Research on Emergency Rescue Scheme for Reservoir Maritime Based on Improved CBR

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Abstract. This paper is concerned with the existing problems of reservoir emergency rescue and aims to propose a new approach to select emergency rescue scheme for reservoir maritime by using improved case-based reasoning (CBR) approach. Based on the existing characteristic attribute type and attribute similarity calculating method, the difference attribute and multi-valued sequence value are proposed. By the analysis of example, the effectiveness of this method is analyzed and verified. The result shows that improved CBR can improve the accuracy of case retrieval to a certain extent, and the approach based on improved CBR can provide effective emergency rescue scheme for reservoir maritime.

Introduction

With the development of economy, tourism heat in reservoir area and the terrain features of reservoir area, navigation environment in reservoir area is very complex, as a result, marine accidents of ship collision, capsizing, stranding occur frequently. At present, the emergency rescue force in the reservoir area is scattered, and the emergency rescue decision depends on the leadership experience. Therefore, the rationality of the emergency rescue scheme cannot be verified timely, which leads to unsatisfactory rescue results. How to take targeted emergency rescue measures to improve the success rate and reduce losses is very import, and it has become an urgent problem.

CBR is a kind of reasoning method that deals with the current case by analogy with thinking method and process of humans, and has been widely used in emergency decision-making domain. “Dynamic Memory” theory was put forward in 1982 by Rogger Shank, and it was regarded as the origin of CBR. In 1994, Aamodt and Plaza proposed the classic R4 model, in which CBR research was divided into four processes, that is Retrieve, Reuse, Revise and Retain, and most of the later researches were based on this model or improved model [1]. Kim et al [2] studied decision-making support system (DSS) for computer security incidents based on CBR and cooperative response. Fan, Z, P, et al. [3] proposed a new five attribute value hybrid similarity calculation method in case retrieval, and applied it to the gas explosion emergency response.

Figure 1. The procedure of scheme selection model for reservoir maritime emergency rescue based on improved CBR.
In this paper, through the analysis of the past marine emergency rescue case, appropriate case retrieval attributes are selected and improved attributes classification and attributes similarity method are put forward, which provides decision-making support for the maritime emergency rescue scheme.

The Scheme Selection Model for Reservoir Maritime Emergency Rescue Based on Improved CBR

According to the classical R^4 CBR model, the procedure of scheme selection model for reservoir maritime emergency rescue based on improved CBR is shown in Figure 1, which mainly includes four steps, that is construction of case database of reservoir maritime emergency rescue, calculation for case similarity based on KNN, calculation for attribute index weight and case selection and revise.

Construction of Case Database of Marine Emergency Rescue in Reservoir Area

By analyzing the typical marine accident cases, selecting retrieval characteristics attributes from these influencing factors of ship properties information, accident information, meteorological condition and navigation environment. On the basis of literature [4], this paper divides characteristic attributes into the equal symbol attribute, the difference symbol attribute, the number attribute, the fuzzy attribute and the multi-valued sequence attribute. The detailed information of retrieval characteristic attributes are as follows:

1. Ship Type. Equal symbol attribute, all optional values are "cargo ship", "fishing boat", "ferry", "kayak".
2. Ship scale. Difference attribute, all optional values are "small", "medium", "large", "luxury".
3. Crews. The number attribute, the attribute value is the number of passengers on board, the value range from 1 to 200, more than 200 are calculated in 200.
4. Accident type. Equal symbol attribute, all optional values are "collision", "stranded", "capsizing".
5. Whether it is sunken. Equal symbol attribute, all optional values are "yes", "no".
6. Whether a fuel leak occurred. Equal symbol attribute, all optional values are "yes", "no".
7. Exploding scale. Fuzzy attribute, in the range of 0 to 1.0.
8. Wind level. Fuzzy attribute, in the range of 0 to 12.
9. Wave level. Difference attribute, all optional values are "wavelets", "light waves", "medium waves", "big waves" and "huge waves".
10. Weather. Multi-valued sequence attribute, all optional values are "thunderstorm", "heavy rain", "moderate rain", "light rain", "cloudy", "sunny".
11. Visibility. Fuzzy attribute, in the range of 0 to 12 miles.
12. Water depth. Fuzzy attribute, in the range of 2m to 78m.

