ARPN Journal of Engineering and Applied Sciences

EFFICIENT IMAGE SEQUENCE COMPRESSION FOR CAPSULE ENDOSCOPY USING IWT

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ABSTRACT

In multimedia environment many videos have been introduced which occupies more memory space, especially in the medical field. In this paper, a new low complexity and lossless image compression system for capsule endoscopy (CE) is approached. The compressor consists of a low-cost YCbCr color space converter and variable-length predictive with a combination and unary encoding. All these components have been heavily optimized for low-power and low-cost and lossless in nature. As a result, the entire compression system does not incur any loss of image information. Unlike transform based algorithms, the compressor can be interfaced with commercial image sensors which send pixel data in raster-scan fashion that eliminates the need of having large buffer memory. The results shows increase in PSNR value of 54db the proposed algorithm offers a solution to wireless capsule endoscopy with lossless and yet acceptable level of compression.

Keywords: capsule endoscopic video, IWT, YCBCR, PSNR, CR.

1. INTRODUCTION

Hospitals and various medical organizations produce huge volume of digital medical image sequences which includes Computed Tomography (CT), Magnetic Resonance Image (MRI), Ultrasound and Capsule Endoscope (CE) images. These medical image sequences require considerable storage space [1].The solution to this problem could be the application of compression. Medical image compression is very important in the present world for efficient archiving and transmission of images. Image compression can be classified as lossy and lossless. In lossy compression scheme there is loss of information and the original image is not recovered exactly. Lossy scheme seems to be irreversible. But lossless scheme is reversible and this represents an image signed with the smallest possible number of bits without loss of any information thereby speeding up transmission and minimizing storage requirement. Lossless reproduces the original image without any quality loss [2]. Medical imaging does not require lossy compression due to the following reason. The first reason is the incorrect diagnosis due to the loss of useful information. The second reason is the operations like image enhancement may emphasize the degradations caused by lossy compression. Hence efficient lossless compression methods are required for medical images [3].Lossless compression includes Discrete Cosine Transform, Wavelet Compression, Fractal Compression, Vector Quantization and Linear Predictive Coding. Lossless consist of two distinct and independent components called modeling and coding. The modeling generates a statistical model for the input data. The coding maps the input data to bit strings [4].

In Video compression, the motive is to reduce the data redundancy significantly, both in spatial and frequency domain, without much affecting the quality of the video [5], [6]. Almost lossless reversible image compression model is proposed for both continuous and discrete time cases, exploiting integer wavelet transform (iWT) employing lifting scheme (LS). This paper presents an approach for an Enhanced Video Compression Method using Partial Integer Wavelet Transform Algorithm. The compression algorithm is capable to work with white light imaging and narrow band imaging with average compression ratio respectively. The proposed Partial Endoscopy Algorithm overcomes the difficulty of Endoscopy that loses its efficiency in transmitting lower bit planes. In this paper, we include integer wavelet transformation and region of interest coding to Partial Endoscopy and hence make it more superior to Endoscopy Algorithm and it is proved with the results. The compression of the proposed algorithm is superior to Endoscopy for lossy as well as lossless coding. Our coder proves the better performance for medical videos compression in terms of PSNR and MSE.

2. METHODOLOGIES USED

2.1 Overview

The compression algorithm has main four steps: color space conversion, sub-sampling, integer discrete cosine transformation (iDCT), and coefficient quantization. The block diagram of the proposed image compressor is shown in Figure-1.

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2.2 RGB to YCbCr conversion

YCbCr, also written as YC_BC_R or $Y'C_BC_R$, is a family of color space used as a part of the color image pipeline in video and digital photography systems. Y′ is the luma component and C_B and C_R are the blue-difference and red-difference chroma components. Y′ (with prime) is distinguished from Y, which is luminance, meaning that light intensity is nonlinearly encoded based on gamma corrected RGB primaries.Y′CbCr is not an absolute color space; rather, it is a way of encoding RGB information. The actual color displayed depends on the actual RGB primaries used to display the signal [7]. Therefore a value expressed as Y′CbCr is predictable only if standard RGB primary chromaticities are used; rather, it is a way of encoding RGB information. The actual color displayed depends on the actual RGB primaries used to display the signal [8]. From the Figure.2 the clarity is increased from the original to the reconstructed. Therefore a value expressed as Y′CbCr is predictable only if standard RGB primary chromaticities are used.

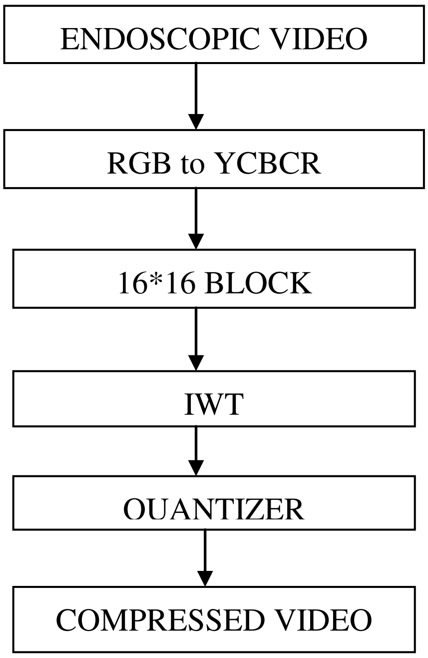

Figure-1. Block diagram.

