Turk J Elec Eng & Comp Sci, Vol.19, No.1, 2011, © TÜBİTAK
doi:10.3906/elk-1003-461

Adaptive Wiener-turbo systems with JPEG & bit plane compressions in image transmission

Ersin GÖSE
Turkish Air Force Academy, Electronics Engineering Department,
34149, İstanbul-TURKEY
e-mail: e.gose@hho.edu.tr

Abstract

In recent years, for transmission of 2D colored images over the fading channels, a new scheme has been denoted as "adaptive Wiener-turbo systems with JPEG & bit plane compressions" (AW-TSwJBC). In this paper, the performance of AW-TSwJBC is introduced over Rician and Rayleigh fading channels. We benefited from the neighborhood relation of pixels for each color plane by using a new iterative block, the "adaptive Wiener-turbo" scheme, which employs a turbo decoder, JPEG encoder/decoders, and adaptive Wiener filtering. In our approach, we could also alter compression ratios due to the importance of the image to be transferred. Based on the simulation results obtained in this study, AW-TSwJBC can recover high quality JPEG and bit plane compression images from the corresponding corrupted JPEG images at high SNR values for Rician (K = 10 dB) and Rayleigh channels. This shows the feasibility of the AW-TSwJBC approach.

Key Words: *Color and bit plane slicing, fading channels, JPEG, image compression, image transmission, turbo coding*

1. Introduction

To protect image quality against transmission errors in compressed images, there are several proposed approaches, including: 1) the channel coding approach; 2) the error resilience approach; and 3) the detection and correction approach. For the channel coding approach, some error correction codes are used to encode images such that transmission errors can be detected and corrected (partially or completely) by adding redundancy to the transmitted information. However, the channel coding approach will moderately increase the transmission bit rate [1].

Images usually contain so much data that they need to be compressed prior to storage or transmission. JPEG (Joint Photographic Experts Group) is the current standard for the compression and decompression of still, continuous tone, monochrome, and color images. JPEG has 4 distinct modes of operation: sequential

DCT-based, progressive DCT-based, lossless, and hierarchical [2]. JPEG, a DCT-based image compression algorithm [3], is the current ISO standard for the encoding of still images. The JPEG algorithm [4] follows a block-based compression approach. It divides the input image into 8 $\times$ 8 pixel blocks, transforms each block using DCT, and then codes the DC and AC coefficients. To reduce redundancy due to correlation between pixels of adjacent blocks, it predicts only the DC coefficient. For intrablock redundancy, it only quantizes the DCT coefficients and does not use predictive coding. In other words, it explores spatial redundancy at the block level and not at the pixel level. Consequently, the JPEG algorithm leaves a fair amount of spatial redundancy unexplored.

In data compression, it is generally desired to get the contribution of individual bits made to the total image. Bit plane slicing methods [5, 6] decompose the image into a series of binary images. Bit plane slicing is helpful for analyzing the relative importance played by each bit of the image and plays an important role in image processing. Bit plane slicing operations can be described as follows. The image is processed by slicing the selected bit planes, starting with the most significant one. For instance, if plane 8 is sliced, the image consists of planes 0-7 only. Therefore, in bit slice algorithms, the user can choose 1 or more among the 8 bits for each gray value (or RGB channel) to see the contribution of the chosen bits.

The images, which are to be transmitted over noisy channels, are extremely sensitive to the bit errors, which can severely degrade the quality of the image at the receiver. This necessitates the application of error control channel coding in the transmission. Powerful and effective channel coding is necessary for image transmission through a wireless environment. For channel coding, we used turbo coding. Turbo codes, which have good performance at low SNRs, were first proposed in [7]; their performance is near the Shannon limit performance with a tolerable complexity. Recently, turbo coding has been adopted in the next generation personal mobile communication standards and applied coding to provide a robust image communication means [8-11]. Moreover, its iterative decoding scheme and soft channel information utilization are especially suitable for compressed image transmission [12-13].

In this paper, the compression and transmission performance of adaptive Wiener-turbo systems with JPEG & bit plane compressions (AW-TSwJBC) [14] were investigated over Rician and Rayleigh fading channels. On the transmitter side, the AW-TSwJBC scheme uses bit plane slicing (BPS), JPEG, and turbo codes for compression and transmission improvement, respectively. The compression scenario reduces the significant amount of data required to reproduce the image at the receiver.

At the receiver, after each BPS is decoded, output bits are mapped to the previous places by reassembling the first bit from the first bit slice, the second bit from the second bit slice, and lastly the last bit from the last bit slice for each pixel. Hence, by collecting all of the pixels, the recovery of the image is achieved. In the case of compression due to the resolution, not all of the BPSs, but some of them, can be taken into account. Thus, corresponding quantized amplitude values of the pixels are found. Resolution loss is a general case in compression, but by sacrificing resolution, we use less memory storage and increase the data rate up to (N) times by simply choosing any number of bit slices.

This paper is organized as follows: In section 2, the system model, which includes a JPEG encoder/decoder, a turbo encoder/decoder, bit plane slicing/combining coding, and adaptive Wiener filtering, is described. Simulation results are given for Rician (K = 10 dB) and Rayleigh channels in section 3, which includes examples of the received image along with BER and SNR performances achieved with the AW-TSwJBC method. Section 4 discusses the AW-TSwJBC method and concludes the paper.

2. System model

The AW-TSwJBC scheme consists of a color and bit planes' slicer, a JPEG encoder, and a turbo encoder on the transmitter side; and an adaptive Wiener-turbo system employing a turbo decoder, a JPEG decoder, adaptive Wiener filtering, and color & bit planes' combiners on the receiver side, as shown in Figure 1. In order to increase the performance of the scheme, at the receiver, JPEG encoders are applied as a feedback link between the adaptive Wiener filtering and the turbo decoder.

