Comparison of Real Time Image Transfer in Wireless Multimedia Sensor Networks

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Abstract

Wireless Multimedia Sensor Networks (WMSN) allows developing many applications which addresses to many areas like mobile healthcare, environmental monitoring and traffic monitoring. During those applications, real time data transmission is very important in terms system security and usability while the multimedia data is processed and transferred. Namely, it is required to transfer data taken from a sensor to another sensor or to a base station as soon as possible. The most time-consuming part is caused by image compression algorithms. In this study, the computation speeds of the basic image compression algorithms Discrete Cosine Transform (DCT) and Embedded Zero-tree Wavelet (EZW) are compared. This operation is realized on the sensors and the transmission time is not added to the computation time. The algorithms are compared via MATLAB. This study may set light to the efficiencies of some algorithms which are derived from the compared algorithms in real time image transmission.

1. Introduction

Image compression is to reduce or minimize the image size without decreasing image quality. To reduce image size is very important for image transmission and storing. The need for accessing data on the internet or to its transmission over the internet increases day by day. To compress the image is necessary to reduce storage cost and to increase transmission speed [1]. Image compression which is efficiently used in standard applications is also used in Wireless Multimedia Sensor Networks (WMSN).

Recently, since several benefits are gathered, WMSNs has been remarked by the researchers [2]. While the traditional sensor networks carry only some basic data like temperature and moisture, WMSNs can transfer real time multimedia data (voice, image, and video) to each other or to a base station. An audio and a visual data may present in a single device. Furthermore, WMSNs may store real time data that is taken from many sensors [3]. However, large amount of multimedia data may cause serious problems for WMSNs such as inefficiency in band width and energy source. Therefore, it would be more logical to process data in the sensors and then transfer to the next sensor. Besides, data must also be processed in real time video transmission. So, delays in data transmission are reduced and so the performance of real time transmission is improved [4].

The most of the energy of WMSNs is used for data collection and the realized operations on it. Therefore, a proper design is required to maximize lifetime of WMSNs [5, 6]. For this purpose, the preferred algorithm must have some abilities like fast and efficient data processing, low memory requirement, high compression quality, low computation cost and a simple system structure. Some traditional image compression algorithms like JPEG and JPEG2000 which does not satisfy most of these features are not efficient for WMSNs [5, 7]. Kose et al [8] has made a comparison between SPIHT which is based on EZW and JPEG2000 which uses DCT on 3D images. They showed that SPIHT gives better results in terms of compression ratio and compression time via the simulation they performed.

There are many image compression techniques based on discrete wavelet transform to provide energy efficiency in WMSNs. Ghorbel et al [9] proposes a performance analysis for WMSNs on image compression. They analyzed Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT) and proved that DWT is better than DCT in terms of energy consumption and image quality. Image qualities for Lena image are found to be 33.55 db (PSNR) and 30.52 db for DWT and DCT respectively. In addition, Alkaline AA-NiMH 2850 mA battery is used in the system and this battery is used for 281.34 hours for DWT and 245.20 hours for DCT.

Basic image compression algorithms DCT and EZW which are used for WMSNs will be mentioned briefly in the following sections and their computation times will be compared.

2. Image Compression Techniques in WMSN

Several image compression algorithms with different compression efficiencies are used in WMSNs. As for this study, the most basic algorithms are considered. Therefore, a comparison of the other techniques which are derived from those algorithms will be enabled.

2.1. Discrete Cosine Transform (DCT) Based Compression

Discrete Cosine Transform (DCT) is the most frequently used transform-based encoding technique. In DCT-based image compression, image source is divided into 8x8 pixel blocks and a 64-element coefficient block is constituted. Each image block is individually encoded [10]. 2D DCT equation is the following.

$$F(u,v) = \frac{1}{4}C(u)C(v)\sum_{x=0}^{k-1}\sum_{y=0}^{k-1} f(x,y)\cos(\alpha)\cos(\beta),$$

$$\alpha = \frac{(2x+1)u\pi}{2k}, \beta = \frac{(2y+1)v\pi}{2k}$$

$$C(z) = \begin{cases} \frac{1}{\sqrt{2}} \; if\ z = 0 \\ 1 \; otherwise \end{cases} \quad (1)$$

Matrices are composed in this way. Matrix P is constituted by subtracting 128 from every element of the matrix. Then, DCT matrix is found as a multiplication of the most frequently used matrix A, its transpose and matrix P.

