Research on Modulation Recognition Algorithm of Digital Communication Signal

Zijian Wang

Information Engineering University, Zhengzhou, Henan, 450000, China

Keywords: Communication signal, Recognition algorithm, Model structure

Abstract: This dissertation mainly studies the recognition of modulation modes of digital communication signals, and studies the modulation recognition algorithms from the perspectives of feature extraction and classifier design. The modulation recognition algorithm based on instantaneous characteristics is studied. The algorithm selects the instantaneous characteristics of seven communication signals, including the peak amplitude spectrum and the absolute amplitude standard deviation, as the classification features. Then, the decision criterion of the decision tree classifier is set according to the classification performance of each feature parameter, and the decision threshold is selected in combination with the simulation results to complete the decision. The construction of the tree classifier. The performance of the algorithm is analyzed through simulation experiments. A modulation recognition algorithm based on the joint features of high-order cumulant and entropy is proposed. In this algorithm, in order to improve the noise resistance and stability of the algorithm, high-order cumulant features are extracted to identify digital communication signals, and entropy features are extracted to classify signals that cannot be identified by high-order cumulant features. According to the classification performance of each characteristic parameter, the decision criterion and threshold value are selected to construct a decision tree classifier, so as to realize the recognition of the signal modulation mode. The performance of the algorithm is analyzed through simulation experiments, and the performance is compared with the modulation recognition algorithm based on the instantaneous characteristics of the signal.

1. Introduction

The diversification of modulation patterns of communication signals makes the intercommunication of information in different communication systems an urgent problem to be solved, and the recognition of modulation patterns of communication signals is the key to solving this problem. Modulation recognition is an important technology between signal detection and demodulation. Its main function is to realize the intelligent reception and processing of modulated signals in communication systems. It plays a key role in various civil and military applications. In the civil field, relevant functional departments can detect and estimate signal bandwidth, transmit power and frequency and other parameters to achieve interception and interference of illegal radio stations, while ensuring the normal progress of legal communications; through spectral analysis of received signals, Recognize the modulation pattern of the communication signal and combine with other signal parameters to distinguish users of different natures, thereby realizing the supervision of spectrum resources and preventing them from being invaded by unauthorized users. In the military field, electronic countermeasures have had a significant impact on the update of modern war combat theory, the comparison of combat forces, the transformation of combat methods, the changes in the battlefield environment, and the course and outcome of wars, bringing about epoch-making changes. The communication system is the basis for the implementation of battlefield command and intelligence transmission. It is connected to electronic systems such as automated command and control systems, battlefield intelligence systems, and fire support systems. It is an important factor affecting the outcome of war. As an important part of electronic warfare, communication countermeasures are mainly composed of communication reconnaissance and communication electronic defense and offense. Communication reconnaissance is the prerequisite

  DOI: 10.25236/mmmce.2021.033

and basis for the implementation of communication countermeasures. It uses communication receiving equipment to intercept enemy communication signals and detect and analyze the signals. The use of communication reconnaissance technology can realize a comprehensive analysis of the enemy's communication technology system, and then become familiar with the composition of its internal communication network. The identification and classification of the modulation mode of the intercepted signal is one of the important tasks of the communication reconnaissance system, and it is also the key and prerequisite for the realization of interference guidance. According to the results of signal parameter estimation and modulation pattern recognition, the received signal can be demodulated and other subsequent related information processing procedures to realize the interception of the enemy's communication content to obtain the required intelligence information; it can also be performed by intercepting the signal. Analyze, select parameters with high reference value to implement blocking interference to the enemy's communication, or generate false signals to implement deceptive interference to the enemy's communication, and realize the communication confrontation against the enemy.

2. Modeling of Communication and Communication Reconnaissance System

The main purpose of communication is to realize the transmission and interaction of information between the source and the destination. The overall technical system involved in the completion of the communication process is called the communication system. In real life, users need to transmit information in various forms and types. In order to ensure the universal applicability of the equipment in the communication system, it is necessary to convert all kinds of information to be transmitted into the original electrical signal, namely the baseband signal. The main source of information in the communication system is the function is to complete this transformation process. The main function of the transmitting device is to make a series of transformations to the baseband signal output by the source to match the characteristics of the channel, and at the same time have enough power to achieve the needs of long-distance transmission; its internal generally includes amplification, encoding, encryption, Modulation and other processes. Channels are used as a medium to transfer modulated signals containing information from the sending end of the system to the receiving end to complete the transmission of information. According to the nature of the transmission medium, channels can be divided into wired channels and wireless channels. The noise source represents the sum of the scattered noise inside the entire communication system during the information transmission process. Noise is a kind of interference to the transmitted signal. A common type of noise in communication systems is thermal noise. Because the statistical characteristics of this noise obey the Gaussian distribution and the frequency spectrum is uniform, it is also called Gaussian white noise. This paper chooses Gaussian white noise as the noise model. The receiving device extracts the signal in the channel, amplifies and inversely transforms it, so as to accurately restore the baseband signal. Since the signal is affected by noise and interference during transmission, the receiving device usually needs to have the function of reducing or eliminating the effect. The sink corresponds to the source, which is the destination of information transmission, and its main function is to restore the electrical signal to the original information.

