Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2014, 6(6):1756-1761

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Biological opposite degree algorithm and its application in coal and gas outburst prediction

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ABSTRACT

In order to predict coal and gas outburst, biological contrary degree algorithm is proposed based on contrary degree and biological theory and prior values and posterior values. In the nature, there are prior data and posterior data; such as positive words and negative words. According to the contrary matrix, the testing data can be predicted based on the testing data by using biological contrary degree algorithm. Meanwhile, the accuracy of biological contrary degree algorithm is 100%. The results show that new algorithm is feasible and effective.

Keywords: biological contrary degree, coal and gas outburst, prior value, posterior value, prediction method.

INTRODUCTION

Coal mine safety is a very imperative issue in the coal mining industry since accidents in mining companies are very likely to cause death, injury and huge losses of property [1-3]. Coal and gas outburst often happen in China. So, it's very necessary to study the coal and gas outburst prediction method. In this study, a new prediction algorithm (biological contrary degree algorithm) is proposed. Biological contrary degree (BCD) algorithm is based on biological contrary degree between prior data and posterior data. In the nature, the contrary degree is inseparable from the synonyms and antipodal opposites in people's daily life [4]. The person would think physically that "father" and "papa", "mother" and "mama", "father" and "man", "wife" and "woman" are the synonyms; "grandpa" and "grandma", "parents" and "children", "male" and "female" are the antipodal opposites. However, the closeness of relationships between those words are not the same, people always think that "father" and "papa" are closer than "father" and "man". Because of "papa" must be "father", and "man" is not necessarily be a "father". Similarly, the extent of the conflict between opposite words is not the same. Judging from intuition, the contrary degree between "male" and "female" is relatively absolute, and the contrary degree should be very high. So, for intelligent information processing, especially in nature situation, it is very important for using a precise method to represent the relationship between the real relationships.

Biological contrary degree

Learning from the vocabulary of many European languages, they have negative and positive vocabularies. In order to express the relation between the words, Professor Fanjin Mai and Dr. Ting Wang summed the vocabulary to negative and positive, as shown in figure 1 [5-7]. For example: "law", "optimistic", "solar system", "man", "noon", "yesterday", "red", "above" and "peak" are the positive words; "guess", "pessimistic", "upset", "aliens", "woman", "morning", "tomorrow", "feel", "blue", "below" and "hole" are the negative words.

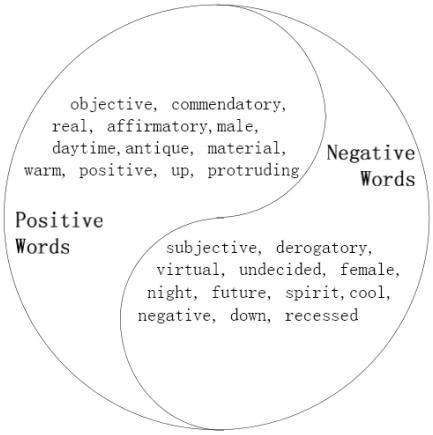

Figure 1: the negative and positive words

Biological contrary degree calculation model

In order to calculate the relationship, the semantic network between words as a type of graphite is shown. The graphite is consisted of carbon element. Its structure is composed of many continuous bedding planes, which are parallel to the interarea, as shown in figure 2 [8]. In order to show the relationship between different parts of the words, the second model is introduced, as shown in figure 3. From the figure 3, the positive words a, b, c and d are similar to a', b', c' and d'. The positive y has no negative word to correspond and the negative x has no positive word to correspond too, however, the y and x have a similar or opposite connection with a, b, c, d, a', b', c' and d'.

