Research on Radar Intelligence Anti-interference Technology Based on Information Assistance

Long Sicheng
College of Environment
Hohai University
Nanjing, China

Ma Qinghua
College of Computer & Information Engineering
Hohai University
Nanjing, China
dspmqh@hhu.edu.cn.com

***Abstract*—In order to achieve good effects of anti-interference performances in the electronic counter-countermeasure(ECCM) conditions, Radar must take the initiative to understand the complex electromagnetic environment, combined with the feedback information to distinguish the type of interference, the interference pattern by building a database parameter technique, the use of game theory, from the anti-interference for library use of effective anti-interference measures; the use of auxiliary information from other sources, information fusion, in order to protect intelligence radar operational performance in complex electromagnetic environments.**

Keywords—interference, anti-interference, assistant information, cognition

I. INTRODUCTION

Radar is an electronic device that uses electromagnetic waves to detect target coordinates and other related parameters. The radar target signal is always accompanied by noise, clutter and various interferences. The extremely weak radar signal detection is performed in such an interference background environment. Broadly speaking, the radar's environment includes target echo information, echo information of the target cooperative equipment, noise interference of the receiving system, nature's passive clutter, interference from adjacent radio equipment and industrial electrical equipment, and artificial interference. Source and passive interference, etc.

In high-tech warfare, radars used for early warning and detection provide intelligence information for air defense operations, maritime surveillance, and missile warnings. They require early, accurate, continuous, and complete warning information to be the main basis for command decisions. The radar used for weapon control is used to track the target, guide and control the antiaircraft gun to aim or direct the missile to the target, which is an important part of the weapon system. The radar has become the main weaponry of information warfare. Under the conditions of modern information warfare, electronic reconnaissance methods use advanced technologies such as electricity, magnetism, sound, light, and heat to form an all-dimensional, three-dimensional electronic reconnaissance system for land, sea, air, and space, and can implement all-weather, full-time domains. Reconnaissance and surveillance, radar's precise location, combat parameters are easily detected by the enemy, and thus become one of the enemy's primary targets of attack, its ability to survive greatly reduced. At the same time, there are more and more modern electronic interference techniques, increasingly stronger interference capabilities, wider interference frequencies, and increasingly stronger interference power, which can generate different levels of interference for different frequencies and radars, and even cause interference. The complex electromagnetic environment that the radar can't cope with is formed until the radar is “squeaked”, which greatly reduces the ability of the radar to find the target, greatly shortens the radar warning time, destroys the radar's role, and reduces the radar's combat effectiveness.

In order to ensure the operational effectiveness of radar in complex electromagnetic environments, it is necessary to fully understand the complex environment in which the radar is located. Firstly, through the perception of radar complex environment, radar actively adopts some anti-interference methods in the frequency domain, space domain, time domain and energy domain, such as adaptive transmit waveform, frequency agility, emission silence, and decoy, etc. Combat performance in a complex electromagnetic environment. Secondly, on the basis of the interference signals that have entered the radar receiving channel, the working mode and parameters of the interference, clutter, and jammer need to be further studied based on the resolution of their own cooperative objectives and interference. By extracting the characteristic parameters of the interference, the type of interference is identified. If the interference is an interference type already existing in the interference library, the corresponding anti-interference measures in the anti-interference measure library are called for the targeted elimination of the influence of interference; if the interference is new For interference, the characteristic parameters of the new interference are extracted, the new interference is extended to the interference library according to certain interference database building principles, and a new effective countermeasure algorithm is developed for the new interference, and the results are added to the anti-interference measure database in time. Through the comprehensive recognition of the radar environment, the anti-interference measures database of radars has been constantly upgraded and upgraded, and the ability of anti-interference and countermeasures of radars has been continuously improved to ensure the operational performance of radars in complex electromagnetic environments.

In the following, several key links such as the recognition of interference environment, the construction of interference patterns, the game strategy of interference and anti-interference, and the scalable and expandable concept of interference library in the intelligent anti-interference decision-making process based on environmental cognition are separately Instructions.

II. INTERFERENCE WITH ENVIRONMENTAL COGNITION

The rapidly changing electromagnetic environment in the battlefield has led to radar designs that have to consider the complex environment including cognitive and non-cooperative targets, as well as interference and clutter. In other words, radar must have good environmental comprehensive cognitive ability. That is, radar has sufficient intelligence or cognitive ability to detect, analyze, study, reason and plan for the history and current conditions of the surrounding complex electromagnetic environment, and use the corresponding results to select the units participating in the work and their corresponding working modes. Work unit operating parameters, using the most appropriate operating parameters (including frequency, waveform, transmit power, beam width, etc.) to complete the various functions. The smart radar can help the user to automatically select the optimal unit of work and its parameters, optimize the resource occupation and work, and even can plan the work of the system for a long period of time according to the existing or upcoming work.

