Radar digital beam research and battlefield experimental simulation of air-sea integrated

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Abstract. We have studied the electronic warfare design scheme of airborne integration sharing a radar digital beam. This multi-beam integration technology adaptively switches from one type of system radar to another type of system radar according to different detection targets. Due to various bandwidths, the study of various target spectrum conversions of different bandwidths from the notch angle, the narrowband interference in the broadband environment, and the interference of the spectrum template, it is adopted that the recursive neural network algorithm optimization using multiple beams, the beam forms a null trap at the frequency of the interference, thereby solving the waveform interference problem of different targets, and realizing the effect of the integrated communication of the air-sea integrated communication of the conformal antenna, and simulation experiments, and achieved good results.

1. Introduction
The radar detection target signals are composed of the air ground target signal and the target signal in the sea in the early battlefield electromagnetic situation. That is to say, each target has its own independent antenna structure and independent sensor carrier. The battlefield electromagnetic field situational awareness system is huge, and the signals transmitted by each other are time-consuming, large in quantity and unresponsive. It can not meet the requirements of modern battlefield transmission signal electronic response to determine life and death. We can detect all empty Haitian targets with only one kind of radar signal, which not only saves equipment costs, reduces weight, but it also greatly shortens the time of transmission back and forth between different targets. The targets targeted by the antennas that separately detect the air-ground targets, if they are tanks and aircraft, are treated in stealth, its usually using a half-space RCS electromagnetic scattering analysis method. What the detection of underwater targets represented is a sonar sensor based on active sonar by submarines. it is carried out for the fusion of all the above target signals, The Kalman filter algorithm is used in the early stage to solve the antenna interference problem of multi-domain data fusion. A radar digital wave velocity technology based on array signal processing is initially formed. It points out a research method of synchronous data association, which is applied to space-time filtering software and hardware systems, reflecting the transformation law and transformation design of different frequencies.

When the conductive particles are affected by external conditions, the electronic energy level transition occurs, and in the process of generating electromagnetic radiation of different frequencies, the sensor get obtains the relationship between the parameters including the conductivity of the noisy target. the target beam shape is analyzed by locating the target, its are found that the target background noise temperature and the target size feature of the target.
In 1960, the US Naval Air Command took the lead in researching antennas for targets such as aircraft and missiles, ships, etc., and using sonar to detect underwater targets, and combining the two to form a conformal array antenna, basically satisfying the miniaturization and totality of the antenna. Caliber requirements.

At this stage, the materials with the forbidden band width are connected to form two different heterostructures. The heterojunction energy band produces a photovoltaic effect under the action of the external field, thereby changing the velocity distribution of the electrons, and deriving the application of the Boltzmann equation to solve the problem of the change of conductivity of different layers of materials, the radar vector sub-radar of air-sea integrated.

The multi-antenna system dynamic resource allocation algorithm provides ideas for multi-target multi-sensor data fusion and separate target control. Harbin Industry is studying the gateway arrangement method of minimizing the number of gateways to meet the requirements of heterogeneous network communication. It is solved that the problem of maximizing the bandwidth allocation of the system packet transmission rate, and so it is realized that the time-sensitive heterogeneous network radar data fusion achieve joint control of airborne target data.

2. Modeling and Battlefield Situation Analysis of Airborne Integrated Radar Signals

It is more mature that the radar antenna design method for studying the integration of air and sea for the antenna array element on the large-size platform, a random sparse area array is used to represent the air-ground target signal, and the horizontal axis of the antenna element represents the sonar signal, which are all obey a certain gaussian distribution within a certain range. In recent years, with the development of wireless optical communication signals integrated with air and sea, the laser pulse is incident on seawater, and the sonar signal is laser acoustic signal. The field consists of the average JONSWAP spectrum and the gradient and directional derivative. The wave dynamic model determines the direction of the sound source through the microphone array.

Radar digital multi-beam technology adopts the key technology of multi-layer fast multipole[1]. It is based on the eighth-order nonlinear high-order wave theory, the RaoWilton-Glisson (RWG) basis function is used to establish the electromagnetic field mixed field integral equation. The equation solution is based on the incident electromagnetic vector sensor array. At the same time, the beam direction can be directed to the steering ground target, reflecting the polarization information of the complete electromagnetic vector signal, and the digital array multi-beam forming method is synthesized by the polarization information of the sonar and the air ground target. The mathematical model method for constructing conformal array signals in engineering: the system function A with high-order Genocchi polynomial can be transformed into the multiplication of orthogonal matrix Q and triangular matrix R, that is A=QR, the model is difficult to achieve high privacy and security, so the direction of beam design theory in recent years, it is based on quantum computing quantum radar, using qudit encoding and quantum key distribution protocol BB84 protocol.

