Research on maritime delimitation technology and model based on GIS

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Keywords: GIS; Maritime delimitation technique; Equal scale algorithm; Model determination.

Abstract. The Marine Geographic Information System (GIS) is used as an effective tool for spatial information data collection and storage, access and management, analysis and problem solving, and its application in maritime delimitation. Through research, it is found that the simple GIS maritime delimitation technology has many defects in dealing with the complex territorial sea area division. For example, the algorithm is not strict and the data structure is not uniform, which cannot meet the demand of high-precision maritime delimitation technology. To this end, combined with the proportional ocean coordinate determination method can improve the vector data in GIS, and provide a solution for the high-precision ocean demarcation model.

1. Introduction

According to the relevant provisions of the 1983 United Nations Convention on the Law of the Sea (hereinafter referred to as the "Convention"), the international maritime delimitation mainly includes the unilateral ocean outer boundary and the multilateral ocean outer boundary delineation. Among them, the unilateral maritime external boundary limits include the three external boundaries of the territorial sea, the exclusive economic zone and the continental shelf; the multilateral maritime boundary delineation includes the delineation of the adjacent and adjacent situations of the relevant countries. Due to the relationship between national sovereignty and territorial security, the issue of international maritime delimitation is extremely complex, involving not only national legal, political, diplomatic, military, and national sentiment issues, but also geodetic surveys, map mapping, map projection, demarcation techniques, and error analysis related scientific and technical issues. Therefore, while strengthening the analysis and research of the Convention and the practice of international sea area demarcation, we should pay attention to the study of maritime delimitation technology.

The maritime demarcation geographic information system, based on a large database group, based on a large database group relies on the latest GIS technology and multimedia technology to vividly generate the graphics, images, texts and data required for maritime demarcation. Varieties of information products can be used as technical support for China's maritime delimitation, and provide timely and effective services for the demarcation of sea areas between China and neighboring countries. By combining the Bessel method, it is possible to establish ocean coordinates which can improve the GIS platform data and make the maritime demarcation more precise.

2. Marine demarcation GIS structure

The maritime delimitation GIS consists of four parts: maritime delimitation technology, comprehensive demarcation plan, demarcation sea environment and maritime demarcation information database. The system structure is as shown on the right. The maritime demarcation technique is to use modern information technology, based on the maritime delimitation theory, combined with the international maritime delimitation case, to automatically generate various maritime demarcation lines on the computer [1]. The marine demarcation plan comprehensive assessment system can calculate the spherical area or the sea area under various projections, carry out the accuracy analysis and the area comparison between the schemes; the distribution of oil and gas resources and fishery resources on both sides of the demarcation and the impact of various schemes on resources The evaluation can reflect the political and geographical situation of the demarcation line of neighboring countries and the sea area of fishery agreements with neighboring countries; and multimedia technology can be used to display the natural environment of the demarcated islands, as well as humanities and geography. Demarcation of the sea environment space database and maritime delimitation information database to provide marine environmental conditions and maritime delimitation intelligence information for maritime delimitation. As shown in the figure is the GIS infrastructure.

