

A NEW RESTITUTION ALGORITHM TO SOLVE THE MULTIPATH FADING PROBLEM IN AERIAL COMMUNICATION

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ABSTRACT:

The thesis focuses on the multipath fading problem in aerial communication. At the beginning of this paper, we build the model of the aerial communication channel and complete the analysis on the essence of multipath fading interference. According to the analysis, we propose a new algorithm, which is applicable for the special aerial channel. This new algorithm is based on the structure of a linear transversal equalizer, making use of the characteristics of the channel model. Last but not least, we give the simulation results, which showed that the proposed new equalizers are even effective when the multipath signal's amplitude is equal to the main signal's amplitude. Another good point of the method is that this equalizer is only composed of adders and multipliers, which means that the method is suitable for project application. Compared with other algorithms, the new algorithm is more easily to implement.

1. INTRODUCTION

There is an increasing demand for aerial communication, which is important for aerial cooperation, navigation and so on. Communication systems are often degraded by the multiple propagation paths that exist in many environments between the transmitter and receiver locations. In these environments a number of time delayed signals from the desired transmitter will be received simultaneously to the disadvantage of the receiver SNR. Fortunately, the wide bandwidth of spread spectrum communications systems permits these separate signals to be resolved into a multi-path profile channel. However, shorter length coding schemes are often subject to significant autocorrelation side-lobes, which when incorporated into the receivers cause further interference. Usually, image information contains considerable data, which limits the length of the code. As a result, this problem still influences the restitution. For example, while information obtained from the camera on a plane were transferred to another mobile terminal (such as an aircraft, a car), the receiver SNR must be higher in order to make the BER less than 10^{-6} . Sometimes, no matter how great the SNR is, the BER can't be reduced. In brief, the purpose of the letter is to solve the problem.

2. SYSTEM MODEL

The image transmission system employs direct sequence spread spectrum module. The aerial channel model and receiver are both important for the analysis of the problem.

2.1 Channel model

Considered the application environment of the image system involved this paper, we give a channel model after test and measurement. Different from Rayleigh channel, the channel model we built is composed of two ways, which can represent

the special aerial channel with flat reflecting surface. The channel model is shown by figure 1. When we built the model, the diagram is shown in figure 2.

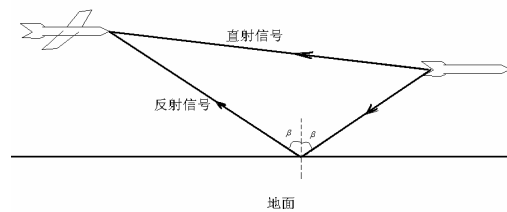


Figure 1. two-ray ground reflection model

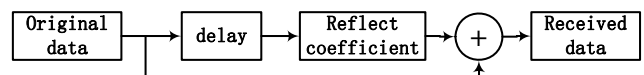


Figure 2. two-ray ground reflection block diagram

Received signal can be expressed as:

$$y(t) = f(t) + \alpha f(t - \tau) \tag{1}$$

Where $f(t)$ = the original data
 α = reflect coefficient
 τ = reflect path delay

To know the distortion more clearly, we make emulation in systemvue2006. The result is showed in figure 3. Figure (a) in it is the original signal, while (b) is two-ray signal.

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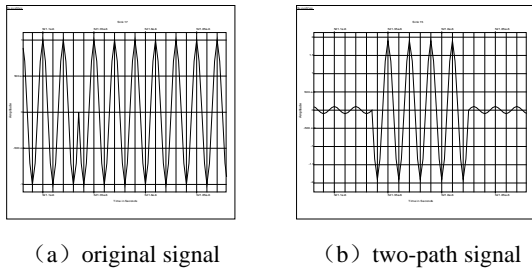


Figure 3. comparison between original signal and two-ray signal

2.2 Receiver

The receiver is composed of despread, demodulation, judgement, etc. First, the signal received is through digital down converter. After that, the signal is tested by matched filter, which stopped after the head of the frame is found. When the receiver reached acquisition, it comes to tracking state. In order to make carrier and PN in synchronism, two loops for carrier and PN are necessary. Go into details, non-coherent delay locked loop is used as PN loop, while carrier loop is realized by COSTAS loop. Figure 4 gives the diagram in details.

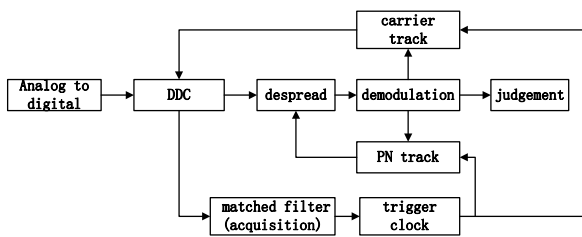


Figure 4. Schematic diagram of receiver

3. EQUALIZER MODEL

According to the analysis above, we propose a new algorithm, which is applicable for the special aerial channel. This new algorithm is base on the structure of a linear transversal equalizer, making use of the characteristics of the channel model. In order to reduce the multipath signal's energy while enhance the main signal's energy, we add some of the middle entries in the linear transversal algorithm.

