International Journal of Engineering & Technology, 7 (3.19) (2018) 33-38

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

A Computation Model of Micro-Blog Information Credibility Based on Bayesian Network

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Abstract

With the rapid development, Microblog as an important interactive media, has become a kind of transmission carrier of the false information. Therefore, the research significance of Micro-blog information credibility becomes more and more important today. In this paper, different representative factors are selected from three facets--text contents, information dissemination and information source--which influence the information credibility of Micro-blog. We choose Netica software to build Bayesian network model and use the rumors grabbed from Sina Weibo as experimental data in order to get the relationship between conditions and phenomena from the changes of probability distribution in Bayesian network. On the basis of this, we find the influences of the representative factors on the subjective credibility of objective unreliable information.

Keywords: *Bayesian network, Microblog, credibility, Netica*

1. Introduction

The development of the Internet has never stopped, and the Internet has become the chief medium of dissemination today. For our country, according to the 39th Statistical Report on Internet Development in China which published by CNNIC in January 2017, up to December 2016, the number of net citizens in China has reached 731 million, and the popularity rate of Internet has climbed up to 53.2%. With the improvement of Internet applications, the Internet has become one of the most important places for people to obtain information and express their views.

After the birth of Twitter, Micro-blog has become an important platform for people to communicate and share information along with the development of the network and the advancement of information technology. Micro-blog is a radio social networking platform that shares short and real-time information via a focus mechanism. It shows the traits of convenience, shareability and interactivity. The publishing, forwarding and pushing of the information on Micro-blog are under a series of properties, such as network topology, timeliness and randomness, which contributes to the improvement of user engagement, information dissemination and network media service. At the same time, however, many problems have been caused because of rapid-increasing micro-bloggers and rapid-spreading information. Micro-blog information credibility is in fact one of them. Only on Sina Weibo, the number of false information processed in 2016 was as high as 2330. One of the information, for example, is a video clip of a missile force driving along the highway, which described by a micro-blogger in the words that "Hainan expressway was closed off due to the transportation of the Dongfeng 21D to Sansha. We can just sit and wait for the South China Sea Arbitration on July 12." But the investigation finds that the video clip has been around for a long time and it is irrelevant to the South China Sea Arbitration. It is on Micro-blog that false information like this has been published and disseminated--thus, the information tends to cause a widespread attention of social public opinion. In other words, Micro-blog boosts the production and dissemination of false information, which having a negative impact on social order and public opinion. The properties of Micro-blog provide a powerful catalyst for the rapid spread and widespread diffusion of the information with different credibility. Reliable and unreliable information is mixed and fermented in Micro-blog, and because of that, the research significance of Micro-blog information credibility becomes more and more important.

The significances of researching Micro-blog information credibility are as follows: Firstly, the spread of unreliable information on Micro-blog does harm to the platform itself and could cause a noticeable negative effect on micro-bloggers. Secondly, relevant research findings can be used to deal with the dissemination of false information, promote the establishment and improvement of relevant mechanisms, and enhance the effective filtering of Micro-blog information. Thirdly, people could know the credibility problem of Micro-blog information through relevant research results, which helps them to develop their critical discernment as well as increase their self-discipline.

Because of the important research significances, more and more scholars have paid attention to the research of Micro-blog information credibility. Their researches could be divided into the following two categories：

On the one hand, taking the literatures published by C.Castillo et al. [1], H.S.Al-Khalif et al.[2] and Gao Mingxia[3] as examples, scholars obtained the research results of Micro-blog information credibility based on the choices of information characteristics they

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needed. The contents of this kind of literatures are mostly about the analyses of information text content, and fewer literatures have all-round studies on text content, micro-bloggers and information dissemination.

On the other hand, taking the researchers conducted by A.Gupta et al. [4], M.Gupta et al. [5] and Bian Xianhua et al. [6] as example, researchers evaluated Micro-blog information credibility based on the improvement of analytic procedure and modeling algorithm. The researches like these mostly talk about optimizing the existing methods such as classification, and relatively few researches propose completely new methods.

According to the work of former researchers, this paper have an all-round study on different representative factors selected from three facets [7-9]--text content, information dissemination and information source--which have a great influence on Micro-blog information credibility. We choose Netica software to build Bayesian network model and use the rumors grabbed from Sina Weibo as experimental data in order to find the relationship between the factors. On the basis of that, we find the influences of the representative factors on the subjective credibility of objective unreliable information, and then draw the research conclusions.

