Research on Complex Electromagnetic Environment Simulation System

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Abstract. With the battlefield electromagnetic environment become more complex, these also weaken operational effectiveness of information technology equipment. Therefore, to seize the electromagnetic superiority become the key of the war in the information control and then take the initiative. In view of the complicated electromagnetic environment simulation, this paper studies the hardware and software of complex electromagnetic environment simulation system. The system has the function of electromagnetic signal parameters editor, multi-domain real-time monitoring function, parameter real-time control function, test evaluation function, the target database management function and system configuration function. To improve the ability of combat troops in complex electromagnetic environment is of great significance.

1. Introduction
Complex electromagnetic environment simulation is a comprehensive subject. It includes complex signal generation and analysis [1]-[2]. Complex electromagnetic environment simulation with real electronic equipment has outstanding advantages, but it is very difficult to realize usually, and cannot be the main means of complex electromagnetic environment simulation [3]. In order to meet the requirements of simulation training for complex electromagnetic environment, we can use special electronic warfare simulator to replace the real equipment. Electronic warfare simulators not only include a single analogue device that produces a particular signal, but also a comprehensive simulation system composed of multiple analogue devices that can produce complex signal environments. Simulators usually have the advantages of relatively low cost, flexible function, strong adaptability and easy deployment, can be used in the field live-fire drills, can also be used in indoor form vivid electromagnetic signal environment, and meet the requirements of electronic warfare concealment[4]-[5]. It is of great significance to develop a complex electromagnetic environment simulation system combining software and hardware to improve the combat ability of troops in complex electromagnetic environment.

This paper studies a method to build a certain level of complex electromagnetic signal source, uses vector signal transmitter and frequency signal generator to generate complex electromagnetic environment. In this paper, the designed system platform has the function of electromagnetic signal...
parameters editor, multi-domain real-time monitoring function, parameter real-time control function, test evaluation function, the target database management function and system configuration function.

2. Research on simulation methods of complex electromagnetic environment

The generation of complex electromagnetic environment is the precondition and foundation of the test of weapon system in complex electromagnetic environment, and the world countries attach great importance to the simulation of complex electromagnetic environment. Throughout the domestic and foreign main methods in complex electromagnetic environment simulation, according to the different use of equipment and means, generally can be divided into three categories: the real electronic equipment to generate complex electromagnetic environment, complex electromagnetic environment generated by the simulator, using computer simulation technology to generate complex electromagnetic environment. From the perspective of the practical application of complex electromagnetic environment simulation generated, the above three methods have their own advantages, also have their own limitations, they also have different using occasions, which is based on the actual complex electromagnetic environment simulation of electronic equipment and electronic simulator generating method is used in the field live-fire, real soldiers drill, and based on the computer simulation method for generating complicated electromagnetic environment simulation are used to combat simulation and indoor deduction. This paper focuses on the simulation of complex electromagnetic environment simulation.

Based on emulator generating complex electromagnetic environment, the electromagnetic environment is generated by simulation of computer and simulators, and its schematic diagram is shown in figure 1. The control centre is used to generate the model that is required to simulate electromagnetic environment, and is responsible for managing the operating status of each simulator, such as running, stopping, etc. Signal simulator is composed of simulator control software and signal generator. Its main function is to adjust signal generator according to control command from the control centre of work status, to produce the actual electromagnetic signal.

![Figure 1. Complex electromagnetic environment block diagram based on simulators](image)

The complex electromagnetic environment model is composed of a number of data frames based on time, as shown in table 1. Each frame data contains the working moment, the required simulator and the parameter information of each simulator.

| Point in time | Required simulator       | Parameter Settings                   |
|--------------|--------------------------|--------------------------------------|
| Time 1       | Radar simulator          | Power, frequency and other parameters|
| Time 2       | Clutter simulator        | Gaussian noise IQ modulation         |
| Time N       | Electronic interference  | Power, frequency and other parameters|
Simulator usually has a relatively low cost, flexible, adaptable, easy deployment, etc., can be used for field live-fire drills, can also be used to form the electromagnetic signal environment of realistic indoors. There are many types of simulators, which can be divided into radiation-type simulator and injection simulator according to the way of radiating electrical signals. According to the different simulation objects, it can be divided into radar signal simulator, communication signal simulator, clutter signal simulator, etc. According to the partition of the application, it can be divided into the electromagnetic signal environment simulator, the main combat equipment model matching simulator and so on.

3. Research on simulation methods of complex electromagnetic environment assessment

The evaluation of electromagnetic environment includes three aspects: pretreatment of electromagnetic signal, extraction of effective parameters and evaluation based on evaluation algorithm.

3.1. Electromagnetic signal processing

Due to the complex electromagnetic environment, there may be many kinds of signals in the same channel which are similar in time and frequency domain. In this case, the conventional time-frequency filtering method can not be used to extract effective signals. The array signal processing technology developed later is a main method of multi signal separation, but this method needs to know the precise array parameters which can not be achieved in the non cooperative battlefield environment.

BSS algorithm can recover the waveform of the source signal from the observed mixed signal under the condition of unknown mixing process and source signal. According to the number of source signals, blind signal separation algorithm can be divided into adaptive blind separation (the number of source signals is equal to the number of observation signals) and underdetermined blind separation (the number of source signals is greater than the number of observation signals).

