Research on Ship Motion Estimation Compression Method Based on AIS

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Abstract

With the mandatory use of automatic identification systems, maritime systems and shipping companies will receive a large amount of AIS information for ship monitoring. In order to store a large amount of AIS information and ensure the quality of data information and storage costs, it is necessary to compress AIS information. The paper combines the characteristics of AIS data and the needs of the actual trajectory study. Based on the Douglas-Peucker algorithm, this method is improved by combining the trajectory of the ship's motion, and a dynamic D-P compression method is proposed. Experiments show that the proposed algorithm can effectively and quickly compress the ship trajectory data provided by AIS under the condition of low distortion, and plays a role in enlightening the ship track reconstruction and playback.

Keywords

Dynamic Douglas-Peucker compression algorithm ship track AIS 1 Status of Ship AIS.

1. Status of Ship AIS

First, ship AIS information is widely used. AIS information is used in applications such as management, ship search and rescue, ship traffic flow surveys, ship inquiries and monitoring, and the combination of AIS information and electronic charts to display different requirements for dynamic ship information in different scales. It has increasingly shown AIS information. Convenience, speed and importance. Second, the ship AIS content is more. This includes information on both dynamic and static information. The static information includes: IMO number, call sign, name, length, width, draught, destination port, selected route, etc.; dynamic information includes: ship position, track direction, speed of ground, heading, navigation status, steering rate, etc. . Third, ship AIS information is published at a high frequency. Ship AIS information is generally published in 2S to 6min. In view of the above reasons, how the maritime regulatory authorities and shipping companies deal with these massive data becomes a problem. In fact, ship ASI information has a lot of invalid and redundant information. For example, there may be tens of thousands of static messages for the same ship. However, as long as several of them can satisfy the requirements, the rest is redundant information; for example, for a parked or a constant heading. Ships can replace AIS information of thousands of ships with two or three AIS messages. There are many situations where such information contains redundancy. Then delete these invalid or redundant information, not only save storage space but also reduce storage costs. Therefore, in the case of lower distortion, how to compress these invalid and redundant AIS information is particularly important.

2. Data compression

2.1 Introduction to Data Compression

Data is compressed because of the redundancy of the data itself. Data compression is the use of various algorithms to compress data to a minimum or no redundancy, and to reduce distortion as much as possible, thereby improving transmission efficiency and saving storage space. Data compression technology is generally divided into lossy compression and lossless compression. Commonly used lossless compression algorithms are: Huffman coding, arithmetic coding, run-length coding, and the like. Typical lossy compression algorithms include predictive coding, transform coding (wavelet transform, discrete cosine transform, etc.), ADPCM coding, and the like. Lossless compression refers to the use of statistical redundancy in data compression, can be completely restored to the original data without loss of any information, but its compression rate is subject to theoretical restrictions on statistical redundancy of data, generally 2:1 to 5:1 . This method has been successfully applied to the compression of text data, programs, and certain specific image data. Lossless compression can save 100% of the original data, without any loss of information, for the study of small amounts of data, not only convenient conversion, but also can be converted between the lossless compression format, but also can be directly converted to lossy compression Format; However, due to the limitation of the compression rate, the compression rate is relatively low, and the space occupied is large. Moreover, the processing speed of the current decoding chip cannot keep up, and the hardware support is lacking, so the lossless compression algorithm cannot completely solve the storage and transmission. The problem is that lossy compression is used for the processing of certain signals.

Lossy compression is also commonly referred to as information compression. Since people cannot distinguish the presence of certain frequency components, it is allowed to lose a part of the information in the compression process of images, video, etc. This part of information will not cause serious impact on the original data. Although the original data cannot be fully restored after decompression, data that is very close to the original data can be obtained, and a larger compression ratio can be obtained, which can be used when the requirement is not particularly accurate. Common lossy compression algorithms include predictive coding, transform coding, subband coding, fractal compression, wavelet compression, statistical block coding, and pulse coding. Currently, these algorithms are mainly used for compression processing of speech, images, and video. The class algorithm has been gradually developed and is almost mature, and has been applied to the development of multimedia. In general, lossy compression is more efficient than lossless compression, but lossy compression is distorted [18]. Therefore, real-time compression of ultrasonic data requires a method with fast operation speed and high compression performance. When redundant data and irrelevant information are eliminated as much as possible [10], attention must be paid to retaining useful information and improving data reproduction capability.

