Research on Key Technologies of Target Positioning Based on Electronic and Optical Sensors

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Abstract: In order to safeguard China's important sovereignty and marine rights and interests, it is of great significance to monitor waters. In the development of the current international situation, many countries and regions have applied spaceborne electronic sensors and optical sensors because of their outstanding advantages in the application process. Spaceborne electronic sensors and optical sensors are widely used in water monitoring. In the current application process of electronic sensors and optical sensors, the basic knowledge of both sensors needs to be understood. At the same time, only a deep discussion of the target positioning of the two sensors can ensure the full application of key technologies of electronic and optical sensor target positioning and improve the final quality of water monitoring.

1. Introduction
In recent years, China's maritime rights and interests have been continuously infringed. Therefore, it is necessary to strengthen the monitoring of China's maritime conditions. The main feature of the spaceborne sensor is that the target's monitoring range is relatively large and will not be limited by national borders. Therefore, it is widely used in investigative agencies in various countries. Electronic sensors and optical sensors are the more commonly used spaceborne monitoring methods. The use of spaceborne electronic sensors has a strong monitoring range, and the target interception rate is relatively high, which is relatively affected by weather conditions. However, the positioning accuracy of electronic sensors in the application process is relatively low, and the recognition results are not intuitive, and further calculation and analysis of the results are needed. The positioning accuracy of the spaceborne optical sensor is relatively high, and the recognition of the target is relatively intuitive, but it is easily affected by the weather during the detection process [1]. There are some problems if using electronic sensors or optical sensors to monitor targets alone. Therefore, combining electronic sensors with optical sensors to identify and monitor targets is an important development trend of target positioning monitoring technology. Before the target data is fused, the fused data sources need to be unified to ensure that the data sources come from the same target. This requires effective correlation between different sensor detection targets, in order to ensure the uniformity and accuracy of electronic and optical sensor target positioning, thereby improving the accuracy of target correlation and the reliability of water monitoring work.

2. Electronic Sensor Target Positioning Principle
In the application process of the spaceborne electronic sensor positioning system, passive positioning technology is one of the main application methods. During the operation of the spaceborne passive positioning system, the spaceborne electronic sensor does not need to emit high-power electronic signals, it only needs to determine the specific position of the target based on the obtained target electronic signals. In general, the hyperbolic positioning method is mainly used in the passive
positioning method. This positioning method is also called the time difference positioning method. The main factor that affects the chance of different receiving signals from the same transmitting source is the corresponding time, and the position of the target can be judged by the lag time and tracked simultaneously [2]. On an airplane, there will not be different factors in the relative position between the radiation source and the observation point. Generally, the time required for the electromagnetic waves to reach the two positions is different, which will produce a certain time difference. Based on this, it can be applied as a hyperbola.

In the application of the hyperbolic positioning method, the acquired signal r(k) needs to be sampled first, and the Fourier transform of k must be accurately changed. When the short-term average power of the transformation result is calculated, the following calculation formula must be used:

\[ p(k) = \frac{1}{k} \sum_{i=0}^{k} [r(k+1)]^2 \]

According to the above formula, the average value of p(k) can be calculated. The calculation formula is:

\[ \mu(k) = \delta \mu(k-1) + (1-\delta)p(k) \]

In the calculation formula, \( \delta \) is a continuous value, and \( \mu(k) \) represents the average value of p(k). When judging a signal source, it needs to be judged according to the signal source judgment identity. The identity is as follows:

\[ I = c\delta^2 \]

In the identity, I represents the threshold, c represents the continuous value, and \( C_1^2 \) represents the noise power of the input low-pass filter. If \( \mu(k) > C_1^2 \) during the calculation, it means that the signal source is from the radiation source target.