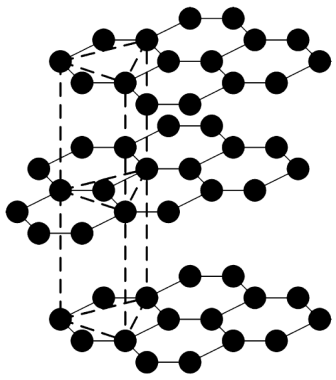

Figure2: the structure of graphite

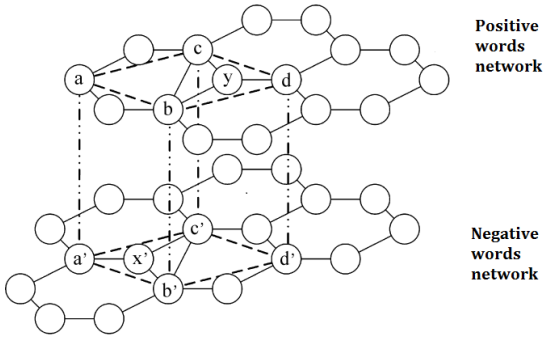

Figure3: type of graphite semantic model

For a semantic corpora, the calculation of opposite degree needs to solve the semantic displacement, and to calculate the relationship between the semantic displacement and the similarity. The semantic distance can be used to reflect the level of the similarity between two words. Define $Dist(a,b)$ as the semantic displacement of a and b, as shown in formula 1 (Fanjin Mai and Ting Wang, 2008).

$$Disp(a,b)=\begin{cases} Dist(a,b)\,(\text{when a and b are in the same layer}) \\ -Dist(a,b)\,(\text{when a and b are not in the same layer}) \end{cases} \quad (1)$$

Where, $Dist(a,b)$ is the distance, $Disp(a,b)\in(-\infty,+\infty)$.

The computational formula between the semantic displacement and the similarity $Sim(a,b)$ are shown in formula 2.

$$Sim(a,b)=\begin{cases} \lambda^{Disp(a,b)}, when Disp(a,b)\in[0,+\infty) \\ Con(a,b)=\lambda^{Disp(a,b)}, when Disp(a,b)=(-\infty,0) \end{cases} \quad (2)$$

Where, λ is parametric parameter, $\lambda\in(0,1)$, which indicates the semantic similarity (when the distance is 1). $Con(a,b)$ is the semantic opposite degree. In short, opposite degree can show the relationship between words precisely, which expands the range of common semantic similarity to negative number. Biological contrary degree conceptual framework

The definition of opposite degree are presented, mainly involves the following aspects:
(1) A priori value refers to the value for the training;
(2) A posteriori numerical refers to numerical prediction analysis;
(3) Opposite degree is a priori and posteriori numerical value between degrees of difference, $(-\infty,+\infty)$ is the range of the values.

In general, the definition of opposite degree is C, a priori value is A, the posterior value is B. Here is the formula.

$$C=\frac{B-A}{A}=\begin{cases} <0, B<A \\ =0, A=B \\ >0, B>A \end{cases} \quad (3)$$

C is close to $+\infty$, it shows that B is more big, and indicates that the difference of B and A is greater. C is close to $-\infty$, it shows that B is small, and indicates that the difference of B and A is greater; C is close to 0, indicating that B and A are closer; C is equal to 0, show that the A is equal to B.

There is a prior matrix $A_{m\times n}$.

$$A_{m\times n}=\begin{bmatrix} a_{11} & a_{12} & \ldots & a_{1n} \\ a_{21} & a_{22} & \ldots & a_{2n} \\ \ldots & \ldots & \ldots & \ldots \\ a_{m1} & a_{m2} & \ldots & a_{mn} \end{bmatrix}$$

The classification column vector of $A_{m\times n}$ is X.

$$X=\begin{bmatrix} x_1 \\ x_2 \\ \ldots \\ x_n \end{bmatrix}$$

There is a posterior matrix $B_{p\times n}$.

$$B_{p\times n}=\begin{bmatrix} b_{11} & b_{12} & \ldots & b_{1n} \\ b_{21} & b_{22} & \ldots & b_{2n} \\ \ldots & \ldots & \ldots & \ldots \\ b_{p1} & b_{p2} & \ldots & b_{pn} \end{bmatrix}$$

The opposite degree of $A_{m\times n}$ and $B_{p\times n}$ can be calculated by using the following formula.

$$C(a_{ij},b_{kj})=\frac{b_{kj}-a_{ij}}{a_{ij}} \quad (4)$$

Based on the opposite degree calculation, the correspondin

g classification column vector Y of $B_{p\times n}$ can be calculated.

$$Y=\begin{bmatrix} y_1 \\ y_2 \\ \ldots \\ y_p \end{bmatrix}$$

Biological contrary degree calculation steps

(1) According to the following formula, calculated separately for each line of the opposite, and returns the absolute value of the minimum value. $C(k)$ is the opposite degree calculation results of the k line data of $B_{p\times n}$ and each line of $A_{m\times n}$, the minimum absolute value can be got (if the results obtained with two or more than two of the same value, it returns the first value).

$$C(k)=\min\begin{cases} |\sum_{j=1}^{n}\frac{b_{kj}-a_{1j}}{a_{1j}}| \\ \ldots \\ |\sum_{j=1}^{n}\frac{b_{kj}-a_{ij}}{a_{ij}}| \end{cases} \quad (5)$$

(2) Returns the corresponding x_i to the y_p, the k line classification of $B_{p\times n}$ can be obtained.

