Partition and Transmission of Coded Image Data Using Hierarchical QAM Over Wireless Erroneous Channel

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Abstract

Recent advances in image compression have enabled the creation of efficient, embedded source coders. These source coders generates PSNR scalable bit stream, in which each additional bit is used to refine an image and improve reconstruction quality. The encoded bit streams are highly susceptible to bit errors and single bit errors can render the entire image useless. Since wireless channels suffer from significant bit error rate, some mechanisms to protect the encoded image is required. Without such mechanism, the channel bit errors will prevent accurate decoding of the image. Asymmetric modulation method, Hierarchical Quadrature Amplitude Modulation (HQAM), which provides Unequal Error Protection (UEP) can give the higher protection to the transmitted significant bits. This paper examines the partitioning suitability of the SPIHT coded image bits and transmit the bits using 16-HQAM technique over erroneous wireless channels. The performance is evaluated using gray test image for different values of modulation parameter.

1. Introduction

For the transmission of images over wireless communication channels, bandwidth limitation and high probability of error are two major concerns. Therefore, compression is applied to the transmitted data in order to conserve the bandwidth. However, compression increases bit dependency that in turn introduce error extension effects. Another problem unique to wireless networks is the extremely hostile and random nature of the channels that introduce distortion and considerably degrades the image quality. Error control coding is used to control the errors, however, the addition of check bits that carry no information further increases the data rate and consequently the bandwidth. [1-6]

This paper proposes the use of an asymmetric modulation method known as Hierarchical Quadrature Amplitude Modulation (HQAM) for the transmission of images over wireless mobile channels. It is a modification of Quadrature Amplitude Modulation (QAM) and provides unequal error protection (UEP). This is a simple and efficient approach in which non-uniform signal-constellation is used to give different degrees of protection to the transmitted bits. The advantage of this method is that different degrees of protection are achieved without an increase in bandwidth in contrast to channel coding that increases the data rate by adding redundancy to the transmitted signal [2, 7-9]. Performance comparison is carried out through computer simulation using 16-HQAM techniques with gray image as test image for different values of the modulation parameter.

This paper has been organized as follows: In section 2, general model of image transmission is given. Section 3 considers an overview of SPIHT image compression technique. In section 4 overview of Hierarchical QAM describes. Based on computer simulation results, the performance of HQAM for the partitioning and transmission of SPIHT coded images is considered in Section 5.

2. Model of image transmission system

The essentials of the image transmission system considered here are shown in Fig. 1. The source encoder encodes the source image using appropriate image compression technique. For the protection of coded image in Fig. 1 channel encoder add redundancy to the coded image by using appropriate channel coding technique. Modulator modulates the coded image and transmits through wireless channel. QAM is invariably used as the modulation technique [10, 11]. The channel introduces noise and distortion to the transmitted image. The demodulator receives the image data with error and demodulates it. After channel decoding, the coded image is decompressed.

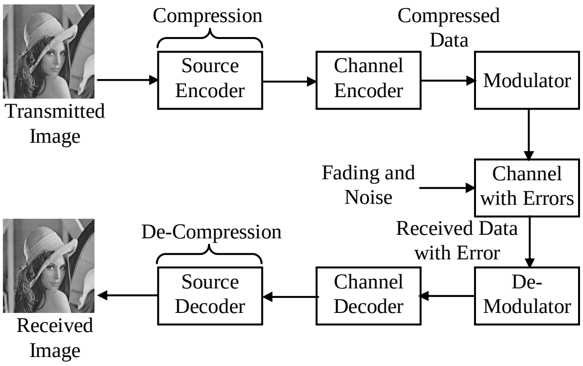


Figure 1: Model of image transmission system

3. Overview of SPIHT image coding

There are three coding steps in SPIHT encoder, which is shown in Fig.2. From the figure, we can see that the first step is sampling. SPIHT encoder employs a two-dimension discrete wavelet transform (DWT) with pyramidal structure to achieve wavelet coefficients. After a *p*-level wavelet transform, an image can be decomposed to be a series of sub-images (or sub-bands) with different resolutions. The sub-bands can be organized into spatial-orientation tree structure.