$$F(k \times k) = A(k \times k)P(k \times k)A^T(k \times k) \quad (2)$$

Quantization occurs then. With this operation, how much the image is compressed is determined optionally. Quantization formula is given in (3).

$$C_{i,j} = round(\frac{D_{i,j}}{Q_{i,j}}) \quad (3)$$

A well-known DCT-based compression schema is JPEG [11]. DCT-based image compression techniques provide enough compression efficiency and the coding is applied to small individual image blocks, and so, low-memory applications can be realized [12]. 60% of the total energy is consumed during encoding in DCT compression algorithm. PSNR value is lower than DWT-based techniques. In an application realized on Lena image, it is found to be 30.52 db and 33.55 db on the average for DWT [13].

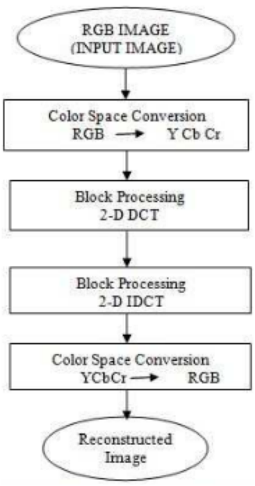

Fig. 1. Flowchart for DCT technique [14]

2.2. Embedded Zerotree Wavelet (EZW) Based Compression

Embedded Zerotree Wavelet is one of the first algorithms used in WMSNs. Although it provides a good compression, it is quite complex since it is based on predicting the absence of important data by exploiting the similar images. Its property is that the bits in a bit stream are produced according to their importance [15]. A fully-embedded code is obtained as a result and this code is stream of binary decisions which distinguish the image from an empty one. Encoding can be ended at any point with an embedded encoding algorithm and again an image that is same with the encoded image is produced with a bit rate corresponding to the cropped bit stream. In addition to producing a fully embedded bit stream, EZW produces compression results that can compete with many compression algorithms. This performance is achieved by a technique which does not require training, preloaded tables or codebooks and pre-knowledge about source image [15].

EZW algorithm is based on four concepts [15]:

- Discrete Wavelet Transform
- Predicting the absence of important data via similar images
- Entropy-coded successive prediction scaling
- “universal” lossless data compression achieved by adaptive arithmetic encoding

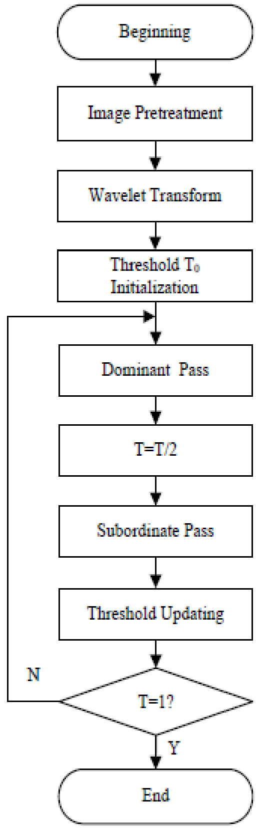

Fig. 2. The flowchart of improved EZW algorithm [16]

3. Comparison of Image Compression Algorithms in WMSN

We are comparing the images which are compressed by applying EZW and DCT using MATLAB.

Fig. 3. Original image

(a) (b)

Fig. 4. (a) Compressed by DCT (b) Compressed by EZW

Results of the realized work are given in Table 1.

Table 1. Comparing the DCT and EZW

	DCT	EZW
Compression Ratio (%)	80	80
Compression Time (sn.)	7,423100	6,015462
PSNR (db)	30,07	23,53

6. Conclusions

Transmitting and storing data after compression is especially important for WMSNs because these networks have limited bandwidth and battery power. The most energy-consuming part in a network is data transmission between sensor nodes and base station. As the amount of data increases, the energy consumption also increases proportionally. Different from other networks, this problem is more conspicuous in WMSNs since operations are carried on larger amount of data. Therefore, it is an obligation to compress data before transmission in WMSNs. In this study, some image compression techniques used in WMSNs are examined and a performance analysis is done for two basic algorithms: DCT and EZW. Lena image which is frequently used in the literature is used in the experiments to provide coherence. According to the results, EZW produces better results in terms of both computation time and PSNR value. It is inevitable that other techniques which are derived from these examined algorithms will show similar performance results.

In the next study, the comparison of all methods used in WMSNs will be realized and it is planned to determine which algorithm is efficient in which special case.

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