2. Related Works

Credibility refers to the degree that things or people can be trusted. The literatures [10-11] have defined the concept of information credibility. It shows that information credibility reflects not only the objectivity and authenticity but also people's subjective cognition of the information to some extent. Therefore, "reliable" and "unreliable" describe the information authenticity in the narrow sense as well as show the people's subjective trust degree to information. Today's study of information credibility is mainly developed in three aspects: information content credibility, information source credibility and information dissemination credibility [12].

Nowadays, operating characteristics of Microblog, hidden nature of micro-blogger, group characteristics and other factors lead to a decrease in information credibility：

Microblog lacks the check function during using time. As the main "pass-holder" of Micro-blog, individuals cannot effectively check all kinds of information. At the same time, two characteristics of Micro-blog information, timeliness and interactivity, reduce the time for users to verify the information. Compared to the authenticated users, anonymous users abound in Micro-blog now. Users would have a sense of security in using time because of the anonymous function, yet at the same time, the restriction of users' behaviors is reduced in some degree. As a result, biased and even extreme views are easily formed and proposed. The users with some similarities tend to form user groups in the process of using Micro-blog. The achievability of unified viewpoints or actions often makes it easy for users to neglect the authenticity of information.

From a personal point of view, the overflow of false information reduces people's recognition of network information and is easy to trigger negative emotions and reactions. From the perspective of network information environment, the unreliable information with an increasing number on Micro-blog aggravates the pollution. For many traditional media which may be inclined to gather information from Micro-blog, their duty to lead the public opinion would increase on account of the increase of false information, so the media have to spend more time and effort on identifying information.

In recent years, there are many researches carried out on the basis of Bayesian theory and Bayesian network. Bayesian network is widely used in the fields of credibility research and rumor identification.

For example , considering of the Bayesian theory, Andre C.R.Martins [16] viewed individual opinions and behaviors as external phenomena and separated out their credibility, then he put forward the CODA model which made an effective description of the relationship between individual views and tendencies. Based on the knowledge of Bayesian network, the paper [17] published by Hien Trang Nguyen et al. gave a way to calculate the credibility and prestige of Web Services. The Bayesian network established in this way took the relevant service as the root node, took the properties of the service as the child nodes and obtained the final trust value with recommendation trust, direct trust and QoS trust. Hu Zhigang et al. [18] constructed the Bayesian network by using the historical performance information of service, and then proposed a method to evaluate the QoS credibility of the dynamic and uncertain grid. According to present problems of the ad-hoc network and the node attributes, Wang Xiaodong et al. [19] built a model to evaluate the credibility of ad-hoc network nodes by using Bayesian network. After analyzing the structure pattern of online shopping software, Si Guannan et al. [20-25] established a multi-layer credibility evaluation system and realized the credibility index evaluation of online shopping software on the basis of Bayesian network bottom-up analysis. Liang Hongquan et al. [26] considered the interpersonal trust model and studied the trusted relationship of network nodes. Taking the network interaction and identity authentication as factors, they thought fully of the impacts these factors could have on credibility. After that, then they aggregated direct credibility and indirect credibility in order to give a credibility measurement model based on dynamic Bayesian network. By thinking about the problem of malicious nodes in IoT, Lin Qing et al. [27] used Bayesian network to quantify the probability of trust between the nodes and determined the trust level of the nodes.

In the relevant research fields of Micro-blog information, Bayesian networks are also popular among researchers. For instance, Chen Hui [28] took social network relationship as a starting point and then analyzed the data of Micro-blog data organization structure, trust network construction and user emotion computing. By building multi-layer Naive Bayesian model, She realized the false topic detection of Micro-blog. In order to achieve the purpose of identifying the Micro-blog rumors, V.Qazvinian et al. [29] analyzed Twitter text contents, user behaviors and Twitter elements, and constructed several Bayesian classifiers. A.H.Wang [30] studied the statistical characteristics of Twitter text information and the features of user network, which aimed to use a Bayesian classifier to filter Twitter spams.

However, in these researches of Micro-blog information, Bayesian network was mostly used to do classification and regression analyses and less used for the expression and reasoning of uncertain knowledge, which limited its good predictive ability. In this paper, more attention is paid to doing effective cause-effect predictions and getting the relationship between selected factors with a good use of Bayesian network.