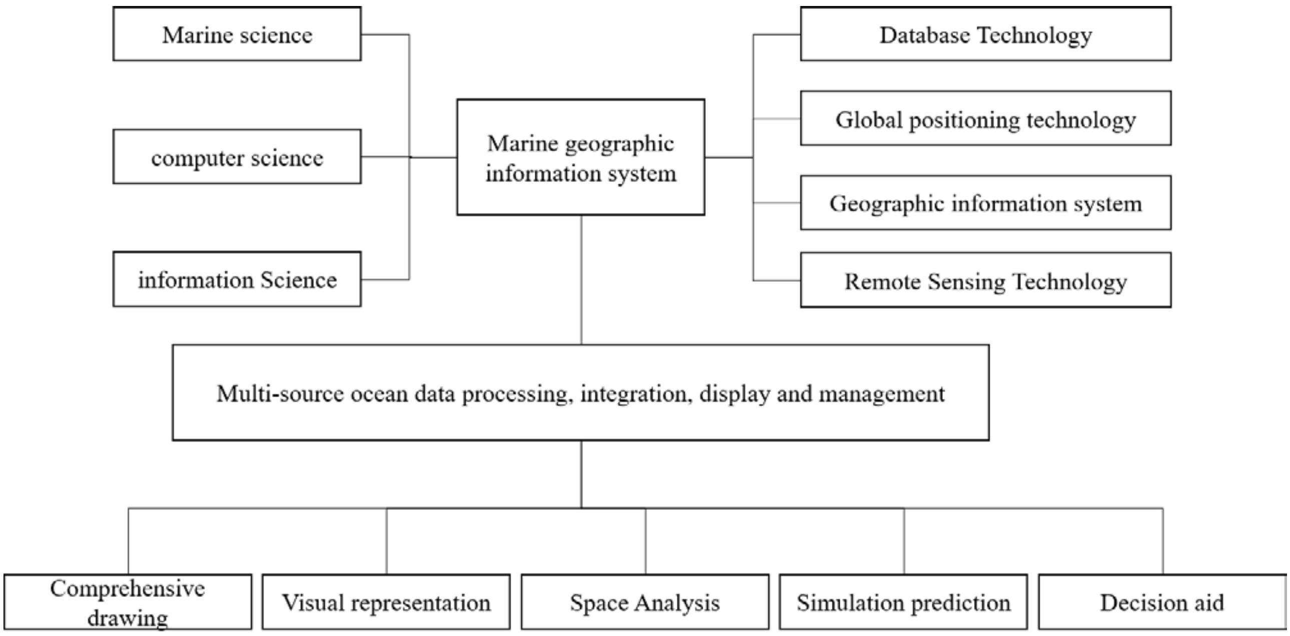

Fig.1 Ocean demarcation GIS infrastructure

3. Algorithm Description

The isometric approximation method is based on the principle of geometry to achieve the generation of maritime boundaries in the case of adjacent or opposite coasts [2]. The idea of the method is as follows: Firstly, according to the vectorized territorial sea baseline, the computer automatically discriminates the type of coastline; then determines a starting proportional point (referred to as the starting point), starting from the starting point, exploratorily spanning in a certain direction with a certain step. Take one step and use it as the initial tentative position of the new proportional point; search for the shoreline on both sides, and find the closest point to the distance of the trial position; then calculate whether the difference between the two distances is less than the tolerance. If so, then this point is absorbed as a point on the proportional dividing line; otherwise, the heuristic position is re-adjusted, and the closest point to the distance is searched again, and then the difference between the distances is less than the tolerance, so iteratively continues until The test position meets the conditions of the proportional point. Finally absorb this point as a point on the proportional line, continue the step test, and repeat the above operation until the outer rectangle of the two baselines is outside [3]. Coastal proximity, the calculation process is similar. It can be seen from the above that when the proportional value is 1, it is the intermediate line iterative approximation method.

3.1 Several related concepts

(1) One-sided buffer decision point: Any point on the bilateral overlap claim area controls the expansion direction of the baseline buffer. (2) Buffer unit step: the minimum unit of the baseline buffer step. (3) Proportional control factor: The base buffer unit step ratio. (4) Accuracy impact factor: the maximum value of the base buffer unit step.

3.2 Algorithm Description

As shown in Fig. 2, under the premise that the baseline L_1, L_2 and the one-sided buffer decision point F have been set, the natural integer multiples $i\lambda_1$ and $i\lambda_2$ of the buffer unit step are ($i = 1, 2, 3...$) Calculate the baseline L_1, L_2 based on the globe ellipsoid buffer for the buffer step synchronization.