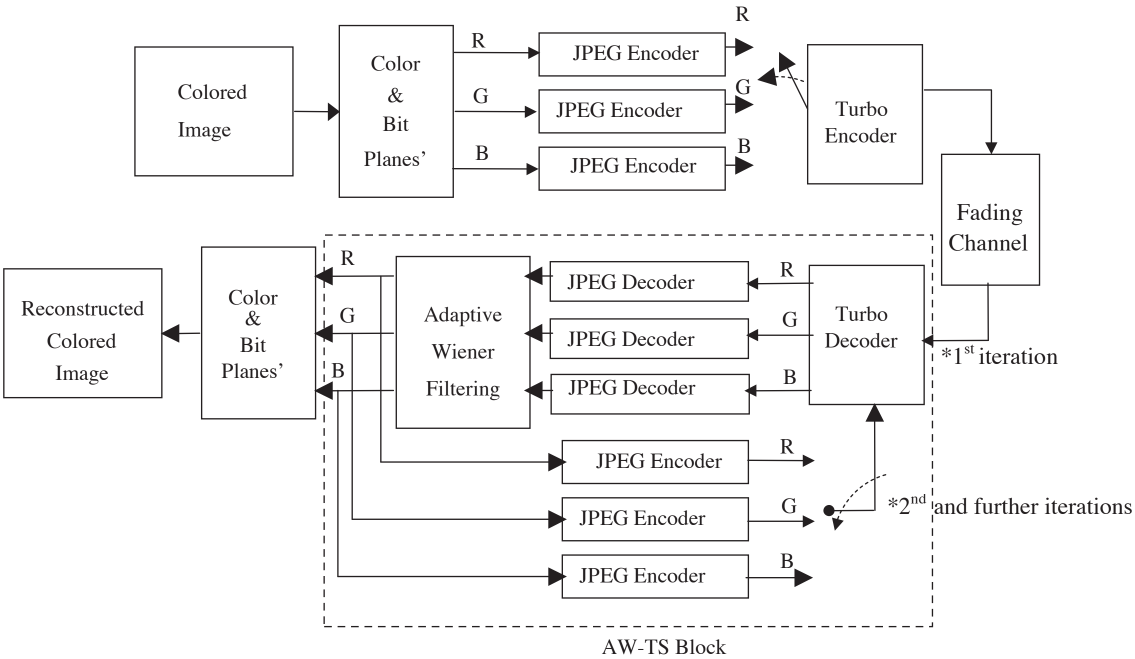


Figure 1. AW-TSwJBC system model.

On the transmitter side of the AW-TSwJBC scheme, the colored image is sliced into RGB planes and each of RGB planes is separated into various bit planes. As an example, we considered 8 bits for each color plane, and thus a total of 24 bit planes were encoded with JPEG encoders prior to the turbo encoder. The turbo encoder employs 2 identical systematic recursive convolutional encoders (RSC) connected in parallel with an interleaver preceding the second recursive convolutional encoder. Both RSC encoders encode the information bits of the bit slices. The first encoder operates on the input bits in their original order, while the second one operates on the input bits as permuted by the interleaver. These bit planes are transmitted over Rician and Rayleigh fading channels by the turbo encoder block.

On the receiver side, the turbo decoder, which contains 2 component decoders concatenated in parallel, performs a suboptimal log-MAP algorithm. In order to perform the MAP algorithm, an accurate estimation of the channel conditions, i.e. the noise variance, is required. When the required numbers of iterations have been completed,;he hard decision is made to obtain the estimated symbols at the second decoder. At the first iteration of the turbo decoding process, turbo coded noisy symbols are used, but at the following second and further iterations, the symbols are passed through an adaptive Wiener filtering block. There is a link between the turbo decoder and the adaptive Wiener filtering that contains JPEG encoders. After sufficient iterations, the estimated symbols are rearranged as RGB planes, decoded by the JPEG decoder, and filtered with the Wiener filter. The filtered RGB planes are combined at the color/bit planes' combiner, and finally the reconstructed color imaged is observed.

2.1. Bit plane slicing/combining coding

Highlighting the contribution made to the total image appearance by specific bits plays an important role for the AW-TSwJBC system. An application of this technique may be data compression. The image is composed of N bit planes, ranging from plane 1 for the least significant bit to plane N for the most significant bit. In terms of N bit planes, plane 1 contains all of the lowest order bits in the bytes comprising the pixels in the image, and plane N contains all of the high-order bits. In other words, plane 1 is the least significant bit (LSB) and plane N is the most significant bit (MSB), as shown in Figure 2. This decomposition reveals that only some highest order bits contain visually significant data. Also, note that plane N corresponds exactly with an image threshold at gray-level 2^N. In that case, we have $2^8 = 256$ gray levels.

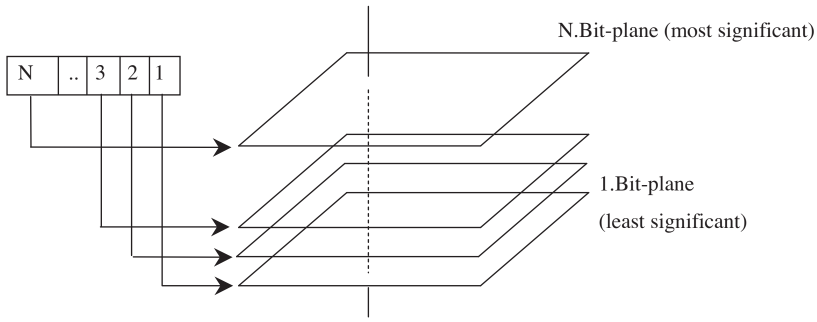


Figure 2. N bit plane decomposition of an image.

For each color plane, note that the 8, 7, etc. bit planes can be arranged from lowest to highest order sequence, each containing visually more significant data. In our study, the image was sliced into 24 planes (first, the colored image was sliced into RGB color planes, and then each color plane was sliced into 8 planes). Each pixel in the image was represented by 8 bits, or 256 gray levels. Plane 8 corresponded exactly with an image threshold at gray level 256.

Bit plane combining is the reverse process of the slicing. The planes are recombined in order to reconstruct the image. But it is not necessary to take into consideration all of the slice contributions. Especially in the event that the data rate is important, some planes can be ignored until the changes in gray level have an acceptable impact on the image. This approach will increase the data rate, resulting in extra compression.

2.2. Channel model

The main emphasis on the channel model is focused on the performance of AW-TSwJBC in a fading environment modeled by the Rician probability density function. Thus, our results reflect the degradations due to the effect of fading on the amplitude of the received signal. The block diagram of the considered system operating over a fading environment is shown in Figure 1. If the binary phase shift keying (BPSK) output of the transmitter is $x(i)$, the channel output $y(i)$ is

$$y(i) = \rho(i) \cdot x(i) + n(i), \tag{1}$$

where $n(i)$ is the Gaussian noise where the noise variance is $\sigma^2 = \frac{N_o}{2E_s}$, and $\rho(i)$ is the fading amplitude. The Rician probability density function (pdf) can be written as

$$P(\rho) = 2\rho(1+K)\ e^{(-\rho^2(1+K)-K)} I_o\left[2\rho\sqrt{K(1+K)}\right], \tag{2}$$

where I_o is the modified Bessel function of the first kind, order zero, and K is the fading parameter. The Rician pdf turns into a Rayleigh pdf if the parameter K is chosen as 0.