Calculation for Attribute Index Weight

The procedure of the acquisition of attributes weight based on the cloud model [5,6] is as shown in Figure 2.
Calculation Method of Case Similarity Based on KNN

KNN algorithm is used to calculate the comprehensive similarity among cases in this paper [7]. The formula is shown in Eq.1

$$SIM (a,b) = \sum_{i=1}^{n} \omega_i \cdot sim(a_i, b_i)$$  \hspace{1cm} (1)

Where, $SIM (a,b)$ is the comprehensive similarity of the current case $a$ and the historical case $b$, $\omega_i$ is the normalized weight of characteristic attribute $i$, $sim(a_i, b_i)$ is the similarity of retrieval characteristic attribute $i$, $n$ is the number of the characteristic attributes.

According to the different types of attributes, the corresponding attribute similarity calculation method is also different.

**Equal Symbol Attribute.** The equal symbol attribute enumerates all possible values of the attribute, and then judges the similarity based on whether the values are equal or not. If the values are equal, then $sim(a_i, b_i)=1$, otherwise $sim(a_i, b_i)=0$.

**The Difference Attribute.** The difference attribute also enumerates all possible values for the attribute. If the values between the two cases are exactly the same, then $sim(a_i, b_i)=1$, if the values between the two cases differ by one level, then $sim(a_i, b_i)=0.5$, otherwise $sim(a_i, b_i)=0$.

**The Number Attribute.** The attribute value of each characteristic attribute is a point in the corresponding feature space, and the distance between the points reflects the difference between the characteristic attribute values. Therefore, the similarity of the number attribute is calculated based on the distance. In this paper, the calculation method based on Euclidean distance is used, as shown in Eq.2.

$$sim(a_i, b_i) = 1 - \frac{dist(a_i, b_i)}{z_i} = 1 - \frac{1}{max_i - min_i} \left| a_i - b_i \right|$$  \hspace{1cm} (2)

where, $max_i$ represents the maximum value of the characteristic attribute $i$, and opposite

**The fuzzy Attribute.** The fuzzy interval attribute refers to the interval of uncertainty or uncertainty boundary, and the membership degree function is usually used to calculate the similarity between attributes. According to the difference between the phases, the relevant calculation method is as follows:

The calculation formula of the similarity between the number attribute value and the fuzzy interval attribute value is shown as follows:

$$sim(a_i, [b_1, b_2]) = 1 - \frac{dist(a_i, [b_1, b_2])}{max_i - min_i}$$  \hspace{1cm} (3)

$$dist(a_i, [b_1, b_2]) = \int_{b_1}^{b_2} dist(a_i, x) \, dx$$

$$= \begin{cases} 
(b_2 + b_1 - 2a) / 2 & a \leq b_1 \\
[(b_2 - a)^2 + (b_1 - a)^2] / 2(b_2 - b_1) & b_1 < a < b_2 \\
(2a - b_2 - b_1) / 2 & b_2 \leq a 
\end{cases}$$  \hspace{1cm} (4)

The similarity calculation formula between fuzzy interval attribute value and fuzzy interval attribute value is as follows:

$$sim([a_1, a_2], [b_1, b_2]) = 1 - \frac{dist([a_1, a_2], [b_1, b_2])}{max_i - min_i} = 1 - \frac{1}{(max_i - min_i)} \cdot \int_{b_1}^{b_2} \frac{dist(x, [b_1, b_2]) \, dx}{(a_2 - a_1)(b_2 - b_1)}$$  \hspace{1cm} (5)
Multi-valued Sequence Attribute. For the case of multiple attribute values, this paper uses the multi-valued sequence comparison method to calculate the attribute similarity. This method is reference for the gene sequence comparison method [8], and determines the sequence similarity by comparing the importance of corresponding degree. Main procedures are as follows:

Construct a comparison sequence.

Construct the sequence contrast matrix. The number of multi-valued attribute options is n, then the sequence comparison matrix is constructed.

Assign a value to the contrast matrix assignment. The assignment formula is shown as Eq.7.

\[
\begin{align*}
    f_{ij} = \begin{cases} 
        2n-1, & i = j = 1 \\
        \vdots \\
        n, & i = j = n \\
        n-1, & |i - j| = 1 \\
        \vdots \\
        1, & |i - j| = n - 1 
    \end{cases}
\end{align*}
\]

(7)

Where, \( i = 1, 2, ..., n \), \( j = 1, 2, ..., n \), \( f_{ij} \) represent the values of the \( i \)-th column of the matrix.

