC_v by an RCT, and Y channel is encoded by a conventional gray scale image compression algorithm. In the case of chrominance channels (C_u and C_v), the signal variation is generally much smaller than that of RGB, but still large near the edges. The chrominance image is compressed using hierarchical prediction scheme. After compression the image is quantized and encoded to produce the efficient lossless compressed image.

2.1 RCT TECHNIQUE

The lossless compression operates in a luminance-chrominance colour space instead of the standard RGB colour space. It is well known in image and video compression that this typically enables more efficient compression due to the decorrelation of the RGB channels. In addition, it also enables the use of slightly different compression schemes for the luminance and the chrominance components. This could potentially be useful since rendered gaming scenes often provide most details and dynamics in the luminance components.

For lossless compression, the colour space transforms needs to be exactly reversible. Reversible colour transform for 16-bit colour (bicolour) picture coding. The work is motivated by the increasing needs of multimedia applications on low-end devices such as mobile phones and PDAs. They have limited resources and up to 16-bit displays. Current image/video coding systems can hardly manage this case effectively. To enhance coding efficiency on this condition, a reversible colour transform customized for hi colour systems is derived from YC_rC_b and JPEG 2000 RCT. The transforms prove simple but highly de correlating, and able to reduce the computation time of decoding. For the compression of colour images, the RGB is first transformed to YC_uC_v by an RCT technique.

2.2 HIERARCHICAL DECOMPOSITION

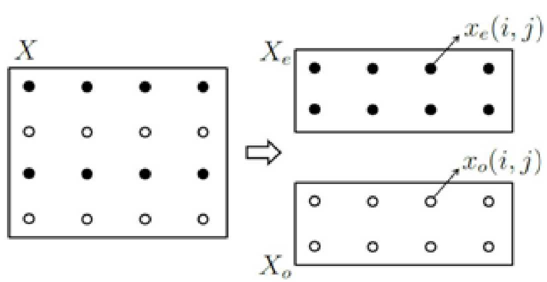

Fig.1 Input images and its decomposition

The chrominance channels C_u and C_v resulting from the RCT usually have different statistics from Y, and also different from the original colour planes R, G, and B. In the chrominance channels, the overall signal variation is suppressed by the colour transform, but the variation is still large near the object boundaries. Hence, the prediction errors in a chrominance channel are much reduced in a smooth region, but remain relatively large near the edge or within a texture region.

For the efficient lossless compression, it is important to accurately estimate the pdf of prediction error for better context modeling, along with the accurate prediction. For this, we propose a hierarchical decomposition scheme as depicted in Fig.4.2, which shows that pixels in an input image X is separated into two sub images: an even sub image X_e and an odd sub image X_o. Then, X_e is encoded first and is used to predict the pixels in X_o. In addition, X_e is also used to estimate the statistics of prediction errors of X_o.

For the compression of X_o pixels using X_e, directional prediction is employed to avoid large prediction errors near the edges. For each pixel $x_o(i,j)$ in X_o, the horizontal predictor $x\hat{}_h(i, j)$
and vertical predictor $x\hat{}_v(i,j)$ are defined as,

$$\hat{x_h}(i,j) = x_o(i,j-1)$$
$$\hat{x_v}(i,j) = round\left(\frac{x_e(i,j) + x_e(i+1,j)}{2}\right)$$

and one of them is selected as a predictor for $x_o(i, j)$. With these two possible predictors, the most common approach to encoding is “mode selection,” where better predictor for each pixel is selected and the mode (horizontal or vertical) is also transmitted as side information. However, the vertical predictor is more often correct than the horizontal one because upper and lower pixels are used for the “vertical” whereas just a left pixel is used for the “horizontal.” The horizontal predictor is more accurate only when there is a strong horizontal edge. For example, the frequency of selecting horizontal predictor is just 0.03% ~ 1.45% for the images in Kodak set which is one of the image sets used in the experiments. Hence, the vertical predictor is used for most pixels, and mode selection is used only when the pixel seems to be on a strong horizontal edge. The proposed method develops an algorithm for determine the mode selection. By using the algorithm,

