DWT BASED IMAGE COMPRESSION FOR WIRELESS SENSOR NETWORKS

Tanasan Srikotr, Teerapat Charoenpru and Prayoth Kumsawat

School of Telecommunication Engineering, Institute of Engineering

Suranaree University of Technology

m5740833@g.sut.ac.th

ABSTRACT

In this paper, we present a method of data compression in digital image signal data using Discrete Wavelet Transform (DWT) for compressing digital image with minimal image distortion and acceptable compression efficiency. We use MATLAB simulation to evaluate the various image compression techniques such as, Discrete Wavelet Transform Skipped High Pass Sub-band (DWT-SHPS), Discrete Wavelet Transform Average High Pass Sub-band (DWT-AVG) and Discrete Wavelet Transform Artificial Intelligent Optimum High Pass Sub-band (DWT-AIO). The evaluation is performed under the wavelet compression framework from the view point of quality of image (PSNR) and compression ratio (CR). Different combinations of parameters and transformation levels have been compared against the JPEG compression standard. This evaluation could help the designer to predict the performance of a given DWT compression algorithm for wireless sensor system.

1. INTRODUCTION

Wireless Sensor Network (WSN) has been gaining popularity in the research community and development of Internet of Things (IoT). WSN can capture multimedia content from the environment. However, the large number of data generated by the image sensor remains as a challenging problem, because the power consumption and finite processing of WSN is strongly affected by the number of data to be processed and transmitted. For these reasons, power consumption is a critical issue in WSN.

In recent years, people have done a lot of research work on data compression algorithm and proposed many compression algorithms for WSN. In [1], Chew proposed (2008) survey of image compression algorithms for wireless sensor networks. The result is 8 popular image compression algorithms; it is found that SPIHT wavelet-based image compression is most suitable image compression algorithm for implementation in a hardware constrained environment. In [2], Nasri (2010) proposed technique for image compression called SHPS based on Discrete Wavelet Transform and distributed processing and compression technique. In [3], Hongliang (2010) proposed a program based on compression and difference transmission for image acquisition in wireless sensor networks. In [4], Chaudhari (2014) proposed wavelet transform based fast fractal image coding. FFT based fractal image coding with variable quadtree partition is applied to the approximation subband and three detail subbands of the transformed image. In [5], Wu (2014) proposed the fractal encode algorithms to overcome the problem of the time-consuming drawback. First, a FIC using DWT. Second, embedding the DWT technique into the genetic algorithm (GA). The proposed GA method is faster than the full search method.

This paper is organized as follows: Section 1, the JPEG image coding and DWT are introduced. In Section 2, the experiments are shown. The model and algorithm are described in Section 3. The conclusions of our study can be found in last section.

1.1 Preliminary

1.1.1 Joint Photographic Experts Group (JPEG)

The JPEG is global standard lossy image compression algorithm. The JPEG consists following steps in Figure 1.The JPEG compression consists of the following main steps. First step image should be divided into 8×8 pixels. The next step of JPEG consists of Discrete Cosine Transform (DCT). In order to keep some important DCT coefficients, quantization is applied on the transformed block. In this step, using the quantization matrix multiply by quality factor to adjust the quality of the data compression. After that, we used lossless compression encoding. The zigzag scanning is used. The 8×8 blocks are reordered as single 64-element columns. The DC coefficient is treated separately from the 63 AC coefficients. Finally, in the final phases coding algorithms such as Run Length Coding (RLC) used for AC coefficients and Differential Pulse Code Modulation (DPCM) used for DC coefficient and entropy coding are applied by using Huffman coding. For JPEG decompression we reverse the JPEG compression, we basically obtain a JPEG decompression.