2.2 Data Compression Methods and Processes

At present, commonly used for the compression of vector data are: Douglas-Peucker method [1], vertical distance method [22] and optical column method [2]. The basic idea of the traditional D-P compression algorithm is to virtually connect a straight line between the two ends of the head and tail, and find the distance from the remaining points to the straight line. Select the maximum distance point d-max, and compare d-max with the threshold D. If d-max<D, all the intermediate points on this curve will be rounded off. The point with the largest distance from the straight line remains, if d-max Max>=D, the coordinates of the corresponding point of d-max are retained, and the known curve is divided into two parts to be calculated repeatedly by dividing the points into boundaries. See Figure 1 below:

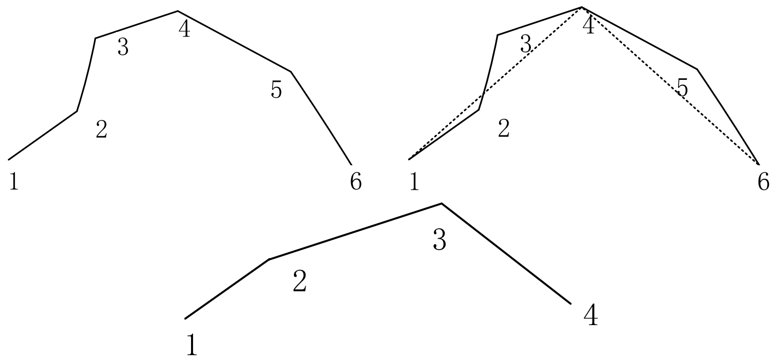

Figure 1 D-P compression algorithm

The traditional D-P algorithm is more based on the static discrete point compression in the two planes. It can well compress the space point to the greatest extent and react to the change of heading for the compression energy of the ship's navigation trajectory. However, the data information received by the ship AIS includes: dynamic information and static information, among which the dynamic information includes factors such as speed change, time change, and change in the turn rate. For traditional D-P compression algorithms, dynamic information compression cannot be satisfied. However, the ship's dynamic information can more accurately reflect the ship's in-flight conditions, so it is very important for us to study ship behavior. There are many problems that cannot be solved in this traditional D-P compression algorithm. For example, during the navigation of a ship, the speed of change of the sea area and the environment will be greatly changed. There will be some special movement modes such as reversing, anchoring, and the like during navigation of the ship. If the traditional compression algorithm is used to compress the entire route, the first calculation amount cannot be tolerated by the general computer; the second will have a large deviation and cause many problems to be solved. Based on the joint efforts of the research team in this laboratory, we adopted the improved D-P compression algorithm and proposed a piecewise three-dimensional compression ship AIS data information, namely dynamic D-P compression [16]. The dynamic D-P compression method not only takes into account the heading and speed changes during the ship's navigation, but also can effectively compress the ship's AIS information while maintaining a low degree of distortion.

2.3 Ship AIS dynamic data segmented three-dimensional compression method

The basic idea: ship AIS dynamic data segmented three-dimensional compression method, with longitude X axis, dimension as Y axis, and time as T axis. In chronological order, calculate the distance between all the two points between the first and the last point, and find the maximum distance from the point to the straight line. If the calculated maximum distance is still less than the given threshold deviation, all points between the first and last two points are deleted, leaving only the first two points. If the maximum distance is greater than the threshold deviation, then the first point is the first point, and the point where the maximum value is the last point. Similarly, the point where the maximum value is located is the starting point, and the tail point is used as the ending point for recursive compression.

The process of ship sailing can consider sailing and speed according to its special case, and it is a special case in the dynamic D-P compression method when the ship's forward navigation path is unchanged. There are many advantages to this situation compared to the traditional D-P compression method. The traditional D-P compression is as follows: Figure 2 below shows the original compression, and the first to seventh points after compression. There are only two points 1, 7, as shown in Figure 3. Dynamic D-P compression is shown in Figure 4, after the compression of 1,3,4,7 four points left in Figure 5.

