Performance evaluation of image transmission using diversity selection combining technique

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Abstract. This paper discussed a simulation of SPIHT image compression transmission on wireless channels by using RS code and diversity selection combining technique in wavelet domain to get better reconstruction image by minimizing errors that caused by fading and noise. RS Code and Diversity Selection Combining Method were used to combat errors during image transmission on wireless channels. When the bit stream data arrived at the receiver, the coding was used to recover the errors in the bitstream. Diversity was used to obtain multiple data streams corresponding to the transmitted image at the receiver. These individual image data streams were combined to form a composite image with the better quality. The results show both methods demonstrated quality improvement of the received image.

1. Introduction

Transmission in a telecommunications system, the information in the form of data, sound, image, and video will be transmitted from the transmitter to the receiver via a communication channel. During transmission, the degradation of the quality information might be happened due to the interference, delay spread, attenuation, noise and fading [1-2].

In the wireless channel, multipath fading and noise are the most dominant disturbances. It occurs because the transmission of information signals is spread to all directions through the air. As a result, the signals that have been received at the receiver are the sum of the information signals from path 1, path 2, path 3, and so on. So that, the signals will be subtracted and even eliminated to each other due to the difference arrival phase at the receiver [3-5].

The effect of multipath fading and noise can lead to error detection at the receiver of the telecommunication system. For example, the effect of this disturbance may cause the information signal that sends bit 1 may change to bit 0 at the receiver and vice versa so that the system performance will decrease at the receiver [6-7].

Several studies on the use of diversity technique on image transmission over wireless channels have been done — the use of diversity technique Equal Gain Combining on radio frequency. However, it is not a good technique because the increment of Signal to Noise Ratio (SNR) will not automatically increase PSNR, but it only implies to degrade BER [6]. The use of Diversity Selection Combining on radio frequency improves 1 dB the performance of image reconstruction compares to the system without using Diversity Selection Combining [7]. The use of diversity techniques on the wavelet domain to get better reconstruction image that used a two-state Gilbert-Elliott channel [8].
For this purpose research, diversity technique is used [8]. However, this research uses model channels Rayleigh fading distribution and Gaussian noise. The selection combining techniques use wavelet domain diversity Method [8], and for channel model, fading distribution Rayleigh is used and noise which has Gaussian distribution [6-7].

To combat the errors that occur in the wireless channel, the use of coding channel is advantageous. In this research, RS Coding and diversity selection combining are chosen due to its high ability in detecting and correcting errors on the image that caused by fading and noise [6-7].

The experiment is done by comparing the system with and without using diversity selection combining. The evaluation of the quality improvement system on the image transmission is calculated by the use of Bit Error Rate (BER) and Peak Signal to Noise Ratio (PSNR). BER indicates how many bits with errors or symbols occurred at the receiver and compares to the number of bits or symbols received in a transmission, while PSNR is used to evaluate the quality of reconstructing image [6-19].

In this research, image information with size 8 bpp is compressed with a rate of 0.8 bpp. Set Partitioning In Hierarchical Trees (SPIHT) algorithm is used to get the image transmission system to maximize bandwidth use [20-23]. The diversity selection combining technique is used to improve image quality at the receiver. RS coding (31.15) is used to protect the data during the transmission process [24-25].

2. Design System

Figure 1 is the design system of compressed image transmission SPIHT with Diversity Selection Combining technique in Wavelet Domain. The transmitted image is a grayscale image of 256 × 256 with a depth of 8 bits. The original image is decomposed by wavelet transformation before compressing [6-8]. The wavelet transformation image is compressed with the SPIHT algorithm [9] so that it produces the series of bit streams with the number corresponding to the bits per pixel (bpp) which is an independent variable of the system. RS channel coding is used to reduce errors that occur during transmission [6-8].

![Diagram block of compressed image transmission SPIHT with Diversity Selection Combining technique in Wavelet Domain](image)

**Figure 1.** Diagram block of compressed image transmission SPIHT with *Diversity Selection Combining technique* in Wavelet Domain
The process of diversity combining uses two diversity channels by implementing error correction with interleave bit stream binary 100 bit in a row and grouped bit stream to blocks. Figure 2 showed the coding method with interleave and RS channel coding for a given data block. Blocks are transmitted by rows and then interleave the blocks by column. Diversity combining method uses the basis of combination block on the wavelet domain. The received bit stream from diversity channel that uncorrelated are divided to L blocks and compare to block by block. The diversity rule used on compressed image transmission system SPIHT is based on the dividing block. [8]

![Figure 2. Interleaving scheme with coding for a given data block.](image)

3. Research Method

The transmission method used in this research is Equal Error Protection (EEP) by using the same type of RS Code (31, 15) in the coder and the decoder [12-18]. The diversity technique used is referred to the algorithm for diversity technique [8]. However, the channel model used is AWGN and Rayleigh Fading. Following is the design system for Diversity Combining Method for Compressed Images Transmission.

