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Research on a New Model Structure for Unknown Radar Emitter Signal Sorting

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Abstract:

Aiming at the defects and shortcomings of the traditional radar emitter signal sorting model structure, this paper proposes a new sorting model structure for the unknown source signal in complex dense electromagnetic environment, comprehensively utilizing the inter-pulse parameters and intra-pulse of the signal. Modulation features are sorted. The paper studies the problem of radar emitter signal sorting with a new idea. The characteristics and innovation of the new sorting model structure are expounded, and the functions and functions of each component of the model structure are briefly described.

Keywords: radar emitter signal sorting, new model structure, feature extraction, feature selection, clustering sorting.

1 Introduction

Radar emitter signal sorting refers to the process of separating randomly interleaved signal streams using inter-pulse and intra-pulse parameters of the signal. The traditional radar emitter signal sorting model structure mainly uses the five basic parameters of TOA, RF, PA, PW and DOA for sorting [1~6]. When the signal density in the electromagnetic environment is not very large, the sorting model is more effective when the conventional parameters

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are relatively stable. That is, the sorting method is only suitable for the sorting when the conventional radar signal parameters are basically unchanged under certain conditions. In the modern electromagnetic environment, the waveform design of radar is becoming more and more complicated. Traditional radar signals such as fixed-frequency, jagged, and jitter are becoming less and less common in modern radar design, and complex radar has become the current radar design. Hot spots, these characteristics make the electromagnetic environment of the battlefield deteriorate sharply. It is impossible to solve this problem by relying on the traditional sorting model structure. Therefore, it is necessary to study the structure of the new sorting model.

2 A New Sorting Model Structure

Based on the existing model, this paper proposes the sorting model structure as shown in figure 1 to study the sorting problem of complex radiation source signals. The model is for the unknown radiation source signal in complex dense electromagnetic environment, and comprehensively utilizes the inter-pulse parameters and intra-pulse modulation characteristics of the signal for sorting. Firstly, the interleaved signals are pre-sorted by conventional parameters, then the intra-pulse data corresponding to the missing pulses are selected, and the intra-pulse modulation features which are favorable for signal sorting are extracted, and then the radar source signals are selected by the feature selection algorithm. Key features, clustering method is used to cluster the selected features, and finally the two sorting results are combined to complete the final sorting.

The new model of new unknown radiation source signal sorting shown in figure 1 is mainly composed of reconnaissance reception, parameter measurement, multi-parameter comprehensive clustering, radiation source signal intra-pulse feature extraction, feature selection and intra-pulse feature clustering. The composition is briefly described below.

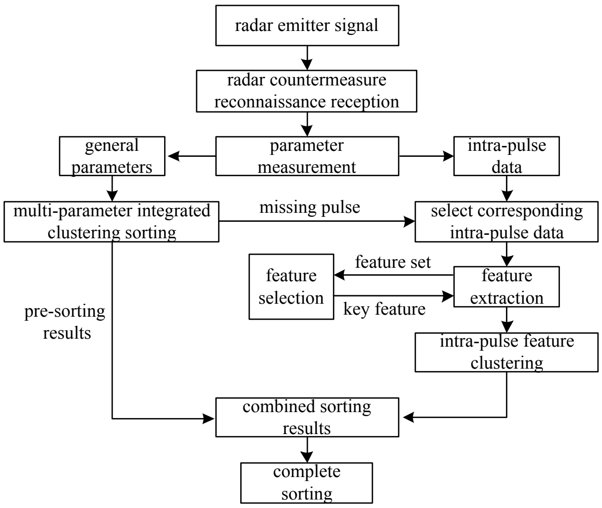

Figure 1 New model structure for unknown radar emitter signal sorting

3 Main Composition of New Model Structure

3.1 Radar Signal Reconnaissance Reception

The task of radar signal reconnaissance and reception is completed by the reconnaissance receiver. During the reconnaissance and reception process, the signal propagation is as follows: after the radar signal is transmitted from the radar antenna, it passes through the propagation space to reach the radar against the reconnaissance aircraft antenna, and the reconnaissance receiver is from a large number of some signals are selected in the radar signal for amplification and processing, and finally the reconnaissance data is obtained on the terminal device. At present, there are six types of receivers commonly used in radar reconnaissance: crystal video receivers, superheterodyne receivers, instantaneous frequency measurement receivers (IFMs), channelized receivers, compression receivers, and acousto-optic receivers. The signals that can be measured by various receivers and the accuracy of measurement are different. Therefore, modern radar reconnaissance aircraft often combine several receivers to form an integrated receiver. Early radar anti-reconnaissance aircraft terminals commonly used analog processing equipment and indication and recording equipment, modern radar anti-reconnaissance aircraft terminals generally use computer control and processing, as well as digital, graphical display and recording [7].

Modern radar anti-reconnaissance aircraft generally have a variety of working conditions. For example, in frequency measurement, it often includes: automatic search status, manual status, automatic tracking status, and the like. Therefore, in the reconnaissance process, it is sometimes necessary to select the appropriate working state and range gear to get the correct measurement data.

3.2 Radiation Source Signal Parameter Measurement

Each transient signal intercepted by the radar reconnaissance equipment must be characterized by a set of parameters that provide the need to associate a set of signals with its particular source of radiation and identify the source of radiation from the numerous sources of intercepted signals. information. Typical measured pulse parameters include TOA, RF, PA, PW, and DOA. In some systems, the polarization of the input signal is also measured. Intra-pulse Frequency Modulation is another parameter that can be used to sort and identify the source of radiation. It can also be used to determine the chirp slope or phase encoding of a pulse compression signal.

