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무선 통신하에서 강인한 영상전송시스템 설계

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Design of Image Transmission System over the Wireless Communication

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요 약

본 논문에서는 Decision Feedback Equalization(DFE)과 다이버시티 기법을 접합하여 영상전송시스템을 구현하였다. 제안된 시스템은 기존의 DFE 를 변형시키지 않고 다이버시티 기법을 도입함으로서 보다 간단한 형태를 나타내면서 시스템의 성능을 향상시킬 수 있었다. 또한 본 연구에서 JPEG 의 특징인 블록단위의 손상에 대응하여 좀 더 나은 영상품질과 시스템의 속도를 위하여 주파수 영역에서의 블록 보간법을 포함하고 있다. 제안된 시스템의 성능분석을 위하여 세 가지 다이버시티 기법의 경우와 등화기 탭 수의 변화 및 채널의 변화에 따른 컴퓨터 시뮬레이션을 사용하였다.

Abstract

In this paper, we propose a reliable image transmission system with Decision Feedback Equalization (DFE), and use diversity combining techniques over multipath fading channels. It is shown that the proposed system has the features of simplicity in implementation with DFE and diversity combining techniques without modifying DFE. This study includes error concealment techniques for reconstruction of missing blocks in JPEG. To verify and compare the performance of our proposed system, the computer simulations have been performed in three diversity combining cases.

I. Introduction

Image transmission in wireless communication systems is one of the future potential services. This services are likely to include applications which require high transmission rates over the harsh wireless environment results in the problem of multipath inter-symbol interference (ISI) due to frequency selective fading. Equalization is a technique used to combat ISI. There are three broad classes of equalization – linear equalizer, DFE, and maximum likelihood sequence estimator (MLSE). The DFE is usually considered good compromise between complexity and performance. The European wireless local area network system is a typical example of a high-speed wireless communication system, which adopts DFE in order to overcome the adverse effect of multipath ISI. Diversity reception and equalization can provide even greater reductions in ISI, and the ultimate performance of this has been investigated by Balaban and Salz [1]. Due to the quite limited bandwidth in wireless networks, images are usually transmitted as compressed version with

VLC(variable length coding). On the other hand, one disadvantage of using VLC is that, even when single bit of error occurs, a bundle of picture blocks may be destroyed before the next resynchronization achieved [2]. This is the error propagation property of the variable length codes. To solve this problem, Picture block shuffling (block interleaving) method is used [3]. The block shuffling intends to make the error block uniformly located and eases the error concealment at the decoder. Fortunately, image data such as JPEG contains a great deal of redundancy even after compression and the missing information can be reconstructed by error concealment techniques. In this paper, we concentrate to design equalizer, diversity combining method and error concealment for improving the visual quality in wireless communication.

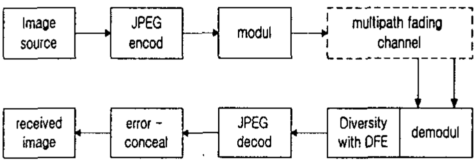

Fig. 1 System Diagram

The organization of this paper is as follows, In Section 2, we describe the diversity combining with DFE. Section 3 provides the error concealment method. Section 4 presents the computer simulation results and discussion. Conclusions are presented in Section 5.

II. Diversity Combining Techniques

2.1 Selection Combing with DFE

The configuration of the selection combining with DFE is shown in Fig. 2. The selection combining needs one DFE for each diversity branch. The symbol $\overline{E}_k^1$ means the value of average estimation error obtained by cumulating over N_B symbol. This value is used as the criterion for selecting the likelihood branch at every symbol. The average estimation error $\overline{E}_k^i$ is given by the following equation [4].

$$\overline{E}_k^i = \frac{1}{N_B}\left(\sum_{k=k_0-N_B-1}^{k_0} | e_k^i | \right) \quad , \ (i = 1,2) \qquad (1)$$

where e_k^i is the estimation error for the DFE of branch i. The output data will be obtained by using the above equation and comparing $\overline{E}_k^1$ and $\overline{E}_k^2$ at every symbol. In this procedure, if $\overline{E}_k^1$ for the branch 1 (top DFE)is smaller than $\overline{E}_k^2$ for the branch 2(bottom DFE), the detected symbol of DFE in the branch 1 will be selected as the output data of the receiver.

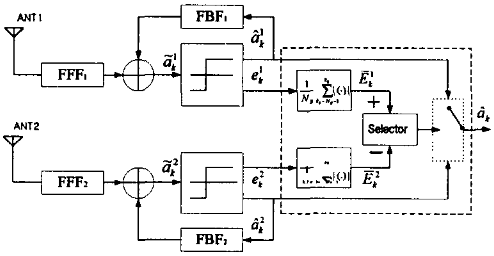

Fig. 2 Selection Combining with DFE

2.2 Equal Gain Combining with DFE

Fig. 3 shows the simple configuration of the Equal Gain combining with DFE. This combining is equally weighted and then added. So it is not optimal method.

$$E_k = w_1 \cdot \tilde{a}_k^1 + w_2 \cdot \tilde{a}_k^2 \qquad (3)$$

where w_1 : the equalizer 1 equal gain factor

w_2 : the equalizer 2 equal gain factor.