Figure 1 is the process of diversity combining that uses two diversity channels by implementing error correction and grouping the bit stream into blocks. The algorithm of this diversity is based on block chosen of bit $h(l)$ from the one-bit stream which based on the characteristic of wavelet transformation. The rule can be defined as follow [8]:

3.1. Diversity selection is combining rule for approximation block coefficient.

If the value of the approximation block coefficient from channel diversity 1 is less than the value of the approximation block coefficient from diversity channel 2, the value of the approximation block coefficient is 1. Then, if the value of the approximation block coefficient from diversity channel 1 is more than the value of the approximation block coefficient from channel 2, the value of the approximation block coefficient will be -1. If the value of the approximation block coefficient from channel diversity 1 is the same with the value of the approximation block coefficient from channel diversity 2, the value of the approximation block coefficient is 0. The value of approximation block coefficient is given in equation 1 below [8]:

$$h_{i,j}^1 = \begin{cases} 1 & d_1(i,j) < d_2(i,j) \\ -1 & d_1(i,j) > d_2(i,j) \\ 0 & c_{i,j} = c_{i,j} \\ \end{cases}$$

![Diagram](image)
3.2. Diversity combining rule for detail block coefficient

If the value of detail block coefficient from channel diversity 1 is less than the value of block coefficient detail from channel diversity 2, the value of block coefficient detail from channel diversity will be 1. Then, if the value of detail block coefficient from channel diversity 1 is more than the value of detail block coefficient from channel diversity 2, the value of detail block coefficient from channel diversity will be -1. If the value of detail block coefficient from channel diversity 1 is the same with the detail value of block coefficient from channel diversity 2, then, the value of detail block coefficient will be 0. The value of the detail block coefficient is given in equation 2 below:[8]

\[
h'_d(i, j) = \begin{cases} 
1 & t_1(i, j) < t_2(i, j) \\
-1 & t_1(i, j) > t_2(i, j) \\
0 & c_{h1}(i, j) = c_{h2}(i, j) 
\end{cases}
\]  

(2)

4. Results and analysis

The results of image reconstruction of the compressed image transmission over Rayleigh Fading and Noise AWGN with the rate of 0.8 bpp with and without diversity can be seen in table 1. With the SNRs range from 10 dB to 20 dB, the system with diversity will obtain low BER and high PSNR when compared to the systems without using diversity. From the simulation, the following data are obtained:

| SNR (dB) | BER | PSNR Diversity (dB) | BER | PSNR without Diversity (dB) |
|----------|-----|---------------------|-----|-----------------------------|
| 10       | 0.020 | 14.74               | 0.020 | 14.69                        |
| 12       | 0.017 | 19.55               | 0.017 | 19.37                        |
| 14       | 0.014 | 24.59               | 0.015 | 21.27                        |
| 16       | 0.012 | 26.20               | 0.014 | 24.60                        |
| 18       | 0.012 | 30.25               | 0.013 | 27.16                        |
| 20       | 0.011 | 33.73               | 0.012 | 32.09                        |

From the results of table 1, figure 3 is the representative of the SNR 14 dB where the image reconstruction of the compressed image transmission over Rayleigh Fading and Noise AWGN with the rate of 0.8 bpp has the improvement when using the diversity compared to the systems without using diversity.

**Figure 3.** The comparison result of image reconstruction between using diversity.
(a) and without diversity (b) for SNR 14 dB.

From the results of table 1 that has been obtained from the comparison of the system with and without diversity can be shown in the form of graphs as seen in Figure 4 below.

![Graph](image.png)

**Figure 4.** The system performance comparison with and without diversity of image compression transmission with rate 0.8 bpp for channel fading and noise

A previous study [8] used transmission method Unequal Error Protection (UEP) with different RS code types in the coder (31, 19) and the decoder (31, 15). The use of UEP increased of about 1.4 dB. However, the transmission method used in this research was EEP by using the same type of RS Code (31, 15) in the coder and the decoder. The use of EEP increased of about 1.64 dB. This result was achieved due to the use of wavelet domain diversity and EEP. EEP was performed well even when the image was transmitted using a low bit rate of 0.8 bpp that can be seen in table 1.

The result of this study shows the improvement of the performance of the system with diversity selection combining and RS code in the SPIHT image compression transmission with the rate of 0.8 bpp on channel fading Rayleigh distribution and noise normal distribution compared to the system without diversity. However, every time the value of SNR is increased, it will not automatically increase the value of PSNR, but the increment of SNR value will be impacted to the decreasing of BER. It can be seen from SNR 10 and 12, the value of PSNR with and without diversity does not change significantly, but the value of BER is different. When SNR value reached over 12, the value of PSNR increased significantly. This condition is caused by the channel models that use fading Rayleigh distribution and noise normal distribution.

5. **Conclusion**

The use of RS Code and diversity selection combining technique for SPIHT compressed images improve system performance when compared it to the systems without using diversity selection combining and RS code. Image testing is carried out with a compression ratio of 0.8 bpp. The image compression ratio is tested on the fading and noise channel models. Diversity selection combining is used to choose to fade with the largest SNR value while RS code is used to detect and correct errors caused by noise. The simulation result showed that the use of diversity selection combining and RS code on image compression transmission system was improved to 1.64 dB when it compared to image compression without using both systems.
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**Acknowledgments**

The Author would like to thank Engineering Faculty of Universitas Andalas, for the fund support for the research on the fiscal year 2018 under the Contract No. 005/Un.16.09.D/Pl/2018