The smart radar's environmental cognitive working model is shown in Figure 1.

The working unit of the smart radar transmits the radar signal. After a complex battlefield electromagnetic environment, the received radar echo signal is sent to the radar scene analyzer. The radar scene analyzer fuses the relevant environmental information received from the external sensors and the radar echoes, and sends the fused environmental information to the radar environment judger; the radar environmental judger obtains prior knowledge about the environment according to the previous one. , Combined with the fusion information about the environment sent by the radar environment analyzer, according to certain rules, the radar environment is recognized, and the radar environment information is fed back to the intelligent environment illumination system, from the intelligent environment illumination system from the waveform library. Radar emission waveforms are selected, and the cognitive function of the environment is completed through power control and selection of appropriate frequency points and launch opportunities, making the smart radar achieve the best compromise in space-time-energy and other resources and performance. By continuously interacting with the environment, we will enhance our awareness of interference and provide more accurate information for the identification of interference and the implementation of subsequent anti-interference programs. To a certain extent, smart radar has a strong self-adaptive ability of the environment, and can realize the harmony and unity of the radar working parameters, the use environment, and the user's needs by using the spatial state model and parameter recursive estimation.

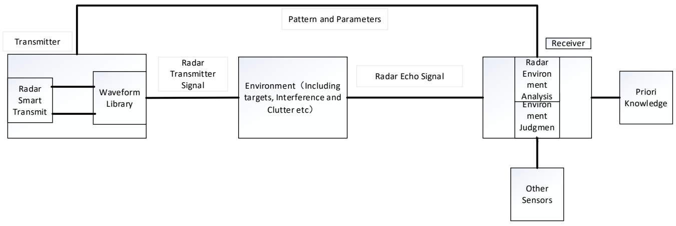

Figure1. Interference with environmental cognition

III. INTERFERENCE STYLE LIBRARY

Through the recognition of the interference environment, we have a comprehensive understanding of the environment in which the radar is located. For electromagnetic interference coming from one's own cooperation target equipment, it is possible to avoid "false injury" to friendly target information through resource scheduling management including space-time energy; for noise and some stationary clutter, environmental awareness can be adopted. The clutter map is constructed to minimize the impact of noise and clutter on the smart radar; for the active interference released by the enemy, the interference of the environment must be recognized, and the characteristics of the interference should be extracted to accurately identify the type of the interference. And for this type of interference, targeted effective anti-interference measures are taken. In this process, interference style database building technology is very important. Figure 2 shows the schematic diagram of interference style database building technology.

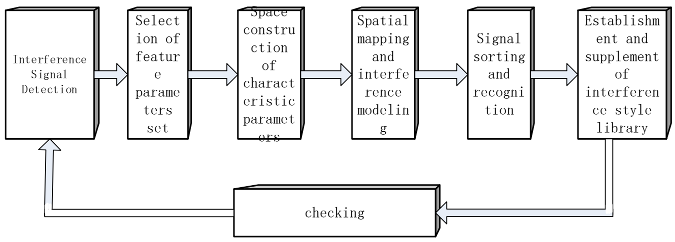

Figure2. Interference style library build plan

The high probability of active interference type identification is the basis of the entire radar anti-interference process. At present, the identification of radar active interference types largely depends on the experience of radar operators. However, in a complex EW environment, it is difficult for radar operators to correctly identify different types of radar interference signals in real time. Therefore, the intelligent research of radar anti-interference technology has important military significance.

Through the recognition of the radar interference environment, parameters such as amplitude, frequency, azimuth, arrival time, repetition period, repetition frequency, and modulation type of the interference signal are obtained. Taking the analysis of the interference mechanism of various typical interference types as the starting point, the characteristics of different types of interference signals in the time domain, frequency domain, and other transform domains are summarized, and the characteristic parameters with large differences among various types of signals are selected. Certain criteria establish a set of interference signal feature parameters and construct a feature parameter space. Then the spatial mapping and interference modeling are further analyzed. Combined with some prior information in the training phase, advanced algorithms such as statistical decision, support vector machine, neural network and fuzzy recognition are used to sort the interference signals and interfere with the interference types. Classification to identify the type of active interference signal. If the interference type already exists in the interference pattern library, only the interference pattern parameters need to be reported to the intelligent decision system, and the intelligent decision system calls the corresponding anti-interference implementation scheme from the anti-interference measure library. If the interference type does not exist in the current interference pattern library, the new interference characteristic parameters are used to add the interference type to the interference pattern database according to a certain rule, and the intelligent decision system is requested to update the anti-interference measure library in time. Corresponding countermeasures. Interference pattern library and anti-interference measure library with synchronous expandable function.