When the hyperbolic positioning technology is applied, the main operation process is to establish a related mathematical model. From the mathematical model, the hyperbolic positioning method can be analyzed. The hyperbola is based on two measurement stations, and combined with a measurement station can determine two pairs of hyperbola. The determined two pairs of hyperbola take the two measuring stations as the focal point respectively. At this time, the two pairs of hyperbola will cross, and the intersection point generated in the case of crossover is the required position of the radiation source [3]. Using the same model building method, you can use the principle of plane to push to space. After the radiation signal from the space source emits a radiation signal, there is a certain time difference between the two measuring stations on the ground. A hyperboloid with two measuring stations as the focal point and then combining one measuring station to determine three curved surfaces. At the same time, the satellite's altitude information is fully combined to accurately determine the position of the target. Samsung's time-of-flight positioning technology used in the target monitoring process of spaceborne electronic sensors is based on this principle. However, in the actual application process, the data on the satellite is not used for processing, but after the satellite measurement station acquires the radiation source signal, it is adjusted and amplified, and the acquired radiation source signal is sent to the processing station on the ground. The station analyzes and processes the signal. The time difference between the signal passing through the downlink channel and the uplink channel can be determined, and then the time difference in the signal transmission from the radiation source to the space measurement station can be further calculated according to the distance of the downlink channel, and the position of the radiation source can be accurately calculated. Using Samsung time difference positioning technology, accurate positioning data can be obtained, and the amount of calculation is relatively small. It is a commonly used passive positioning method.

3. Optical Sensor Target Positioning Principle
After analyzing the positioning error and positioning process of the spaceborne electronic sensor, the guidance of the spaceborne electronic positioning can be obtained. Based on this, the spaceborne
optical sensor can come to the fleet targets for optical detection after hours of detection by the electronic sensor. Imaging positioning [4]. In the application of it, the application of spaceborne hyperspectral sensors to the detection of ship formation targets is mainly considered. In the actual application process, the target image can be obtained, and the coordinates of the entire image are based on the optical satellite sub-satellite point as the origin. At the same time, it can be aligned to the geodetic coordinate system, and useful information can be extracted from the image, that is, the resolution \( s \) (m / pixel) of the image, the pixel size \( m \) (m / pixel) of the image, and the distance of the target from the image. The distance of the lower point is \( d \) (meters), and the actual distance \( S \) of the target reaching the image point of the optical satellite can be calculated. The calculation formula is:

\[
S = s \cdot \frac{d}{m}
\]

When an optical satellite operating in a specific orbit is applied, because its operating parameters can be accurately determined, the actual distance \( S \) from the target to the point below the satellite can be calculated according to the above calculation formula. The corresponding target fully considers the coordinates of the sub-satellite point and the space height \( H \) of the satellite operation, and can obtain the pitch angle \( \beta \) between the satellite and the target and the azimuth angle \( \alpha \) of the target in the geodetic coordinate system, and the calculation formula between the various parameters as follows.

\[
S = \sqrt{x^2 + y^2}
\]

\[
\alpha = \arctan \frac{y}{x}
\]

\[
\beta = \arctan \frac{s}{H}
\]

4. Unity of Electronic and Optical Sensor Target Positioning Coordinates

In the process of applying the electronic and optical sensor-based target positioning technology, it is necessary to ensure the uniformity of the electronic and optical sensor target positioning coordinates. Therefore, after analyzing the positioning principle of the spaceborne electronic sensor and spaceborne optical sensor, the results of the two positioning are based on the coordinate system where the sub-satellite point is used as the origin of the coordinates during the satellite positioning process. However, during the two positioning processes, the sub-satellite points of the spaceborne electronic sensor and the spaceborne optical sensor are different. Therefore, before the position information is correlated, the two positioning data need to be processed uniformly to ensure that they are on the same coordinate system. At this time, the positioning data of the on-board electronic sensor and the positioning data of the on-board optical sensor need to be converted into a unified geographic coordinate system, and then converted to the same rectangular coordinate system for processing [5].

After integrating the positioning results of the electronic sensor and the optical sensor into the geographic coordinate system, in order to ensure the simplicity and convenience of the calculation process, they need to be transformed into the same rectangular coordinate system. In the conversion process, only the arbitrary coordinates need to be selected as the origin of the geodetic coordinate system, and the unified positioning coordinates can be calculated and obtained.