2.3. Adaptive Wiener filtering

The goal of Wiener filtering is to obtain an estimate of the original BPS from the degraded version [15]. The Wiener filter requires estimating the signal mean m_f, noise mean m_v, signal power spectrum $P_f(w_1, w_2)$, and noise power spectrum $P_v(w_1, w_2)$. Instead of assuming a fixed m_v, $P_f(w_1, w_2)$, and $P_v(w_1, w_2)$ for the entire image, they can be estimated locally. This type of Wiener filter is called an adaptive Wiener filter. A prior probability model of the image is of central importance for adaptive Wiener filter design. Modeling the statistics of natural images is a challenging task. Ideally, to represent an inhomogeneous image, a different model may be required at each pixel. This will cause computational overload in processing images. In order to avoid such unmanageable complexities, simpler image models that make the analysis feasible but still take into account the inhomogeneity of the image are needed. The following are the rules used to implement Wiener filters with a bit-sliced plane image model.

We did not use an adaptive Wiener filter prior to the turbo decoder at the receiver, because the aim of the Wiener filter is noise cancellation of colored images at the receiver. An applied Wiener filter reduces noise in an image. It compares each pixel with its neighbors in the mask, and if the pixel is larger or smaller in value than others, it places the pixel by the largest or smallest of the neighbors. This is good for removing single noisy pixels from an image. We used considerable noise reduction capacity of the Wiener filter. It was shown that in the single-channel case, the a posteriori signal-to-noise ratio (SNR) (defined after the Wiener filter) is greater than or equal to the a priori SNR (defined before the Wiener filter), indicating that the Wiener filter is always able to achieve noise reduction [16]. Before the turbo decoder, the coded and interleaved symbols are independent. Therefore, the adaptive Wiener filter, which uses prior information of colored images, cannot be used before the turbo decoder. After the turbo and JPEG decoder process, a colored image is created and the adaptive Wiener filter used for noise reduction can be applied. Finally, the output of the adaptive Wiener filter improves the performance of the turbo decoder in an iterative manner.

In our problem, the Wiener filter was applied to all planes of the image, and, hence, we still assumed that the additive noise on the bit plane $v(n_1, n_2)$ was zero mean and white with variance of σ_v^2. Let $f^j(n_1, n_2)$ show each plane, from first to eighth. Their power spectrums $P_v^j(w_1, w_2)$ are then given by $P_v^j(w_1, w_2) = (\sigma_v^j)^2$. Consider a small local region in which the plane $f^j(n_1, n_2)$ is assumed to be homogeneous. Within the local region, the plane $f^j(n_1, n_2)$ is modeled by

$$f^j(n_1, n_2) = m_f^j + \sigma_f^j w^j(n_1, n_2), \tag{3}$$

where m_f^j and σ_f^j are the local mean and standard deviation of $f^j(n_1, n_2)$ and $w^j(n_1, n_2)$ is the zero mean white noise with a unit variance affecting each plane. Within the local region, then, the Wiener filter $H^j(w_1, w_2)$,

$h^j(n_1, n_2)$ is given by

$$H^j(w_1, w_2) = \frac{P_f^j(w_1, w_2)}{P_f^j(w_{1,2}) + P_v^j(w_1, w_2)} = \frac{(\sigma_f^j)^2}{(\sigma_f^j)^2 + (\sigma_v^j)^2} \tag{4}$$

$$h^j(n_1, n_2) = \frac{(\sigma_f^j)^2}{(\sigma_f^j)^2 + (\sigma_v^j)^2}\delta(n_1, n_2) \tag{5}$$

Then the restored planes $p^j(n_1, n_2)$ within the local region can be expressed as

$$p^j(n_1, n_2) = m_f^j + (g^j(n_1, n_2) - m_f^j)^* \frac{(\sigma_f^j)^2}{(\sigma_f^j)^2 + (\sigma_v^j)^2}. \tag{6}$$

If we assume that m_f^j and σ_f^j are updated at each symbol,

$$p^j(n_1, n_2) = m_f^j(n_1, n_2) + \frac{(\sigma_f^j)^2(n_1, n_2)}{(\sigma_f^j)^2(n_1, n_2) + (\sigma_v^j)^2(n_1, n_2)}(g^j(n_1, n_2) - m_f^j(n_1, n_2)). \tag{7}$$

From the degraded planes, we can estimate $(\sigma_g^j)^2(n_1, n_2)$ only, and since $(\sigma_g^j)^2(n_1, n_2) = (\sigma_f^j)^2(n_1, n_2) + (\sigma_v^j)^2(n_1, n_2)$, the equation changes to

$$p^j(n_1, n_2) = m_g^j(n_1, n_2) + \frac{(\sigma_g^j)^2(n_1, n_2) - (\sigma_v^j)^2(n_1, n_2)}{(\sigma_g^j)^2(n_1, n_2)}(g^j(n_1, n_2) - m_g^j(n_1, n_2)). \tag{8}$$

After the RGB bit planes are Wiener-filtered with the above approach, the MAP-based turbo decoding algorithm is considered. Thus, in equation (4), $p^j(n_1, n_2)$ takes the degraded planes as the new inputs for the turbo decoders. The resulting outputs of the RBG planes can be expressed as

$$p_{i+1}^{(1)}(n_1, n_2) = m_{g_i}^{(1)}(n_1, n_2) + \frac{(\sigma_{g_i}^{(1)})^2(n_1, n_2) - (\sigma_v^{(1)})^2(n_1, n_2)}{(\sigma_{g_i}^{(1)})^2(n_1, n_2)}(p_i^{(1)}(n_1, n_2) - m_{g_i}^{(1)}(n_1, n_2))$$

$$p_{i+1}^{(2)}(n_1, n_2) = m_{g_i}^{(2)}(n_1, n_2) + \frac{(\sigma_{g_i}^{(2)})^2(n_1, n_2) - (\sigma_v^{(2)})^2(n_1, n_2)}{(\sigma_{g_i}^{(2)})^2(n_1, n_2)}(p_i^{(2)}(n_1, n_2) - m_{g_i}^{(2)}(n_1, n_2))$$

$$p_{i+1}^{(3)}(n_1, n_2) = m_{g_i}^{(3)}(n_1, n_2) + \frac{(\sigma_{g_i}^{(3)})^2(n_1, n_2) - (\sigma_v^{(3)})^2(n_1, n_2)}{(\sigma_{g_i}^{(3)})^2(n_1, n_2)}(p_i^{(3)}(n_1, n_2) - m_{g_i}^{(3)}(n_1, n_2)), \tag{9}$$

where i is the iteration index for each plane, between the Wiener process and the turbo decoder. i can be taken from 1 to the desired number. If it is taken as 1, the MAP-processed RGB plane (at the output of the decoder) enters the Wiener filter only 1 time. In this case, we have $P_1^j(n_1, n_2)$ and $P_2^j(n_1, n_2)$ for each RGB plane, and for the reconstructing of the image, only $P_2^j(n_1, n_2)$ is taken into consideration. If the i index is taken as 0, the output of the decoders is never refiltered by the Wiener filter. The simulation results have shown that it is not necessary to set this index too high.