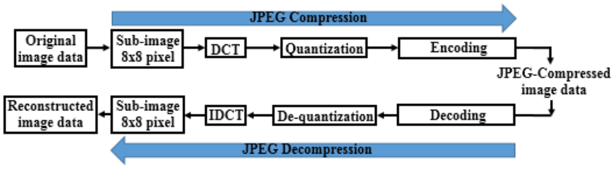
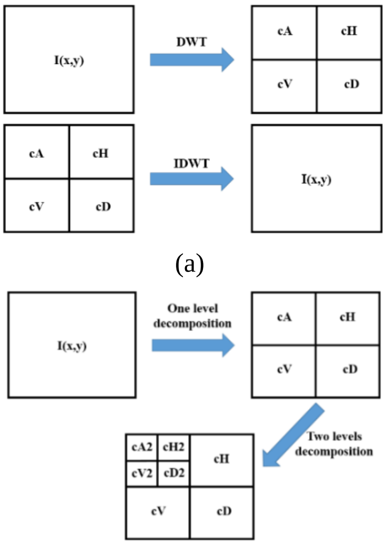


Fig. 1 JPEG compression and JPEG decompression.

1.1.2 Discrete Wavelet Transform (DWT)

The Discrete Wavelet Transform (DWT) and Inverse Discrete Wavelet Transform (IDWT) consist following steps in Figure 2 (a). The DWT input data (I(x,y)) need to divide into 4 sub-bands cA, cH, cV and cD with wavelet decomposition filters are filled by many types of wavelet families. We call cA is low pass sub-band (approximate) cH, cV and cD are high pass sub-band (detail). The IDWT all of coefficient cA, cH, cV and cD send into wavelet reconstruction filters are filled by many types of wavelet families for reconstruct data.



(a)

(b)

Fig. 2 a) DWT and IDWT and b) Multilevel DWT decomposition.

For the next level of DWT decomposition, we apply the wavelet transform to the approximation subband (cA) of the previous decomposition level as shown in Figure 2 (b).

1.2 The Proposed Method

1.2.1 DWT Compression Algorithm

Based on DWT. Image will divided 4 sub-bands cA, cH, cV and cD. The cA is approximation coefficients refer to low pass sub-band and cH, cV and cD are details coefficients refer to high pass sub-band in horizontal, vertical, and diagonal, respectively. For first technic DWT-SHPS compression algorithm, we will discard high pass sub-band (cH, cV and cD) because most detail of image data are in low pass sub-band (cA). In backward wavelet synthesis, we use approximation coefficients (cA) and details coefficients (cH, cV and cD) with integer 0 in the similar dimension of cA for used in IDWT process. Second technic DWT-AVG compression algorithm, we will find thresholds form each high pass sub-band and set coefficients to zero if coefficients less than the threshold. And the last one technic: DWT-AIO compression algorithm, we use artificial intelligence (Genetic Algorithm) to find thresholds form each high pass sub-band for set coefficients to zero if coefficients less than the thresholds. However, all techniques need to continue with quantization and encoding. In this paper, Run-Length Coding (RLC) is applied to reduce the length of the DWT coefficient sequences. DWT compression and DWT decompression are shown in Figure 3.

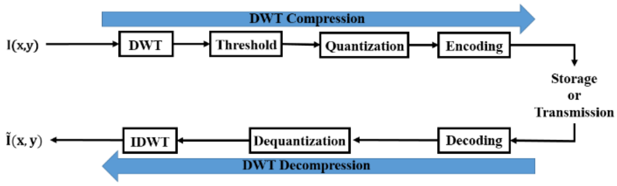


Fig. 3 DWT compression and DWT decompression

2. EXPERIMENT

To demonstrate the effectiveness of our proposed method, a series of experiments have been conducted. Four gray level images with standard dimension 512 × 512 pixels named: "Lena", "Tiffany", "Baboon" and "Airplane (F16)" are used for conducting our experiments. The compression ratio (CR) and quality factor (PSNR) are used as performance measures to quantify the difference between the original image and the processed image. The CR and PSNR can be represented as follows:

$$\mathrm{CR} = \frac{\text{Total number of bits in original file}}{\text{Totle number of bits in compressed file}} \qquad (1)$$

$$\mathrm{PSNR\ (dB)} = 20\log_{10}\frac{2^{B}-1}{\sqrt{MSE}} \qquad (2)$$

Where B represents the bits per sample and MSE represents the mean square error can be represented as follows:

$$\mathrm{MSE} = \frac{1}{\mathrm{m} \times \mathrm{n}}\sum_{\mathrm{i}=0}^{\mathrm{m}-1}\sum_{\mathrm{j}=0}^{\mathrm{n}-1}[\mathrm{I}(\mathrm{i},\mathrm{j}) - \bar{\mathrm{I}}(\mathrm{i},\mathrm{j})]^{2} \qquad (3)$$

Where m is number of rows, n is number of columns, I is original image data and $\bar{\mathrm{I}}$ is reconstruct image data.