Adaptive blind separation can be divided into time domain and frequency domain. If the algorithm used converges, the time-domain algorithm can achieve better performance, but the complexity of the existing algorithm is usually relatively high and the convergence speed is relatively slow. The frequency-domain algorithm transforms the time-domain signal into the frequency-domain signal through the short-time Fourier transform, and the convolution mixing in the time-domain is transformed into the instantaneous mixing in the frequency-domain through the short-time Fourier transform. In this way, the existing instantaneous mixing blind separation algorithm with superior performance can be used, and the operation amount can be greatly reduced.

Underdetermined blind separation is a very complex problem, but it can usually be realized by using the sparsity of the signal, because many signals have sparsity characteristics, or they can be thinned by appropriate mathematical transformations such as Fourier transform, short-time Fourier transform and wavelet transform. So far, the two-step method is a common method to solve the problem of underdetermined blind source separation. The first step is to use k-means clustering algorithm to estimate the aliasing matrix; the second step is to use the shortest path method to recover the source signal.

3.2. Extraction of characterization parameters

The complexity of complex electromagnetic environment is mainly manifested in four aspects: time domain, frequency domain, energy domain and spatial domain. In the sense of strict grid, the factors that affect the complexity of electromagnetic environment also include the intensity and intensity of electromagnetic radiation background noise, the direction of signal coming, polarization, modulation mode, pulse width and many other factors. There are many complex parameters to represent the electromagnetic environment, and the evaluation indexes selected in different application scenarios are also different. Although it is difficult to accurately characterize the complex electromagnetic environment from the spatial, frequency, time and energy domains, it is still necessary to define the following parameters to understand and describe the electromagnetic environment. Such as
background noise level intensity, time occupation, frequency occupation, frequency coincidence, space coverage, spectrum density, etc. During the complexity characterization and evaluation of battlefield electromagnetic environment, it is necessary to specify the electromagnetic radiation evaluation object in a specific time period, a specific space range and a certain frequency band range. The influence of surrounding electromagnetic environment on the evaluation object shall be measured according to the efficiency degradation of the evaluation object.

3.3. Evaluation algorithm
In complex electromagnetic environment assessment. In the early 1960s, the emergence of pulse radar and high-sensitivity receiver led to high pulse density battlefield electromagnetic environment and electromagnetic signal blocking. In order to predict the future state of electromagnetic environment, Tetley studied the analytical prediction method of electromagnetic environment based on mathematical model of computer simulation. In recent years, many domestic scholars have conducted preliminary research on the complexity assessment of electromagnetic environment. But most of the evaluation methods are not very mature and lack of stability. In reference, fuzzy mathematics theory is used to evaluate the complexity of electromagnetic environment. Firstly, a decision set is constructed, and then experts determine the single factor judgment matrix and the weight coefficient of each single factor. Finally, the complexity of electromagnetic environment is determined according to the principle of maximum membership. This method is relatively mature and reasonable.

4. The design of simulation system

4.1. Overall framework of the simulation system
As shown in figure 2, the overall framework of the simulation system is divided into three layers: control layer, middle layer and signal layer. Control layer includes the control centre and the database, the middle layer including simulator and the necessary instruments of assessment, such as microwave millimetre wave signal analyser and real-time spectrum analyser, signal layer that is formed by complex electromagnetic environment, weapons and equipment testing in the signal.
Figure 2. Block diagram of complex electromagnetic environment simulation system

4.2. The software implementation of Simulator control terminal
The simulator control terminal mainly composed of simulation model, network communication module and database. The model solution module realizes that the analogue signal type is transformed into a series of control parameters, which is the core of the simulator construction. Network communication module realizes network communication between control terminal and control centre and signal generator. The database is used to store the simulation type supported by the software, the simulation type of the current simulator, and the signal generator parameters.

4.3. The software implementation of control centre module
The control centre consists of equipment management module, control module, environment editing module, equipment deployment display module, network communication module and analysis evaluation module. Software programming uses object-oriented design method, each module corresponds to a class. Environment model editing module is used for the editing of electromagnetic environment. This module has the following functions:

1) Test object editing, the test object parameters mainly include working frequency, bandwidth, modulation format and location.

2) Simulation source editing, the simulation source is the main element that constitutes the electromagnetic environment, and its setting mainly includes the parameters required by power, dimension, working time and equipment type.
(3) The presupposition and the consistency test of electromagnetic environment complexity, the test object provides the frequency range, scope and bandwidth of the assessment of electromagnetic environment. We can evaluate the electromagnetic environment complexity of every time point, the calculation is provided by the function of the system evaluation module interface.

5. Conclusion
In this paper, the realization process of electromagnetic environment simulation and evaluation system is studied, and the construction method of database and modules is introduced in detail. The design and development of a set of complex electromagnetic environment simulation and evaluation system platform. By adopt the method of hardware and software definition generate actual signal to realize the electromagnetic environment simulation, by extracting the real-time spectrum data and electromagnetic monitoring data, electromagnetic environment assessment method based on improved fuzzy mathematical theory is adopted to evaluate the electromagnetic environment complexity. Test results show that the system can effectively build a certain level of complex electromagnetic environment, through to the signal analysis instrument to capture data for real-time processing, can extract signal time domain characteristic parameters, frequency domain characteristic parameters and evaluate the complexity of electromagnetic environment in real time. Having a certain use value.

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