2.4. AW-TS decoding process

In the first iteration process, we considered only MAP-based decoding. The goal of the MAP algorithm is to find the a posteriori probability of each state transition, message bit, or code symbol produced by the underlying Markov process, given the noisy observation y [17, 18]. Once the a posteriori probabilities are calculated for all possible values of the desired quantity, a hard decision is made by taking the quantity with the highest probability. When used for turbo decoding, the MAP algorithm calculates the a posteriori probabilities of the message bits for the filtered planes, which are then put into log-likelihood ratio (LLR) form [19]. Before finding the a posteriori probabilities for the message bits, the MAP algorithm first finds the probability of each valid state transition, given the noisy channel observation y.

Soft bit information is deinterleaved and evaluated at the hard decision section for each RGB color plane. They are injected to JPEG decoders and then passed to adaptive Wiener filtering. In order to enhance image quality, in the second and further iterations, adaptive Wiener filtering outputs are fed into JPEG encoders. JPEG encoder outputs are then evaluated as new inputs of the turbo decoder block. When a satisfactory result is observed, a hard decision is found. Thus, at the last iteration, AW-TS outputs are combined in the color and bit planes' combiner and the reconstructed colored image is obtained.

3. Method and experimental evaluation

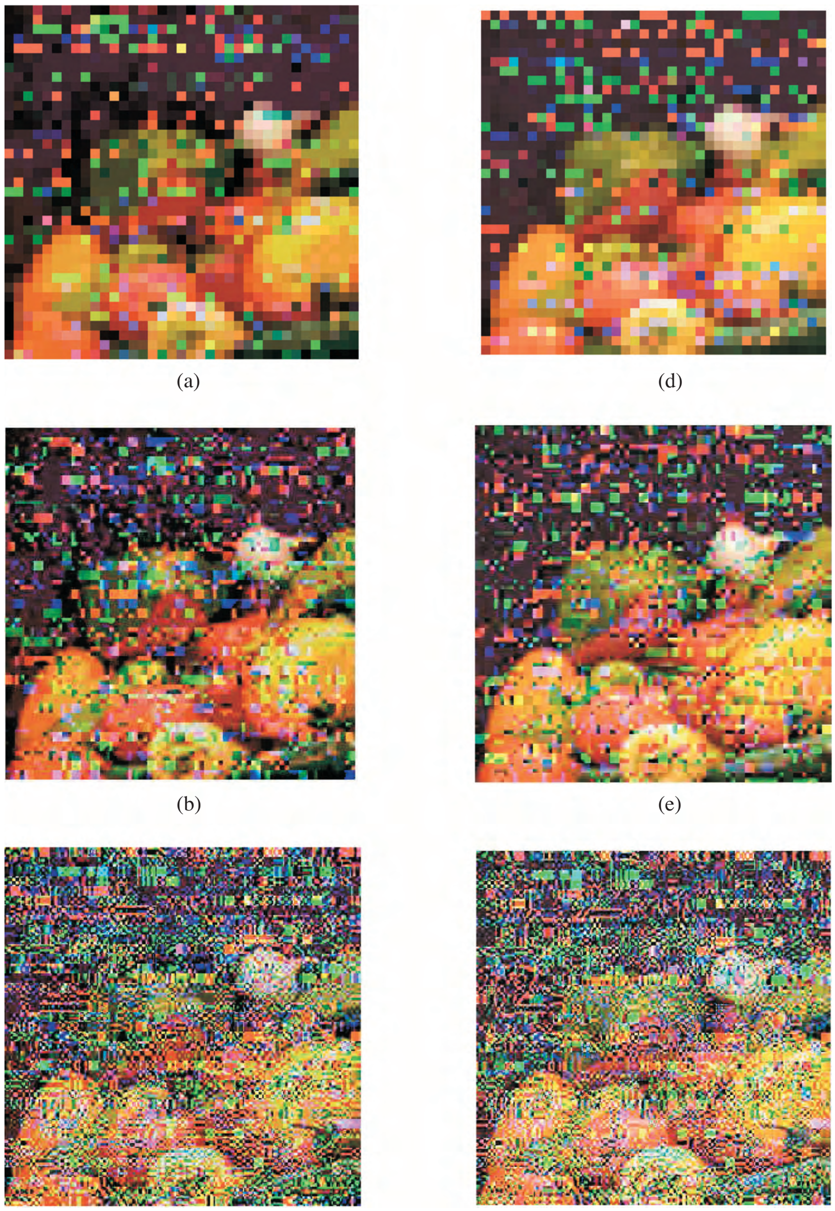
The AW-TSwJBC scheme was experimentally evaluated for the transmission of a 500×500 test image over Rician and Rayleigh channels. The first step of the transmission was based on partitioning the image into 3 RGB planes, and then each of them was sliced into 8 BPSs. Thus, $3 \times 8 = 24$ planes were coded independently, carrying some important and highly protected neighborhood relations to the receiver, enabling us to use an adaptive Wiener filter, and hence the whole performance of the system was improved.

In [20], the effect of constraint length, the generator polynomials, and the interleaver used in the component codes of turbo codes were investigated. Some generator polynomials were compared and it was shown that [7,5] gives the best performance among them. The effect of increasing the constraint length of the component codes used in turbo codes was also studied. It was shown that increasing the constraint length of the turbo code improved its performance, with the K = 4 code performing about 0.25 dB better than the K = 3 code at a BER of 10^{-4}, and the K = 5 code giving a further improvement of about 0.1 dB. However, these improvements were provided at the cost of approximately doubling or quadrupling the decoding complexity. The other vital influence on the performance of the code, the design of the interleaver, was investigated, and it was shown that random interleavers gave the best performance for turbo codes with long frame lengths. Therefore, a turbo code with a constraint length of 3, the generator polynomial [7,5], and a random interleaver was considered in this paper.