3. Bayesian Network Model

This paper uses Netica to construct Bayesian network and reason the probabilities. The software with an intuitive user interface is developed by Norsys. Netica, a powerful Bayesian network software, has many useful functions such as nodes relationship definition, network construction and bayes probability prediction [19].

3.1 Node Variables Setting

The node variables in Bayesian network represent the attribute characteristics of the selected study subjects and there are two types can be selected by users and processed by Netica: discrete variables and continuous variables. Since probability reasoning

uses discrete tables, it is necessary to convert continuous variables into discrete variables before processing.

Different representative factors are selected from three facets [7-9]--text content, information dissemination and information source--which influence the information credibility of Micro-blog. From the facet of text content, as the most direct impression of Micro-blog information on people, publishing form has a significant impact on information credibility. Considering the information dissemination, forwarded number can visualize the speed of information transmission. And as a positive and incentive factor, it can influence the user's subjective impression of information. When it comes to information source, the factor that has a greater impact is whether the information publisher has been authenticated [29]. And this factor bridges the gap between the virtual environment and the real world.

Besides, set information credibility as the fourth node variable.

The followings are the four node variables and their corresponding states:

（1）Publishing Form: words and images, audio and video.

（2）Forwarded Number: low, middle, high.

（3）Identity Authentication: yes, no.

（4）Information Credibility: reliable, unreliable.

3.2 Construction of Directed Acyclic Graph

In order to make analyses on Bayesian network， the needed network should be constructed first. There are generally three ways to build the Bayesian network [31]:

(1) Determine if the directed edges exist according to the conditional independence of the variables and determine the direction of directed edges according to the relative conditions between the variables.

(2) Set up a network according to user knowledge or the causal relationships between the variables.

(3) Combine (1) with (2).

This paper uses method (2) to build the Bayesian network model and the network can be seen in Fig.1. Because the network has not been compiled and the states of node variables have not been assigned, the color of credibility bars in the figure is pale gray.

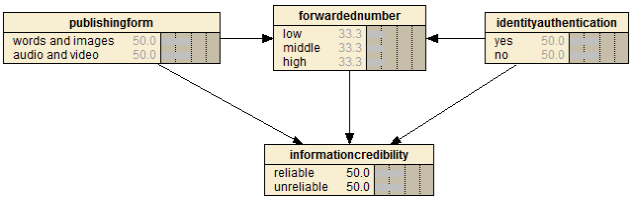

Fig.1 Uncompiled Bayesian Network

3.3 Determination of Conditional Probability Distribution

There are generally 3 ways to determine the conditional probability distribution of node variables [26]：

(1) Determine the conditional probability distribution according to the prior knowledge or specialist knowledge.

(2) Calculate the conditional probability according to the experimental data.

(3) Combine (1) with (2).

This paper determines the conditional probability distribution in way (1).

Information credibility reflects not only the objectivity and authenticity but also people's subjective cognition of the information [10-11]. In the process of quantifying the experimental data obtained, because only the objectivity and authenticity of the Micro-blog information could be defined and controlled in the research, the CPT of node "Information Credibility" in the network was not determined here. On the basis of the structure of directed acyclic graph and the fact that the forwarded number of Micro-blog information is a positive and incentive factor of Micro-blog information credibility, the changes on the subjective credibility of objective unreliable information were found out through the changes of forwarded number.

The experimental data(such as table 1, and table 2) used in this paper includes 60 rumors which have been clarified by the official account "Weibo Refutes Rumors" from December 24, 2016 to February 24, 2017 on Sina Weibo.

Table 1: Quantitative Standard of "Forwarded Number" Data

Name	Level		
	Low	Middle	High
Forwarded Number	0<Forwarded Number<=100	100<Forwarded Number<=1000	Forwarded Number>1000

Table 2: Original Data

Number	Publishing Form	Forwarded Number	Identity Authentication	Information Credibility
1	audio and video	132 (middle)	yes	-
2	words and images	0 (low)	no	-
3	audio and video	170 (middle)	yes	-
4	words and images	0 (low)	no	-
5	words and images	0 (low)	no	-
6	words and images	0 (low)	no	-
7	words and images	0 (low)	no	-
8	words and images	1 (low)	no	-
9	words and images	3 (low)	no	-
10	words and images	0 (low)	no	-
11	words and images	186 (middle)	yes	-
12	words and images	0 (low)	no	-
13	words and images	0 (low)	no	-
14	words and images	7 (low)	yes	-
15	words and images	1787 (high)	yes	-
16	words and images	0 (low)	no	-
17	words and images	7 (low)	no	-
18	words and images	0 (low)	no	-
19	audio and video	4 (low)	no	-
20	audio and video	3 (low)	no	-
21	words and images	29 (low)	yes	-
22	words and images	1 (low)	no	-