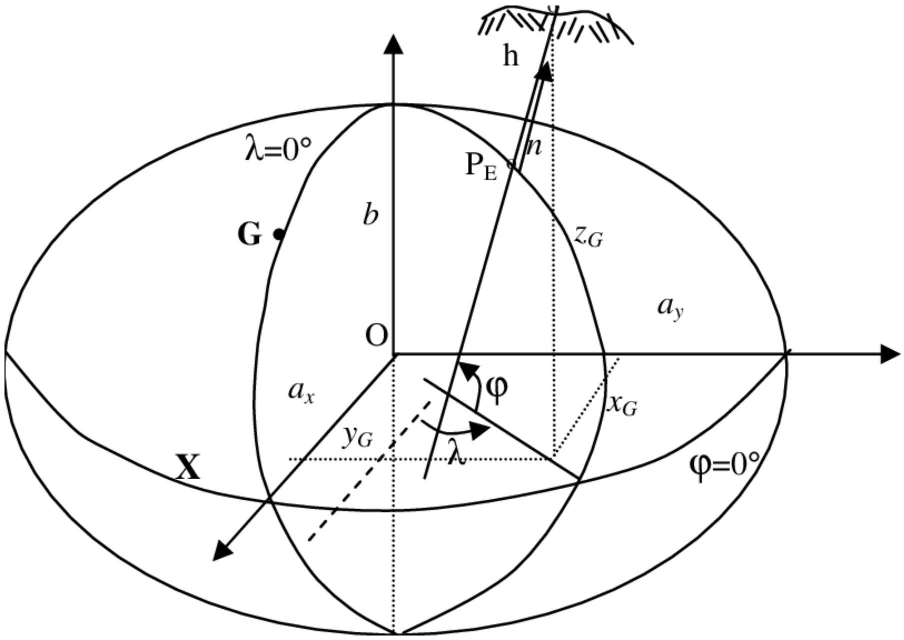

Fig.2 Schematic diagram of the phase wise approximation algorithm for high-precision buffer boundary

Using the position information of the one-side buffer decision point F, determining the boundary of the one-side buffer of the required extracted baselines L_1, L_2 and intersecting, sequentially recording each intersection point, and finally connecting in a reasonable order to form a distance proportional line L_3 (in This is indicated by a broken line in Fig. 2). Obviously, the distance from the arbitrary point P of the equidistant line L_3 to the nearest point on the baseline L_1, L_2 (the distance of the earth ellipsoid) $\vec{PA}, \vec{PB}$ is kept at a fixed ratio, and the proportional size is equal to the proportional control factor λ_1/λ_2 in the algorithm. In addition, the accuracy influence factor max

(λ_1, λ_2) determines the resolution accuracy of the distance proportional line L_3.

4. Solution step

4.1 Initialization

(1) A separate identification code is assigned to the baselines L_1, L_2 of different countries, and is displayed on the chart surface. (2) Determine the one-sided buffer decision point F. (3) Determine the proportional control factor α. (4) Determine the accuracy influence factor β. (5) Determine the buffer unit step λ_1 and λ_2. It can be obtained by solving the equation (1).

$$\begin{cases} \alpha = \lambda_1 / \lambda_2 \\ \beta = \max\left(\lambda_1, \lambda_2\right) \end{cases} \tag{1}$$

4.2 Unilateral buffer boundary extraction

As shown in FIG. 3, for any baseline L in the baselines L_1, L_2 (buffer unit step is λ), the i-side buffer boundary extraction process at the i ($i=1, 2, 3...$) times maybe It comes down to the following steps:

Step 1: According to the construction method of the linear element buffer based on the earth ellipsoid in the literature [4], the buffer B_i generated by the buffer line $i\lambda$ ($i=1, 2, 3...$) is solved.

Step 2: Extract the buffer boundary L_i of the buffer Bi in step one, and the first and last points are all P_3.

Step 3: Prolong the two ends of the baseline L until the boundary with the buffer L_i is at two points P_1 and P_2.

Step 4: Split the buffer boundary L_i by using the P_1 and P_2 intersection points in the third step, and form three sub-line segments S_1, S_2 and S_3.

Step 5: According to the endpoint characteristics of the neutron line segments S_1 (P_1... P_2), S_2 (P_2... P_3) and S_3 (P_3... P_1) in step 4, the two one-sided buffer boundaries of the baseline L can be expressed as: $l_1= S_1$, $l_2 = S_2 \cup S_3$. For the case where P_3 coincides with P_1 (or P_2), then: $l_1 = S_1$, $l_2 = S_2$ (or S_3). Step 6: Solve the distance d_1 and d_2 of the one-side buffer decision point F to the two one-side buffer boundaries l_1 and l_2, as shown in Fig. 3.