(3) Repeat (1) and (2), until calculate all the results.

(4) Output Y.

Analysis of Calculation Results

The coal and gas outburst data comes from Pingdingshan Coal Mine Industry Company [9, 10]. There five key indicators for prediction. They are height (H), gas emission initial velocity (V), comprehensive index (I), coal mine seam structure thickness (T), structure complexity (C). Five sets of data were selected as training data; two sets of data were selected as testing data. The training data and testing data are shown in table 1 and table 2. The last column CGO (coal and gas outburst) indicated the situation of coal and gas outburst; if there was a coal and gas outburst, it would be yes; otherwise, it would be no coal and gas outburst.

Table 1 Training data

No.	H(m)	V(m/s)	I	T(m)	C	CGO
1	-392	15.3	76.0	0.8	1.1	Yes
2	-437	7.6	12.8	0.2	0.8	No
3	-446	12.7	31.5	0.4	1.3	Yes
4	-424	7.9	16.8	0.3	0.3	No
5	-395	10.9	21.6	0.6	1.2	yes

Table 2 Testing data

No.	H(m)	V(m/s)	I	T(m)	C	CGO
6	-380	8.9	12.5	0.1	0.6	No
7	-530	13.0	38.4	0.6	2.3	Yes

According to BCD, the calculation results of 6th group data are shown in table 3; the calculation results of 7th group data are shown in table 4. And the bold font results indicate $S(k)$.

Table 3 The calculation results of 6th group data

Testing data's No.	BCD of H	BCD of V	BCD of I	BCD of T	BCD of C	C(6)
1	-0.0306	-0.4183	-0.8355	-0.8750	-0.4545	0.5228
2	-0.1304	0.1711	-0.0234	-0.5000	-0.2500	0.1466
3	-0.1480	-0.2992	-0.6032	-0.7500	-0.5385	0.4678
4	-0.1038	0.1266	-0.2560	-0.6667	1.0000	**0.0200**
5	-0.0380	-0.1835	-0.4213	-0.8333	-0.5000	0.3952

Table 4 The calculation results of 7th group data

Testing data's No.	BCD of H	BCD of V	BCD of I	BCD of T	BCD of C	C(7)
1	0.3520	-0.1503	-0.4947	-0.2500	1.0909	**0.1096**
2	0.2128	0.7105	2.0000	2.0000	1.8750	1.3597
3	0.1883	0.0236	0.2190	0.5000	0.7692	0.3400
4	0.2500	0.6456	1.2857	1.0000	6.6667	1.9696
5	0.3418	0.1927	0.7778	0.0000	0.9167	0.4458

Based on the table 3 and table 4, the prediction results are shown in table 5.

Table 5 Testing data

No.	Testing data's No.	C(k)	Testing data's CGO	Prediction results
6	4	0.0200	No	No
7	1	0.1096	Yes	Yes

The prediction results show that the BCD algorithm has a positive role in classification and prediction. The accuracy of BCD is 100%.

CONCLUSION

In order to study the characteristics of coal and gas outburst accidents and to avoid the mine disaster, a combination algorithm of biological theory and mathematical method is proposed. The biological contrary degree algorithm based on the contrary properties in biology and the mathematical method to express opposition of the relationship between the two data. By combining the instance data of coal and gas outburst, the efficiency of the algorithm is verified. Among them, two groups of data of biological contrary degree is smaller, the correlation is greater; according to this characteristic, learning from the 5 groups data of coal and gas outburst prediction data, two groups of coal and gas outburst is predicted. The correct rate of prediction results is 100%. The improved biological contrary degree algorithm and its application research are the next research aspects.

Acknowledgement
This study was financially supported by Self-determined and Innovative Research Funds of WUT (2014-JL-007) and Specialized Research Fund for the Doctoral Program of Higher Education (No. 20120143110005).

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