

Viewpoint Ranking Method Based on PageRank in Group Discussion

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Abstract. Real-time display viewpoint ranking information in the divergent discussion process, has a great significance in group discussion of Hall for Workshop of Meta-synthetic Engineering. Since divergent discussion has the characteristics of continuity and randomized complexity, a viewpoint ranking method based on PageRank in group discussion is proposed. On the basis of information organization model, timing factor and semantic relations of experts' comments are taken into account to compute the support degrees among experts. The *PR* values of experts' viewpoints can be calculated based on the support degrees, and then ranking experts' viewpoints according to the *PR* values. The example is given to validate the validity and practicability of this method.

Introduction

Hall for Workshop of Meta-synthetic Engineering (HWME) is guided by the meta-synthetic method, it is a decision support system for the purpose of studying the "open complex giant system" and solving complex problems [1-4]. Expert group is a core part of HWME [5], and experts play a major role in presenting, discussing, constructing questions and making final decision. The computer technology and expert knowledge, wisdom, data and various kinds of information are combined by group discussion. Therefore, how to support group discussion will be a key subject to study the development of HWME [6].

Divergent and convergent discussions are included in effective group discussion. At present, in the face of convergent discussion, the consensus algorithm of group decision is proposed in the literature [7], which makes the viewpoints of expert group finally reach the agreement; In the literature [8], based on the complete consistent linguistic judgment matrix, a ranking method is proposed; In the literature [9], a group decision method based on interval two tuple linguistic information is proposed to solve the problem of ranking schemes; In the literature [10], a method for ranking the weights of the schemes based on the interval number complementary judgment matrix is proposed. The domestic and foreign researchers have been fully studied the ranking problem in convergent discussion. In the face of divergent discussion, foreign researchers propose Information system model based on problem [11] and Carneades dispute framework [12]; There have been some research in domestic, e.g. Electronic Common Brain Audiovisual Room (ECBAR) is proposed in the literature [13]; Group discussion environment is proposed in the literature [14]; Cyberspace for Workshop of Meta-synthetic Engineering (CWME) is proposed in the literature [15]. The information organization, process control and the result visualization in the divergent

discussion have been studied by the domestic and foreign researchers. However, how to rank the experts' viewpoints during the group discussion has not yet been studied.

If the ranking information can be real-time displayed, it would facilitate the analysis to improve the efficiency in divergent discussion. However, on one hand, the continuity of discussion is one of the characteristics of the divergent discussion. Expert group can stimulate thinking in the discussion process, and the continuity of thinking leads to the continuity of discussion, so as far as possible to avoid experts from discussion into voting or expression of preference procedures; On the other hand, the divergent discussion has the characteristic of randomized complexity. With the deepening of discussion, experts' viewpoints vary in the discussion. Meanwhile, the relationship between new comments and other comments cannot be predicted [16]. The above characteristics of divergent discussion bring some difficulties to rank viewpoints. PageRank is a web page ranking algorithm. It can give a global rank based on the importance of the web page. Viewpoint ranking method based on PageRank in group discussion is proposed in this paper. By calculating the PageRank value to rank experts' viewpoints, so our method can improve the efficiency of group discussion.

PageRank Overview

PageRank [17] is first presented by Sergey Brin and Larry Page, and as the core algorithm of Google. The algorithm references citation analysis methods in the theory of information retrieval, and improves the quality of Google search. It has been recognized by the majority of users.

PageRank is used to evaluate and rank the importance of the web page. It depends on the quality and quantity of the linked web page. In general, if one web page is linked to this web page, the web page is the equivalent of voting for this web page. Web page has more links, the web page gets more votes. If a web page is linked by a higher quality and quantity of page, the higher the PageRank value, then this page is more important.

PageRank is calculated as follows equation (1):

$$PR(W_j) = (1 - d) + d \sum \frac{PR(W_i)}{S(W_i)}. \quad (1)$$

$PR(W_j)$ is the PageRank value of page W_j , page W_i links to page W_j , $S(W_i)$ is the number of page W_i linking out, d is the attenuation factor.