2.3 Integer wavelet transform

In the Integer wavelet transform, a function Ψ (“psi“), which in practice looks like a little wave, is used to create a family of wavelets Ψ (at + b) where aand b are real number, “a“dilating (compressing or stretching) the function Ψ and “b“translating (displacing) it [9]. The word continuous refers to transform, not the wavelets, although people sometimes speak of “continuous wavelets”.

The continuous wavelet transform turns a signal f (t) into a function with two variables (scale and time), which one can call c (a,b):

This transformation is in theory infinitely redundant,

$$c(a,b) = \int f(t)\psi(at+b)dt \tag{1}$$

but it can be useful in recognizing certain characteristics of a signal. In addition, the extreme redundancy is less of a problem than one might imagine, a number of researchers have found ways of rapidly extracting the essential information from these redundant transforms. Figure-2 illustrates the sub bands of IWT.

LL	HL
LH	HH

Figure-2. Subbands of IWT.

2.4 Quantization

When a image has been processed of the IWT, the total number of transform coefficients is equal to the number of samples in the original image, but the important visual information is concentrated in a few coefficients. To reduce the number of bits needed to represent the transform, all the sub bands are quantized. From [10] Quantization of IWT sub bands is one of the main sources of information loss. In the JPEG2000 standard, the quantization is performed by uniform scalar quantization with dead-zone about the origin. In dead-zone scalar quantizer with step-size Δ_j, the width of the dead-zone is $2\Delta_j$. The standard supports separate quantization step-sizes for each sub band. The quantization step size Δ_j for a sub band j is calculated based on the dynamic range of the sub band values. The formula of uniform scalar quantization with a dead-zone is shown in equation (2).

$$q_j(m,n) = \mathrm{sign}(y_j(m,n)) \left\lfloor \frac{|W_j(m,n)|}{\Delta_j} \right\rfloor \tag{2}$$

Where $W_j(m,n)$ is a DWT coefficient in sub band j and Δ_j is the quantization step size for the sub band j. All the resulting quantized DWT coefficients $q_j(m,n)$ are signed integers.

After the quantization, the quantized IWT coefficients are then use entropy coding to remove the coding redundancy [11].

3. EXPERIMENTAL RESULT AND ANALYSIS

The proposed methodology has been simulated in Matlab R 2010a. To evaluate the performance of the proposed methodology we have tested it on Capsule Endoscopy (CE) videos. Medical video is taken from Sundaram Medical Foundation (SMF) and MR-TIP database. Input image sequences are taken from these videos. More than 6000 frames were taken and tested. We have taken 2000 frames and tested. In this proposed method the quality of reconstructed images is increased using YCbCrcolor space. The results are evaluated based on Compression Ratio and Peak Signal to Noise Ratio. Figure-3 shows Capsule endoscopy image sequences. The images in these CE sequences are of dimension 256x256. In the Figure-4 the PSNR value of the reconstructed images is increased to 52 db.

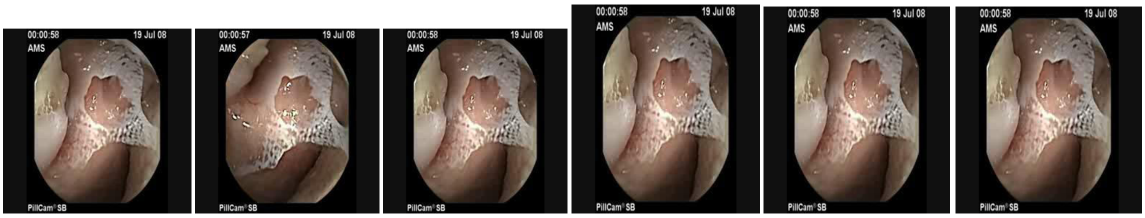

Figure-3. Capsule endoscopy image sequences.

Table-1. Comparison of PSNR values.

Frames	Average PSNR
F1	53.13
F2	53.60
F3	54.17
F4	54.64

The compression ratio and image quality in terms of PSNR are shown in Table-1 and in Table-2 for endoscopy image sequences. We see that there is a significant improvement in both compression ratio and image quality. We have achieved a higher Compression Ratio compared to the methods proposed in [12][13][14][15][16]. Table-2 illustrates this. It can reduce radio frequency transmission power and also bandwidth, higher image quality is necessary for accurate diagnostics.

Table-2. Compression ratio.

Frame samples	Compression ratio (%)
F1	85.2
F2	85.36
F3	85.57
F4	86.10
F5	86.32
F6	86.45
F7	86.67
F8	85.97
F9	86.37
F10	86.76
AVG	86.077

Original	Reconstructed
	 CR=85.36%,PSNR=53.06Db
	 CR=86.10%,PSNR=53.80dB
	 CR=86.32%,PSNR=54.15dB

Figure-4. Reconstructed images.

CONCLUSIONS

In this paper we have approached an integer wavelet transform algorithm based on image compression which is specially designed for endoscopic video. In order to increase the efficiency YCbCrcolor space is implemented. A quantization scheme is also implemented to achieve higher compression. Appeared results show the expected compression ratio and PSNR value.

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