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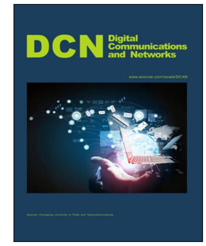

Adaptive FEC coding and cooperative relayed wireless image transmission

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Cooperative Diversity (CD)

Abstract
High quality image transmission through smart devices requires high transmission rate, throughput and low Bit Error Rate (BER). At the same time, energy efficiency is always the top issue for the battery-based smart devices such as smart phone, tablets, etc. In this paper, an adaptive Forward Error Correction (FEC) coding and cooperative relayed image transmission system is proposed, through which both transmission quality and energy efficiency could be promised under complex mobile communication channel environment. There are four steps in the proposed scheme: (1) Discrete Wavelet Transform (DWT) and wavelet based Decomposition, (2) Pixel-Position (PP) information and Pixel-Value (PV) information split based unequal image resource allocation, (3) transmission through channel fading and AWGN communication environment, (4) multiple-relays and adaptive channel coding. Comparing to traditional methods, our proposed method is more practical to transmit high quality images through battery-limited smart phone platforms.

Introduction

Comparing to traditional mobile communication terminals, larger display screen and higher data transmission rate are main characters of nowadays' smart devices, onto which hundreds of applications can be installed. To satisfy customer's expectations, newly released smart phones are coming with much higher pixel camera for high quality pictures instead of regular sizes from traditional cameras. Thereby, due to limited battery energy supply, energy usage efficiency is required for high quality image transmission, especially under severely noisy channel.

We apply Embedded Zero-tree Wavelet (EZW) for efficient image compression. Firstly, Discrete Wavelet Transform (DWT) was used to extract the coefficient of an original image; after

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wavelet based decomposition, Pixel-Position information and Pixel-Value information will be extracted form original image; after wavelet decomposition, image was extracted to large group of number '0' which can be compressed largely, followed by a couple number of none zero values. The large group of zeros contains Pixel-Position (PP) information, which is more important, the number of large value containing Pixel-Value (PV) information, which is less important for image transmission [2]. In this paper, an adaptive Forward Error Correction (FEC) was applied on the important part of the image information, under bad communication channel, several mobile terminal as relays are used to set up a transmission network. For overcome the MIMO system's limitation such as limited size and hardware complexity in wireless cellular system, Cooperative Diversity (CD) is used to 'extend' the antenna number. Convolutional coding method is also used for protect important part of image information (Pixel-Position), to achieve low BER and high data rate.

Our contributions for this work are as follows:

1. Unequally allocated energy to transmit important Pixel-Position information and unimportant Pixel-Value information, due to the unequal importance of Pixel-Value and Pixel-Position for image information containing.
2. Proposed an adaptive Forward Error Correction (FEC) scheme, for achieving low BER under multipath fading channel and AWGN channel environment. Plus, evaluated the BER performance under complex channel conditions.
3. Applied Cooperative Diversity with convolutional coding and multiple-relays in quality promised image transmission channel. Also, we analyzed the tunable coding ratio and relay number performance.

Symbols and Parameters shown as below:

Symbol	Definition
S	Sender
R	Receiver
BS	Base station
R1, R2	Relay1, Relay2

Fig. 1 shows the proposed system model with adaptive FEC and cooperative relays. At the transmitter side, unequal error protection (UEP) is applied based on Pixel-Position and Pixel-Value (PP and PV) unequal allocation. EZW (Embedded Zero-tree Wavelet) was applied for image compression. Then, we proposed A-FEC (Adaptive Forward Error Correction) and Cooperative relays for quality promised image transmission. Those relays and convolutional coding are needed for noisy channel and long transmission distance. Our four components are explained in *Methodology* section. (Figs. 2 and 3)

Peer work review

Paper [1] introduced an efficient image compression method named Embedded Zero-tree Wavelet (EZW). The compression processes are as following: first, Discrete Wavelet Transform (DWT) was applied to original image for coefficient decomposition, and then, the digital bits of image are generated as importance order in bit stream, the low frequency parts are set to zeros, which are regarded as Pixel-Positions (PP), and can be compressed largely,and the high frequency information containing less important information is regarded as Pixel-Value (PV). The amount of zeros (low frequency part) can be compressed largely by using the numbers of zeros instead of transmit exactly all zeros in the Pixel-Position (PP) information. By this way, EZW compression method achieves high compression ratio and at the same time, it promises image quality. While, in their work, they did not apply this method on image transmission via mobile devices, which means they did not evaluate image transmission among smart devices under different communication environments. Then, paper [2], provided a method for image compression based on unequal importance of the pixel-position and Pixel-Value information. Besides this, unequal error protection (UEP) has used in this paper for information protection and energy saving. While, the transmission for compressed image through smart device is not considered yet. Besides, paper [3] explained the concept of data transmission through noisy communication channels by using Cooperative Diversity. In their work, a cooperative communication network has been built up to achieve high energy efficient, and handle high noise interference, for individual smart devices data transmission such as smart phone or PDAs. While, they have been only considered 1-D signal communication, but lack of research on 2-D image transmission. Recently, paper [5] provided a cooperative wireless communication network based on Alamouti communication technic. Compared with Maximum Ratio Combining (MRC), the balanced Cooperative Diversity network is more efficient and robust under complex channel environments. But they did not compress the preprocessed image first, which can largely reduce the energy cost for multi-media communication.

Comparisons of aforementioned research work are shown in Table 1

Methodology

A. Pixel-Position and Pixel-Value unequal resource allocation

For original high quality images, wavelet transform is applied to extract wavelet coefficients, then, the coefficients were stored in a matrix which is X-Y sized. After that, the matrix was scanned through the importance order from most important to least important. If the magnitude is larger than the threshold, it is called as larger value, or it is small value if smaller than threshold. Small values of coefficient are represented by Pixel-Position values, in which, zeros are grouped and represented by position data [1,6]. After compression, Pixel-Position data and Pixel-Value data are listed as a decreasing importance order. Any incorrect bits of Pixel-Position data may cause an avalanche of following bit errors. Thereby Pixel-Position data should be highly protected, under the same level of noise channel, a missing or failed transmission of Pixel-Position data may cause greater image quality degradation than errors of Pixel-Value data. In other words, bits missing occurs in Pixel-Value data may not hurt much for reconstructed image, but bits missing at Pixel-Position data will normally