Information Organization Model for Divergent Discussion

Obtaining and analyzing efficiently various data generated in the discussion, it needs the support of information organization model. The information organization model contains that defining, data structures of information and establishing their relations [18, 19]. In this paper, each comment among experts contains ID, forward ID, spokesman, time, semantic relation, discussion content and other information. The semantic relations in this paper are divided into five types: intensely support (IS), support (S), neutrality (N), opposition (O), intensely opposition (IO).

Experts as the nodes, comments are directed arcs that the connection of different nodes, which constructs digraph $F = (H, L)$, as shown in Figure 1. $H = \{h_1, h_2, \dots, h_n\}$ is a collection of experts, n is the total number of experts in the discussion; L represents directed arcs that connect to different nodes. $L = \{l_{ij} | i, j \in [1, n], i \neq j\}$ represents the

collection of directed edges in a digraph, l_{ij} is the directed edge $h_i \rightarrow h_j$, representing that expert h_i supports the degree of expert h_j . In the process of discussion, the support degrees among experts will be changed with the advanced of time. On the directed arc, discussion information is represented by triple (T, A, C) , where $T_{ij} = (1, 2, 3, \dots, t)$ is the timing sequence, $A_{ij} = (a_1, a_2, a_3, \dots, a_t)$ is a collection of semantic relations that expert h_i speaks to expert h_j (ranking by timing), $C_{ij} = (c_1, c_2, c_3, \dots, c_t)$ is a collection of the discussion contents that expert h_i speaks to expert h_j (ranking by timing), where t is the total number that expert h_i speaks to expert h_j . In the discussion, some experts do not express any viewpoints; therefore their viewpoints will not be evaluated by other experts, that is to say experts are not been linked, such as node h_4 in Figure. 1.

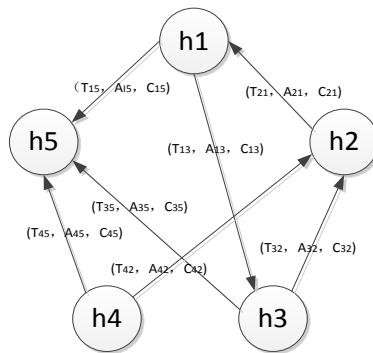


Figure. 1. The digraph of discussion information

The purpose of this paper is to rank experts' viewpoints in group discussion, according to the characteristics of group discussion, based on information organization model, designing the computational methods of support degrees and PageRank values to solve the rank of experts' viewpoints in group discussion.

Rank Viewpoint Based on PageRank

The ranking method based on PageRank is to calculate the support degrees of experts' viewpoints according to the information among experts. Specifically, when expert h_i speaks to expert h_j , it is equal to express the support degree. The number of support and the support degree are larger, the higher the PageRank value, the more important the expert viewpoint.

First, this section describes how to calculate the support degrees according to the information among experts, and then introduces how to calculate the PageRank values of experts' viewpoints.

Support Degree of Expert Viewpoint

The directed arc includes some important information: discussion timing, semantic relations and discussion contents, these are represented by triple (T, A, C) . In this paper, the support degree is calculated by the weighted arithmetic average operator, which it takes timing factor as weight to make the utility value of semantic relation weighted. The support degree is calculated by the following equation (2):

$$e_{ij} = \sum_{k=1}^t Q_k U(a_k). \quad (2)$$

Among them, t is times which expert h_i makes comments on expert h_j , a_k is the k_{th} semantic relation, $U(a_k)$ is the utility value of semantic relation, as shown in Table 1.

Table 1. the utility value of semantic relation

a	$U(a)$
intensely support	1
support	0.5
neutrality	0
opposition	-0.5
intensely opposition	-1

Q_k is timing factor, $Q_k = \frac{k}{q}$. The greater timing factor closes to the current moment, the greater impact on the current support degrees. Among them, k is times, $q = \frac{t(1+t)}{2}$ is the sum of timing sequences in discussion, $\sum_{k=1}^t Q_k = 1$. Figure 1, for example: expert h_3 is voted 5 times by expert h_1 , semantic relation collection is $A_{13} = \{a_1 = O, a_2 = N, a_3 = N, a_4 = N, a_5 = S\}$, according to equation (2), the support degree of expert h_3 is calculated: $e_{13} = (-0.5) \times \frac{1}{15} + 0 \times \frac{2}{15} + 0 \times \frac{3}{15} + 0 \times \frac{4}{15} + 0.5 \times \frac{5}{15} = \frac{2}{15}$.