3.1 Equalizer theory

Equalizer is usually used as a method of solving frequency selective fading, whose main idea is to build an inverse filter. According to the channel model, the signal received can be expressed as equation (1), where, $f(t)$ is direct signal, $\alpha f(t - \tau)$ is reflection signal.

The Fourier transform of equation(1) is:

$$Y(w) = F(w)[1 + \alpha e^{-jw\tau}] \tag{2}$$

The transfer function of the channel is :

$$H(w) = 1 + \alpha e^{-jw\tau} \tag{3}$$

Thus, the inverse filter:

$$H^{-1}(w) = \frac{1}{1 + \alpha e^{-jw\tau}} \tag{4}$$

Obviously, when equation (5) is true,

$$|-\alpha e^{-jw\tau}| < 1 \tag{5}$$

$$H^{-1}(w) = \lim_{n \rightarrow \infty} \sum_{i=0}^n (-\alpha e^{-jw\tau})^i = \lim_{n \rightarrow \infty} [1 + (-\alpha e^{-jw\tau}) + (-\alpha e^{-jw\tau})^2 + \dots + (-\alpha e^{-jw\tau})^n] \tag{6}$$

transferred to time domain,

$$y'(t) = y(t) + (-\alpha)y(t-\tau) + (-\alpha)^2 y(t-2\tau) + (-\alpha)^3 y(t-3\tau) + \dots + (-\alpha)^n y(t-n\tau) \tag{7}$$

we can constitute the equalizer based on the equation (7).

But, equation(5) can't be true all the time in practice, which means equation(7) is ineffective when equation(5) is false. In the thesis, we give a new algorithm to compensate the signal distortion even when equation (5) is false. The principle is shown in equation (8).

$$\tilde{H}(w) = 1 + \alpha e^{-jw\tau} + 1 + (-\alpha e^{-jw\tau})^2 + 1 + (-\alpha e^{-jw\tau})^3 + \dots + 1 + (-\alpha e^{-jw\tau})^n \tag{8}$$

Transferred to time domain, equation (8) is expressed as equation(9).

$$y''(t) = y(t) + (-\alpha)y(t-\tau) + y(t) + (-\alpha)^2 y(t-2\tau) + y(t) + (-\alpha)^3 y(t-3\tau) \dots + y(t) + (-\alpha)^n y(t-n\tau) \tag{9}$$

Clearly, the main signal can be strengthen while the reflect signal is weaken under the action of improved equalizer.

3.2 Structure of equalizer

The structure of equalizer deduced by equation (7) is shown in figure 5. As we can see, the equalizer is realized by tapped delay line filter, whose structure is similar to FIR filter. Thus, linear transversal equalizer is another name of it. Also, the structure is easy to realize.

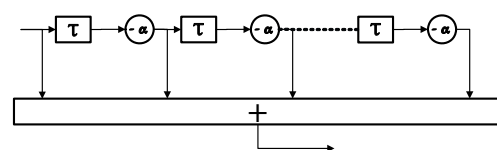


Figure 5. linear transversal equalizer

The improved equalizer structure is shown in figure 6. Although it is a little more complicated than linear transversal equalizer, the effect of it is obvious when equation (5) is true. We can use pipelining in practice.

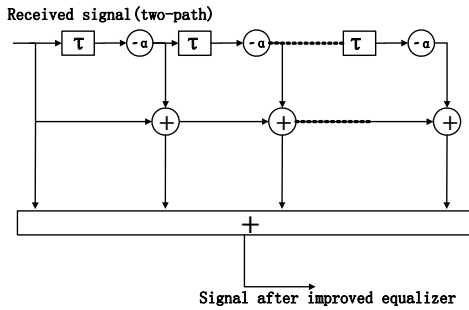


Figure 6. improved linear transversal equalizer

4. SIMULATION RESULTS

4.1 Simulation Introduction

To verify the performance of the equalizer, we did some emulation with the software SYSTEMVUE2006. The model built in it is shown in Figure7. Moreover, some groups of emulation are compared to make the characteristics of equalizer more clearly. The simulation results will be shown in the next parts.

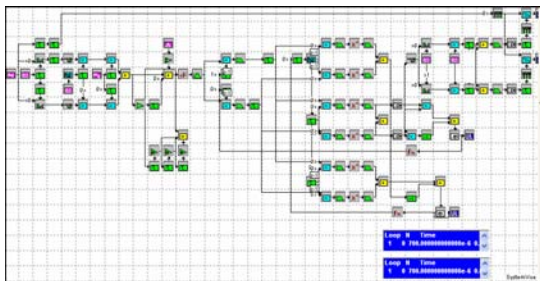


Figure 7. the model built in systemvue2006

The position of equalizer in the receiver is shown in figure 8. It is just behind the A/D convertor, meanwhile, the output of the equalizer should be similar to the input of the DDC.