The detection and measurement of radar radio frequency pulses DOA and RF are respectively performed by the direction finding antenna, the direction finding receiver, the frequency measuring antenna and the frequency measuring receiver of the radar reconnaissance system. The radar signal pulse parameters mainly refer to the TOA, PW and PA of the pulse, and they must also be measured and quantized before they can be sent to the signal processing input for signal processing.

Modern radar reconnaissance equipment uses digital receivers to perform digital frequency measurement, direction finding and intra-pulse modulation analysis. According to the needs of signal processing, the digital receiver is used in parallel with the analog direction finding and frequency measuring receivers, so that the analog direction finding, the frequency measuring receiver, the instantaneous field of view width, the large instantaneous bandwidth, the high probability of interception, and the fast processing speed can be utilized. The advantages of the digital receiver can also be used to improve the accuracy of the measurement parameters, high resolution, and strong ability to detect and identify fine features, thereby improving the signal processing capability and technical indicators of radar reconnaissance equipment [1,8].

3.3 Feature Extraction

Feature extraction is the extraction of the most characteristic data from the original data by linear or non-linear transformation. For the in-pulse feature extraction, the feature with the intra-class aggregation and inter-class separation is extracted from the intra-pulse data, so that the features between the signals are clearly distinguished, so as to prepare for sorting and identifying the radar signal. Considering that the envelope of the radar signal is greatly affected by noise and multipath interference, the range of the feature extraction method is different. Therefore, it is necessary to find a suitable feature extraction algorithm to analyze it, thus supplementing the new features other than the conventional parameters. A new sorting path is provided when parameter sorting performance is degraded.

3.4 Feature Selection

Feature selection is to select some features that best characterize the nature of the data from the feature set of the original data, so as to reduce the feature dimension of the feature space, reduce or even eliminate the subjectivity of feature extraction. The feature selection is used to select the in-pulse features, aiming at solving two problems. First, the relationship between the elimination and the cluster classification problem to be solved is not close, and it is possible to influence the characteristics of the cluster classification effect in the subsequent processing; Even though many features are closely related to cluster classification, too many features will lead to problems such as large amount of calculation and poor promotion ability. Therefore, while ensuring the effect of cluster classification, it is expected to be completed with as few features as possible. The clustering problem of radiation source signals, feature selection is the theoretical tool for solving this problem.

3.5 Clustering and sorting

Clustering and sorting refers to the separation of interleaved data streams through clustering methods of unsupervised learning. Unsupervised learning methods are widely used in the field of pattern recognition. They are based on the probability distribution model of the sample for clustering, or clustering directly based on the distance between samples or similarity metrics. For the pulse flow intercepted in a complex dense electromagnetic environment, the probability distribution of the pulse is difficult to model, so it is clustered by the similarity measure.

In complex and dense electromagnetic environment, the inter-pulse parameter overlap will be very serious, and the pulse flow in the same direction of arrival will increase sharply, which may cause the possible failure of DOA sorting parameters. The multi-parameter integrated clustering method uses inter-pulse parameters. Pre-sorting, as far as possible to obtain reliable clustering results (meaning that each cluster contains only one type of radiation source), which can sort out the most meaningful clusters for subsequent recognition, which helps to improve The accuracy and reliability of signal recognition.

The intra-pulse feature clustering and sorting refers to clustering the intra-pulse features by clustering method after feature extraction and selection of the missing pulse. As mentioned above, the number of pulses originating from the same direction increases sharply in a complex dense electromagnetic environment. The clustering results are obtained as reliably as possible by multi-parameter integrated clustering, and the remaining pulses are missed. These missing pulses are conventional. When the parameter domain is used for clustering and sorting, it is not easy to determine the category. Therefore, the feature extraction method is used to obtain new features for sorting. By processing the missing pulse in different parameter domains, the sorting accuracy rate can be improved on the one hand, and the other can improve the sorting accuracy rate. The aspect can solve the problem that the calculation amount is large when the inter-pulse parameter and the intra-pulse characteristic component vector are sorted. It provides a new idea for signal sorting of radiation sources in complex electromagnetic environments.

4 Conclusion

The innovation of the sorting model structure is: (1) The new model performs subsequent processing on the missing pulse after the pre-sampling of the inter-pulse parameters, and extracts its corresponding intra-pulse features for further sorting, which is extended by this process. The feature parameter domain reduces the probability of pulsed average misselection. (2) The new model adopts a step-by-step sorting mode. First, the radar pulse data is pre-sorted, and then the pulsed parameters are further processed by the intra-pulse parameters, and the sorting method based on the inter-pulse parameters and the intra-pulse characteristics is combined. Instead of simply combining the inter-pulse parameters and the intra-pulse features into a joint feature vector, the computational complexity is reduced, which is more conducive to the real-time effective processing of the radar radiation source signal. (3) Feature selection of different types of extracted features in the new model structure, and selecting the optimal feature set. The amount of data that needs to be processed is further reduced while ensuring the correct rate of sorting. (4) The new model structure constitutes a complete radar emitter signal intelligent sorting system, which can realize the rapid automatic sorting of radar emitter signals in complex multi-variable electronic countermeasures environment, thus realizing the automation and intelligence of electronic countermeasure equipment. It will greatly improve the existing manual discriminating methods and improve the technical level of ELNT, ESM and RWR systems.

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