Case Based Reasoning of Railway Engineering Construction Risk Management Based on Knowledge Ontology

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Abstract
Case matching is an important link in the process of the railway engineering construction risk to control measures. Taking into account the risk factors of construction of complex events and factors, risk event, with the complex relationship between risk results, so commonly used conventional method of computing the similarity between attributes are clearly subject to certain limitations. Therefore, this paper is in the railway engineering construction risk ontology basis, citing the risk knowledge semantic similarity computation theory which constructed with hierarchy analysis method to determine the mathematical model of the case feature attribute weights, for further development of risk measures provide the scientific references basis. Finally, through a verified tunnel project risk events of case-based reasoning which based on ontology knowledge of railway engineering construction risk management is more convincing.
Key words: RAILWAY ENGINEERING, KNOWLEDGE ONTOLOGY, RISK CONTROL, MEASURE REASONING

1. Introduction

Case based reasoning is a case study to store experience and knowledge [1], the use of similar cases to solve the current problems of the solutions to compare, it is necessary to establish knowledge ontology [2]. Case matching is an important link in the process of the railway engineering construction risk control measures.

Considering the complex factors that influence the construction of risk events, and the influenced factors, risk events, risk consequence has a complex relationship between, so the common methods of conventional attribute similarity calculating obviously to certain limitations [3, 4].

This paper in the railway engineering construction risk ontology basis, citing the risk knowledge semantic similarity computation theory which constructed with hierarchy analysis method to determine the mathematical model of the case feature attribute weights, for further development of risk measures provide the scientific reference basis. Finally, through a verified tunnel project risk events of case-based reasoning, the case-based reasoning based on ontology knowledge of railway engineering construction risk management is more convincing[5, 6, 7, 8, 9, 10].

2. A body of knowledge bases on the risk of semantic similarity calculation

The main idea of the concept of semantic similarity[11] calculation is determined by the degree of similarity between the two concepts of distance with size, the more similar the two concepts are, the smaller the semantic distance, whereas the similarity, the greater the distance. Between ontology concepts through a line connected to a correlation between the relationship between the size of the concept of similarity between concepts are closely related to how much, if between the two concepts is associated with many lines, that the similarity between them must be very low: whereas if the two concepts are connected by a line, it must be very great similarity between them. Therefore, the path between two concepts, namely the number of lines associated with the two concepts can be used as a measure of semantic distance. But given the size of the path: the two concepts and two concepts under different types of the same class may under the same, but the semantic similarity of circumstances, may various, so only the distance as the similarity between the two concepts may lack of accuracy. Therefore, this paper introduces the concepts of distance from the most recent common ancestor of the root node as a measure similar calculation.

Definition 1: p and q are the risks of railway construction project ontology tree nodes between any two concepts; the distance between the two concepts is defined as follows:

1. If p and q are risk ontology tree node with a concept, then;
2. If there is no common ancestor between p and q, then;
3. If not, is the sum of all edges from p to q or from q to p elapsed.

Definition 2: Railway Construction Risks ontology tree, the concept of similarity p and q if the corresponding concept Cp represents the corresponding node p, q concept Cq corresponding representative node, the node, as shown in equation (1) by show.

$$Sim(C_p,C_q)=\begin{cases}1 & \text{if dist}(p,q)=0\\ \dfrac{\omega\times N+1}{dist(p,q)+\omega\times N+1} & \text{if dist}(p,q)>0\\ 0 & \text{if dist}(p,q)<0\end{cases} \quad (1)$$

Wherein, A is the adjustment factor, generally greater than or equal A 2, N denotes the distance of the nearest node p and q root node and railway construction risk engineering body root nodes.

3. Basing on case characteristics property rights on AHP weight determination

Risk cases develop each feature attribute to impact on the risk control measures are not the same, some impact, some small effect, so the risk weights case is important for the effectiveness of risk control measures. The most direct and effective way to obtain weight value determination method are experts in the field, of course, can also be obtained through a number of algorithms, but the case because of the risk characteristics of the weights is different from the weight calculation, it does not have a specific value. So this paper uses expert knowledge and experience in combining mathematical methods AHP.