Calculate the attribute similarity. Let \( k \) be the number of sequence bits of the target sequence \( S_1 \), \( m \) be the number of sequence bits of the comparison sequence \( S_2 \), \( S_{1i} \) represents the sequence of the \( i \)-th bit sequence of the sequence \( S_1 \), and \( S_{2i} \) represents the sequence of the \( i \)-th bit of the sequence \( S_2 \). The similarity formula of the multi-valued sequence attribute is calculated as shown in Eq.8.

\[
    sim(s_1, s_2) = \frac{\sum_{i=1}^{\min(k, m)} f_{i(s_1, s_2)}}{\sum_{i=1}^{k} f_{i(s_1, s_2)}}
\]

(8)

Case Selection and Case Revise

By setting the case similarity threshold (set to 0.6), the similar case results with similarity greater than the threshold are returned, and the solution (the emergency rescue scheme) of the case with the highest similarity is selected as the assistant decision-making scheme of the current maritime accident by case revise.

Example Analysis

Set the current case as \( a \), select the case of historical cases \( b, c \) as the comparison object, using the attribute type and attribute similarity calculation method created in this paper and the method used in literature [4], the similarity calculation results are shown in Table 1.

Compared with literature [4], the attribute type proposed in this paper is more rich and detailed, and the difference attribute proposed in this paper has a certain scientificity. For the difference attribute of ship scale, wave level and other attributes, it still has a certain similarity if the attribute values differ by a level. For multi-valued sequence attributes, it is reasonable to calculate the similarity degree according to the influence of different weather conditions on emergency rescue. Therefore, the classification of characteristic attributes proposed in this paper and the corresponding similarity calculation method have improved the accuracy of attribute similarity calculation to a...
certain extent, which is helpful to improve the accuracy of case retrieval results. Finally, modifying the solution (emergency rescue scheme) of case 3 or directly applying it to the current case of emergency rescue.

Table 1. Case similarity calculation results.

<table>
<thead>
<tr>
<th>Attribute name</th>
<th>Case a</th>
<th>Case b</th>
<th>Case c</th>
<th>weight $\omega_i$</th>
<th>$\text{sim}(a, b)$ (this paper)</th>
<th>$\text{sim}(a, c)$ (this paper)</th>
<th>$\text{sim}(a, b)$ (literature [4])</th>
<th>$\text{sim}(a, c)$ (literature [4])</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ship type</td>
<td>Cargo ship</td>
<td>Cargo ship</td>
<td>Fishing boat</td>
<td>0.0398</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Ship scale</td>
<td>Medium</td>
<td>Medium</td>
<td>Small</td>
<td>0.0823</td>
<td>1</td>
<td>0.5</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Crews</td>
<td>15</td>
<td>12</td>
<td>30</td>
<td>0.0929</td>
<td>0.9849</td>
<td>0.9246</td>
<td>0.9849</td>
<td>0.9246</td>
</tr>
<tr>
<td>Accident type</td>
<td>Collision</td>
<td>Strand ed</td>
<td>Collision</td>
<td>0.0992</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Whether it is sunken</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>0.0827</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Whether a fuel leak occurred</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>0.0833</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Exploding scale</td>
<td>0</td>
<td>0-0.2</td>
<td>0-0.1</td>
<td>0.0930</td>
<td>0.9</td>
<td>0.95</td>
<td>0.9</td>
<td>0.95</td>
</tr>
<tr>
<td>Wind level</td>
<td>4-5</td>
<td>2-3</td>
<td>10-11</td>
<td>0.0827</td>
<td>0.8333</td>
<td>0.5</td>
<td>0.8333</td>
<td>0.5</td>
</tr>
<tr>
<td>Wave level</td>
<td>Medium wave</td>
<td>Light wave</td>
<td>Big wave</td>
<td>0.0936</td>
<td>0.5</td>
<td>0.5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Weather</td>
<td>Heavy rain, little rain, cloud, sunny</td>
<td>Heavy rain</td>
<td>0.0908</td>
<td>0.28</td>
<td>0.4</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Visibility</td>
<td>1.5</td>
<td>10-15</td>
<td>0.15</td>
<td>0.0894</td>
<td>0.5926</td>
<td>0.95</td>
<td>0.5926</td>
<td>0.95</td>
</tr>
<tr>
<td>Water depth</td>
<td>45</td>
<td>30</td>
<td>50</td>
<td>0.0703</td>
<td>0.8026</td>
<td>0.9342</td>
<td>0.8026</td>
<td>0.9342</td>
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<tr>
<td>Comprehensive similarity</td>
<td>0.7138</td>
<td>0.5897</td>
<td>0.6416</td>
<td>0.4654</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Summary

In this paper, an improved method of maritime emergency rescue scheme based on improved CBR is studied by improving the similarity calculation method of attribute type and its attribute. This paper focuses on the case similarity calculation method based on KNN algorithm. Finally, the results of the method are analyzed by the example. The results show that the improved CBR can improve the accuracy of the case retrieval to a certain extent. The selection method of maritime emergency rescue scheme based on CBR is of practicality and effectiveness.

References