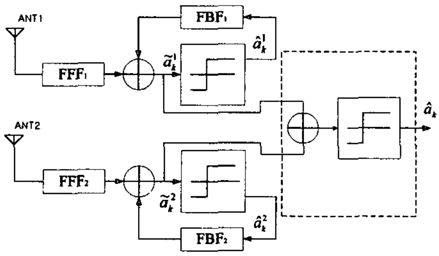

Fig. 3 Equal Gain Combing with DFE

2.3 Maximal Ratio Combining with DFE

In MRC, the received signals from all the diversity branches are weighted and combined to maximize the output SNR. Using the output data of equalizer , we compute gain factor of MRC.

$$w_1 = \frac{\tilde{a}_1^2}{\tilde{a}_1^2 + \tilde{a}_2^2}, \quad w_2 = \frac{\tilde{a}_2^2}{\tilde{a}_1^2 + \tilde{a}_2^2} \tag{4}$$

where $\tilde{a}_1$: the equalizer 1 output

$\tilde{a}_2$: the equalizer 2 output

III.Reconstruction of Corrupted Block in JPEG

DCT-based image transmission over noisy channels is subject to block damages that may cause significant picture degradation. The only solution is error concealment, as retransmission is usually not allowed at real-time applications consists in the concealment of these damages. Block interpolation techniques is used for reconstruction of missing data and simulate lost information.[5] Post processing techniques that perform error concealment can be applied in the spatial or in the DCT domain for still pictures. The DCT coefficient estimate is achieved by a weighted average of the value of the coefficients belonging to the 4-connected blocks near the damaged one.

$$y_{block}(i,j) = \frac{\sum_{block=1}^{4} x_{block}(i,j)}{w(i,j)} \tag{5}$$

where block = 1,2,3,4 ; 4-connected block

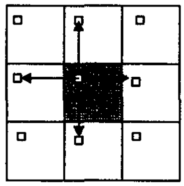

Fig.4 4-connected block interpolation

For 8-bit images, the reconstructed image quality is measured using the *peak-signal-to-noise ratio* (PSNR) .

$$PSNR = 10\log_{10}\left(\frac{255^2}{MSE}\right) \tag{6}$$

and

$$MSE = \frac{1}{M \times N}\sum_{i=1}^{M}\sum_{j=1}^{N}\left[f(i,j) - \hat{f}(i,j)\right]^2 \tag{7}$$

IV. Simulation Results

Computer simulations were used to verify and compare the performance of our proposed system according to the diversity combining methods. A 256×256 image of a Lena is used as a test image. For simulation, test image is compressed by using JPEG standard, and the images modulated by BPSK are transmitted over a multipath-fading channel. First, we simulated the three system cases from 0dB to 14 dB (SNR) to compare the performance. From Fig.5, we can say that the MRC with DFE produces the better performance compared to other two diversity combining techniques. Second, the reconstructed image has a PSNR = 24.5dB and the error concealed image a PSNR = 29.74 dB. So we obtain good visual quality.

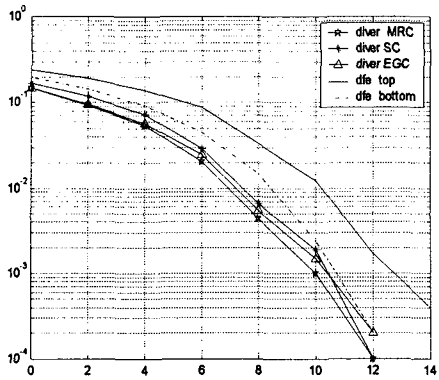

Fig.5 BER Comparisons of the 3 diversity schemes (Selection, EqualGain, Maximum Ratio Combining)

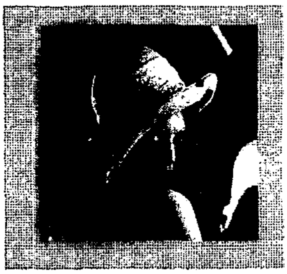

Fig.6 Reconstructed image (PSNR =24.5 dB)

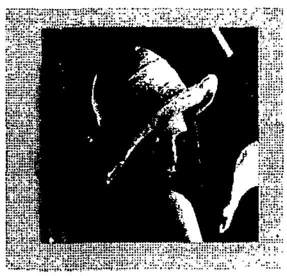

Fig.7 Error concealed image (PSNR =29.74 dB)

V. Conclusions

There are a lot of components, which are corrupting the system caused by geographical features in wireless communication environments. In this paper, we proposed an efficient image transmission system with DFE combined with diversity reception to improve the performance. The performance of the proposed systems has been verified through computer simulation. Especially, the performance of DFE with MRC has better compared to that of two other diversity-combining techniques. It is also proved that the error concealment is very useful techniques for improving image quality without retransmission.

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