3.1. Establishment of judgment matrix.

Firstly, experts in the field based on the principle of the importance of risk control measures, the feature attributes pair wise comparison, according to the relative importance of rating assignment, and the formation of judgment matrix, which can reduce the influence of subjective uncertainty to some extent. Feature attributes such as case, the comparison between two to give judgment matrix, as shown in equation (2) below.

$$A=\begin{bmatrix}a_{11} & a_{12} & \cdots & a_{1n}\\ a_{21} & a_{22} & \cdots & a_{2n}\\ \vdots & \vdots & \ddots & \vdots\\ a_{n1} & a_{n2} & \cdots & a_{nn}\end{bmatrix} \quad (2)$$

3.2. Hierarchical ordering.

Calculating and determining all grades respectively and values in each row of the matrix rank the relative importance of values and, as shown in equation (3) and (4) below.

$$V_j=\sum_{j=1}^{n}a_{ij}\,(j=1,2,\cdots,n) \quad (3)$$

$$\sum_{i=1}^{n}V_i=V_1+V_2+\cdots+V_n \quad (4)$$

Weight equals to the weight of each attribute judgment matrix rank the relative importance of each row values divided by the sum of all grades, as shown in equation (5) below.

$$w_i=\frac{V_i}{\sum_{i=1}^{n}V_i},\ w=(w_1,w_1,\cdots,w_1)^T \quad (5)$$

4. Risk Case similarity calculation

For the similarity of the current risk events and the case-based between risk calculations, we use semantic similarity value and the characteristic attributes case weights between concepts conceptual similarity property features comprehensive calculation. Hypothetical case library has m risk cases, each case has n characteristic attribute weights feature attributes, the current risk events and each case base case corresponding feature attribute similarity matrix, as shown in equation (6) shows.

$$Sim=\begin{pmatrix}sim_{11} & sim_{12} & \cdots & sim_{1n}\\ sim_{21} & sim_{22} & \cdots & sim_{2n}\\ \vdots & \vdots & \ddots & \vdots\\ sim_{m1} & sim_{m2} & \cdots & sim_{mn}\end{pmatrix} \quad (6)$$

The similarity of the current risk events and the case base m a risk cases can use the formula (7) is calculated.

$$\begin{pmatrix}sim_{11} & sim_{12} & \cdots & sim_{1n}\\ sim_{21} & sim_{22} & \cdots & sim_{2n}\\ \vdots & \vdots & \ddots & \vdots\\ sim_{m1} & sim_{m2} & \cdots & sim_{mn}\end{pmatrix}\times\begin{pmatrix}w_1\\ w_2\\ \vdots\\ w_n\end{pmatrix}=\begin{pmatrix}\Delta_1\\ \Delta_2\\ \vdots\\ \Delta_n\end{pmatrix} \quad (7)$$

