Research on Spread Spectrum Communication Signal Anti-Jamming Technique based on MIMO and Prior Filtering Theory

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Abstract. In this paper, we conduct research on spread spectrum communication signal anti-jamming technique based on MIMO and prior filtering theory. In order to improve the bandwidth utilization of spread spectrum system, people will multicarrier technology is applied to medium and long-range underwater acoustic communication. The technique by combining new technology and spread spectrum technology to raise the utilization ratio of the bandwidth of the system is recently researched and through the inserted between element cyclic prefix to resist the multipath interference of underwater acoustic channel. In the experiment part, we conduct numerical analysis and real-world simulation to test the performance of the proposed approach. The result proves the effectiveness and feasibility of our method.

Introduction

Research background

With the development of wireless communication technology, communication environment increasingly complex, even in ordinary narrow-band receiver, receives the multiple situation is becoming more and more popular, for example, of Shared frequency interference in a cellular and satellite communications adjacent interference problems [1-2]. As only an antenna, antenna anti-interference techniques do not apply, the researchers from the perspective of single channel signal separation, according to different scenarios, proposed many solutions. In order to improve the bandwidth utilization of spread spectrum system, people will multicarrier technology is applied to medium and long-range underwater acoustic communication. The technique by combining new technology and spread spectrum technology to raise the utilization ratio of the bandwidth of the system is recently researched and through the inserted between element cyclic prefix to resist the multipath interference of underwater acoustic channel [3]. It is worth mentioning that when the spreading factor is 1, the technology is degraded as the original signal, the system lost the spread spectrum gain and multipath diversity gain. With the increase of spreading factor, spread spectrum gain and multipath diversity gain will be increased, but the system data rate fell sharply again. On the other hand, inheriting the disadvantage of high loss rate of the technology, the traditional multi-carrier spread spectrum of signal to noise ratio increases with the number of carrier, while a larger extent, limits the system data rate of room for improvement, and makes the system performance deterioration. Therefore, it is necessary for research community to develop novel methods for enhancing the accuracy and feasibility of the approaches [4-5].

Overview of our method

In this paper, we conduct research on spread spectrum communication signal anti-jamming technique based on MIMO and prior filtering theory. In bandwidth resources increasingly nervous, have higher requirements on the rate of communication, multiple input multiple output system can without any increase in channel bandwidth more effectively under the condition of using the system capacity and improve the quality of the wireless transmission link, so the application of the system has received extensive attention. Due to multiple transmitting antenna for receiving sensor, makes the equilibrium problem of MIMO systems have become much more relatively complex. So the simple and effective equalizer is important in MIMO system. Channel equalization is roughly divided into three categories, namely blind equalization algorithm, equalization algorithm based on

training sequence and half blind equalization algorithm. Blind equalization algorithm has high spectrum efficiency, especially in the case of some noncooperation, it is the only method to solve the problem of equilibrium, but it is a computational complexity is high, the loss of part of the balance for the price. Equalization algorithm based on training sequence is low complexity, high accuracy, but to a large extent affected the effective utilization of spectrum resources. Half blind algorithm between the two kinds of algorithm, the use of a few training sequence given initial value, balanced with relevant methods, this method will not seriously affect the spectrum efficiency, and has lower computational complexity and precision of the equilibrium results, at the same time can eliminate some inevitable blind equalization method fuzzy problems. The detailed research will be introduced in the following sections.

Our novel methodology

MIMO system modelling

In view of the traditional particle filter of the particle degradation phenomenon, genetic evolution mechanism is adopted to improve the particle resampling, through genetic operation such as selection, crossover and mutation, is retained particles with high quality and no loss of diversity in the process of particle collection in sequential estimation. In addition, the evolution mechanism of genetic algorithm, the algorithm under the condition of time-varying amplitude interference also has good separation effect. The signal can be formulated as the following.