The conventional communication system model has been introduced above, and it can be seen from the above introduction that the baseband signal needs to be modulated accordingly at the transmitting end before it can be sent to the channel for transmission. The classification and recognition of signal modulation patterns is the research content of this article. Only by thoroughly understanding the modulation principles of different types of communication signals and finding the essential differences between various types of signals can a modulation recognition algorithm with higher performance be designed. The following describes the commonly used communication signal modulation styles.

3. Modulation Recognition Based on Instantaneous Characteristics

The instantaneous characteristics of the communication signal contain rich modulation

information, and the calculation is simple, requires less prior knowledge, and has high real-time performance; the instantaneous characteristics of the signal extracted under a certain signal-to-noise ratio can well reflect the difference between different modulation patterns. the difference. This chapter mainly studies a modulation recognition algorithm based on instantaneous features. It uses the instantaneous information of the signal to extract seven instantaneous feature parameters such as the peak amplitude spectrum and the absolute amplitude standard deviation, and combines the classification performance of each feature parameter to set the corresponding decision criteria, choose a suitable decision threshold to construct a decision tree classifier, so as to realize the recognition of eight modulation patterns of digital communication signals. In this section, seven instantaneous features are selected to realize the classification of eight digital signals. Two of them were proposed by Nandi et al., which can distinguish MASK from digital signals and complete the intra-class distinction of MASK; then the five instantaneous features proposed in the literature are selected to realize the comparison of other digital signals. Classification. According to the instantaneous information of the digital communication signal, the above classification features are extracted, and the performance of each feature is analyzed through simulation experiments. Decision tree classifiers are also called multi-level classifiers. Its construction is based on probability theory and hypothesis testing theory. It simplifies complex classification problems by decomposing complex problems level by level. The structure of a general decision tree classifier is composed of three parts: the root node, the intermediate node and the leaf node. Among them, the root node and the intermediate node represent a certain attribute feature relative to the input sample, and the leaf node represents the corresponding sample category. Comparing the attribute characteristics of the input sample with the thresholds set at the root node and the intermediate node, it can be judged how to enter the next level, and this decision step is repeated until the recognition of the sample attribute is completed. Decision tree has the advantages of simple structure, small amount of calculation, easy implementation and high real-time performance, and when the selected feature parameters have good classification performance, there will be a higher recognition rate and faster classification speed. This classifier has high practical value in practical projects that require high real-time performance. This chapter selects decision tree as the classifier in the debugging and recognition algorithm, and combines the classification performance of each instantaneous feature extracted in the previous section to complete the design of the decision tree classifier.

When SNR>1dB, the f1M parameter values corresponding to MPSK and MFSK have good distinguishability, which can effectively separate MPSK and MFSK. The parameters p1M and p2M used for recognition within the MPSK class have good distinguishability under low signal-to-noise ratio. Therefore, when SNR=2dB, the recognition rate of 2PSK and 8PSK has reached more than 99%, and when SNR=4dB, the recognition rate of 4PSK the recognition rate has also reached 96%. When MFSK is identified within the class, because the corresponding f2M parameter value of 2FSK is greater than the decision threshold when SNR<5dB, and its modulation mode is misjudged, 2FSK cannot be effectively identified at this time. Since the f3M parameter value of 8FSK is less than the set threshold when SNR<12dB, it is misjudged as 4FSK. At this time, the recognition rate of 8FSK is low. When the SNR 4dB, the accuracy of the algorithm in this chapter for the five digital signals 4ASK, 4FSK and 2/4/8PSK is above 96%; when the SNR 8dB, the algorithm in this chapter is accurate for the other digital signals except 8FSK. The recognition rate is higher than 96%. In summary, the algorithm in this chapter has a low recognition rate for 8FSK, and can effectively recognize the remaining seven signals under the condition of SNR 8dB. When SNR12dB, the average recognition rate of the algorithm in this chapter for digital signals is more than 95%; under the condition of SNR 13dB, the accurate recognition rate of eight kinds of digital signals is more than 99%. Since the instantaneous characteristics of communication signals are greatly affected by noise, when the SNR is low, the instantaneous characteristics of some signals are interlaced or the difference is too small. At this time, the characteristic parameters are no longer distinguishable, which causes the algorithm to affect some signals. Poor classification performance. Therefore, extracting characteristic parameters with good anti-noise performance is a research

direction to improve the classification performance of modulation recognition algorithms.