IV. INTERFERENCE AND ANTI-INTERFERENCE GAME STRATEGY

Interference and anti-interference are a pair of contradictory relations. They are displayed on the battlefield as the control and anti-control of the use of the electromagnetic spectrum by the opposing parties. This is manifested in the game between the commanders at all levels. Find out the weak links that interfere with each other and carry out targeted design to achieve the miraculous effect of defeating the enemy. In the actual electronic confrontation, both sides are constantly changing their strategies (based on the performance of the disturbance and the performance of anti-interference) in the struggle to win. This needs to be solved by game theory. The game theory approach takes a step further than the purely strategic adaptive technology, which can maximize the total benefit of a party in the fight, while the total loss is minimal.

In radar countermeasures, the purpose of the radar is to send signals to detect targets, and the purpose of the jammers is to emit interference signals that prevent the radar from detecting targets. From this point of view, the radars and jammers of both sides of modern electronic warfare constitute the players in the game. The battlefield environment is changing rapidly, especially with the rapid development of science and technology, radar's working system, radar's working mode, jammer's interference mode can be changed at any time. However, how the radar system and working model will change will be unknown as an interfering party. What kind of interference method will the interfering party adopt? The radar is also unaware of this. Therefore, the essence of the modern electronic confrontation process is a game process, and the evaluation of the corresponding anti-interference effect is also a dynamic process.

Using game theory, we can study the dynamic evaluation of anti-interference effect in radar countermeasures, and use the anti-interference effect as a game profit function to quantitatively describe the anti-interference effect in terms of time, space, frequency, and energy, and seek anti-interference effects. The comprehensive assessment algorithm provides the decision-making basis for the radar parties involved in the confrontation. The application of game theory in the dynamic evaluation of anti-interference effect can be used to evaluate the electronic countermeasures in advance without knowing the specific strategy adopted by the interference machine. In this way, it is possible to dynamically adjust the favorable countermeasures against radar based on the evaluation results. Therefore, it can effectively and reliably counter the disturbances such as interference interference of the jammer, which is of great significance to the tactical subordinates of the electronic warfare.

V. ANTI-INTERFERENCE EFFECTIVENESS ASSESSMENT

Radar anti-interference effectiveness evaluation is an important part of radar operational effectiveness assessment, and it is also an important basis for radar to intelligently adopt an active anti-interference method by feedback of radar anti-interference effect to radar transmitter. At present, some mainstream radars in China have made anti-interference designs based on the characteristics of radars. However, how effective and how the anti-interference designs used in complex electromagnetic environments are required to be analyzed and demonstrated by a large number of tests to obtain quantitative results The analysis provides an important basis for radar anti-interference performance design improvement.

According to the types of interference that radars face, the anti-interference performance of radar-based interference and deception interference can be evaluated separately. In the evaluation of counteracting interference interference performance, noise power conversion or signal (dry) noise ratio conversion method is used to evaluate radar anti-interference performance, reflecting that in a interference environment, the radar adopts a series of anti-interference measures and means to target synthesis. The ultimate improvement in detection capabilities, not just the suppression of interference. If the suppression of interference, while affecting the echo signal strength of the target, the overall anti-interference performance of the radar will be compromised. In the evaluation of anti-spoofing interference performance, radar anti-interference performance evaluation was conducted using true target tracking probability and false target rejection probability. For intensive false-target interference, the conclusion that radar anti-intensity false target capability is strong can be obtained by comprehensively considering the true target tracking probability and the false target rejection probability.

In order to describe the anti-interference ability of radar, to measure the radar working quality under complex interference environment, some factors or coefficients need to be used as indicators of radar anti-interference quality. Since the anti-interference technology involves a wide range of areas and can have different metrics from different angles, it is difficult to define a complete system that takes into account various impacts and estimates the correlation between radar sub-systems and anti-interference capabilities. coefficient.