$$y_m(k) = \sum_{i=1}^{M} w_{mi}^{*} x_i(k) = w_m^H x(k) \qquad (1)$$

In contrast to the mechanism of interference suppression, single channel blind source separation mainly adopts one letter fanaticism date processing method, disturbance of the received signal of single road separation analysis, estimate, and ingredients, it will not damage under the premise of communication signals, maximum separation of communication signals and disturbance, achieve the goal that guarantee the normal communication, and the one letter blind source separation method could spread spectrum and spread spectrum communication signal processing. Formula 2~3 shows the process.

$$\widehat{H} = X_K S_K^H \left(S_K S_K^H\right)^{-1} \left(S_K S_K^H\right)^{\mathrm{T}} \qquad (2)$$

$$S(T) = \sum_{n=0}^{N-1} c^m(n)\, g_c(t - nT - kT) \exp(jwt) \qquad (3)$$

Using particle filter for mixture of two communication signals of single channel signal blind source separation problem is studied, for single channel blind signal separation, this paper proposes a good solution, but these studies are limited to two way power on essentially the same communication signal blind source separation, without the presence of malicious interference study of separation performance. Restricted to the transmission of sound waves in the water features, making the underwater acoustic channel is large, limited bandwidth and multipath propagation loss such as complicated structure, the Doppler effect is obvious characteristics, there is still one of the wireless digital communication channel is difficult. Main research direction of the underwater acoustic communication is short-range high-speed underwater acoustic communication and remote low-speed underwater acoustic communication. Short-range high-speed underwater acoustic communication mainly adopts coherent communication technology and multi-carrier modulation technique. The demonstration of MIMO is shown below.

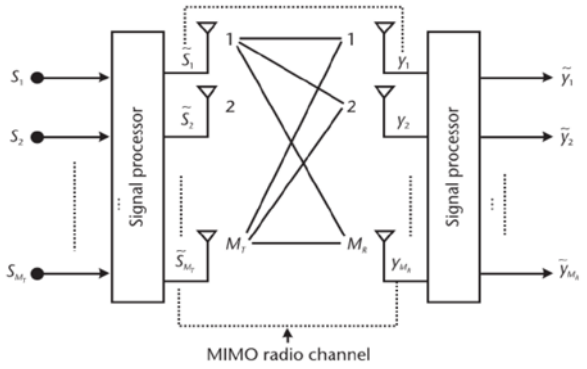

Figure 1.Demonstration of traditional MIMO system.

Spread spectrum communication

The parallel combinatorial spread spectrum communication is a kind of high efficiency way of spread spectrum communication is a good way to meet the requirements of communication system of transmission efficiency, solve the communication system of communication time is short and send a large amount of information, the contradictory between and inherits the traditional advantages of anti-jamming, anti-crack spread spectrum communication system. UWB wireless communication is not the traditional sine carrier, but using a non-sinusoidal narrow nanosecond pulse modulation and transmission of data, also called impulse radio, is a kind of carrier communication technology which is shown in the following figure 2.

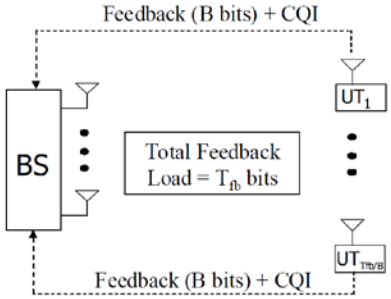

Figure 2.Demonstration of spread spectrum communication.

In this article, we put forward the parallel combinatorial spread spectrum communication system based on pulse modulation, using nanosecond narrow pulse for transmission of data information, namely uses the ultra-wideband communications is a kind of pulse modulation technology the parallel combination of spread spectrum communication system. At the same time to compare the parallel combinatorial spread spectrum system based on pulse modulation and conventional sinusoidal carrier modulation bit error performance of the parallel combination of spread spectrum system, both in the parallel combinatorial spread spectrum part to choose the same parameters, which has the same information rate. And the carrier frequency difference is smaller, the false value judgment is more error-prone, therefore presented in this article to the fuzzy method is only suitable for a certain difference in carrier frequency, carrier frequency differences more hours need training sequence and fuzzy. In the expression 4~5 we show the corresponding procedures.