23	words and images	0 (low)	no	-
24	words and images	0 (low)	no	-
25	words and images	0 (low)	no	-
26	words and images	0 (low)	no	-
27	audio and video	1268 (high)	yes	-
28	words and images	0 (low)	no	-
29	words and images	1301 (high)	yes	-
30	words and images	5 (low)	yes	-
31	words and images	10000 (high)	yes	-
32	words and images	0 (low)	no	-
33	words and images	0 (low)	no	-
34	words and images	0 (low)	no	-
35	audio and video	2197 (high)	no	-
36	words and images	0 (low)	no	-
37	words and images	0 (low)	no	-
38	words and images	2 (low)	yes	-
39	words and images	77 (low)	yes	-
40	audio and video	0 (low)	no	-
41	words and images	2 (low)	no	-
42	audio and video	403 (middle)	yes	-
43	words and images	1 (low)	no	-
44	words and images	2 (low)	no	-
45	words and images	0 (low)	no	-
46	audio and video	832 (middle)	yes	-
47	words and images	0 (low)	no	-
48	words and images	0 (low)	no	-
49	words and images	0 (low)	no	-
50	words and images	0 (low)	no	-
51	words and images	0 (low)	no	-
52	audio and video	93 (low)	no	-
53	words and images	0 (low)	no	-
54	words and images	476 (middle)	no	-
55	audio and video	87 (low)	yes	-
56	words and images	6 (low)	no	-
57	words and images	3 (low)	no	-
58	words and images	9273 (high)	yes	-
59	words and images	0 (low)	no	-
60	words and images	0 (low)	no	-

The CPTs are filled out with the data as it is shown in Fig.2 to Fig.4. Node "Publishing Form" and node "Identity Authentication" have no parent nodes, so their prior probabilities are used to represent their node probabilities.

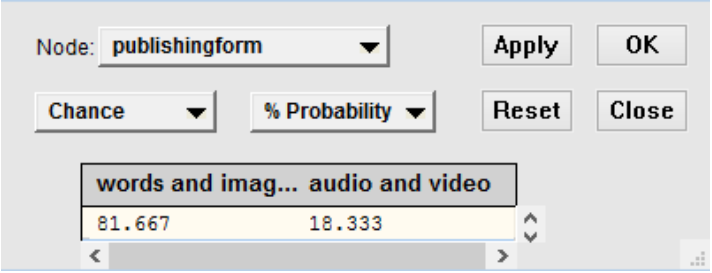

Fig.2 CPT of "Publishing Form"

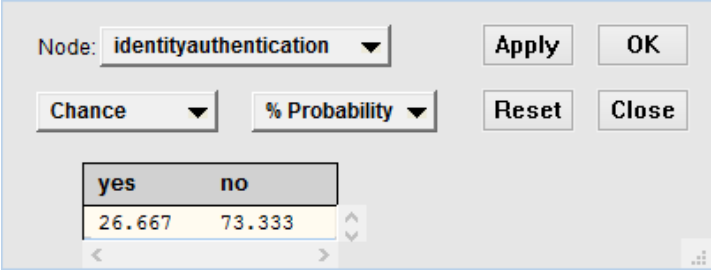

Fig.3 CPT of "Identity Authentication"

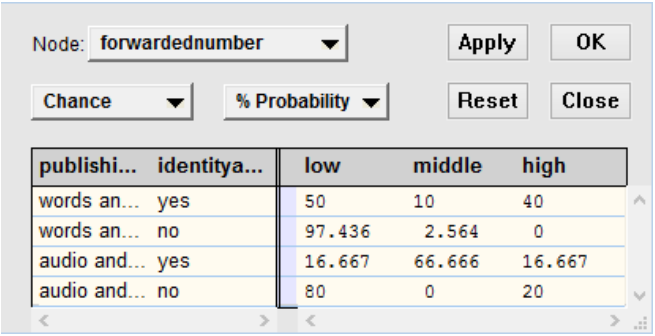

Fig.4 CPT of "Forwarded Number"

Specifically speaking, in Fig.4, the state combinations of the parent nodes are on the left side and the conditional probabilities of child node, "Forwarded Number", are on the right side. For example, the "50" (%) in the first row on the right of the CPT means:

$$P\begin{pmatrix} forwardednumber = low \mid publishi... = \\ wordsan..., identitya... = yes \end{pmatrix} = 0.5$$

The sum of the probabilities on each row in the CPT must be accurate to 1.0.