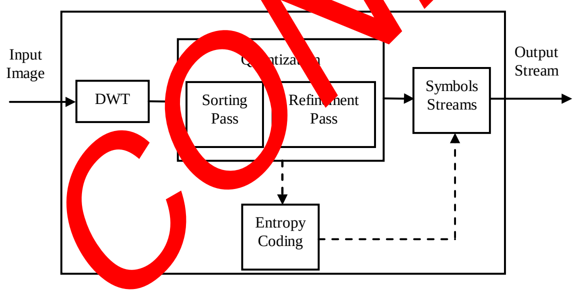
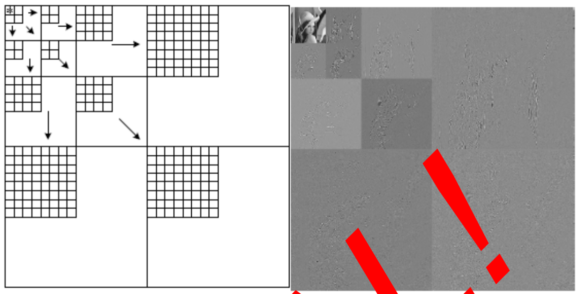


Figure 2. SPIHT encoder

A 3-level DWT spatial orientation tree structure and corresponding decomposition of the Lena image are shown in Fig.3 (a) and (b). In Fig.3 (a), the arrows between sub-bands represent father-children relationship between wavelet coefficients, in which, the coefficient in the lowest frequency sub-band and coefficients in the highest frequency sub-bands have no child, each coefficient in the remainder sub-bands has four children.



(a) (b)

Figure 3. (a) 3-level DWT spatial-orientation tree (b) 3-level decomposition of the Lena image

The second step in SPIHT encoder is quantization, which includes two passes: sorting pass and refinement pass. Three lists are introduced to store important information during coding process. They are list of insignificant pixels (LIP), list of significant pixels (LSP) and list of insignificant sets (LIS). Thus symbol stream can be achieved after the quantization. The last step in SPIHT encoder should be entropy coding. However, according to [12], entropy coding will increase computation complexity and introduce possible error propagation while data compression is limited.

4. Hierarchical QAM

Hierarchical Quadrature Amplitude Modulation (HQAM) is more spectrally efficient and dc-free modulation scheme [13]. It provides different degree of protection to the transmitted data bits, in which the high priority (HP) data bits are mapped to the most significant bits (MSB) and the low priority (LP) data bits are mapped to the least significant bits (LSB) of the modulation constellation points. Using HQAM will, therefore, result in improved image quality compared with QAM specially at low channel SNR conditions, since the highly sensitive HP data bits are mapped to the MSBs with low bit error rate (BER) in HQAM. For the sake of simplicity only 16-HQAM is considered in this paper.

In Hierarchical QAM, it is possible to give higher protection to the most important data (significant bits) by changing the value of modulation parameter α. α is the ratio of the distance *b* between quadrants to the distance c between the points within a quadrant. In the constellation diagram referring to Fig. 4(b) the modulation parameter $\alpha = b/c$. For a given transmitted signal power the sum of b and c should remain constant. The value of α should not exceed the square root of the carrier power p_c. Otherwise, the constellation points of the same quadrant will overlap. When $\alpha = 1$, i.e. $b=c$ HQAM results in QAM as can be seen from Fig.4(c).