$$MD(r,t)=\sum_{i=1}^{r} q_i PN_i(t)+\sum_{j=1}^{s} q_j PN_j(t) \qquad (4)$$

$$MD(r,\mathrm{n}_l)=l-(r-l)=2l-r,(0\le l\le r) \qquad (5)$$

Prague cartridge receiver, receiver and channelized receiver has a good overall performance, but the Prague cartridge receiver by optical Bragg cell signal spectrum separation, the complexity of the system, dynamic range and high sensitivity is very low; Compression receiver input RF signal compression with dispersive delay line into a narrow pulse, the data rate is very high, and signal compression of side-lobe affects the detection performance of system and lose intra-pulse modulation signal information. The figure 3 shows the structure.

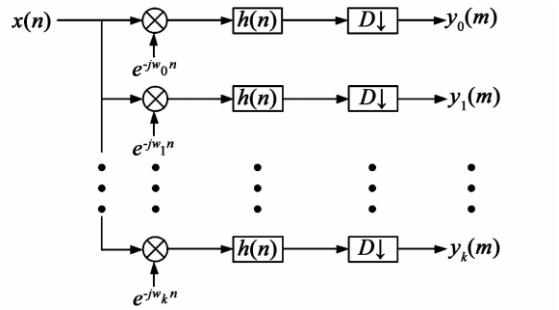

Figure 3.Demonstration of the spread spectrum structure.

The combined signal anti-jamming technique

Because this article from the cyclic autocorrelation function of time delay estimation error estimation error, the cyclic autocorrelation function estimation is consistent gradual unbiased estimates, so in this paper, time delay estimation is also gradual unbiased estimates. Grams of Latin America are often used to measure the performance of unbiased parameter estimation. As the BLAST system is put forward, transmit diversity technique combined with orthogonal coding technique, MIMO technology can not limited to Shannon theory system capacity constraints, on the premise of not to increase system bandwidth to improve the system capacity and spectrum efficiency of communication system, until now still is a frontier topic in the field of wireless communications. Of digital channelized receiver based on single channel independent sub-channels, so the channel can be independent design, high flexibility, but system hardware resources use efficiency is low, when the required number of many sub-channels, system hardware resource consumption is large, and the structure is complex, so the digital channelized receiver based on single channel is applied to only need less quantum channel in the system. Channelized receiver based on single channel using some of the thoughts of parallel form a multi-channel receiver receive build multi-channel digital channelized receiver, its complete with each channel receiver structure. Based on poly-phase DFT channel structure to the channelized receiver based on WOLA a special case, its implementation using poly-phase filtering structure so as to improve operation efficiency, relative to the digital frequency filter structure, hardware and power consumption is smaller, the system does not have a special request to the data sampling rate when general channel is realized by using poly-phase DFT structures. The corresponding signal phase is shown below:

$$C(t)=\begin{cases} c(t+m\Delta h), & 0\le t\le T_a-m\Delta h \\ c(t-T_a+m\Delta h), & T_a-m\Delta h\le t\le T_a \end{cases} \qquad (6)$$

By using the principle of transform domain, looking for can reflect differences between signal and interference of spectral domain, and then in the spectral domain structure filter, the difficulty of this method is that not all signals can reflect differences in the spectral domain. Based on the parallel combinatorial spread spectrum ultra wideband pulse modulation system and conventional UWB system in ultra-wideband part using the same parameters, baseband input data using the same information transmission speed. By constructing multi-channel converting single channel blind source separation method of general positive definite cases of blind source separation problem, the shortcomings of this method is sensitive to noise, and that there are when the signal frequency deviation and phase deviation separation effect not beautiful. According to characteristics of communication element finite character set, in the code and the joint estimation of parameters, combined with the evolution strategy of genetic algorithm, can improve the estimation precision of particle filter and reduce the convergence time. In spread spectrum sequence cycle is constant, the K value, the greater the system of information transmission rate is higher, but the system performance decreases, conform to the contradictory relationship between validity and reliability of communication system. So, in the case that could satisfy the requirement of a certain level of bit error rate which can change the M/r value or change at the same time of M and r values for different information transmission rate and realize the effective transmission of information. At the same

time, the system uses the narrow pulse transmission information, and can obtain a lower detection and intercept probability and improve the security performance of the system.