As it can be seen in Fig.5, the color of credibility bars becomes darker because that the CPTs have been improved and the network has been compiled.

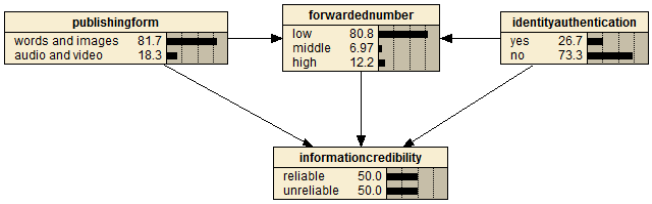

Fig.5 Compiled Bayesian Network

4. Analysis of Experimental Results

The probabilistic prediction of Bayesian network is that using Bayesian network to analyze and solve practical problems. Bayesian network model has already been constructed, conditional probability distributions of the evidence node have been obtained, both of which contribute to get the probability changes of query node states.

4.1 Probability Analysis of Forwarded Number

4.1.1 Taking "Publishing form" as the Evidence Node

Assuming that "Publishing Form" is taken as the evidence node.

If the state of evidence node is "words and images", setting the percentage of this state to 100% in Netica and then updating all network probabilities. The results are shown in Fig.6. At the time, the probability of forwarded number having a "low" level is changed from 80.8% to 84.8%, the probability of the "middle" level is changed from 6.97% to 4.55% and the probability of the "high" level is changed from 12.2% to 10.7%.

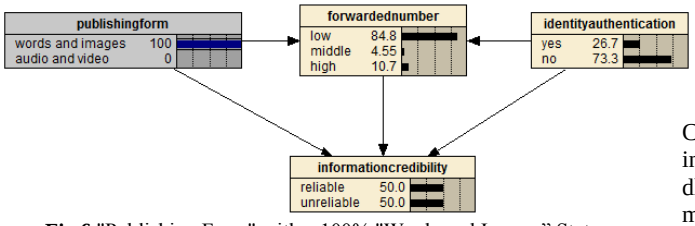

Fig.6 "Publishing Form" with a 100% "Words and Images" State

If the state of evidence node is "audio and video", setting the percentage of this state to 100% in Netica and then updating all network probabilities. The results are shown in Fig.7. At the time, the probability of forwarded number having a "low" level is changed from 80.8% to 63.1%, the probability of the "middle" level is changed from 6.97% to 17.8% and the probability of the "high" level is changed from 12.2% to 19.1%.

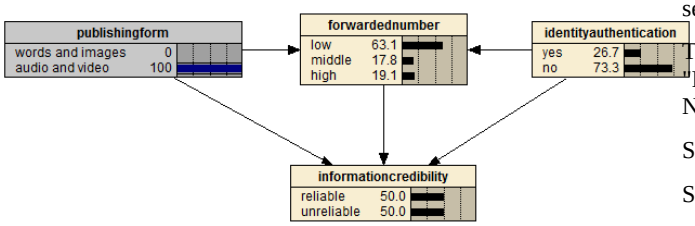

Fig.7 "Publishing Form" with a 100% "Audio and Video" State

Compared with that is in the state of "words and images", the probabilities of forwarded number having a "high" level and a "middle" level are increased by 8.4% and 13.25% when node "Publishing Form" is in the state of "audio and video".

So in conclusion, posting Micro-blog information with audio and video can increase the forwarded number and enhance the credibility of Micro-blog information to a certain extent then.

4.1.2 Taking "Identity Authentication" as the Evidence Node

Assuming that "Identity Authentication" is taken as the evidence node.

If the state of evidence node is "yes", setting the percentage of this state to 100% in Netica and then updating all network probabilities. The results are shown in Fig.8. At the time, the probability of forwarded number having a "low" level is changed from 80.8% to 43.9%, the probability of the "middle" level is changed from 6.97% to 20.4% and the probability of the "high" level is changed from 12.2% to 35.7%.