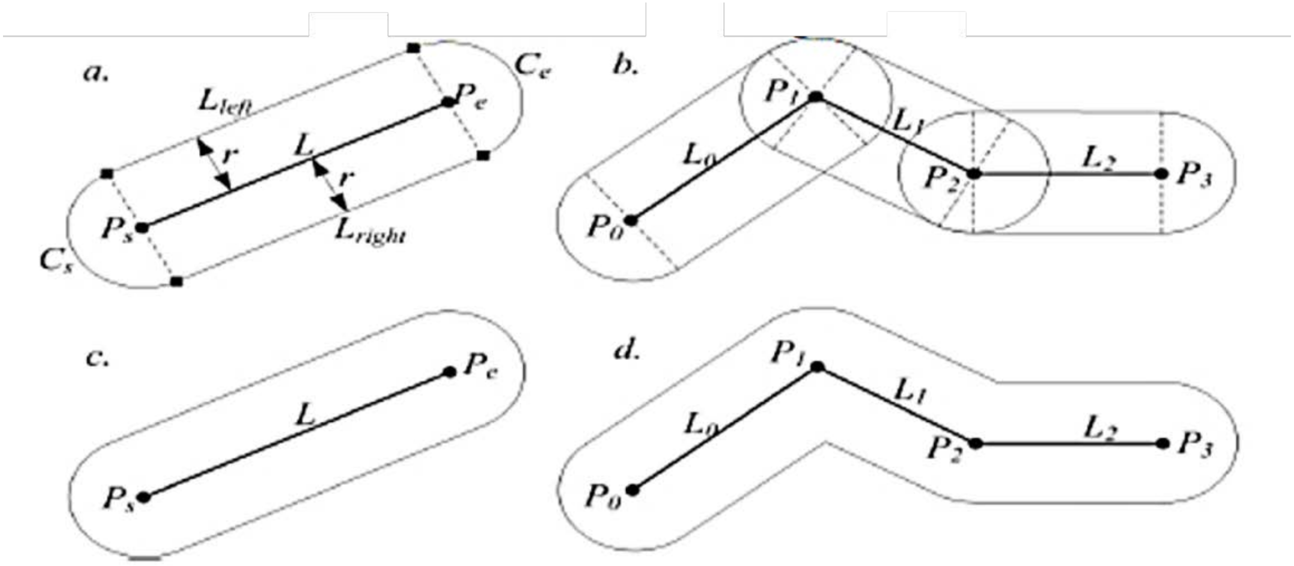

Fig. 3 Unilateral buffer boundary extraction

4.3 Unilateral Buffer Boundary Approximation

According to the principle of unilateral buffer boundary extraction in the above, $i\lambda_1$, $i\lambda_2$ ($i=1, 2, 3...$) are used as the buffer steps of the baseline L_1, L_2, respectively, and the corresponding single-sided buffer boundary is obtained synchronously. In this process, if there is a crossover of the unilateral buffer boundary belonging to different countries (determined by different identification codes), the intersection point is obtained and recorded which is:

$$P = P \cup \left(L_i^1 \cap L_i^2 \right) \quad \left(i = 1,2,3,... \right) \tag{2}$$

Where P is an unordered point set and P is empty when $i=1$. The solution process termination flag Δ_i of the disordered point set P is judged by whether the one-side buffer boundary L_i^1 and L_i^2 cover the entire demarcation sea area among them:

$$\Delta_i = \left(i\lambda_1, i\lambda_2 \right) - D\max\left(L_1, L_2 \right) \quad \left(i = 1,2,3,... \right) \tag{3}$$

Where max ($i\lambda_1$, $i\lambda_2$) ($i=1,2,3…$) is the baseline maximum buffer step; D_{max} (L_1, L_2) is the maximum distance between the baseline L_1 and L_2. According to equation (3), for any i process termination flag Δ_i, if $\Delta_i \geq 0$, the process terminates and proceeds to the distance proportional line generation process; otherwise, it transfers to the one-sided buffer boundary extraction process.

4.3 Distance proportional line generation

Then connect the points in the unordered point set P obtained in Section 3.4 and draw them onto the chart plane to get the distance proportional line L_3 [5]. In practical applications, the algorithm generally uses the minimum distance (0. 05mm) that can be resolved by the human eye on the graph, and the algorithm is solved as the precision influence factor max (λ_1, λ_2), and the generated point in the unordered point set P. The interval is generally small, and each point has a strong correlation, so that the above sorting method can generally receive better results.

