Research on Blind Estimation Method of Low SNR Long Pseudo Code Direct Spread Signal

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Abstract: In order to solve the blind estimation problem of low signal-to-noise ratio DSSS spread spectrum codes, a method of covariance matrix cumulative averaging and discrete Karo hunen-Lo v e (K-L) transform of DS signals is proposed. The method is to periodically segment the received DS signal with a random determination value to form a continuous plurality of observation vectors on the premise of the parameters such as the spreading code period and the code rate of the known DS signal. The covariance matrix is summed and averaged, the discrete KL transform is implemented to obtain the principal component of the signal, and the spreading code of the observed signal is estimated by the principal component eigenvector. Then, the observation signal is despreaded, thereby implementing blind despreading processing of the direct sequence spread spectrum signal. Theoretical analysis and numerical results show that the method is very robust and is not susceptible to noise. Under normal circumstances, it can work in an environment with signal-to-noise ratio lower than - 20 dB.

1. Introduction

Since the power spectral density of direct sequence spread spectrum (DS/SS or DS) communication signals is usually very low, it is often overwhelmed by noise, and thus has significant anti-interference and anti-interception. But in fact, if the relevant parameters of the DS signal are known, blind estimation of the PN (pseudo noise) code of the DS signal will become possible, which will be of great significance for civil management and military reconnaissance of such spread spectrum communication. It has been proposed to use the delay autocorrelation method to perform codeless despreading (also called "blind despreading") on DS signals under narrowband interference to achieve the purpose of interception, but some of the parameters involve spectral correlation calculations, resulting in It becomes difficult to process in real time, and the method only performs codeless despreading of the DS signal, and does not fully obtain and use the structural information of the DS signal itself. In this paper, statistical network analysis combined with neural network and principal component analysis neural network are used to estimate the PN code sequence of DS signal, but all involve autocorrelation search of information code and PN code waveform synchronization starting point, and its noise robustness. Very poor, with more serious defects. It has been proposed to estimate the DS signal PN using a constrained Hebbian rule, but it is also necessary to know the starting point at which the information code is synchronized with the PN code waveform.

2. Straight-sequence spread spectrum communication technology

Direct Sequence Spread Spectrum (DS/SS) communication is an information transmission processing technology that is an advanced communication method for communicating with a bandwidth much larger than the transmission information rate. The technique spreads the narrowband information to be transmitted into a wideband signal with a spreading function unrelated to the information to be transmitted, so that it occupies far more bandwidth than necessary for transmitting information. At the receiving end, the spread spectrum signal is despread with the