The JPEG experimental average results are given in Table 1 and DWT by applied any technique by using only “HAAR mother wavelet”. The average results are given in Table 2.

Table 1 JPEG average results

Quality factor (QF)	CR	PSNR (dB)
1	74.08	30.15
10	35.91	33.49
20	23.36	35.07
30	18.02	36.05
40	15.01	36.75
50	12.80	37.28
60	11.03	37.92
70	9.25	38.80
80	7.46	40.13
90	4.65	42.90

Table 2 DWT average results

1 level DWT		
Techniques	CR	PSNR (dB)
DWT-SHPS	4.65	34.75
DWT-AVG	2.92	35.70
DWT-AIO	3.99	35.37
2 level DWT		
Techniques	CR	PSNR (dB)
DWT-SHPS	12.56	33.44
DWT-AVG	3.50	34.85
DWT-AIO	9.53	33.61

3. ANALYSIS

The performance of our proposed algorithm has been evaluated considering CR and PSNR. Table 2 shows DWT-SHPS is the most suitable for DWT because CR has the highest of all DWT technics and acceptable PSNR around 30 (dB). Moreover DWT-SHPS is low complexity technic then DWT-AVG and DWT AIO. Table 1 shows performance of JPEG algorithm. The default QF of JPEG is 75-80. The JPEG is high CR and high PSNR.

When making comparisons between JPEG algorithm and DWT-SHPS are given in Figure 4 will be JPEG better performance in both the CR and PSNR, but to see that the DWT-SHPS is close to the performance of JPEG between QF=10 to QF=60 by PSNR of DWT-SHPS less then JPEG 2-3 (dB).

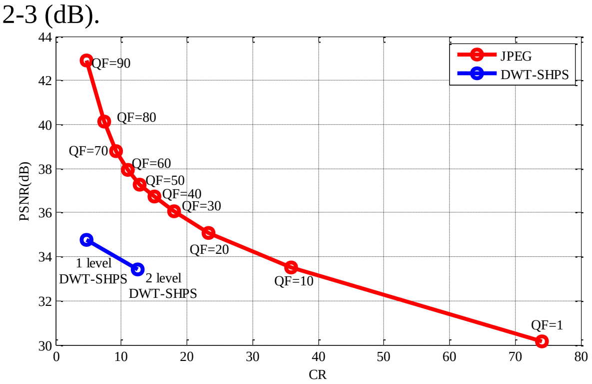


Fig. 4 JPEG VS DWT-SHPS.