4. Modulation Recognition Based on the Joint Feature of High-Order Cumulant and Entropy

It can be deduced from statistical theory that the high-order cumulant corresponding to Gaussian random variables is zero; the high-order cumulant corresponding to non-Gaussian random variables is not zero, and it contains a lot of information. Therefore, for the digital signal containing Gaussian white noise and the digital signal without noise, their corresponding high-order cumulants are theoretically the same. Therefore, extracting the high-order cumulant of the noise-added signal can minimize the influence of noise on the signal. The high-order cumulants of different digital signals are different, so the high-order cumulants of the received signal can be extracted as the classification feature to identify the modulation pattern of the signal. At the same time, it can also be found that the theoretical value of the high-order cumulant of each signal is related to the average power E of the received signal. Due to the influence of the signal power, there may be a big difference between the estimated values of the high-order cumulant of similar signals. Therefore, in order to eliminate the influence of signal power and improve the classification performance of characteristic parameters, the normalized high-order cumulant is selected as the characteristic parameter for identifying the signal modulation mode. When SNR=0dB, the recognition rate of algorithm 2 for the five signals is above 97%. At this time, algorithm 1 can only recognize 4ASK and 4FSK signals, and the recognition rates are 82.22% and 93.94%, respectively. When the SNR increases to 5dB, algorithm one can identify six types of signals, and the recognition rate of five of them can reach 100%; at this time, algorithm two can still only identify five types of digital signals. When the SNR increases to 10dB, the first algorithm can effectively identify the remaining signals except 8FSK, and the second algorithm can achieve 100% recognition rate for the remaining signals except 8PSK. When SNR=15dB, the recognition rate of the eight digital communication signals by the two algorithms reaches 100%. Comprehensive comparative analysis shows that the second algorithm can effectively identify the five signals of 2/4ASK, 2/4PSK and 8FSK under the conditions of various signal-to-noise ratios; although the characteristic parameters are also very distinguishable when the SNR is low, due to the decision threshold of the decision tree is not adaptive, so that the second algorithm at this time cannot effectively identify 2/4FSK and 8PSK. Algorithm 1 can effectively identify 4ASK and 4FSK under various signal-to-noise ratio conditions. However, because the instantaneous characteristics are greatly affected by noise, when the signal-to-noise ratio is low, the instantaneous characteristics of different signals are not very distinguishable, which results in the algorithm. Under the condition of low signal-to-noise ratio, the recognition rate of 2/8FSK and 2ASK is not high. Under the condition of SNR<4dB, the average recognition rate of a pair of digital signals of the algorithm is not as good as algorithm two, but in the range of 4~7dB of signal-to-noise ratio, its average recognition rate of digital signals is worse than algorithm two. In summary, the joint features based on high-order cumulants and entropy values have good noise immunity. Under the condition of low signal-to-noise ratio, the algorithm in this chapter has high performance for other digital signals except 2/4FSK and 8PSK. Accurate recognition rate. Under certain signal-to-noise ratio conditions, 2FSK and 4FSK can be effectively identified, but the recognition performance of 8PSK is not high. This is because the decision threshold of the decision tree is not self-adaptive, even if the eigenvalues of different signals have large differences and obvious discrimination under the condition of low signal-to-noise ratio, but the eigenvalues do not meet the threshold decision conditions at this time. The misjudgment situation results in the low accurate recognition rate of 2/4FSK and 8PSK when the signal-to-noise ratio is low.

5. Conclusion

Modulation recognition is used in the communication system to intelligently receive and process modulated signals, and it is an important technology between signal detection and demodulation. In the communication reconnaissance system, modulation recognition is the prerequisite and key to

intercept and demodulate enemy communications, guide interference and obtain intelligence. This paper mainly studies the recognition of modulation modes of digital communication signals, and studies the modulation recognition algorithms from the perspectives of feature extraction and classifier design. The main work of this paper is as follows: Introduced the conventional communication system and the commonly used signal modulation principle inside the system, and carried out modeling and simulation of the corresponding modulation signal. After that, the research object of this article-communication signal modulation recognition technology is introduced in the introduction to the communication reconnaissance system. Finally, the method based on wavelet transform is selected to realize the classification of analog and digital communication signals, and to make preparations for the subsequent research on modulation and recognition of digital communication signals.

References

[1] Wang Song. Research on Automatic Modulation Recognition Algorithm of Digital Communication Signal. Electronic World, 2014(10): 57-57.

[2] Wang Song. Research on Automatic Modulation Recognition Algorithm of Digital Communication Signal. Electronic World, 2014.

[3] Meng Lingling, Liu Chunliang. Research on modulation recognition of digital communication signals. Radio Communication Technology, 2006(01):39-40.

[4] Shi Fangzhou, Liu Xuesong. Research on likelihood algorithm for PSK signal modulation recognition. 2008.

[5] Zhang Zhimin, Ou Jianping, Huang Fukan. Research on automatic recognition of digital communication signal modulation. Computer Engineering, 2011, 37(006): 153-156.

[6] Yang Shengyi. Discuss the automatic recognition algorithm of digital communication signal modulation mode. Big Science and Technology, 2013(9):336-337.

[7] Niu Qian. Research on Several Issues of Digital Communication Signal Modulation Recognition. Engineering Technology (Abstract Edition), 2016, 000(004): 00038-00038.

[8] Xie Mingxiang, Zhang Jintao. Gabor transform method for modulation recognition of digital communication signals. Ship Electronic Engineering, 2006, 26(2):144-144.