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Compression of Color Medical Images with Different Color Spaces

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Abstract- **This paper presents the compression of color medical images with different color spaces. Even though multimedia data storage and communication technologies have attained rapid growth, compression of color medical images remains a challenging task. In the proposed method, color medical images are converted to different color spaces such as YCbCr, NTSC and HSV. Then decomposition of different color space image is done using curvelet transform. The decomposed images are then compressed using huffman coding. The results obtained for different color spaces were compared in terms of compression ratio and bits per pixel.**

Keywords- bits per pixel, color spaces, compression ratio, curvelet transform, huffman coding

I. INTRODUCTION

Image compression plays a critical role in telemetric as well as telemedicine applications. In telemedicine, medical images were generated from medical centers with image acquisition devices such as Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Electrocardiogram (ECG) and Positron Emission Tomography (PET). The medical images generated from these devices must be transmitted conveniently over the network for further processing by another medical expert. These huge amounts of data increase the storage cost and network traffic during transmission. Therefore, compression of medical images is essential in order to reduce the storage and bandwidth requirements.

The *R*, *G* and *B* components are highly correlated and therefore direct encoding is not efficient. Decorrelation of the components improves the results of compression. Therefore in the proposed method the medical images were converted into different color spaces such as YCbCr, NTSC and HSV. Decomposition of color space converted image is achieved using curvelet transform. Most of the natural images exhibit discontinuities across curves (Curve singularities). Curvelet transform is a new multi scale transform which is used as an effective tool in image denoising, image decomposition, texture classification and contrast enhancement, etc. Compared to wavelet, curvelet can represent any discontinuity in image more effectively with minimum number of non-zero coefficients. This is because, wavelet transform generate non-zero value for three discontinuities namely, Horizontal, Vertical and diagonal. But for any curve discontinuity it will generate three different non-zero coefficients for each discontinuity. Discontinuities across a simple curve affect all the wavelets coefficients on the curve. So wavelet can only capture limited directional information. Curvelet transform can handle such discontinuity more precisely because of its localization in scale, position and orientation. Also, to overcome the missing directional selectivity of conventional two-dimensional discrete wavelet transform, curvelet transform is applied. Finally curvelet decomposed image is compressed using huffman coding which is a lossless compression technique.

II. REVIEW OF LITERATURE

Several reversible color transforms have been defined for image compression. An entire family of multiplier less reversible color transforms has been proposed and their performance in lossless image compression was measured in [1]. Also, it is shown that it is possible to automatically select a suitable color space without significant loss in compression efficiency. These reversible low complexity color transformation is based on additions and shift operations only. Automatic selection of suitable color space transformations is done using four methods such as automatic selection based on entropy, automatic color space selection including prediction, selection based on a reduced set of pixels and block based selection of color spaces. The main drawback of this automatic color space selection is that the switching between different color spaces introduces nonlinearity, which adversely affects the compression. A new family of reversible low complexity color transformations has been proposed in [2]. A suitable color space is selected based on a technique examining the entropies of prediction errors in the luminance and chrominance components. When selection is done based on only 10^4 pairs of pixels, the bit rate increases. A set of color spaces that allow reversible mapping between red-green-blue and luma-chroma representations in integer arithmetic has been proposed in [3]. A new color space known as YCoCg has been defined. This transform can be made lossless by using lifting technique and is suitable only for CMYK image format. A comparative study of color transforms for color image coding has been proposed in [4]. Curvelet transform which provides a multiresolution representation with several features that make them different from existing representations such as wavelets have been proposed in [5]. The curvelet construction was originally developed for providing efficient representations of smooth objects with discontinuities along curves. Curvelet transform has been developed to solve the classical image processing problem of data compression. An orthonormal version of the ridgelet transform for discrete and finite-size images have been proposed in [6]. Finite Radon transform has been used as a building block for the construction of the transform. The finite Radon transform is defined as summations of image pixels over a certain set of lines. Taking one dimensional wavelet transform on the projections of the finite radon transform in a special way results in the finite ridgelet transform. This leads to the orthonormal bases for images. Ridgelet transform is not suitable for images with discontinuities along curves. An algorithm which is created in Delphi to implement Huffman coding has been discussed in [7]. This method removes redundant codes from the image and compresses a BMP image file (especially grayscale image) and it is successfully reconstructed.