On the receiver side, 24 bit planes were reassembled by considering the neighborhood relationship of the pixels. Each of the noisy bit planes were evaluated iteratively by a combined block, which was composed of a 2D adaptive noise removal filter and a turbo decoder. In AW-TSwJBC, there is an iterative feedback link between the Wiener filter and the turbo decoder. Our scheme employs a plane-wise adaptive Wiener-based turbo decoder and uses statistics (the mean and standard deviation of each plane) of the local neighborhood of each pixel in order to obtain the highest probability of the symbols.

Figures 3-6 show the reassembled bit planes and the resultant image at the decoder output for SNR =

2 and 4 dB values for Rician and Rayleigh channels. In Figures 3a-3e, the performance of AW-TSwJBC is evaluated for 2 and 4 dB SNR values.



(a) (d)

(b) (e)

(c) (f)

Figure 3. Reconstructed image for SNR = 2dB for a Rician channel (K = 10 dB). (a) Total 96.875% compression (with 87.5% JPEG and 75% bit plane), (b) Total 93.75% compression (with 75% JPEG and 75% bit plane), (c) Total 87.5% compression (with 50% JPEG and 75% bit plane), (d) Total 93.75% compression (with 87.5% JPEG and 50% bit plane), (e) Total 87.5% compression (with 75% JPEG and 50% bit plane), (f) Total 75% compression (with 50% JPEG and 50% bit plane)

In Figure 3a, for each R, G, and B plane, we had 8 bit plane slices, and 2 of them were transmitted, enabling a 75% compression ratio, by BPS compression. The transmitted planes were then recompressed using

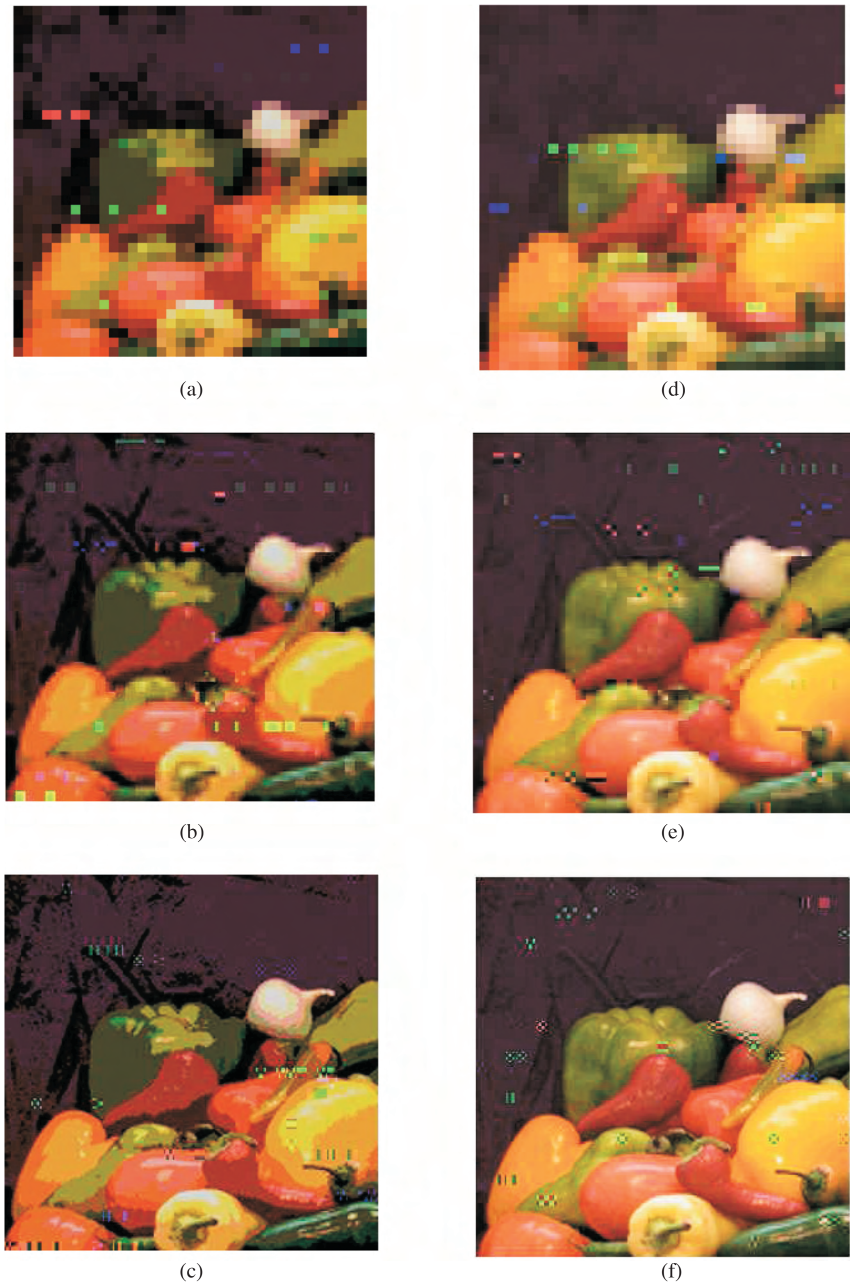


Figure 4. Reconstructed image for SNR = 4dB for a Rician channel (K = 10 dB). (a) Total 96.875% compression (with 87.5% JPEG and 75% bit plane), (b) Total 93.75% compression (with 75% JPEG and 75% bit plane), (c) Total 87.5% compression (with 50% JPEG and 75% bit plane), (d) Total 93.75% compression (with 87.5% JPEG and 50% bit plane), (e) Total 87.5% compression (with 75% JPEG and 50% bit plane), (f) Total 75% compression (with 50% JPEG and 50% bit plane)

the JPEG approach, which is based on discrete cosine transform (DCT) compression. The JPEG process involved first dividing the image into 8 × 8 pixel blocks. Each block's information was transformed to the frequency domain; every 1 × 1 low-frequency element was transmitted, the others were discarded, and hence an 87.5% compression ratio was obtained by JPEG. In this case, some high-frequency elements that contain a lot of detail can be lost. The more of these high-frequency elements that are discarded, the smaller the resulting file and the lower the resolution of the reconstituted image. As a result, a 75% compression ratio for BPS and 87.5% for JPEG gave us 96.875% total compression.