It is a non-uniform array that the hardware structure of the conformal array antenna. The design should consider the influence of the mutual coupling effect of the array, by adjusting the weight function of the system method, its are arranged the units of the dual-band common-caliber antenna array working in L/X at a specific line equidistant spacing. The relationship between the main lobe and the side lobe of the nth array element[2]:

\[ \Delta \phi = \alpha \Omega e^{i\lambda} \]

In the formula, \( \alpha = \frac{2\pi}{\lambda} \), \( \lambda \) is wavelength; \( W \) is the weighting matrix; \( \Omega \) is the main lobe solid angle; \( \Omega = \int \rho d\Omega \), \( P \) is the array antenna power radiation function[3].

When the multi-beam antenna detects the target in the sea, it is selected that the basis function based on the high-period function. When the air-ground target is encountered, its can be converted into the combined chip compression signal waveform by the combination of the steepest-down method and the Newton method. When the signal is intentionally forwarded into multiple orthogonal waveforms, the true target signal echo and the interference signal have time domain differences, and the
occurrence of fraudulent interference is prevented. Improved channel utilization, this example demonstrates that the mathematical model of the digital multi-beam antenna can adaptively meet the needs of various spectral-frequency template switching.

The mathematical model of the conformal array antenna can be applied to the battlefield to adaptively perceive the different situations of the air-sea integration. The NJBBS curved surface mathematical formula is introduced into the target RCS calculation formula, and the surface Rao-Wilton-Glisson (RWG) basis function is derived. Discrete equations of electromagnetic relations are discrete algebraic equations[4], the target surface current can be decomposed into the sum of the surface currents produced by each triangular bin, expressed is: \[ J(r) = \sum_{i=1}^{N} I_i f_i(r) \], in most cases, secondary scattering between surfaces is considered, and the resulting scattered field is expressed as:

\[
\mathbf{E}(x, y, z) = \sum_{i=1}^{N} \sum_{j=1}^{M} E_i(x_i, y_j, z)
\]

The control points and weights of the Bezier patch are given, and the impedance matrix formed by the single curvature surface is decomposed and compressed. A mixed Ludwig method is used to solve the integral equation for each point in the frequency band. There is a difference between the aircraft and the missile in the chain code, the marker map and the polygon approximation[5].

\[ v = \frac{\pi x}{\lambda} \]

Where \( x \) is the thickness of the waveguide, \( n \) is the refractive index, and \( \Delta \) is a weight of the relative refractive index difference, The control points and weights of the Bezier patch are given, and the impedance matrix formed by the single curvature surface is decomposed and compressed. A mixed Ludwig method is used to solve the integral equation for each point in the frequency band. If there is a chain code between the aircraft and the missile, the difference between the map and the polygon approximation can be marked. The difference between the different shapes of the air-ground target and the electromagnetic scattering is analyzed, and the electromagnetic scattering model of various targets is obtained.

When the same multi-beam radar detects the target in the sea, the high-speed vehicle is regarded as a steel body in the water, and the force in the orthogonal generalized coordinate system can only consider the head and the tail immersed in the water[6]. According to Newton's second law:

\[
m \frac{d\mathbf{\bar{v}}}{dt} + mw \times \mathbf{\bar{v}} + \Delta m \frac{d\mathbf{\bar{v}}}{dt} = \sum \mathbf{F}
\]

In which, \( \mathbf{\bar{v}} \) is the rigid body speed, \( w \) is the rotational angular velocity,

\[ h_i^2 = (\frac{\partial x}{\partial q_i})^2 + (\frac{\partial y}{\partial q_i})^2 + (\frac{\partial z}{\partial q_i})^2, q_i = q_i(x, y, z) \]

The digital multi-beam antenna technology can separate the same frequency band form by spatial domain processing, and can complete the digital baseband signal from the sky target to the water target, and obtain high-resolution and low-sidelobe performance capture and tracking. It can provide high-quality search data, and can deal with a large number of targets in the air, and determine the various parameters of the target scattering field in a complex environment by finding the conductivity values of the stealth materials of various targets. Thus established the battlefield situation of the integrated electronic warfare in air and sea.