After researching and analyzing the target positioning related principles and the error factors in the positioning results of the spaceborne electronic sensors and spaceborne optical sensors, two different sensor positioning results need to be unified into the same coordinate system. The data obtained in the real situation is generally the raw data of the sensor, not the positioning data obtained through calculation. Therefore, in the research of the positioning principle, the application of the associated data of actual engineering has certain practical significance.
5. Association Algorithm Based on Feature Vector

Eigenvectors are common location feature descriptions in the process of graphic matching. In the application process of this method, the amount of calculation is relatively small, and the robustness to positioning errors is relatively good. In the research, it mainly analyzes and studies the construction of matrix, singular value decomposition of matrix, and the construction of association metric [6]. In general, the set of target points obtained by the electronic detection method is a fully connected graph. The fully connected graph can be represented by the adjacent matrix \( A \). At the same time, \( A \) can be subtracted to obtain the Laplacian matrix. The adjacent matrix \( A \) can also be expressed as a Gaussian weighted Euclidean distance between the target points, \( E_i \) and \( E_j \).

\[
A_{ij} = \exp\left[-\frac{1}{2\sigma^2}\|E_i - E_j\|^2\right]
\]

In the formula \( \sigma = c \cdot d_{\text{min}} \), where \( d_{\text{min}} \) is the minimum value of the target point set. \( C \) represents the proportionality coefficient, which is an adjustable value. In addition, the Laplace matrix can be expressed by the following formula:

\[
D(k, k) = \sum_i A(k, i), i, k = 1, 2, \ldots n_i
\]

In the experimental process, if the representation matrix is a nearest-neighbor matrix with Gaussian weighted Euclidean distance as the element and an association algorithm based on the feature vector, the calculation effect is best. \( C \) is an adjustable scale factor, and its optimal value range is 10 ~ 1000. The matrix formula expressed by electronic detection and optical detection is:

\[
E_{ij} = \exp\left[-\frac{1}{2\sigma^2}\|E_i - E_j\|^2\right]
\]

\[
C_{ij} = \exp\left[-\frac{1}{2\sigma^2}\|C_i - C_j\|^2\right]
\]

6. Correlation Algorithm Based on Coordinate Transformation

In order to complete certain law enforcement tasks during the work of the marine surveillance law enforcement fleet, formations need to be prepared. During the execution of the missions, the formations formed have certain stability. Therefore, the characteristics of the formation structure can be used to associate the targets of the electronic and optical sensors. We need to obtain the fleet target position data which is detected by the spaceborne electronic sensors and spaceborne optical sensors at different time periods. In order to ensure the intuitiveness of the comparative analysis, two detected targets can be obtained to determine whether the two detected targets have Correlation. Correlation algorithms with coordinate transformations are relatively simple and easy. The positioning results of the targets of the two detection teams were transformed into the same area for comparative analysis. In the analysis process, the correlation characteristics between the targets were mainly studied. In order to ensure the accuracy of the transformation results, the change relationship between the two detected target position data needs to be determined first. In the algorithm, some points with the most similar local structure in all targets need to be found, and then the corresponding points based on these similar points are corresponding. Transform the relationship and calculate the global change relationship. You can use the transformation relationship that has been obtained to transform the clicks on the associated targets and transform them into the same area of the same coordinate system. The transformed point coordinates can be used as the new feature vector of the target. At the same time, the similarity between the target feature vectors can be calculated by calculating the angle cosine between the feature vectors, and the association measure of the positions between the targets can be obtained, and then the association result of the target can be obtained using the association decision [7].
7. Conclusion
In a word, in the continuous development of the current positioning technology, the demand for positioning technology in various countries and many fields has become more urgent. The continuous development of positioning technology has promoted breakthroughs and innovations in related technologies. During the research on the target positioning correlation technology of electronic and optical sensors, it is necessary to accurately understand and grasp the positioning principle of electronic sensors and optical sensors. Researchers must analyze the unity of the positioning coordinates of the target of the electronic and optical sensors. At the same time, we need to research and analyze the correlation algorithm based on the feature spectrum vector and the correlation algorithm based on the coordinate transformation, so as to ensure the effective application of the target positioning and correlation technology based on electronic and optical sensors, and to improve China's sea areas. The accuracy and reliability of positioning during the monitoring process is also of great significance for protecting China's marine rights and interests.

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