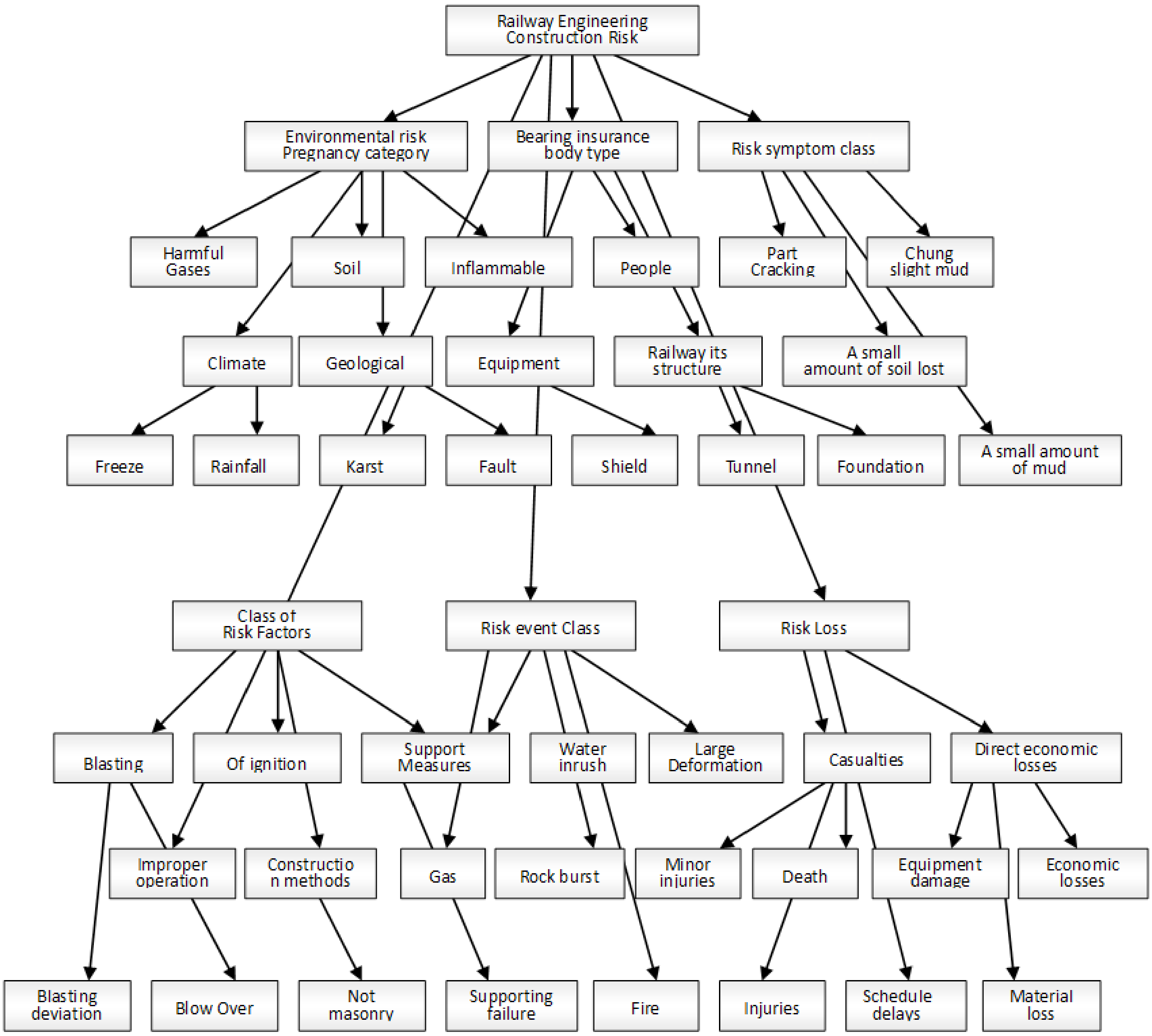

Figure 1. Ontology construction risk diagram (part)

5. Example applications

As many entire railway construction risk ontology concepts, complex relationship, in order to facilitate the calculation of this excerpt use part of the construction risk ontology problem analysis, shown in Figure 1.

According to the mechanism of risk, so we chose pregnancy risk environment, causing risk factors, risk events, risk signs, bearing insurance body, the risk of loss of the seven attributes as key elements of the railway construction project risk on behalf of the main features of each risk cases.

Taking a railroad tunnel, the tunnel is located in the karst area, the tunnel one side is surface rivers, Which is seasonal variation in elevation band, before the construction of the section ahead of the forecast shows that groundwater is not developed, the excavation proves that groundwater is not developed, but a small amount of dissolved pore and dissolved gap, after a period of time before the second masonry construction, heavy rain, the river water level rise, dry Crack in water, such as injection, the occurrence of the tunnel face a few Bay mud, collapse in, water began to rise in the tunnel , the impact of construction. Using the method of the fourth chapter, risk diagnosis, obtain the tunnel water inrush events may take place. For the good response, we will take what measures?

Firstly, we have to analyze the properties of the risk characteristics of the problem, through the understanding of the basic information, we have come to the seven attributes to the risk characteristics of the case are: rain, no masonry, water inrush, a few Bay mud, tunnels, schedule delays (important concepts in each case more than one characteristic property, we choose the most important concept here). If the risk case library has five risk cases, because of space limitations, not reproduced here after the case, now extract feature attributes important concepts to in each case, as shown in Table 1.

Table 1. Case Base Case feature attributes important concepts

Case	Environment risk pregnant	Induced risk factor	Risk events	Risk signs	Bearing insurance body	The risk of loss
Case one	Inflammable	Ignition	Fire	No	People	Minor injuries
Case two	Rainfall	Blow Over	Water inrush	A small amount of mud Chung	Tunnel	Economic losses
Case three	Fault	Supporting failure	Water inrush	A small amount off the earth	People	Injuries
Case four	Karst	Improper operation	Rock burst	Part Cracking	Shield	Equipment damage
Case five	Harmful gases	Blasting deviation	Gas	No	People	Death

5.1. Conceptual similarity between the calculated values

The similarity calculation shows in the table 1, from the «Water bursting» and «Fire» between the two, their common ancestor «risk events» and the root «Railway Construction Risk Project» N is a distance, to take. The similarity of «breaking the water» and «fire» between the

$$Sim(C_p, C_q) = \frac{\omega \times N + 1}{dist(p,q) + \omega \times N + 1} = \frac{2 \times 1 + 1}{2 + 2 \times 1 + 1} = \frac{3}{5} \tag{8}$$

Feature attribute to similarity calculation that the railway project risk events and the case base five risk cases through semantic concepts, as shown in Table 2.

