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The Background and Significance of Radar Signal Sorting Research in Modern Warfare

Shi Qiang Wang[1], Guo Ping Hu[1], Qi Liang Zhang[1], Cai Yun Gao[2,*1], Tong Cai[1]

[1] Air *and* Missile-*Defence College*, Air Force *Engineering* University, Xi'an *710051*, *China*.
[2] Basic *Department*, Air Force *Engineering* University, Xi'*an* 710051, *China*.
[*]E-mail: *1048768838*@qq.com

Abstract:

As an important part of electronic intelligence (ELINT) and electronic support measure (ESM) system, radar signal sorting affects the performance of electronic reconnaissance equipments directly, and is a key technology to campaign decision-making. However, as the radar systems are becoming more and more complicated, as the countermeasure activities in modern electronic warfare are becoming more and more drastic, and as the development of low-probability of intercept (LPI), the regularities of signal sorting are heavily destroyed. This leads to the results of radar signal sorting based on common five parameters are not well. At present, the deinterleaving of advanced radar signals has become the primary bottleneck of signal processing in ELINT and ESM system, and confined farther improvement of the performance of electronic countermeasure equipment. So this paper analyzes and studies the background and significance of radar signal sorting in complex systems.

***Keywords*:** radar emitter signal sorting, electronic warfare, electronic support measure.

[1] [1] [1] * Corresponding author. Tel.: +(86) 15319765259
E-mail : 1048768838@qq.com
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1 Introduction

As one of the key technologies for signal processing of electronic reconnaissance equipment, the research on the theory and technology realization of radiation source signal sorting has been highly valued by various countries. Relevant research literature indicates that domestic and foreign research scholars have carried out signal sorting technology for radiation source signals. A lot of research work has also achieved a lot of results. In foreign countries, a large number of papers on signal sorting have been published in many important international journals and conferences. Each paper has achieved certain innovations and improvements in technology, which has greatly promoted the development of signal sorting. In China, many research institutions and institutions of higher learning have strengthened the research on the identification and sorting of radar signals from complex systems, and explored a theoretical system that can effectively support the technical improvement of radar emitter signal identification and sorting. For example, Xi'an University of Electronic Science and Technology, East China Institute of Electronic Engineering, Chengdu University of Electronic Technology, Harbin Engineering University, Southwest Jiaotong University and other units have conducted research on complex radar and its reconnaissance technology, and have achieved a lot of results.

2 Research Background of Radar Emitter Signal Sorting

Electronic warfare (EW) is an important means of warfare and an important means of warfare in attack and defense in modern warfare. Its purpose is to use electromagnetic energy and directed energy to destroy the use of electromagnetic spectrum and electromagnetic information by weapons and equipment, or to equip enemy weapons. Military operations with personnel to attack and kill, while safeguarding the normal performance of their weapons and personnel and personnel safety [1]. As a "force multiplier" for military forces, the electronic warfare is a key factor in determining the success or failure of modern warfare, and it has an extremely important leading position and role in modern warfare. Without the victory of electronic confrontation, it will lose its electromagnetic power, and there will be no initiative to control heaven, air, sea and land. Therefore, electronic warfare is known as the

"land, sea, air, and sky" war. The fifth dimension of the battlefield has become an important indicator of a country's national defense and military strength and a leading factor affecting the evolution of war forms [2,3]. It is precisely because of the importance of electronic warfare that military science and technology personnel from all countries have always attached great importance to the research and application of electronic warfare technology.

In view of the wide application of radar in the military, and its effectiveness is directly related to the power of various weapons and equipment, the surveillance and warning of the theater, the deployment, connection, command and control of the coordinated operations of various arms, radar confrontation for a long time. Has always dominated the electronic warfare [1,4]. The so-called radar confrontation refers to the general term for measures and actions taken to weaken and destroy the effectiveness of the enemy radar and to protect the normal use of the radar. It mainly includes radar anti-reconnaissance, radar interference, anti-reconnaissance, anti-interference, etc. content. Radar confrontation reconnaissance refers to the activity of searching and intercepting the electromagnetic signals of enemy radar radiation sources, and analyzing and identifying the intelligence information such as tactical parameters and position data [5]. According to different tasks and purposes, radar countermeasure reconnaissance is mainly divided into threat alarm (RWR), electronic intelligence reconnaissance (ELINT) and electronic support reconnaissance (ESM). The signals intercepted by the radar anti-reconnaissance usually contain a large number of radar signals and other electromagnetic radiation source signals, forming a random interlaced signal stream. According to the intercepted radar characteristic parameters, arrival time and position data, the radar signals can be transmitted from the signal stream. Sorted out. Then, the sorted signal is extracted by parameters, and the radar model is identified. According to the recognition result, the type, attribute, use and threat degree of each radar are obtained [5].

It can be seen from the above analysis that signal sorting of radar radiation source is the key link of radar anti-reconnaissance signal processing, which directly affects the performance of radar reconnaissance equipment and is related to subsequent operational decisions [6]. Especially in the electronic support reconnaissance (ESM) system that needs to intercept the radar with high threat level in a timely, comprehensive and accurate manner, high-speed and accurate sorting is to correctly identify enemy radiation source threats and quickly guide the control of interference devices (ECM), or the premise of indicating the target position for the weapon system, and the wrong

sorting will lead to a large number of false alarms and missed alarms, which seriously affect the confrontation effect and even directly related to the victory or defeat of the war. Therefore, the technical level of signal sorting has become an important indicator for measuring the technological advancement of electronic intelligence reconnaissance (ELINT), electronic support reconnaissance (ESM) and radar warning receiver (RWR) systems [7,8]. The process of radar signal sorting is shown in figure 1 [9].