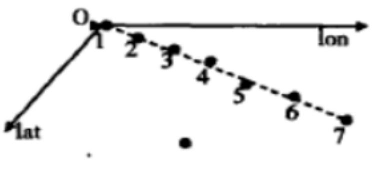

Figure 2 Tracks with unchanged heading

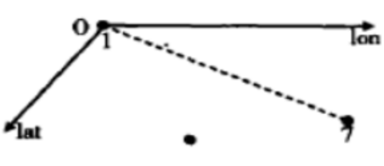

Figure 3 D-P compression

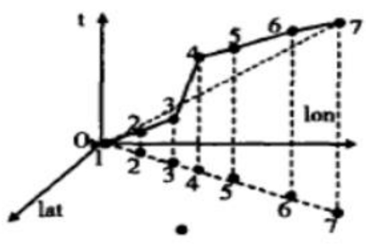

Figure 4 Change of course by heading at constant speed

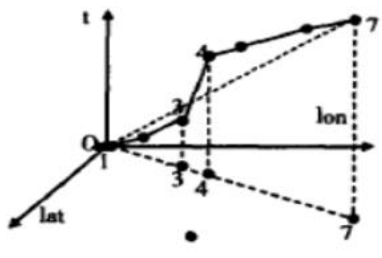

Figure 5 Dynamic D-P algorithm compression effect

3. Improved Douglas-Peucker algorithm

3.1 Dynamic D-P compression method improvement

(1) On the basis of the original two-dimensional plane coordinates, taking the weight time as the third dimension, the dynamic information such as ship speed and trajectory direction can be considered, dynamic compression is achieved, and the compression quality is improved.

(2) The dynamic compression adopts the way of segmentation and merging, and the original path compression is divided into segmented compressed segment sequences by using velocity tolerance to improve the precision and efficiency of compression.

(3) Storage of data after data compression The identification code of the unique storage address of the ship AIS information in the database is stored in chronological order, which improves the speed of operation.

3.2 Formulas Used in Compression

(1) The voyage calculation formula: The distance relationship of spherical coordinates is changed to the relationship of plane coordinates to solve the distance. Two-point coordinates: starting point A1 (φ1, λ1) and reaching point B1 (φ2, λ2). Λ1 (the longitude of the starting point), φ1 (the latitude of the starting point), all in units. TAB indicates the time from A to B, in hours.

Latitude difference: φ=φ2-φ1; longitude difference: λ=λ2-λ1;

East and West distance: $d = \lambda \times \cos(\frac{\pi(\emptyset 1+\emptyset 2)}{360})$, Range: $S1 = \sqrt{\emptyset^2 + d^2}$

(2) Speed calculation formula: $v = \frac{S1}{T_{AB}}$;

(3) Introduce the weighted distance formula: use w to adjust the weight of the time and latitude and longitude in the distance solution, and solve the spatial distance between the spatial point and the point. Three-point coordinates: starting point A (φ1, λ1, t1), ending point B (φ2, λ2, t2), intermediate point C (φ3, λ3, t3), TAB represents the time from A to B, and w is the weight.

$\left|AB = c = \sqrt{(\lambda 2-\lambda 1)^2+(\emptyset 2-\emptyset 1)^2+w(t2-t1)^2}\right|$;

$|AC| = b = \sqrt{(\lambda 3-\lambda 1)^2+(\emptyset 3-\emptyset 1)^2+w(t3-t1)^2}$;

$|BC = a = \sqrt{(\lambda 32-\lambda 2)^2+(\emptyset 3-\emptyset 2)^2+w(t3-t2)^2}|$;

$P = \frac{a+b+C}{2}$;

$S2 = \sqrt{p(p-a)\times(p-b)\times(p-c)}$。

(4) The weighted distance from the empty point to the straight line formula: Use the weight w to adjust the time and latitude and longitude weights in the distance solution, and solve the point where the point deviates from the starting point and sits in a straight line.

$$\mathbf{S} = \frac{\mathbf{2}S\mathbf{2}}{c}$$

3.3 Basic Algorithm of Dynamic D-P Compression Algorithm

(1) Set the speed threshold D1 and the distance threshold D2.

(2) Delete redundant information in AIS data.

(3) Find the typical trajectory retention point that satisfies the threshold.