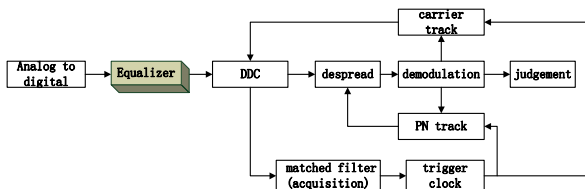


Figure 8. the position of equalizer in the receiver

4.2 Groups of Simulation results

4.2.1 The eye diagram without fading: We give the original signal as figure 9. It is a simulation under the ideal conditions, therefore, the “eye” is perfect.

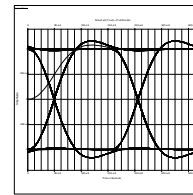
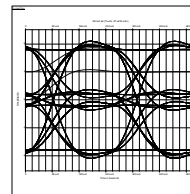
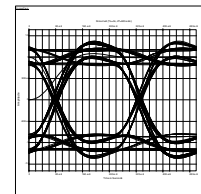


Figure 9. eye diagram of signal without multipath

4.2.2 The eye diagram of two-ray signal and signal after equalizer: In order to compare, we give the two-ray signal and signal after equalizer as figure 10. It is obvious that the equalizer make the closed eye diagram open, which means the signal can be judged correctly. Also, it verified the effect of the equalizer model we built. Go into details, the simulation condition meets the specification as equation (5).



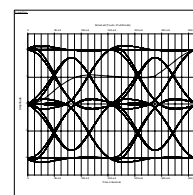
(a) two-ray signal



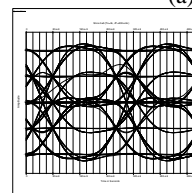
(b) signal after equalizer

Figure 10. comparison of eye diagram between two-ray signal and signal after equalizer

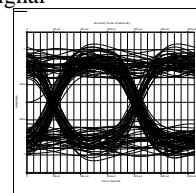
4.2.3 The eye diagram of two-ray signal and signal with improved equalizer: When equation (5) is not true, the equalizer like figure (5) doesn't work any longer. The improved equalizer will be tested in this part. The simulation results is shown in figure 11. What is clear, the eye diagram of the signal after original equalizer, when equation (5) is false, is even worse than that of the two-ray signal. But the improved equalizer can weaken the effect of reflection signal under this condition.



(a)Two-ray signal



(b)Signal after linear transversal equalizer



(c)Signal after improved equalizer

Figure 11. comparison of eye diagram between signal after two kinds of equalizer when equation (5) is false

4.2.4 The eye diagram of signal after equalizer with different stages: As equation (9) expressed, the more stages equalizer has, the better effect it has. With the purpose of verify this conclusion, we choose four different numbers of stages to testify. Figure 12 give the final results.

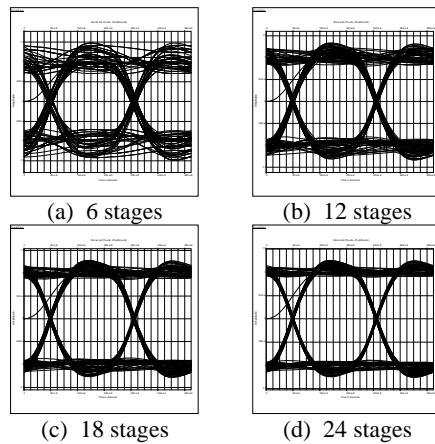


Figure 11. comparison the effect of equalizer with different stages

4.2.5 Summary of simulation results: Computer simulation results obtained using the aerial communication channel model confirms that the new algorithm provides a significant improvement of the signal after restitution. The proposed algorithm can avoid inter-symbol interference caused by multipath signal. Since the cancellation process eliminates some interference sources, the error performance of the subsequent equalization will be improved. Moreover, simulation results also show that the proposed new equalizers are even effective when the multipath signal's amplitude is equal to the main signal's amplitude. Another good point of the method is that this equalizer is only composed of adders and multipliers, which means that the method is suitable for project application. Compared with other algorithms, the new algorithm is more easily to implement.

5. CONCLUTIONS

This letter has described a new anti-multipath signal processing technique for use with spread spectrum systems which is based on the estimation and selective cancellation of individual multipath components. To verify the feasibility of the method, we build the model in systemvue2006 environment. The simulation result, showed by curves and figures, indicates that the method is useful and available. Meanwhile the algorithm is easy to be understood. Otherwise, the computational complexity of new equalizer can be controlled by adjusting the number of stages. Nevertheless, the model built in the paper is special, so it couldn't be used directly in other systems. Meanwhile, the paper only complete the software simulation, the method needs to be verified in hardware environment before it is used in the practical systems, which is the next-term target.

In addition, the parameters of multipath (reflection coefficient and the multipath delay) are needed in the new algorithm. It is to say that the estimation of parameters is necessary. Since we can get these coefficients from the matched filters as many algorithms raised by researchers, our study can make use of them. Besides, changing the coefficients of the equalizer is required, which would be introduced in another paper.

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