III. PROPOSED METHOD

The block diagram of the proposed method is shown in figure.1. The input color medical image that is represented in RGB color space is converted to another color space, the goal being to make the translated image look as similar as possible to the original. The *R, G* and *B* components are highly correlated, and their direct encoding is not efficient. Decorrelation of components improves the results of further compression. In the proposed method, input color medical images were converted to different color spaces such as YCbCr, NTSC and HSV. R, G and B components were converted into a luminance component and two chrominance components.

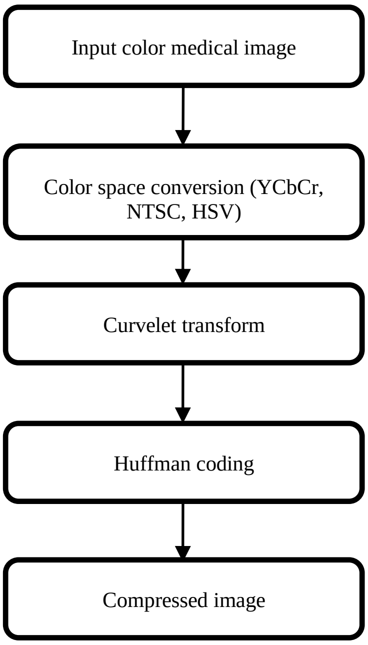


Figure 1. Block diagram of proposed system

The transformation of an image from RGB to YCbCr color space conversion is given by (1).

$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ 0.500 & -0.419 & -0.081 \\ -0.169 & -0.331 & 0.500 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \qquad (1)$$

Where Y is the luminance component, Cb and Cr are the Chrominance components.

The transformation of an image from RGB to NTSC color space is given by (2).

$$\begin{bmatrix} Y \\ I \\ Q \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ 0.596 & -0.274 & -0.322 \\ 0.211 & -0.523 & 0.311 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \tag{2}$$

where Y is the luminance component, I and Q are the chrominance components.

The image in different color space is decomposed using curvelet transform. The curvelet construction was originally developed for providing efficient representations of smooth objects with discontinuities along curves. Curvelet decomposition involves four stages namely, sub-band decomposition, smooth partitioning, renormalization and ridgelet analysis. The image in different color space *f* is initially decomposed into sub bands as given by (3)

$$f \rightarrow (P_0 f, \Delta_1 f, \Delta_2 f, \ldots) \tag{3}$$

Where $P_0 f$ is the low pass component and $\Delta_1 f, \Delta_2 f, \ldots$ are the high pass components. The sub band decomposed image $P_0 f$ is then smoothly windowed into squares of an appropriate scale, as given by (4)

$$\Delta_s f \rightarrow (w_Q \Delta_s f) \tag{4}$$

Where w_Q is the window centered near Q. Each resulting square it renormalized to unit scale as given by (5).

$$gQ = (T_Q)^{-1}(w_Q \Delta_s f) \tag{5}$$

Each square is then analyzed in the orthonormal ridgelet system as given by (6)

$$\alpha_\mu = \langle gQ, \rho_\lambda \rangle \tag{6}$$

Where ρ_λ is the ridgelet. Finally, the curvelet transform is given by (7)

$$\gamma_\mu = \Delta_s \rho_\lambda Q \tag{7}$$

The curvelet decomposed image is then compressed using huffman coding which is a lossless compression technique. Image coding or compression aims at reducing the amount of data while keeping the information by reducing the amount of redundancy. Huffman coding is generally composed of two relatively independent operations namely, devising an alternative representation of the image in which the inter pixel redundancies are reduced and coding the representation to eliminate coding redundancies. Thus the various steps involved in the proposed method are enumerated.