PR Value of Expert Viewpoint

The PageRank value is called *PR* value for short. Google adjusts the rank of web page on the website, according to *PR* value to improve the quality of search. The *PR* value represents the importance of expert viewpoint, the higher the *PR* value, the more important expert viewpoint. This paper ranks viewpoints according to *PR* value in group discussion.

The *PR* value of the expert viewpoint is calculated as follows equation (3):

$$PR(h_j) = (1-d) + d \sum_{h_i \in IMP(h_j)} \frac{PR(h_i)e_{ij}w_i}{S(h_i)}. \quad (3)$$

d is attenuation factor; w_i is the weight of expert h_i , that is given according to quality, experience, ability of experts, knowledge structure, and other factors; $IMP(h_j) = \{h_k | h_k \rightarrow h_j\}$ represents the direct former collection of expert h_j in digraph, it is a collection that other experts make some comments on expert h_j in this paper; $S(h_i) = card(IMS(h_i))$ represents the number of experts in a collection $IMS(h_i)$, $IMS(h_i) = \{h_k | h_i \rightarrow h_k\}$ represents the direct later collection of expert h_i in the digraph, it is a collection of experts who expert h_i make a comment on; $PR(h_i)$ is the *PR* value of expert h_i . Normally, the original *PR* values of all experts are 1, d is 0.85[20]. Figure 1, assuming that $PR(h_1) = 1$, $w_1 = 0.2$, the *PR* value of expert h_3 is calculated by equation

$$(3): PR(h_3) = (1 - 0.85) + 0.85 * \left(\frac{1 * \frac{2}{15} * 0.2}{2} \right) = 0.16133.$$

Case Analysis

Taking water pollution prevention of HWME as application background, the expert group discussion visualization system is developed with MyEclipse + MySQL + JSP, as shown in Figure. 2. Two examples are given to validate the validity and practicability of this method.

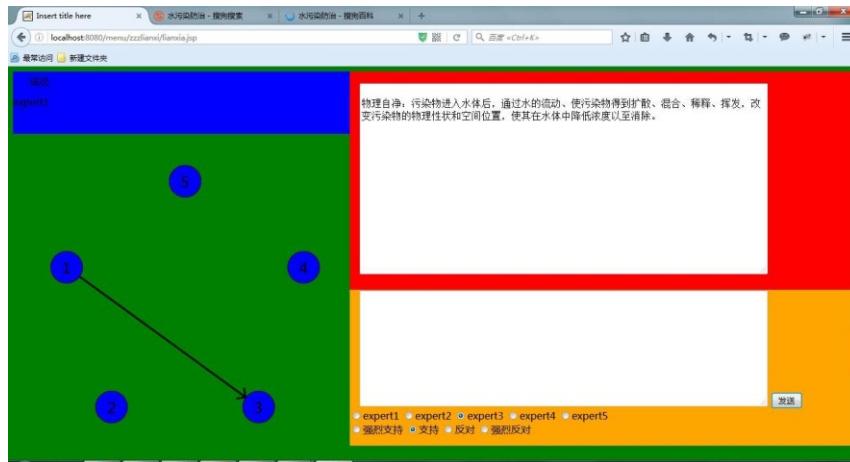


Figure. 2. Group discussion visualization system

Many experts come to HWME to discuss about Taihu water pollution prevention problem. In this paper, viewpoint ranking method based on PageRank is used to rank experts' viewpoints in different group discussions. The utility values of semantic relations are shown in Table 1, the original PR values are 1, d is 0.85.