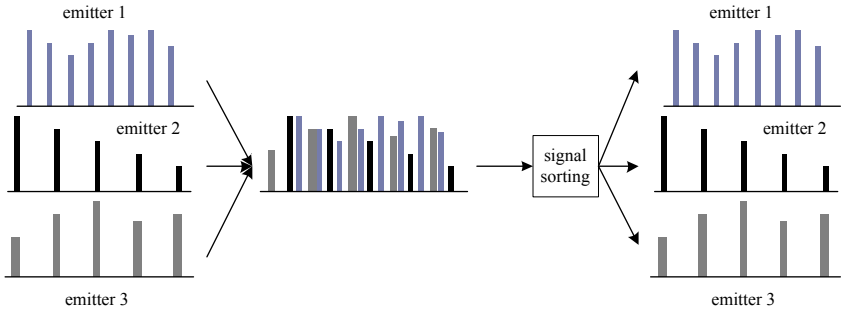

Figure 1 Radar signal sorting diagram

3 Research Significance of Radar Emitter Signal Sorting

The current electronic countermeasures system uses the five basic parameters of time of arrival (TOA), carrier frequency (RF), pulse width (PW), pulse amplitude (PA), and direction of arrival (DOA) to sort radar signals. The environment is relatively simple, that is, the number of radars is small, the radar signal density is low, the signal form is simple, and the signal parameters are less changed, and better sorting effect can be obtained [10~14].

However, with the rapid increase in the number of various electronic countermeasure devices, the signal density of the electromagnetic threat environment has reached millions of orders, and modern radars are moving toward multi-functional and multi-purpose directions. A radar may have multiple working states. With a variety of systems, and in order to improve their performance and anti-interference needs, often use a variety of complex waveform design to minimize the signal regularity used in signal sorting and identification, coupled with low intercept probability (LPI) technology [15], these all put new and higher requirements on the real-time, accuracy and reliability of signal sorting.

In recent years, with the rapid development of ultra-high-speed integrated circuits (VHICs) and very large scale integrated circuits (VLSICs), digital receivers have begun to be widely used in radar, electronic warfare and communication receivers [16,17], especially The IF digital receiver is more and more widely used in modern radar [18]. It uses an analog-to-digital converter (ADC) instead of the detector to directly sample the IF signal, which makes the pulse of the signal in addition to the conventional parameters. Information is preserved to provide in-pulse and individual characterization of the radar signal. Therefore, in the complex and dense electromagnetic environment caused by the sharp increase in the number of countermeasure devices and the widespread application of complex radars, in addition to signal sorting using conventional parameters, the pulse information of the radar signal is analyzed and the intra-pulse characteristic parameters are utilized. Pulse flow separation is a technical approach that is expected to improve sorting performance. Therefore, at this stage, it is of great theoretical and practical significance to combine the inter-pulse parameters and the intra-pulse characteristics to realize the radar emitter signal sorting model and algorithm, which are mainly reflected in the following aspects:

(1) Feature extraction of intrapulse information is an effective way to improve signal sorting performance. In the modern electronic countermeasure environment, due to the large number of applications of various complex radars and the sharp increase in the number of electronic countermeasure devices, the electromagnetic signal environment is increasingly dense, and the instantaneous bandwidth occupied by radar is continuously widening, making it necessary to characterize the characteristics of the radiation source. Domain, airspace, and frequency domain parameters may overlap or partially overlap. The phenomenon of “leak-and-batch” and “batch increase” in the radar signal sorting process will become more and more serious, resulting in reduced performance or even failure of sorting results [19~23]. Therefore, only the traditional five-parameter radar signal sorting technology can not meet the needs of more complex battlefield environment. It is necessary to mine the intrinsic new features implied by

different radiation source signals, and combine them with efficient and accurate sorting of inter-pulse parameters. The enemy radiation source signal [24,25].

(2) The research and application of new sorting models and algorithms are directly related to the performance of electronic countermeasure equipment. As mentioned above, in modern warfare, the massive use of complex radars and guided weapons has formed a complex, variable and serious threat to the electronic countermeasure environment. How to separate the radar source information in real time in a dense electromagnetic environment It is becoming more and more urgent to get the correct parameters, identify and alarm in real time, and correctly guide the interference system to interfere. As one of the important components of the reconnaissance guidance system equipment, signal sorting is directly related to the performance index of the reconnaissance equipment. Wrong sorting results will cause false alarms, missed police, personnel confusion, etc., and will also affect the determination of interference modes [4,26]. In addition, the highly dense signal environment makes the calculation amount of signal sorting processing larger. If the calculated load exceeds the maximum computational load of the ESM system signal processing system, system saturation will occur, resulting in information loss and sorting failure, thus enabling the reconnaissance equipment. The performance is reduced. Therefore, it is imperative to explore real-time effective new sorting models and algorithms.

(3) The research on signal sorting models and algorithms of new radiation sources is an urgent need to rapidly shorten the gap between advanced and developed countries in the field of electronic countermeasures. Electronic warfare is related to the success or failure of war and the vitality of life and death. Therefore, it has always been one of the most secret secrets of all countries in the world. It has the particularity and sensitivity of the field, resulting in the latest foreign research materials that are available and relatively lagging behind. Understand the theoretical methods and technical means currently used in developed countries such as the United States [4,27]. In addition, China's research on radar emitter signal sorting started late, and the current level is still relatively different from that of advanced developed countries. Therefore, research on this aspect is urgent and important.

4 Conclusion

In summary, for the key issues that need to be solved in the research of radar signal sorting in China, it is necessary to theoretically explore and innovate the architecture and new methods of radar emitter signal sorting. It is needed to analyze the radar signal and mine the new intrinsic features implied by different radiation source signals, and design a sorting model and algorithm that adapts to various feature distribution forms.

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