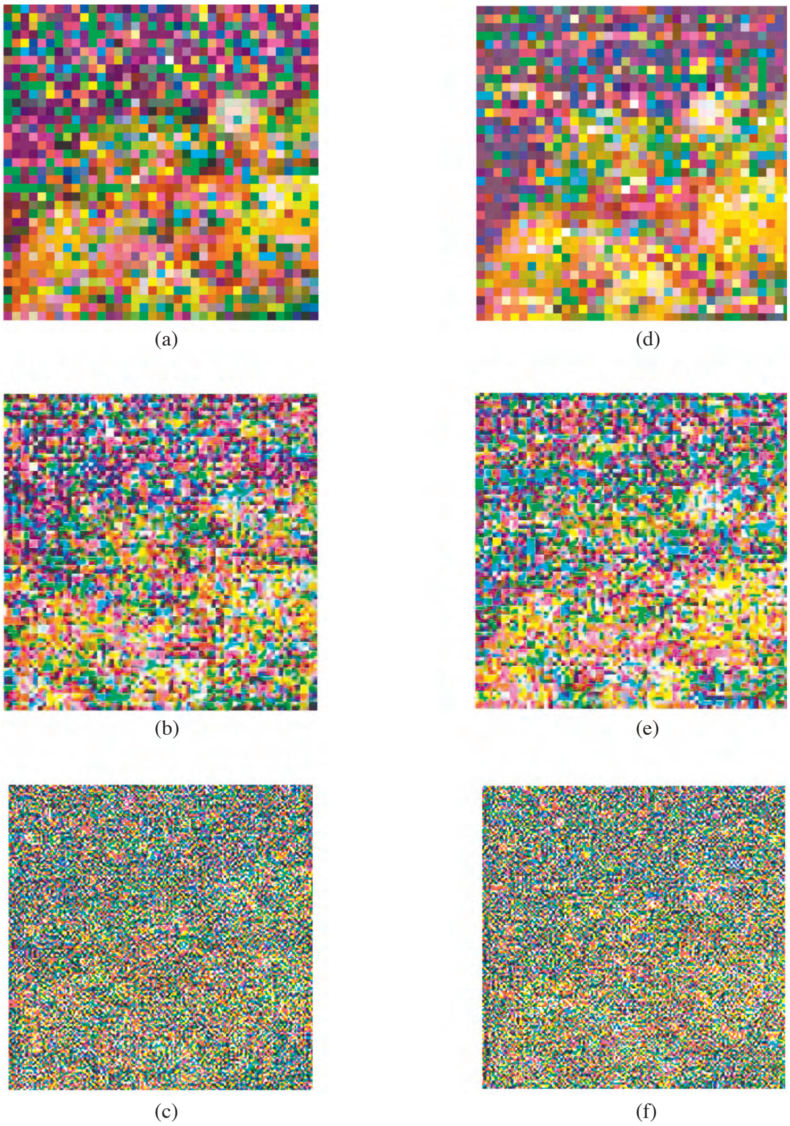


Figure 5. Reconstructed image for SNR = 2dB for a Rayleigh channel. (a) Total 96.875% compression (with 87.5% JPEG and 75% bit plane), (b) Total 93.75% compression (with 75% JPEG and 75% bit plane), (c) Total 87.5% compression (with 50% JPEG and 75% bit plane), (d) Total 93.75% compression (with 87.5% JPEG and 50% bit plane), (e) Total 87.5% compression (with 75% JPEG and 50% bit plane), (f) Total 75% compression (with 50% JPEG and 50% bit plane).

In Figure 3b, these values were 75% for each compression (BPS and JPEG). In other words, we transmitted 2 plane slices and 2 $\times$ 2 low-frequency elements of each 8 $\times$ 8 block; the others were thrown away. Therefore, we