(4) Use the dynamic D-P compression algorithm to compress the typical mooring points that are kept in segments.

4. Experimental results and summary

4.1 Experimental Results of Dynamic D-P Compression Algorithm

Based on the data compression program in the Java development environment and the construction of three-dimensional graphics, we conducted experiments on 200,000 pieces of data of more than 100 ships received by the experimental team.

Figure 6 below shows the berthing period of the ship, which is a plan view of the voyage, where the polka dot is the position of the ship in the AIS message. A(B) is the position where the ship is moored, B is the starting point of the ship, and the ship sails to point C; if the traditional DP compression method is used to calculate point B, it will not be retained, but point B is an important point in dynamic DP compression. From the point of departure of the ship, we can see from Figure 7 and Figure 8 that Point B is a feature point with a large variation in velocity, so the dynamic Douglas-Peucker compression algorithm can be used to find point B and similar feature points. As Figure 9 and Figure 10:

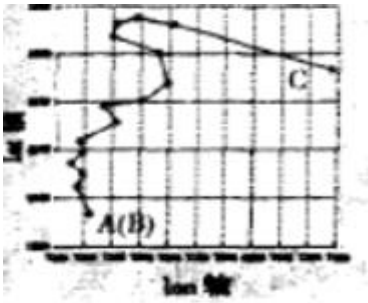

Figure 6 Ship Track Plan

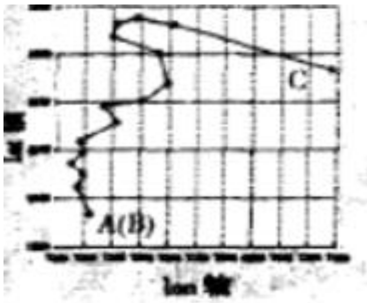

Figure 7 3D view of the ship's trajectory

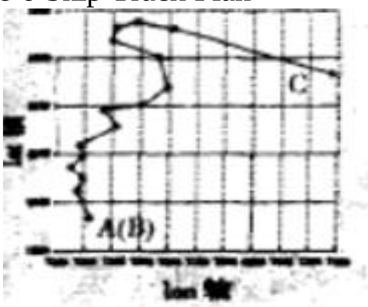

Figure 8 Three-dimensional sectional view of the ship's trajectory D-P

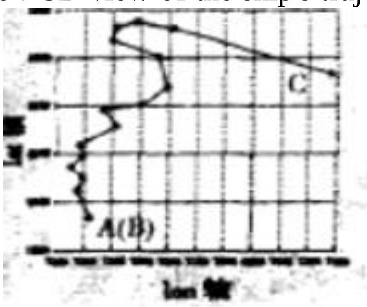

Figure 9 Three-dimensional dynamic algorithm compression effect

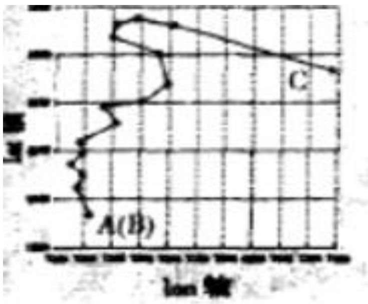

Fig. 10 Cross section of compression effect of three-dimensional dynamic D-P algorithm

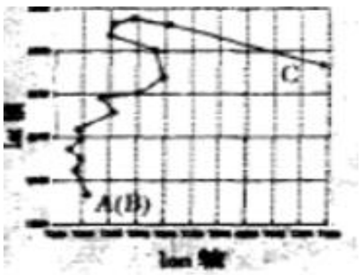

Figure 11 Three-dimensional dynamic compression effect

5. Conclusion

The data compression experiments were performed using 20 AIS information received by JAVA language. The dynamic Douglas-Peucker compression algorithm was compared with the vertical distance method and the optical column method. The results show that the dynamic D-P overcomes the limitations of the traditional Douglas-Peucker method, the vertical distance method and the optical column method, and can be combined with the characteristics of the speed and track change in the dynamic information on the basis of the traditional compression algorithm and be effectively preserved. By remembering the comparison of compressed lines, it can be seen that the improved dynamic D-P compression algorithm has a very good fidelity to the typical trajectory points of the ship when the precision loss is satisfied.

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