Available online at www.sciencedirect.com
ScienceDirect
Signal Processing: *Image Communication* 22 (2007) 543–556
SIGNAL PROCESSING: IMAGE COMMUNICATION
www.elsevier.com/locate/image

A robust joint source channel coding scheme for image transmission over the ionospheric channel

C. Chatellier[a,*], H. Boeglen[b], C. Perrine[a], C. Olivier[a], O. Haeberlé[b]

[a]*SIC Laboratory, EA CNRS 4103, Bvd Marie et Pierre Curie, F-86962 Futuroscope Chasseneuil Cedex, France*
[b]*MIPS Laboratory 12, rue des frères Lumière 68093-Mulhouse, Cedex, France*

Received 24 October 2006; received in revised form 9 May 2007; accepted 9 May 2007

Abstract

In this paper, we propose a joint source channel coding (JSCC) scheme to the transmission of fixed images for wireless communication applications. The ionospheric channel which presents some characteristics identical to those found on mobile radio channels, like fading, multipath and Doppler effect is our test channel. As this method based on a wavelet transform, a self-organising map (SOM) vector quantization (VQ) optimally mapped on a QAM digital modulation and an unequal error protection (UEP) strategy, this method is particularly well adapted to low bit-rate applications. The compression process consists in applying a SOM VQ on the discrete wavelet transform coefficients and computing several codebooks depending on the sub-images preserved. An UEP is achieved with a correcting code applied on the most significant data. The JSCC consists of an optimal mapping of the VQ codebook vectors on a high spectral efficiency digital modulation. This feature allows preserving the topological organization of the codebook along the transmission chain while keeping a reduced complexity system. This method applied on grey level images can be used for colour images as well. Several tests of transmission for different images have shown the robustness of this method even for high bit error rate (BER $>10^{-2}$). In order to qualify the quality of the image after transmission, we use a PSNR% (peak signal-to-noise ratio) parameter which is the value of the difference of the PSNR after compression at the transmitter and after reception at the receiver. This parameter clearly shows that 95% of the PSNR is preserved when the BER is less than 10^{-2}.

Keywords: Image coding; Joint source channel coding; Discrete wavelet transform; Image transmission over noisy channel

1. Introduction

Nowadays, there is a constant increase in services offered by mobile phone providers. The quantity and diversity of information to be transmitted requires increasingly complex coding and transmission technologies. The constraints linked to mobility are very important. Their consequences, such as fading, Doppler effect and spreading delay, produce transmission errors, which can have a dramatic impact on the quality of the signal content. The currently available channel coding and decoding methods linked to equalization, allow the correction of most of these errors, thereby guaranteeing a good quality of service. However, the use of these techniques results in an increase of the quantity of data to be transmitted. This results in an increase of the transmission time if the bit rate is constant, or

*Corresponding author. Tel.: +33 5 49 49 74 39; fax: +33 5 49 49 65 70.
E-mail address: chatellier@sic.univ-poitiers.fr (C. Chatellier).

0923-5965/$ - see front matter © 2007 Elsevier B.V. All rights reserved.
doi:10.1016/j.image.2007.05.001

of the bandwidth for variable bit rate. In this context, image compression algorithms represent a useful alternative since they allow the reduction in size of the transmitted files, whilst ensuring an excellent visual quality.

Amongst all these image coding methods, discrete cosine transform (DCT) and discrete wavelet transform (DWT) are widely used. Their usefulness comes from their capability to compress information to a relatively small number of coefficients and, of course, from their reversibility. When the compression rate is high, there are different types of distortion or artefacts depending on the compression methods. JPEG [24], which is based on DCT, suffers from blocking artefacts. JPEG-2000 [14], SPIHT [12] and EBCOT [6] which are based on DWT suffer from ringing around edges.

Unfortunately compressed images are very sensitive to transmission errors and this sensitivity increases with the compression rate. Fig. 1 below shows the impact of these errors on the quality of a reconstructed image with a bit error rate (BER) in the order of 10^{-4}. This results from the arithmetic coding used at the last compression algorithm stage, necessary for the binary coding of quantized coefficients. Due to this variable length coding (VLC) any error occurring in the bit stream results in a desynchronisation of the decoding algorithm. In most cases, this produces an increasing series of errors, preventing image reconstruction [26].

In order to counteract this phenomenon, marks are introduced in the compression process, which allow the synchronisation of the decoding process for these VLC when transmission errors occur [5,11,28]. Fig. 2 shows the image resulting from the introduction of such marks in a JPEG image. However, as the BER increases so does the number of required marks resulting in a strongly degraded image.

Channel coding or error correcting codes (ECC), which aims at detecting and correcting transmission errors, can also be introduced. The correcting capability of these codes is linked to the redundancy introduced in the transmitted bit stream. Their performance has been widely demonstrated. In order to achieve an efficient image transmission

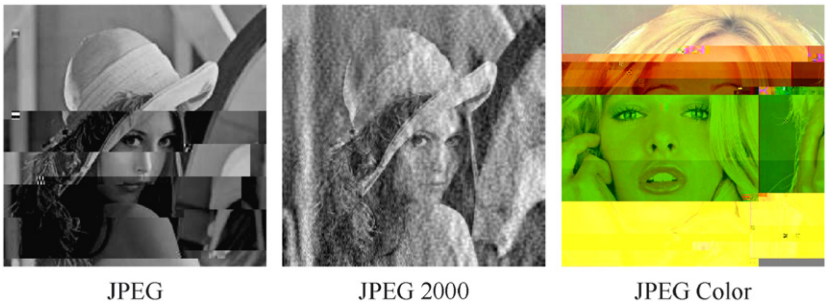

Fig. 1. Images reconstruction when BER is about 10^{-4} and file header not corrupted.

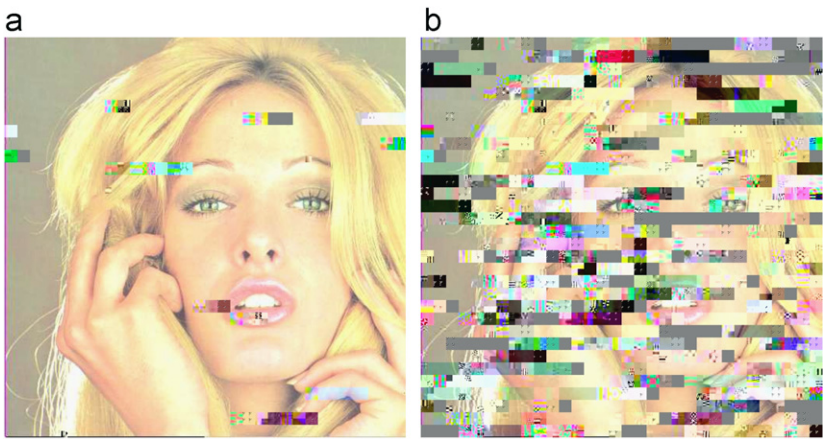

Fig. 2. Resynchronised binary stream for a JPEG image: (a) BER = 10^{-4}, (b) BER = 4.12×10^{-3}.