Figure 4 is a schematic diagram of the sorting of unordered point sets, where A, B, C, and D correspond to the first and last points of the baseline L_1 and L_2, respectively, and the unordered point set $P = \{P_1...P_m\}$ is the unsorted one-sided buffer. The intersection of the district boundaries. Using the principle that the distance between the first and last points of the baseline L_1 and L_2 and the distance is equal to the distance between the first and last points of the line L_3, the nearest point P_1 is searched for in the unordered point set $P = \{ P_1... P_m\}$, and the ordered point set is updated. The set of disordered points is $P' = \{P_1, P_2\}$, $P = \{P_3... P_m\}$. By analogy, when the unordered point set $P = \{P_{i+1}... P_m\}$ is traversed with any point P_i as the test point, the distance set Dist = $\{dist_1...dist_{m-i}\}$ is formed, and the order is sorted. Obtain the unordered point set $P = \{P_{i+1}...P_m\}$ from P_i shortest distance dist1 and corresponding point P_{i+1}, and update the ordered point set and the unordered point set to $P' = \{P_1...P_{i+1}\}$, $P = \{P_{i+2}...P_m\}$ [6].

Finally, when the unordered point set P is empty, the sorting of the unordered point set P ends, and the obtained ordered point set P' is sequentially connected, and is drawn onto the chart plane to obtain the distance. Isometric line L_3.

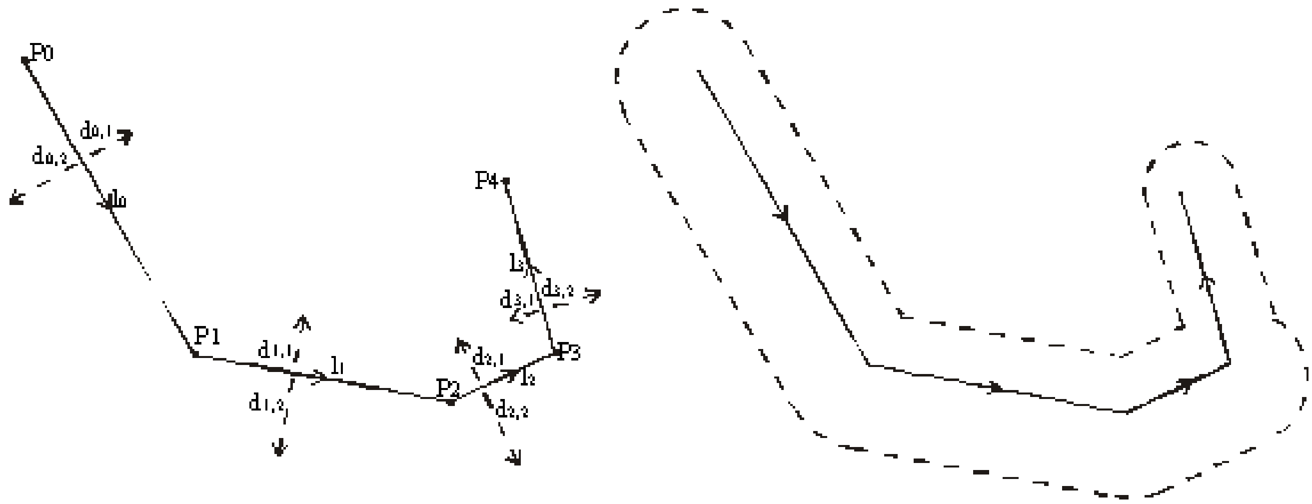

Fig.4 Schematic diagram of unordered point set sorting

The iso-reactive approximation method is easy to implement on the ellipsoid surface through transformation, but the method still has problems such as point generation line and straight generation curve, and the concept is not strict. The calculation accuracy of this method depends on the step length. The smaller the step length, the more accurate the generated proportional line and the corresponding calculation amount. In addition, the isometric approximation method is not suitable for unilateral ocean boundary generation.

5. Conclusion

The high-precision buffer boundary phase approximation algorithm is proposed in this paper. It solves the problems existing in the traditional maritime delimitation and the existing research results, and solves the problem of the accuracy of the current distance contour method applied to maritime delimitation. And through the application of experiments, the effectiveness of the algorithm is verified, which provides a fair and reasonable technical means for the international bilateral sea-boundary demarcation, which has important theoretical and practical significance.

China's current maritime delimitation, because the adjacent Yellow Sea, East China Sea and South China Sea are semi-enclosed seas, many sea areas are less than 400-mile-wide, so the surrounding North Korea, South Korea, Japan, the Philippines, Malaysia, Brunei, Indonesia and Vietnam, etc. Bilateral maritime delimitation issues exist in eight countries. Obviously, the proposed algorithm is also of great significance for solving the severe maritime delimitation situation in China.

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