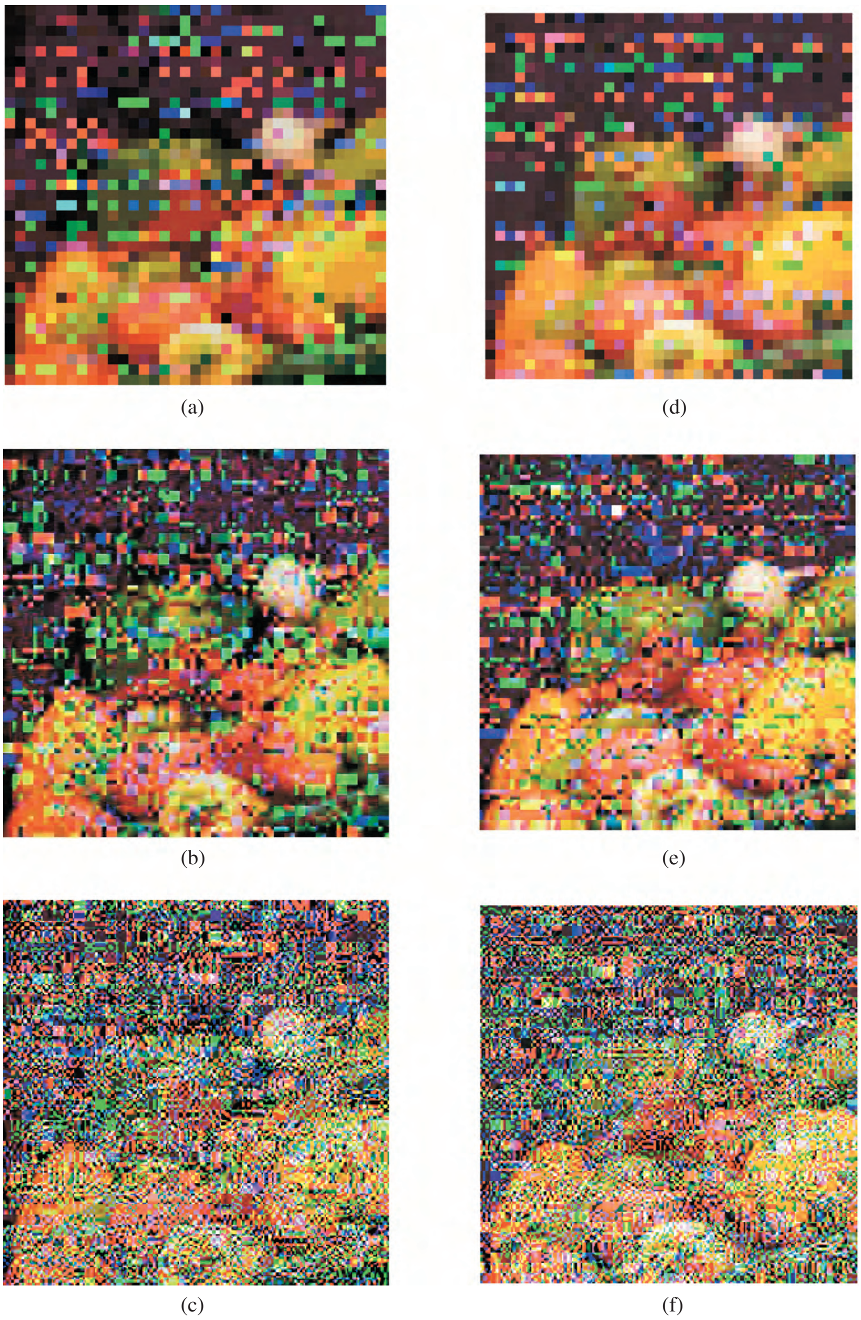


Figure 6. Reconstructed image for SNR = 4dB for a Rayleigh channel. (a) Total 96.875% compression (with 87.5% JPEG and 75% bit plane), (b) Total 93.75% compression (with 75% JPEG and 75% bit plane), (c) Total 87.5% compression (with 50% JPEG and 75% bit plane), (d) Total 93.75% compression (with 87.5% JPEG and 50% bit plane), (e) Total 87.5% compression (with 75% JPEG and 50% bit plane), (f) Total 75% compression (with 50% JPEG and 50% bit plane)

had 93.75% total compression. For Figure 3c, these values were 75% for BPS and 50% for JPEG compression. In this case, we transmitted 2 plane slices and 4 × 4 low-frequency elements of each 8 × 8 block; the others

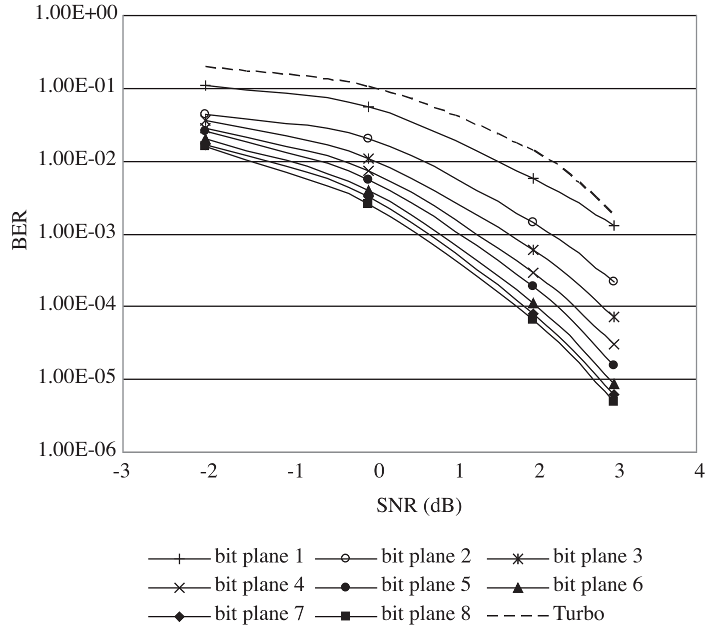


Figure 7. Bit error performance of conventional turbo and AW-TSwJBC with various bit planes over a Rician fading channel for K = 10 dB.

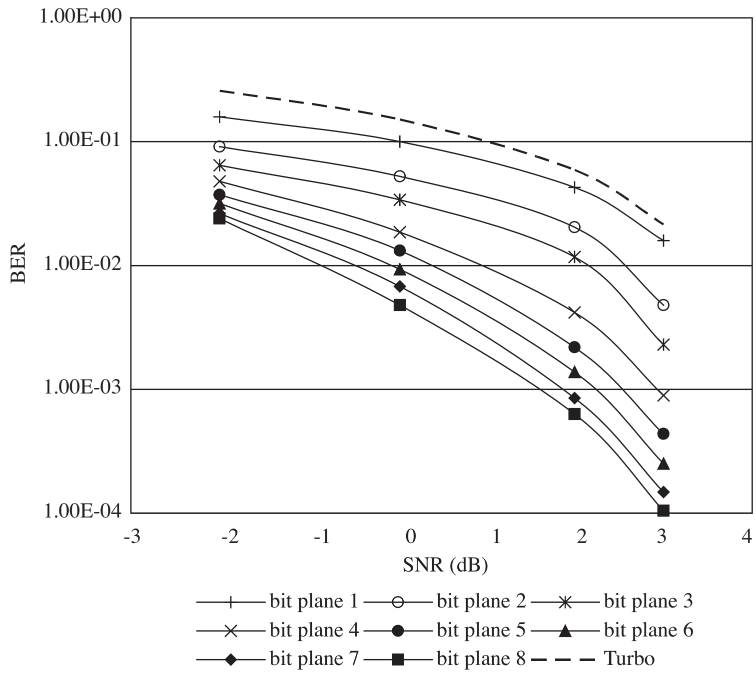


Figure 8. Bit error performance of conventional turbo and AW-TSwJBC with various bit planes over a Rayleigh fading channel.

were thrown away. Thus, we had 87.5% total compression. For Figure 3d, these values were 50% for BPS and 87.5% for JPEG compression. In this case, we transmitted 4 plane slices and 1 × 1 low-frequency elements of each 8 × 8 block; the others were thrown away. Thus, we had 93.75% total compression. For Figure 3e, these values were 50% for BPS and 75% for JPEG compression. In this case, we transmitted 4 plane slices and 2 × 2 low-frequency elements of each 8 × 8 block; the others were thrown away. Thus, we had 87.5% total compression.

Figures 4a-4e, 5a-5e, and 6a-6e were also evaluated for 2 and 4 dB SNR values with the same compression ratios as in Figure 3.

The bit error performance of AW-TSwJBC is evaluated in Figures 7 and 8. Here, the performance of the considered scheme improves as the iteration number increases, using AW-TS with a feedback block. Developed communication models with similar techniques have been proposed in [21-24]. In those works, turbo codes were applied to JPEG compressed images in a wireless environment, while an adaptive Wiener filter was not considered to increase the performance of the receiver. In the AW-TSwJBC receiver, the Wiener filter improves BER performance while adding some complexity. A bit plane slicing algorithm has also been considered in AW-TSwJBC receivers to achieve some compression gains.

4. Conclusions

In this paper, we introduced an AW-TSwJBC system, which is a reliable and efficient compression-transmission system for 2D images using BPS and JPEG (for compression) and turbo coding (for error correction). The traditional methods have been time consuming, but the AW-TSwJBC method promises to speed up the process, enabling a better bit error rate. In compression, we used less memory storage and increased the data rate up to N times by simply choosing any number of bit slices, sacrificing resolution. We investigated the BER performance of AW-TSwJBC for various Rician channel parameters. We have shown that after 0 dB SNR, satisfactory results can be obtained. The results for the Rician channel were better than those for the Rayleigh, but above 0 dB SNR, the reconstructed image for the 2 channels became more satisfying.