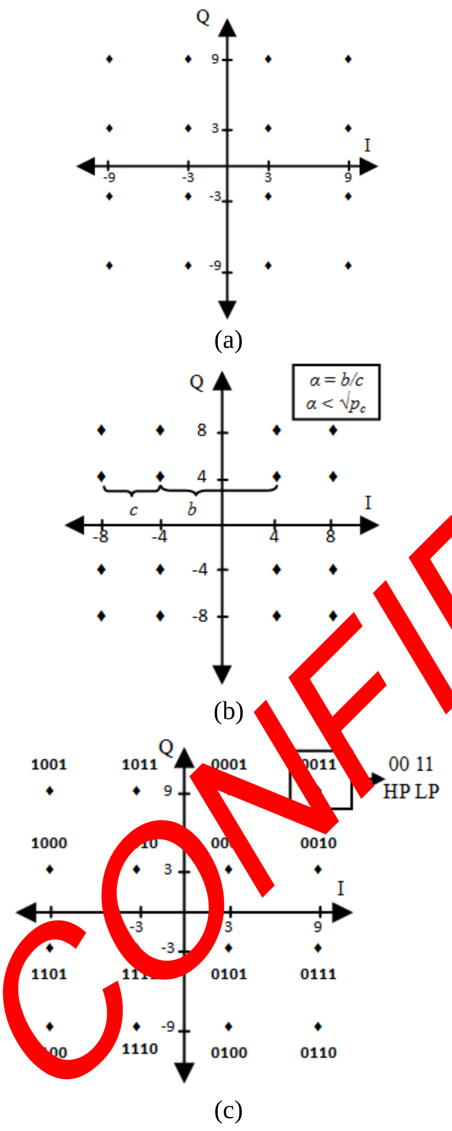


Figure 4: Constellation diagram of (a) 16-QAM and 16-HQAM for (b) α = 2 and (c) α = 1

Referring to Fig.4(c), the two MSB represent the HP bits which have lower BER than the two LSB bits. LSB bits are representing LP bits. It can be seen that the four symbols in every quadrant have the same HP bits but different LP bits; this is also called constellation overlapping and ensure that the HP bits to be transmitted correctly [11].

5. Simulations and results

In order to allow unequal error protection, the SPIHT coded bit stream is partitioned as critical (significant) and non-critical (insignificant) bits to two separate bit stream. The critical bits contain image size, number of bit plane, wavelet decomposition level and sign bits. Other bits are belongs to non- critical bits. The critical bit stream and non-critical bit stream are assigned to the 16-HQAM constellation points (Fig.4(c)) as Higher priority (HP) bits and lower priority (LP) bits respectively. 16-HQAM technique is applied to the HP and LP bit stream and transmitted over the channel. Fig.5 shows the proposed simulation flow diagram of SPIHT coded image transmission and reception using 16-HQAM technique.

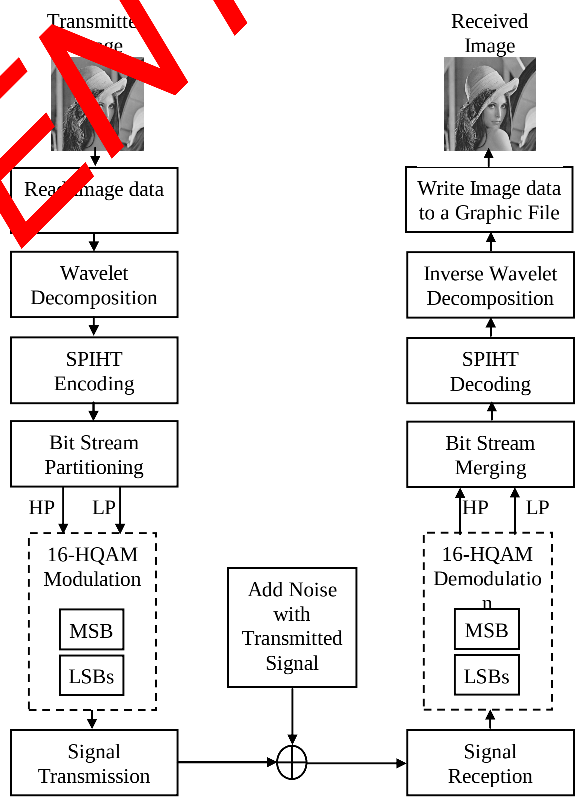


Figure 5: Proposed simulation flow diagram of SPIHT coded image transmission and reception using 16-HQAM technique

For the transmission of SPIHT coded images, the SNR was kept at a fixed value of 18 dB. Fig.6 shows the PSNR vs. Bit rate (bpp) graph where it is seen that for the greater value of modulation parameter the PSNR of transmitted image is higher than the lower value of modulation parameter.