Algorithm

Step1: Acquisition of color medical images.

Step2: Conversion of medical image from RGB to any one of the color spaces such as YCbCr, NTSC and HSV.

Step3: Curvelet decomposition of color space converted image.

Step4: Compression of curvelet decomposed image using huffman coding method.

Step5: Steps 2 to 4 is repeated for remaining two color spaces.

Step6: Compression ratio and Bits per pixel were calculated for compressed images in different color spaces.

Step7: Comparison of results in terms of compression ratio and bits per pixel.

IV. EXPERIMENTAL RESULTS

Various color medical images used for compression are shown in figure 2.

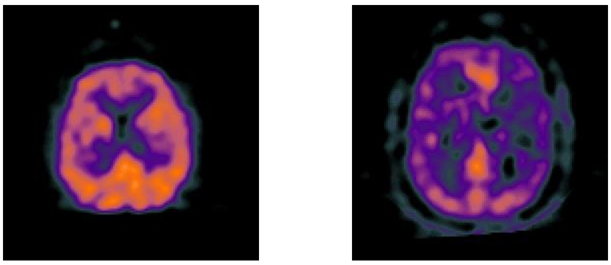
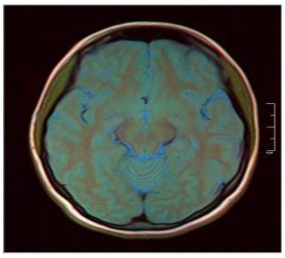


Image1 Image2



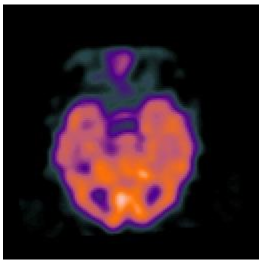
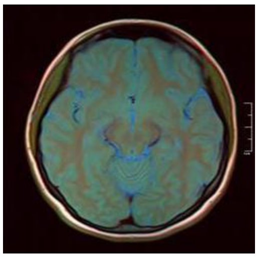
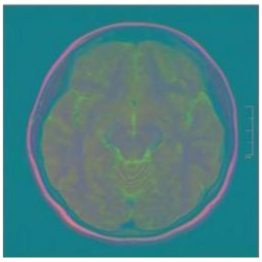


Image3 Image4

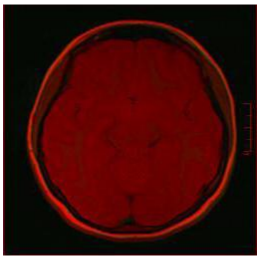
Figure 2. Input color medical images

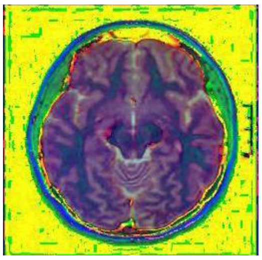
The input color medical image is converted to different color spaces such as YCbCr, NTSC and HSV. The input Image3 in different color spaces is shown in figure 3.





RGB color space YCbCr color space

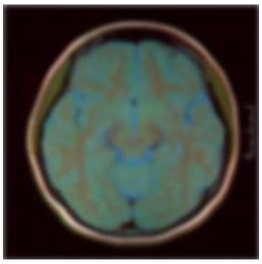


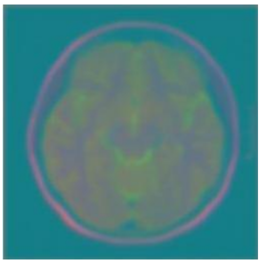


NTSC color space HSV color space

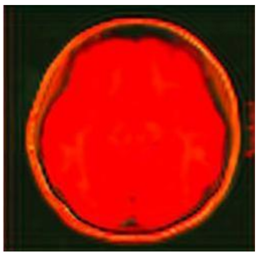
Figure 3. Image3 in different color spaces