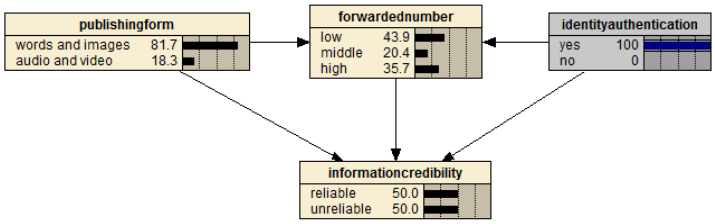

Fig.8 "Identity Authentication" with a 100% "Yes" State

If the state of evidence node is "no", setting the percentage of this state to 100% in Netica and then updating all network probabilities. The results are shown in Fig.9. At the time, the probability of forwarded number having a "low" level is changed from 80.8% to 94.2%, the probability of the "middle" level is changed from 6.97% to 2.09% and the probability of the "high" level is changed from 12.2% to 3.67%.

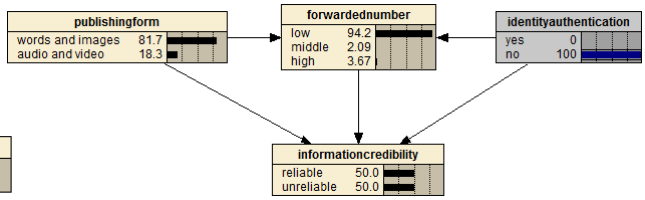

Fig.9 "Identity Authentication" with a 100% "No" State

Compared with that is not a authenticated user, the probabilities of information forwarded number having a "high" level and a "middle" level are increased by 32.03% and 18.31% when the information publisher is.

So in conclusion, it is more likely to happen that the Micro-blog information published by authenticated user has a larger forwarded number, and the credibility of this kind of information would be enhanced to a certain extent.

4.2 Sensitivity Analysis of the Evidence Node

The sensitivity analysis of the evidence node is used to obtain the sensitivity of the particular node to other evidence nodes.

To know which nodes are most likely to have an impact on node "Forwarded Number", the following steps can be performed in Netica:

Step 1: Click node "Forwarded Number".

Step 2: Select "Network" option.

Step 3: Select "Sensitivity to Findings" option under "Network".

Then a window called "Netica Messages" will pop up and a detailed report will be displayed there. The sensitivity of node "Forwarded Number" is shown in Table 3.

The evidence node that most likely has the greatest impact on the credibility of node "Forwarded Number" is "Identity Authentication".

Table 3: Sensitivity of Node "Forwarded Number"

Node	Mutual Info	Percent	Variance of Beliefs
Forwarded number	0.88679	100	0.1842242
Identity authentication	0.20849	23.5	0.0348913
Publishing form	0.03338	3.76	0.0053087
Information credibility	0.00000	0	0.0000000

5. Conclusion

Based on Bayesian network, this paper studies the credibility of Micro-blog information with probabilistic prediction and sensitivity analysis of evidence.

The inspirations of research results are as follows: Micro-blog itself should continue to strengthen the recognition of rumors as well as improve the mechanism of reporting and refuting rumors. Especially for the false information with audio and video or the false information published by authenticated users, actions should be taken as soon as possible to reduce the time the false information existing in Micro-blog. As the Micro-blog information publishers, especially the authenticated publishers, people should pay attention to their personal words and behaviors on Micro-blog and not publish and forward all kinds of unconfirmed information at will. As the audiences for Micro-blog information , they are supposed to strengthen the ability to identify and analyze information. Moreover, they should digest the Micro-blog information after judging them rather than follow the words of others liking a sheep and echo one-sided views.

In the process of Bayesian network construction, the settings of nodes and their states are not sufficient to an extent. Besides, the original data catched in Sina Weibo is not of a large number and is slightly lacking in representativeness. All kinds of the problems will be constantly improved in future research.

Acknowledgement

This work was supported in part by the National Natural Science Foundation of China (No. 61170038, 61472231, 71701115), the National Social Science Foundation of China (No. 14BTQ049), the Shandong Natural Science Foundation(ZR2017MF058), and Special project for Internet development of social science planning special program of Shandong province(17CHLJ23).

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