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same spreading function, and the information code is solved, and any signal not related thereto is expanded into a wider frequency band and suppressed. Two important theoretical foundations for spread spectrum communication: (1) Information theory. The channel capacity formula for the Shannon (Sh~on) theory tells us that under certain channel capacity, the bandwidth occupied by communication and the signal-to-noise ratio used can be interchanged. If you increase the transmission bandwidth, you can reduce the signal to noise ratio. It can be inferred that the advantage of spread spectrum communication is that the spread spectrum method can be used to exchange the benefits of signal to noise ratio. (2) Anti-interference theory. That is, the information transmission error probability is a function of the power ratio of the input signal to the noise and the product of the signal bandwidth and the information bandwidth ratio. The signal-to-noise ratio and the signal bandwidth are interchangeable under a certain error probability and a certain information bandwidth. This also points to the objective law that the bandwidth-increasing method can be used in exchange for the benefits of signal-to-noise ratio. Moreover, if we use the ratio of the output signal-to-noise ratio of the spread spectrum system to the input signal-to-noise ratio (processing gain) to characterize its anti-interference ability, the anti-interference performance of various spread spectrum systems is substantially the same as that of the spread spectrum signal. The ratio of the bandwidth to the bandwidth of the transmitted information is proportional. Since the spread spectrum signal in transmission is a wideband signal spread by a spread spectrum function, the spread spectrum communication system has the following characteristics: (1) Strong anti-interference. General spread spectrum systems have the effect of suppressing interference and improving the output signal-to-noise ratio. We know that a general spread spectrum system modulates a baseband signal with a high-speed PN code sequence at the origin to achieve spread spectrum. The PN code has a very sharp autocorrelation peak, but the correlation between different PN codes is generally poor. It does not show a very prominent cross-correlation peak, so it has a statistical characteristic similar to white noise. Active reception generally adopts the method of correlation reception and matched filtering, that is, using a local high-speed PN code pair identical to the sender and synchronized. The signal is correlated and despread, and the useful wideband signal at the receiving end is compressed into a baseband signal, so that the signal level is raised, and the bandwidth of other signals, interference, noise, etc., which are not related, is further widened, so that the interference level is further reduced. A narrow-band filter is used to align the correlated baseband signal, and the output is mainly a useful signal except for a small amount of interference and noise. Many artificial and non-human interferences are treated as noise by the spread spectrum receiver, unless the power spectral density of these interferences after spreading by the PN code of the receiving end is still higher than the power spectral density of the useful baseband signal, but this is achieved. It is very difficult to get up. Even if the same type of signal is used for interference, if the PN code sequence contained in the useful signal cannot be intercepted, since the cross-correlation between the PN code sequences is weak, the interference does not play much. Therefore, strong anti-interference performance is the most prominent advantage of spread spectrum communication. (2) Good concealment. This is also the result of spectrum spreading caused by the spread spectrum system modulating the baseband signal with a high-speed PN code sequence at the origin. Since the spread spectrum signal is distributed over a wide frequency band, the power in the component band is small, that is, the power spectral density of the signal is very low, and the signal can be transmitted in the background of channel noise and thermal noise. Since the signal is submerged by noise, the enemy is not easy to find the existence of the signal. Even if the existence of the signal is detected, and there is no prior knowledge of the PN code, it will become difficult to intercept the signal. Therefore, the spread spectrum signal has a low probability of interception (LPD). Of course, the spread spectrum system has many other advantages: it can realize code division multiple access, anti-multipath interference, precise timing and positioning.

3. Blind estimation of DS signals

Ds/SS communication adopts a "concealed" strategy, that is, the power spectral density of the signal is reduced by spread spectrum until it is overwhelmed by noise, so that the reconnaissance jammer cannot detect and intercept such signals. How to intercept and interfere with such signals has become an urgent problem in the field of communication confrontation and management. The reconnaissance interception of Ds/ss communication is still an important topic before us because it is the key and core for detecting, interfering and managing DS/SS communication. DS/SS communication is also a new anti-jamming communication system introduced to combat traditional interference. However, Ds/SS communication signals have the characteristics of pseudo noise: they are usually concealed in background noise, and DS/sS communication has lower interception rate and higher anti-interference characteristics than conventional communication-fixed-frequency communication. Ds/ss communication directly implements high-speed PN code sequence modulation on the information sequence, and its signal spectrum is greatly broadened. The signal-to-noise ratio of the unit band in the far-end receiver is transmitted under the same effective radiated power of the transmitter. It is greatly reduced, and thus has a low interception characteristic. The local oscillator of the communication receiver adopts the same PN code sequence modulation as the communication transmitter, and when synchronously correlated, the wideband DS/sS communication signal is despread into a narrow band after mixing. The information signal can pass through the narrowband filter without any suppression, and the noise at the input of the receiver is not related to the PN code sequence of the receiver's local oscillator. After mixing, the spectrum of the broadband noise is further broadened, but only A very small part of the noise energy can pass through the narrow-band filter. Therefore, the input of the information demodulator after the narrow-band filter has a higher signal-to-noise ratio and can receive information normally. That is to say, the communication receiver is synchronized. Related connection After that, it has a higher spread spectrum processing gain, so that the signal-to-noise ratio at the output of the correlator is much higher than the signal-to-noise ratio at the input of the correlator. This shows that Ds/ss communication is stronger than conventional communication. The ability to suppress noise, that is, has strong anti-interference ability, and simply using the general interference signal to overlap with the interfered DS/SS communication signal in the frequency domain level domain cannot achieve the best interference.