2.3 ALGORITHM

2.3.1 Step 1

Calculation of dir(i, j)
if $|x_o(i,j) - x\hat{}_h(i,j)| + T_1 < |x\hat{}_v(i,j)|$ **then**
dir (i,j) ← H
else
dir (i,j) ← V
end if

2.3.2 Step 2

if (i – 1,j) = H or dir (i, j – 1) = H **then**
Calculate dir (i,j) by Step 1
Encode dir(i,j)
if dir (i,j) = H **then**
$x\hat{}_o(i,j) \leftarrow x\hat{}_h(i,j)$
else
$x\hat{}_o(i,j) \leftarrow x\hat{}_v(i,j)$
end if

else
$\hat{x}_o (i,j) \leftarrow \hat{x}_v (i,j)$
Calculate dir (i,j) by Step 1
end if

For implementing this idea, a variable is defined for the direction of edge at each pixel dir(i, j), which is given either H or V. Actually, it is given H only when the horizontal edge is strong, and given V for the rest. Deciding dir(i, j) is summarized in the step 1, where it can be seen that the direction is given H only when $|x_o(i, j) - \hat{x}_h(i,j)|$ is much smaller than $|x_o(i, j) - \hat{x}_v(i, j)|$ by adding a constant T1 to the former when comparing them.

Based on the directions of pixels, the overall prediction scheme is summarized in step 2. It can be seen that the mode selection is tried when more than one of dir (i−1, j) or dir(i, j −1) are H, and the vertical prediction is performed for the rest.

Thus the odd image pixels are predicted using the directional predictor. Then the image is encoded and the pixels are reordered to get the final compressed image.

2.4 PERFORMANCE ANALYSIS

Two of the error metrics used to compare the various image compression techniques are the mean square error (MSE) and the peak signal to noise ratio (PSNR). The MSE is the cumulative squared error between the compressed and the original image, whereas PSNR is a measure of the peak error.

$$PSNR = 20 * \log10 (255 / \mathrm{sqrt}(MSE))$$

3 RESULTS AND DISCUSSION

In proposed system, the RGB image is compressed by using lossless image compression method and it is compared with the existing system JPEG 2000. The parameters compression ratio and the peak signal to noise ratio of the existing system and the proposed system are compared with each other using MATLAB.

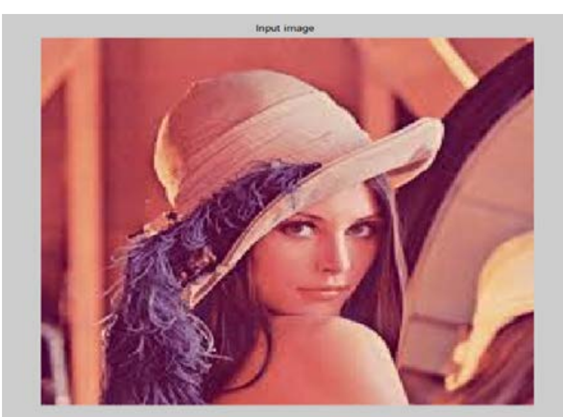

Fig.2.Input image

The original input image is shown in the Fig.2. Then the input image is undergone Reversible Colour Transform technique shown in fig.3. Reversible Colour Transform uses a modified YUV colour space that does not intoduce quantisation errors, so it is fully reversible. large near the object boundaries.

Fig.3.Reversible colour transform

The Fig.4 shows the chrominance image C_u and C_v. The chrominance channels C_u and C_v resulting from the RCT usually have different statistics from Y, and also different fromthe original colour planes R,G,and B. In the chrominance channels, the overall signal variation is suppressed by the color transform, but the variation is still large near the edges.

Fig.4.Chrominance image

The Fig.5. shows the subplot of images. The original image occupies the 1st position. The noisy image is shown in the 2nd position. The final coompressed image is shown in the 3rd position. The final image shows the squared error image.