VI. INTERFERENCE LIBRARY UPGRADES AND EXTENSIONS

Throughout the entire radar equipment life cycle, with the fight against both the interference and radar anti-interference, new and combinative interference patterns will continue to emerge. If radar design and anti-interference measures are still in the early stage of radar development, the anti-interference design of smart radar adopts an open-type, full-life-cycle upgrade design concept, which can prevent the emergence of new types of interference and combinational interference. The corresponding countermeasures shall be promptly updated and the anti-interference measures shall have similar scalable and extensible functions of the virus database. Figure 3 shows a block diagram of the scalable and extensible features of the anti-interference measures library.

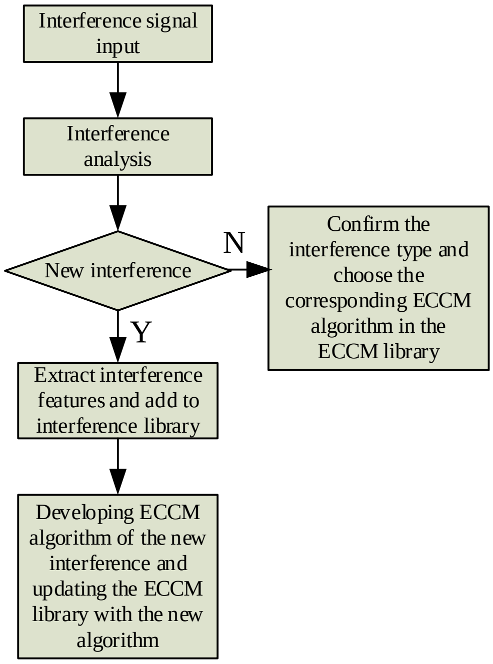

Figure3.Interference library upgradeable scalable schematic

After the recognition of the interference environment and the accurate identification of the interference, if the interference is a new type of interference, it is extended to the interference library, and the anti-interference measure library is also upgraded and expanded in time. The scalable and scalable concept of a virus-like library in a smart radar includes two levels. The first is the improvement of the existing successful anti-interference measures, and the expansion of effective countermeasures for new interferences and complex interferences newly added to the interference library; the second is more effective as the research on interference type algorithms is deepened. Anti-interference measures continue to emerge, and new effective anti-interference measures are continuously upgraded in anti-interference measures.

VII. CONCLUSION

This paper presents a smart radar anti-interference strategy based on the perception of interference environment. Through interaction with the environment, Smart Radar continues to strengthen its ability to recognize the environment. On the basis of correctly identifying the types of interference, through the use of interference-style database building techniques and the use of game theory, effective countermeasures for anti-interference are selected from anti-interference measures to ensure the combat performance of smart radar in complex electromagnetic environments. The interference bank and anti-interference measure library have scalable and extensible capabilities throughout the entire life cycle of the radar to accommodate the emerging complex interference-free and combinatorial interference environment in the future.

REFERENCES

[1] G.T. Capraro, A. Farina, H . Griffiths and M.C. Wicks", "Knowledge-based radar signal and data processing", IEEE Signal Processing Magazine, Vol. 23, pp. 18-29, 2006 .

[2] Guerie J R . Cognitive radar: a knowledge-aided fully adaptive approach [C]//2010 IEEE Radar Conference. Washington: IEEE Press, 2010:1365-1370 .

[3] Akhtar J. Orthogonal block coded ECCM schemes against repeat radar jammers[J]. IEEE Transaction on Aerospace and Electronic Systems, 2009,45(3):1218-1226 .

[4] Greco M, Gini F, Farina A . Radar detection and classification of jamming signals belonging to a cone classs[J]. IEEE Transaction on Signal Processing, 2008,56(5):1984-1993 .

[5] Rabideau DJ, Parker P. Ubiquitous MIMO multifunction digital array radar [C]. The thirty-seventh asilomar conference on signals, systems and computers, 2004:1057-1064 .

[6] S. Haykin, "Cognitive Radar", IEEE Signal Processing Magazine, Vol. 23, pp. 30-41, 2006 (invited) .

[7] Wang Feng,etc. Intelligent Anti-Jamming Technique in Radar[J]. Modern Radar, 2014,36(1):80-82.

[8] Zhao Guoqing. Theory of Radar Countermeasure[M]. Xian, Xidian University Press, 1999.

[9] Zhang Guangyi. Some Measures for Enhancing ECCM Capabilities of Radar Systems[J]. Modern Radar, 2000,(1):6-12.

[10] Li Keda. Basic Anti-Jamming Technology of Modern Radar[J]. Aerospace Electronic Warfare, 2004, 20(2):15-19.