It is determined by the inherent characteristics of DS/SS communication. On the one hand, the DS/SS communication signal is difficult to detect. On the other hand, even if the DS/SS communication signal is detected but the sender's spreading code is unknown, it will be difficult to restore the original. Information. It is difficult to effectively detect and estimate Ds/ss communication signals with classical signal detection and estimation theory. However, no matter how similar the DS/SS communication signal is to the background noise, it is definitely different from the background noise. Therefore, the countermeasure strategy of the DS/SS communication signal should be to use the DS/SS signal and the surrounding noise in the time domain, frequency domain, and correlation. Domain, power spectrum, cepstrum, spectral correlation, high-order spectral domain and different features in the time-frequency domain, the corresponding method is used to distinguish the DS/sS signal, and the DS/SS signal is estimated from the noise. It is supported by broadband weak signal detection and estimation theory and belongs to the category of fine feature extraction of communication signals. As with the hopping communication countermeasures, the DS/SS communication signal must also be detected and estimated DS/SS communication signals before it is possible to effectively interfere with the DS/SS communication. Although the detection and estimation studies of Ds/sS communication signals have been proposed together since the early 1980s, the detection and estimation of Ds/ss communication signals has been a problem that has not yet been fully solved. This is because the power spectral density of the DS/SS communication signal is very low, and it is usually difficult to be found in the noise, and it is more difficult to estimate the parameters. The method of detecting and estimating the DS/SS communication signal in the noise is generally There are broadband radiometers, broadband energy detectors, time-delay multiplying receivers, cumulative averaging methods using digital signal processing in the spectrum and so on. These detection and estimation methods still need to be improved. It is possible to detect the DS/55 communication signal in the noise, and it is possible to talk about the estimation of the DS/SS communication signal parameters. It is generally desirable to know the bandwidth PN code repetition period, PN code rate, PN code pattern structure, etc. of the DS/SS communication signal. It is more difficult to estimate these parameters than to determine their existence. It has been proposed to use the correlation characteristics of the Ds/SS communication signal to perform a correlation operation on the received signal for a period of time to determine the PN code period and to determine the structure of the code sequence. This is conceptually feasible, but verification of the experimental results is required. If the enemy's PN code structure changes frequently, it increases the difficulty of parameter estimation.

4. Conclusion

Under normal circumstances, it has been determined that the active despreading of the PN code can be made to a signal-to-noise ratio tolerance of - 20. 0 dB to - 30. 0 dB, which used the bound Hebbian rule to estimate the PN code. The signal-to-noise ratio tolerance is close to - 10. 0 dB, and the signal-to-noise ratio of snr= - 20. 0 dB can be easily obtained by estimating the PN code sequence by using the correlation matrix cumulative averaging and KL transform method. Tolerance, and it is better to estimate performance when the PN code is longer. This method can better solve the PN code sequence estimation problem of DS communication (especially the civil communication and military tactical communication with short PN code), and further blind decoding, management, reconnaissance and interference of DS communication, and DS CDMA communication. The reconnaissance and blind multi-user detection laid the foundation.

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References

[1] Dominique F, Reed J H. Simple PN code sequence estimation and sychronization techniqueu sing the constrained Hebbian rule [J]. Electronics Letters, 1997, 33(1): 37 38.

[2] Zhang Tianqi, Zhou Zhengzhong. A new spectral method of periodi c detection of PN s equence in low er DS /SS signals [J]. Chinese Journal of Radio Science, 2001, 16(4): 518521.

[3] Zhang Tianqi, Zhou Zhengzhong. Detection and Estimation of DS/ SS Signals by Spectra Analysis and Neural Network s [J]. Sy stems Engineering and Electronics, 2001, 23 (12): 12 15.

[4] French C A, Gardener W A. Spread-spectrum despreading without the code [J]. IEEE Trans Communications, 1986,34 (4) : 404 407.

[5] Anders on T W. Asymptotic theory f or principal component analysis [J]. Ann Math Statist, 1963, 35: 1296 1303.