In previous papers, the benefits of JPEG with turbo coding for image transmission were shown [20-22]. However, the major disadvantages of turbo codes with JPEG are their long decoding delays, due to the large block lengths and iterative decoding complexity. In spite of that, JPEG with turbo coding performance was superior to JPEG with convolutional code [23]. However, increasing demand for high quality image transmission requires more sophisticated receiver structures. Therefore, an adaptive Wiener filter that does noise reduction was applied to the JPEG-turbo receiver while the complexity of the receiver increased. But for practical applications, especially for real applications, the complexity of the JPEG-turbo receiver with Wiener filter should be decreased. To solve the complexity problem, we also considered a bit plane slicing algorithm, which represents the image with less data. In the bit plane slicing algorithm, only the most significant bit planes are taken into account for the image transmission. In the simulation section, it was demonstrated that compression rates were achieved with the range of 75%-96% for the number of used planes. Therefore, the complexity per picture decreased significantly in the receiver.

The performance has a compromising approach while maintaining a very good degree of compression. Hence, we conclude that the AW-TSwJBC system will be a compromising approach in 2D image transmission, recovery of noisy signals, and image compression.

References

[1] Y.H. Han, J.J. Leou, "Detection and Correction of Transmission Errors in JPEG Images", IEEE Transactions on Circuits and Systems for Video Technology, Vol. 8, pp. 221-231, 1998.

[2] ISOIIEC, "Digital compression and coding of continuous tone still images: requirements and guidelines", International Standard Organization, 1994.

[3] G. Lakhani, "DCT coefficient prediction for JPEG image coding image processing", ICIP, IEEE International Conference on Image Processing, San Antonio, Texas, pp. 189-192, 2007.

[4] G.K. Wallace, "The JPEG still picture compression standard", IEEE Transactions on Consumer Electronics, Vol. 38, pp. 18-34, 1992.

[5] Z. Wang, A.C. Bovik, "Bitplane-by-bitplane shift (BbBShift) – a suggestion for JPEG 2000 region of interest coding", IEEE Signal Processing Letters, Vol. 9, pp. 160-162, 2002.

[6] K.R. Namuduri, N. Ranganathan, H. Rashedi, "SVBS: A high-resolution medical image compression algorithm using slicing with variable block size segmentation", Proceedings of the 13th International Conference on Pattern Recognition, Vienna, Austria, pp. 919-923, 1996.

[7] C. Berrou, A. Glavieux, "Near optimum error correcting coding and decoding: turbo codes", IEEE Trans. Commun., Vol. 44, pp. 1261-1271, 1996.

[8] H. Dogan, H.A. Cirpan, E. Panayirci, "Iterative channel estimation and decoding of turbo coded SFBC-OFDM systems", IEEE Transactions on Wireless Communications, Vol. 6, pp. 3090-3101, 2007.

[9] L. Hanzo, J.P. Woodard, P. Robertson, "Turbo decoding and detection for wireless applications", Proceedings of IEEE, Vol. 95, pp. 1178-1200, 2007.

[10] R.K. Deergha, "A robust and secure scheme for image communication over wireless channels", Emerging Technologies: Circuits and Systems for 4G Mobile Wireless Communications, St. Petersburg, Russia, pp. 88-91, 2005.

[11] O.N. Ucan, K. Buyukatak, E. Gose, O. Osman, N. Odabasioglu, "Performance of multilevel-turbo codes with blind/non-blind equalization over WSSUS multipath channels", International Journal of Communication Systems, Vol. 19, pp. 281-297, 2005.

[12] N. Thomos, N.V. Boulgouris, M.G. Strintzis, "Wireless image transmission using turbo codes and optimal unequal error protection", IEEE Transactions on Image Processing, Vol. 14, pp. 1890-1901, 2005.

[13] J. Yang, M.H. Lee, M. Jiang, J.Y. Park, "Robust wireless image transmission based on turbo-coded OFDM", IEEE Transactions on Consumer Electronics, Vol. 48, pp. 724-731, 2002.

[14] K. Buyukatak, O.N. Ucan, E. Gose, O. Osman, S. Kent, "Adaptive Wiener-turbo system and adaptive Wiener-turbo systems with JPEG & bit plane compressions", Istanbul University - Journal of Electrical & Electronics Engineering (IU-JEEE), Vol. 7, pp. 257-276, 2007.

[15] A.D. Hillery and R.T. Chin, "Iterative Wiener filters for image restoration", IEEE Trans. Signal Processing, Vol. 39, pp. 1892-1899, 1991.

[16] J. Chen, J. Benesty, Y. Huang, S. Doclo, "New insights into the noise reduction Wiener filter", IEEE Transactions on Audio, Speech and Language Processing, Vol. 14, pp. 1218-1234, 2006.

[17] M.C. Valenti, "Iterative detection and decoding for wireless communications", A Proposal for Current and Future Work toward Doctor of Philosophy Degree, 1998.

[18] J. Hageneauer, "Iterative decoding of binary block and convolutional codes", IEEE Trans. Inform. Theory, Vol. 42, pp. 429-445, 1996.

[19] W.J. Gross, P.G. Gulak, "Simplified MAP algorithm suitable for implementation of turbo decoders", Electronic Letters, Vol. 34, pp. 1577-1578, 1998.

[20] J.P. Woodard, L. Hanzo, "Comparative study of turbo decoding techniques: an overview", IEEE Transactions on Vehicular Technology, Vol. 49, pp. 2208-2233, 2000.

[21] W. Xiang, S.A. Barbulescu, S.S. Pietrobon, "Unequal error protection applied to JPEG image transmission using turbo codes", ITW2001, Cairns, Australia, pp. 64-66, 2001.

[22] B.A. Banister, B. Belzer, T.R. Fischer, "Robust image transmission using JPEG2000 and turbo-codes", IEEE Signal Processing Letters, Vol. 9, pp. 117-119, 2002.

[23] X. Fei, T. Ko, "Turbo-codes used for compressed image transmission over Rayleigh fading channel", Proc. IEEE GLOBECOMM, Phoenix, Arizona, pp. 629-633, 1997.

[24] N. Abdulaziz, A. Glass, K.K. Pang, "Embedding data in images using turbo coding", 6th Int. Symposium on DSP for Communication Systems, Sydney, Australia, pp. 28-31, 2002.