Table 2. Case Feature attributes similarity value

Case	Environmental risk pregnant	Induced risk factor	Risk events	Risk signs	Bearing insurance body	The risk of loss
Case one	1/2	1/2	3/5	0	1/2	1/2
Case two	1	3/8	1	1	1	1/2
Case three	3/8	3/8	1	3/5	1/2	1/2
Case four	3/8	1/2	3/5	3/5	3/8	1/2
Case five	1/2	3/8	3/5	0	1/2	1/2

5.2. Case Features attribute to weights determined

Choose Railway Construction risk engineering experts attribute pregnant to case basis risk environment characteristics, causing risk factors, risk events, risk signs, bearing insurance body, the risk of loss of any two of the principles of risk control measures importance, obtained judgment matrix:

$$A = \begin{bmatrix} 1 & 1.25 & 0.5 & 1.25 & 0.8 & 1.25 \\ 0.8 & 1 & 0.625 & 0.5 & 2 & 1.25 \\ 2 & 1.6 & 1 & 1.25 & 1 & 2.5 \\ 0.8 & 2 & 0.8 & 1 & 1 & 2 \\ 1.25 & 0.5 & 2 & 1 & 1 & 2 \\ 0.8 & 0.8 & 0.4 & 0.5 & 0.5 & 1 \end{bmatrix} \tag{9}$$

The relative importance of hierarchy and each line is:

$$V_1 = 6.05,\quad V_2 = 6.175,\quad V_3 = 9.35,\quad V_4 = 7.6,\quad V_5 = 7.75,\quad V_6 = 4$$

Each property values and all grades of:

$$\sum_{i=1}^{n} V_i = V_1 + V_2 + \cdots + V_n = 40.925$$

The weight value of each property (two decimal places) is:

$$w = (0.15 \quad 0.15 \quad 0.23 \quad 0.18 \quad 0.19 \quad 0.10)^T$$

5.3. Calculation of risk similar cases

According to the similarity between concepts worth calculation, the railway risk event and the case base five risk cases feature similarity matrix:

$$Sim = \begin{pmatrix} 1/2 & 1/2 & 3/5 & 0 & 1/2 & 1/2 \\ 1 & 3/7 & 1 & 1 & 1 & 1/2 \\ 3/7 & 3/7 & 1 & 3/5 & 1/2 & 1/2 \\ 3/7 & 1/2 & 3/5 & 3/5 & 3/7 & 1/2 \\ 1/2 & 3/7 & 3/5 & 0 & 1/2 & 1/2 \end{pmatrix} \tag{10}$$

The railway risk events and the cases base five risk case similarity values are as follows:

$$\begin{pmatrix} 1/2 & 1/2 & 3/5 & 0 & 1/2 & 1/2 \\ 1 & 3/7 & 1 & 1 & 1 & 1/2 \\ 3/7 & 3/7 & 1 & 3/5 & 1/2 & 1/2 \\ 3/7 & 1/2 & 3/5 & 3/5 & 3/7 & 1/2 \\ 1/2 & 3/7 & 3/5 & 0 & 1/2 & 1/2 \end{pmatrix} \times \begin{pmatrix} 0.15 \\ 0.15 \\ 0.23 \\ 0.18 \\ 0.19 \\ 0.10 \end{pmatrix} = \begin{pmatrix} 0.433 & 0.864 & 0.611 & 0.517 & 0.422 \end{pmatrix} \tag{11}$$

Therefore, the railway risk events and the cases base case two most similar cases can refer to two solutions for controlling risk events.

6. Conclusions

In this paper, using the improved knowledge of semantic similarity theory based on a risk-based body of case attribute to similarity calculation based on AHP case feature attribute weights were determined, the formation of a more scientific, for China Railway Construction Risk Management CBR theory, for the rapid development of the science of risk control measures to provide the best reference, further deterioration of the leather risk events, based on similarity matching risk cases, the conclusion that the risk of incidents and the case base the similarity of events in order to solve the risk event provides a reference.

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