Experiment and analysis

Set-up of the experiment

This section presents the MATLAB simulation on the performance of the algorithm, the observation data length, the difference of signal carrier frequency, signal to noise ratio on the influence of the estimation precision of the algorithm. The detailed simulation will be shown below. To simplify the analysis, hypothesis system and receiving and sending end has accurate synchronization channel exists only in additive white Gaussian noise, multipath and single user conditions.

Simulation results

Mixed signal in the signal for the large signal, signal secondly, small signal and large signal estimation error is less than the small signal obviously. And the greater the power difference, small signal time delay estimation error is, the greater the but even two signal power difference of more than 10 DB to some extent in this paper, the algorithm still can estimate the small signal delay. The following figures show the experimental result in detail.

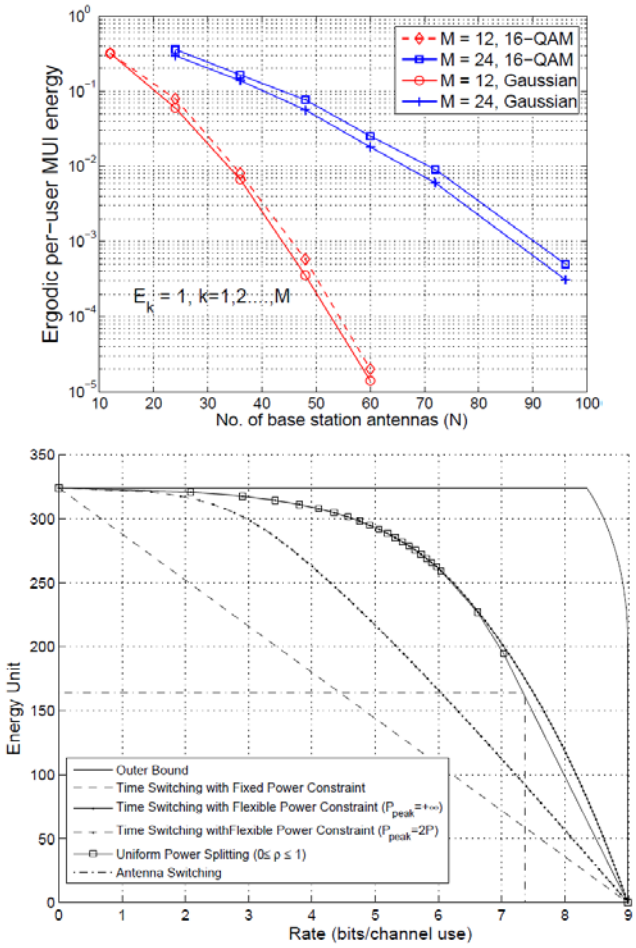

Figure 4.The experimental simulation for the system

We can see that when the parameter increases the system performance degrades dramatically when using the pilot-based method. This is due to the fact that the pilot-based method suffers from pilot contamination. In particular, the EVD-based method is not affected much by the pilot contamination, and it can significantly improve the system performance when the effect of pilot contamination is large. We combine OFDM technology and CSK technology to increase the data rate of a communication system. At the same time system is spread spectrum code sequence.

Through theoretical analysis, can prove that improve the efficiency of the system. Compared with other algorithms, our method performs better.

Conclusion and summary

For single channel to receive two hybrid communication signals, in this article, through the analysis of the statistics received signal cycle and the relationship between the two signal delay, puts forward two methods of time delay estimation under different scenarios, method two under the assumption that filter coefficient under the condition of known channel fading and forming, the analytical solution of the time delay estimation is obtained by cyclic statistics, the simulation shows that the method has good estimation performance, and is not affected by the influence of carrier frequency difference. The numerical and experimental simulation shows the feasibility of our proposed methodology. Moreover, we plan to conduct more mathematical simulation and induction in the future research.

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