Research on Electromagnetic Environment Situation Display of Digital Map Radar based on 3D GIS

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Abstract. In order to meet the requirements of electronic countermeasure application, the visualization analysis method of information electromagnetic environment was studied. The elements of data operation parameters of electromagnetic environment were put forward, and a comprehensive display system of electromagnetic environment information was developed. Then the dynamic display of radar detection range in complex electromagnetic environment based on GIS was completed.

1. Introduction
The integrated display system of electromagnetic environment information consists of interference source state control, interference effect calculation and interference situation display.

a) State control of interference source
It can add and change jamming platform and equipment parameters in configuration library.
It can set the switch and parameters of radiation source automatically (step by step) or manually according to the scenario.

b) Situation display of electromagnetic environment
It can select a single platform to view the radar status separately and generate status chart of the radar operation.
It can generate global radar jamming map. When radar and other equipment are interfered by jamming sources, it can regenerate radar detection area according to jamming model and change the influence of battlefield electromagnetic environment on communication equipment.
Be able to display interference status.
It can display the status of other platforms in the current interference range and calculate the interference status of other platforms in the interference range.

2. Complex electromagnetic environment design explanation
2.1. Calculation of interference effect
The jamming effect calculation module is a module which can generate the jamming analysis and operation results by calling the complex electromagnetic environment operation model, according to the distance, relative angle, jamming performance parameters, radar performance parameters and other relevant parameters between the jammer and the platform to be analyzed [1-2].
Jamming effect calculation is to extract the relevant parameters required by the complex electromagnetic environment from the platform equipment model, transfer the parameters to the
operation model, generate the detection distance of each angle of the jammed radar after the operation, and send the results back to the jamming effect calculation module for subsequent interface display. The operation parameters are shown in the following table.

| S / N | Radar parameter category | Unit | Jamming source parameter category | Unit | Environment parameter category | Unit |
|-------|--------------------------|------|----------------------------------|------|-------------------------------|------|
| 1     | Frequency range          | MHz  | Working frequency                | MHz  | Boltzmann constant            | None |
| 2     | Narrow filter band       | Hz   | Jammer bandwidth                 | Hz   | Ambient temperature           | K    |
| 3     | System noise coefficient | dB   | Jammer gain                      | dB   | Radar cross section           | M2   |
| 4     | Average transmitting power | W  | Interference power               | w    |                               |      |
| 5     | Transmit antenna gain    | dB   | Interference distance            | Km   |                               |      |
| 6     | Receiving antenna gain   | dB   | Feeder loss of jammer            | dB   |                               |      |
| 7     | Detection of required signal to clutter ratio | dB | Polarization mode                | Enumeration type |                               |      |
| 8     | System feeder loss       | dB   | Interference suppression coefficient | / |                               |      |
| 9     | Beam width               | °C   |                                  |      |                               |      |
| 10    | Polarization mode        | Enumeration type |                               |      |                               |      |
| 11    | Working mode             | Enumeration type |                               |      |                               |      |
| 12    | Antenna pattern          |      |                                  |      |                               |      |

2.2. Electromagnetic environment situation display

Situation map is developed on the basis of map, GIS and communication science. It first appeared in the US general combat situation map. The visualization of 3D electromagnetic environment situation map based on GIS map can use situation plotting. The three-dimensional electromagnetic environment, like the two-dimensional electromagnetic environment, is also the representation environment of symbol system. In the three-dimensional electromagnetic environment, the situation symbols in the two-dimensional electromagnetic environment need to be reconstructed to meet the new needs. The symbol system of two-dimensional situation map is relatively complete, which has been practiced for a long time, but it can not express the third element. In the three-dimensional situation, it is easier for people to understand the third symbol intuitively. In the three-dimensional situation, people can observe the current situation from multiple angles, change the line of sight and view direction arbitrarily, avoiding many blind areas in the two-dimensional situation map [3-6].

The electromagnetic environment situation display module extracts the radar detection range array from the calculation result, and then describes the radar detection range according to the array and displays it on the interface by calling the calculation result of jamming efficiency [7-10].

In this part of functions, all the radar platforms that have been calculated can be displayed by clicking the menu; the detection range of the selected objects equipped with radar can be displayed by selecting the display mode on the map.
3. Design process of radar 3D situation display software in typical electromagnetic environments

3.1. Algorithm design of radar 3D situation display
Load the antenna gain into all devices, judge whether the radar is in the jamming area, calculate the jamming power of the current angle in the jamming area of the radar, complete the system noise calculation, calculate the radar detection range under the current angle jamming, calculate the jamming power of each degree in the 360 degree range of the radar and between the radar and each jamming device, and finally form a complete detection measuring range. The algorithm flow is shown in Figure 2.

3.2. Algorithm implementation
The operation model of complex electromagnetic environment is the core of the whole electromagnetic interference operation, which mainly includes: antenna gain loading, effective interference state judgment, judging whether the radar is in the interference area of the jammer, calculating the angle and distance between the radar and the jammer. The radar detection is divided into 360 degrees, and the jamming power between each degree, radar and each jamming equipment is analyzed [11]. When drawing the detection range and jamming range of radar, the key is to calculate...
the jamming power between radar jamming equipment and judge the disturbed range. The calculation procedure is as follows:

a) The gain of the antenna is recorded as Gpoini by cinke function or antenna pattern;

b) The jamming power is calculated by formula \(10 \times (\text{math.log10}(PJ) + \text{math.log10}(\text{Lam} \times \text{Lam}) + \text{math.log10}(FR) - \text{math.log10}(\text{math.pow}(\text{math.Pi} \times 4, 2)) - \text{math.log10}(RJ \times RJ) - \text{math.log10}(FJ)) + GJ + gpoini - Q - KD;\) wherein, the transmitting power of PJ jammer, Lam is the radar wavelength, FR is the radar receiver bandwidth, RJ is the distance from radar to jamming equipment, FJ is the jammer bandwidth, and GJ is the jammer bandwidth Jamming antenna gain, q is the anti-jamming factor of multi factor radar, KD is the polarization loss;

c) The results of multiple interference device operations are superposed and recorded as getplatemc;

d) The system noise is calculated, and the result is recorded as GNR, the formula is \(10 \times (\text{math.log10}(k) + \text{math.log10}(T0) + \text{math.log10}(BN)) + FN;\) where k is Boltzmann constant, t0 is the ambient temperature, BN is the Doppler bandwidth of signal processing, FN is the unified noise coefficient.;

e) Calculate the detection range of current angle radar, the formula is: \(\text{math.pow}(10 \times (\text{math.log10}(PAV) + \text{math.log10}(\text{getlam2}(\text{LAM})) - \text{math.log10}(\text{math.pow}(4 \times \text{math.Pi}, 3)) - \text{math.log10}(\text{GNR + getplatemc})) + GT + GR - L + \text{CITA} - D0) / 40);\) where PAV is the average radar power, Lam is the radar wavelength, GT is the transmission antenna gain, GR is the receiving antenna gain, l is the system loss, and CITA Is RCS, d0 is the minimum detectable signal-to-noise ratio.

![Figure 3. Electromagnetic environment situation display](image)

### 4. Conclusion

Based on the background of electronic countermeasure, the three-dimensional dynamic display of electrical changes in the radar detection range under the complex electromagnetic environment was studied, a typical dynamic simulation of the radar environment, which can display the electromagnetic environment situation intuitively and comprehensively was given, and was of great significance for the commander to make scientific decision.

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