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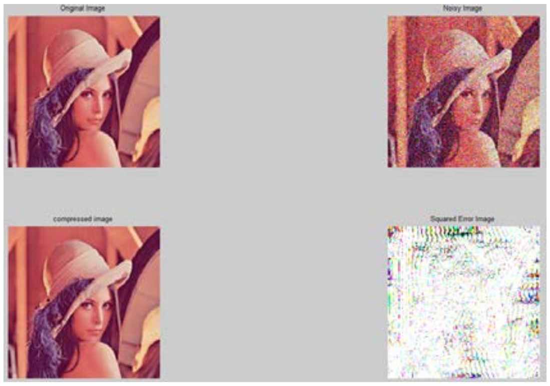

Fig.5. Compressed image

The obtained peak signal to noise ratio is 370.16 and the compression ratio is 78. The proposed system is compared with the existing JPEG 2000.

The obtained parameters such as peak signal to noise ratio and compression ratio are compared with the existing method called JPEG 2000. The obtained result shows the proposed method obtained better compression ratio than the JPEG 2000.

Table 1: Comparison between Proposed and Existing method

PARAMETERS	PROPOSED METHOD	EXISTING METHOD
Peak Signal to Noise Ratio(PSNR)	370.162794	315.726296
Compression Ratio (C.R)	78	75

4 CONCLUSION

The proposed system of the project is based on hierarchical prediction scheme and RCT technique. The reversible colour transform is applied on the RGB image for the colour transformation of the given image. The compression of the RGB image is done by decorrelating the original image by using RCT. After decorrelation of image, each Y component is encoded by conventionless lossless grayscale image compression. The encoding of the chrominance image is done by a hierarchical scheme. The pixels in the chrominance channel are predicted by hierarchical decomposition and directional prediction. The horizontal scheme uses the upper, lower pixels in the image. The compressed image obtained is lossless. The PSNR and compression ratio is measured for the compressed image. The coding is developed for JPEG 2000 also. The PSNR and compression ratio is calculated for the existing method JPEG 2000. Then both the measured values are coompared with each other. From the comparison the proposed method show better performnce than the existing JPEG 2000 method.

REFERENCES

[1] Diego Santa-Cruz and Touradj Ebrahimi, “A Study of JPEG 2000 still image coding versus other standards,” IPXSPC, vo. 2, pp. 673-676.

[2] Gunturk .B.K , .Altunbasak.Y, and Mersereau R.M, “Color plane interpolation using alternating projections,” IEEE Trans. Image Process., vol. 11, no. 9, pp. 997–1013, Sep 2002.

[3] Henrique S. Malvar, Li-wei He, and Ross Cutler, “High-quality linear interpolation for demosaicing of bayer-patterned colour images”, ICASSP 2004.

[4] Information Technology—JPEG 2000 Image Coding System—Part 1: Core Coding System, INCITS/ISO/IEC Standard 15444-1, 2000.

[5] Information Technology—Lossless and Near-Lossless Compression of Continuous-Tone Still Images (JPEG-LS), ISO/IEC Standard,1999.

[6] ITU-T and ISO/IEC, JPEG XR Image Coding System-Part 2: Image Coding Specification, ISO/IEC Standard 29199-2, 2011.

[7] King-Hong Chung and Yuk-Hee Chan, “A Lossless Compression Scheme for Bayer Color Filter Array Images”, IEEE Trans. Image Process., VOL. 17, NO. 2, FEBRAUARY 2008.

[8] Lei Zhanga, Xiaolin Wua, Paul Baob, “Real-time lossless compression of mosaic video sequences”, Zhang .Let al./Real-time Imaging 11(2005) 370-377.

[9] Malvar .H.S and Sullivan .G.J, “Progressive-to-lossless compression of color-filter-array images using macropixel spectral-spatial transformation”, in Proc.DCC, Apr.2012, pp. 3-12.

[10] Malvar .H.S, Sullivan .G.J. and Srinivasan .S, “Lifting-based reversible color transformations for image compression”, Proc. SPIE, vol. 707307, pp. 707307-1-707307-10, Aug.2008.