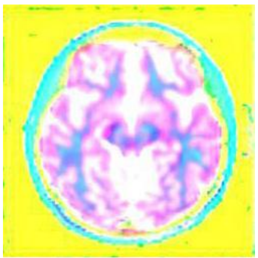
The images in different color spaces are decomposed using curvelet transform and finally compression is done using huffman coding method. The curvelet decomposition of Image3 is shown in figure 4. Compressed image in different color spaces is shown in figure 5. Compression ratio and bits per pixel are calculated for four sets of input images in different color spaces.





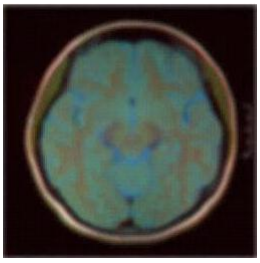
RGB color space YCbCr color space



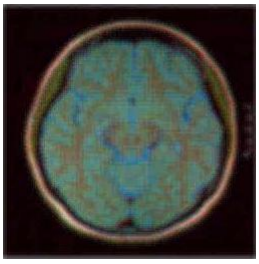


NTSC color space HSV color space

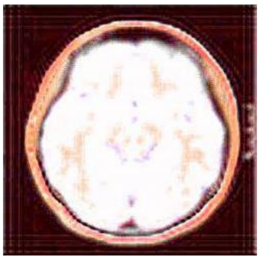
Figure 4. Curvelet decomposition of Image3



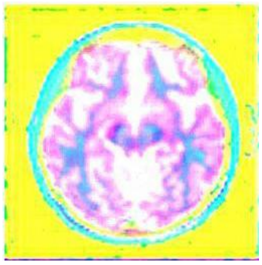
RGB color space



YCbCr color space



NTSC color space



HSV color space

Figure 5. Compressed image in different color spaces

V. PERFORMANCE EVALUATION

A. *Compression Ratio*

Compression ratio is defined as the ratio between the number of bits in the original image to the number of bits in the compressed image. The compression ratio obtained for four sets of input images in different color spaces were tabulated and given in Table I.

TABLE I. COMPARISON OF COMPRESSION RATIO

Images	Color spaces			
	RGB	**NTSC**	**HSV**	**YCbCr**
Image1	14.6235	9.9406	12.1979	11.1521
Image2	15.4734	11.3205	12.4079	10.6639
Image3	17.2409	11.8413	12.0585	10.3399
Image4	15.0558	1.1368	5.8777	9.0673

B. *Bits per Pixel*

Bits per pixel refers the number of bits required to represent a single pixel of an image. The bits per pixel obtained for four sets of input images in different color spaces were tabulated and given in Table II.

TABLE II. COMPARISON OF BITS PER PIXEL

Images	Color spaces			
	RGB	**NTSC**	**HSV**	**YCbCr**
Image1	3.5096	2.3857	2.9275	2.6765
Image2	3.7136	2.7169	2.9779	2.5593
Image3	4.1378	2.8419	2.8940	2.4816
Image4	3.6134	0.2728	1.4106	2.1761

From Table II it is observed that color medical images are compressed with optimum bit rate in YCbCr color space.

VI. CONCLUSION

Thus the compression of color medical images with different color spaces is done and the results are compared in terms of compression ratio and Bits per pixel. From Table I and Table II it is inferred that YCbCr color space provides better results in terms of compression ratio and bits per pixel. Also experimental results show that quality of the compressed image is better in YCbCr color space when compared with remaining three color spaces. Even though the compression ratio in RGB color space is high, it lacks behind YCbCr in terms of bits per pixel. Compression of color medical images in YCbCr color space requires minimum number of bits to represent an image. From the above results, it is concluded that performance of compression in YCbCr color space is better than other three color spaces in terms of both compression ratio and bits per pixel.

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