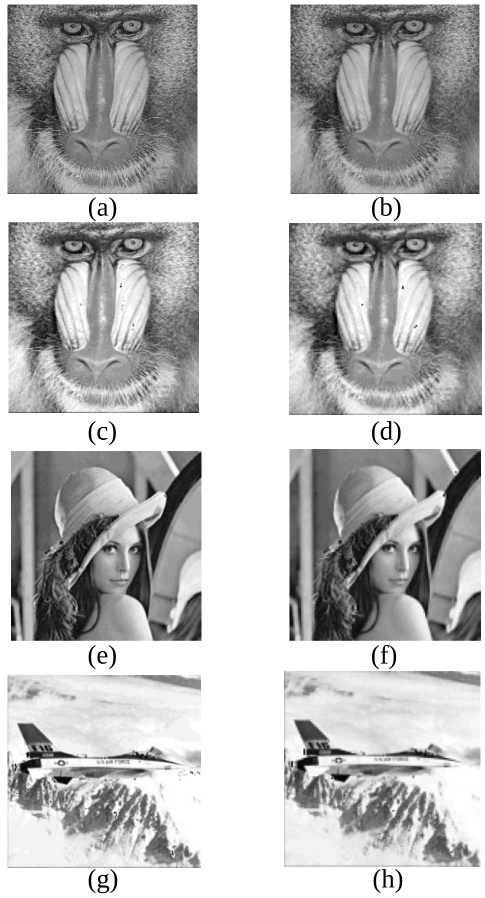


Fig. 5 a) JPEG QF=20, b) JPEG QF=50, c) 1-Level DWT-SHPS Baboon, d) 2-Leve DWT-SHPS Baboon e) 1-Leve DWT-SHPS Lena f) 2-Leve DWT-SHPS Lena g) 1-Leve DWT-SHPS Airplane (F16) and h) 2-Leve DWT-SHPS Airplane (F16).

CONCLUSION

In this paper, a comparative image compression technique that aims at achieving low-complexity and energy efficient compression is proposed. We analyze the performance of the techniques in terms of signal to noise ratio, root mean square error, and compression ratio. The experimental results indicate that the Discrete Wavelet Transform Skipped High Pass Sub-bands (DWT-SHPS) technique is close to the performance of JPEG standard. It efficient and has low complexity with less memory requirements in implementation. Further research can be focused on the development of the DWT-SHPS image compression technique using the embedded system.

REFERENCES

[1] L.-M. K. P. S. Li Wern Chew; Ang, "Survey of image compression algorithms in wireless sensor networks," In Proc. Presented at the Information Technology, 2008. ITSim 2008. International Symposium, Kuala Lumpur, Malaysia, 2008.

[2] M. H. Nasri, A.; Sghaier, H.; Maaref, H., "Energy-efficient wavelet image compression in Wireless Sensor Network," In Proc. Presented at the Communication in

Wireless Environments and Ubiquitous Systems: New Challenges (ICWUS), 2010 International Conference, Sousse, 2010.

[3] L. H. C. L. Z. Ruirui, "A program based on compression and difference transmission for image acquisition in wireless sensor networks," In Proc. Presented at the Education Technology and Computer (ICETC), 2010 2nd International Conference, Shanghai, 2010.

[4] R. E. D. Chaudhari, S.B., "Wavelet transformed based fast fractal image compression," In Proc. Presented at the Circuits, Systems, Communication and Information Technology Applications (CSCITA), 2014 International Conference, Mumbai, 2014.

[5] M.-S. Wu, "Genetic algorithm based on discrete wavelet transformation for fractal image compression," In Proc. Journal of Visual Communication and Image Representation, vol. 25, pp. 1835-1841, 2014.

T. Srikotr was born in Nakhon Ratchasima, Thailand. He received the B.Eng. degree in telecommunication engineering from Suranaree University of Technology, Nakhon Ratchasima, Thailand, in 2014. He is currently working toward the M.Eng. degree in the School of Telecommunication Engineering, Institute of Engineering, Suranaree University of Technology, Nakhon Ratchasima, Thailand. His research interests include digital signal processing and wireless sensor networks.

T. Charoenpru was born in Nakhon Ratchasima Thailand. He received the B.Eng. degree in electronics engineering from Suranaree University of Technology, Nakhon Ratchasima, Thailand, in 2014. He is currently working toward the M.Eng. degree in the School of Electronics Engineering, Institute of Engineering, Suranaree University of Technology, Nakhon Ratchasima, Thailand. His research interests include wireless sensor networks and artificial intelligence.

P. Kumsawat was born in Maehongson, Thailand. He received the B.Eng. degree in electrical engineering from the Royal Thai Air Force Academy, Bangkok, Thailand, in 1994, M.Eng. degree in electrical engineering from Kasetsart University, Bangkok, Thailand, In 1997 and Ph.D. degree in electrical engineering from Suranaree University of Technology, Nakhon Ratchasima, Thailand, in 2006. Since 1999, he has been with the Institute of Engineering, Suranaree University of Technology, where he is currently an Assistant Professor in the School of Telecommunication Engineering. His research interests include digital signal processing and image processing.