The results are shown in Fig.7 for AWGN channel. Here each row represents the value of modulation parameter for 1 to 5 and each column represents bit rate (bpp) for 0.2, 0.6 and 1.0. From the result it is seen that when the value of modulation parameter increases then the quality of image also increases for different bit rate (bpp).

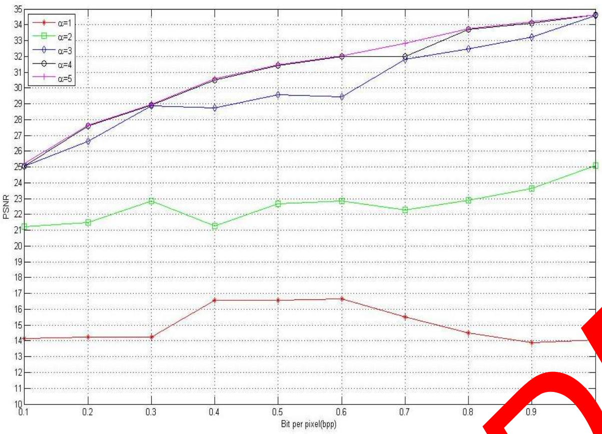


Figure 6: PSNR vs. Bit-rate graph for different values of modulation parameter and transmission over AWGN channel

6. Conclusions

Data compression helps to reduce the transmission bandwidth but it increases sensitivity of data. Channel coding provides protection by adding check bits with image data but it increases redundancy. If error occurs in critical bits or in the check bits then it is not possible to get actual data while transmission over erroneous channel. In this paper, it is shown that how to give more protection to sensitive data in wireless image transmission system. In the proposed system an UEP technique, 16-HQAM is used to protect the sensitive data of the coded image in wireless image transmission system. From the simulation output, it is clearly described with proper figures that how the reconstructed image quality is improved by changing the modulation parameter in erroneous wireless channels. Proposed image transmission system shows the better performances.

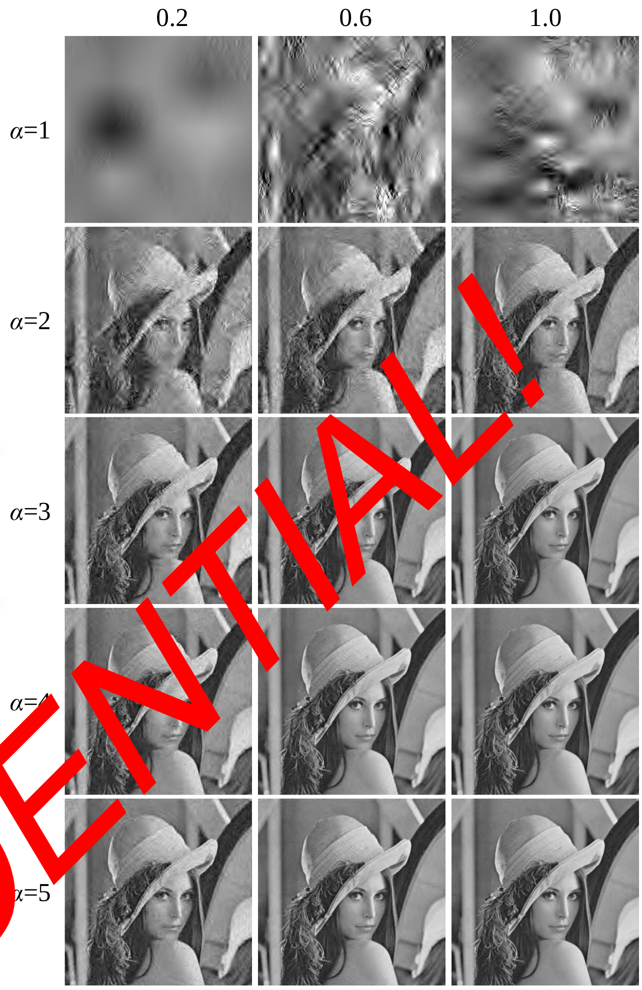


Figure 7: Reconstructed images using different bit-rate (bpp) and different value of modulation parameter for AWGN channel

10. References

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