3. Modeling and Battlefield Situation Analysis of Air-Sea Integrated Radar Signals

Due to various bandwidths, various target spectrum conversions bring about narrowband interference in the broadband environment and interference of the spectrum template, based on the mathematical
model of the original airborne integrated radar digital beam, a neural network algorithm is applied to optimize the anti-interference optimization of the common-caliber antenna. The relationship between the output and the input uses a recurrent neural network:[7]

\[ F = \sum_{i,j=1}^{N} W_{ij} a_j - \theta_j \]

where \( W_{ij} \) is the weight, \( a_j \) is the input of each element of the input layer, and \( \theta_j \) is the output layer error, which is proportional to the output. the weight \( W_{ij} \) decreases by the gradient and is also proportional to the output error. \( W_{ij}(N+1) = W_{ij}(N) + \alpha \theta_j \)

The output layer can suppress the side lobe level of the interference in the desired direction, and minimize the error between the main lobe width and the expected value. When there is interference in a certain direction, each beam will generate a null suppression interference in this direction.[8]

On the basis of the tracking task of the dispersed target radar, the air-sea integration can use the distributed control protocol to generate position information by using the distance sensor, and switch the information through the heterogeneous network channel to obtain the perturbation solution of the velocity potential function. It can get a mathematical model of the control of various targets:

\[
\begin{bmatrix}
    x_{k+1} \\
    V_{k+1} \\
    a_{k+1}
\end{bmatrix} = \begin{bmatrix}
    1 & \frac{dT}{dt} & T \\
    0 & 1 & \frac{dT}{dt} \\
    0 & 0 & 1
\end{bmatrix} \begin{bmatrix}
    x_k \\
    V_k \\
    a_k
\end{bmatrix} + \begin{bmatrix}
    \frac{dT}{dt} \\
    1
\end{bmatrix}
\]

In the formula, \( x_k \), \( V_k \), and \( a_k \) are the target positions of the Kth radar scan, respectively, the degree, acceleration, and T are the target scanning distance variables, the quasi-compression mapping theorem is used to solve the data consistency problem and form formation control.

4. Experimental simulation and verification

Modern battlefield combat platforms face different forms of electromagnetic threats from the same platform. We integrate different radars that are derived from air-ocean targets into the same radar equipment. The experimental simulation uses microstrip slot antennas as an example of a common-caliber conformal antenna array to achieve a circle, the polarization mode is the characteristic of the air-sea integrated conformal antenna. Because the research object mostly adopts stealth material technology, the designed antenna beamforming has multi-peak, multi-shape structure parameters, wide frequency band, phase control, etc., and the antenna system is shared. With beamforming array and notch characteristics[9], it is used to optimize the interference by the recursive neural network algorithm, and the distortion-free signal spectrum is obtained. that is the radar digital beam map of the air-sea integrated, as shown in figure 1, and the beam coverage frequency can be switched arbitrarily. different vector sensors pass data fusion, and the simulation results show that the dynamics of the electromagnetic warfare field of the joint warfare electronic warfare can be sensed and displayed in real time through the design of the conformal antenna.US Navy AN/SPS-48E warship radar conformal antenna, working frequency band in S-band, maximum brain impulse width of 30 microseconds, system sub-module function. In addition, in 2012, China's first publicly converted CS/RB1 radar from S-band to L-band focused on real-time adjustment of antenna pointing in 2D scanning scheme, and then changed from L-band to X-band. The beam achieves low side lobes and achieves miniaturization and high gain. In recent years, the gnss system has integrated two or more satellite navigation systems, and significant progress has been made in mutual conversion of the entire frequency band.
5. Conclusion
We have studied a mathematical model method for airborne integrated radar signals. this radar signal combines the different characteristics of sonar signals and the detection of air-sea integration radar signals, and the process of mathematical model establishment. The conformal array antenna is obtained. the key technology is to analyze the hardware structure. The direction of the antenna pattern is controlled by phase control of each radiating element. Taking the microstrip slot antenna as an example, the designed radar digital beam realizes circular polarization. This kind of radar can detect the air target. the electromagnetic scattering characteristics can detect the underwater sensor parameters such as the position and velocity of the sea target, and use the recurrent neural network algorithm to optimize the working mode, which solves the various kinds of real target signal echoes brought by the time domain difference. The interference problem, the detection target is interfered, and the radar signal beam must point to zero-hidden. The simulation results show that the design of all targets shares the feasibility of a common-caliber conformal antenna, so as to realize the informationized command and control in the air-sea integrated electronic warfare situation.

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