(1) In the first discussion, five experts $H = \{h_1, h_2, h_3, h_4, h_5\}$ are in HWME, experts' weights are $W = (w_1, w_2, w_3, w_4, w_5) = \{0.2, 0.1, 0.2, 0.1, 0.4\}$, The digraph based on workshop is shown in Figure. 1, The semantic relations among experts are:

$$\begin{aligned} A_{13} &= \{a_1 = O, a_2 = N, a_3 = N, a_4 = N, a_5 = S\}, \quad A_{15} = \{a_1 = O, a_2 = N, a_3 = S, a_4 = S\}, \\ A_{21} &= \{a_1 = N, a_2 = N, a_3 = S\}, \quad A_{32} = \{a_1 = IO, a_2 = N, a_3 = S, a_4 = S\}, \quad A_{35} = \{a_1 = O, a_2 = N, a_3 = N, a_4 = S\}, \\ A_{42} &= \{a_1 = O, a_2 = O, a_3 = N, a_4 = S\}, \quad A_{45} = \{a_1 = O, a_2 = O, a_3 = N, a_4 = S, a_5 = IS\}. \end{aligned}$$

The support degrees of experts are calculated by equation (2):

$$\begin{aligned} e_{13} &= (-0.5) \times \frac{1}{15} + 0 \times \frac{2}{15} + 0 \times \frac{3}{15} + 0 \times \frac{4}{15} + 0.5 \times \frac{5}{15} = \frac{2}{15}, \quad e_{15} = (-0.5) \times \frac{1}{10} + 0 \times \frac{2}{10} + 0.5 \times \frac{3}{10} + 0.5 \times \frac{4}{10} = \frac{3}{10}, \\ e_{21} &= 0 \times \frac{1}{6} + 0 \times \frac{2}{6} + 0.5 \times \frac{3}{6} = \frac{1}{4}, \quad e_{32} = (-1) \times \frac{1}{10} + 0 \times \frac{2}{10} + 0.5 \times \frac{3}{10} + 0.5 \times \frac{4}{10} = \frac{1}{4}, \\ e_{35} &= (-0.5) \times \frac{1}{10} + 0 \times \frac{2}{10} + 0 \times \frac{3}{10} + 0.5 \times \frac{4}{10} = \frac{3}{20}, \quad e_{42} = (-0.5) \times \frac{1}{10} + (-0.5) \times \frac{2}{10} + 0 \times \frac{3}{10} + 0.5 \times \frac{4}{10} = \frac{1}{20}, \\ e_{45} &= (-0.5) \times \frac{1}{15} + (-0.5) \times \frac{2}{15} + 0 \times \frac{3}{15} + 0.5 \times \frac{4}{15} + 1 \times \frac{5}{15} = \frac{11}{30}. \end{aligned}$$

The PR values of experts' viewpoints are calculated by equation (3):

$$\begin{aligned} PR(h_1) &= (1 - 0.85) + 0.85 * \left(\frac{\frac{1}{15} * \frac{1}{2} * 0.2}{1} \right) = 0.17125, \\ PR(h_2) &= (1 - 0.85) + 0.85 * \left(\frac{\frac{1}{15} * \frac{1}{2} * 0.2}{2} + \frac{\frac{1}{10} * \frac{1}{2} * 0.1}{2} \right) = 0.17338, \\ PR(h_3) &= (1 - 0.85) + 0.85 * \frac{\frac{1}{15} * \frac{2}{2} * 0.2}{2} = 0.16133, \\ PR(h_4) &= (1 - 0.85) = 0.15000, \end{aligned}$$

$$PR(h_5) = (1 - 0.85) + 0.85 * \left(\frac{1 * \frac{3}{10} * 0.2}{2} + \frac{1 * \frac{3}{20} * 0.2}{2} + \frac{1 * \frac{11}{30} * 0.1}{2} \right) = 0.20383.$$

The *PR* values are stable after several iterations, the final *PR* values is shown in Table 2.

Table 2. The final *PR* values of experts

Expert	<i>PR</i>
h_1	0.15326
h_2	0.15354
h_3	0.15174
h_4	0.15000
h_5	0.15818

From Table 2, we can rank the current experts' viewpoints: $h_5 > h_2 > h_1 > h_3 > h_4$. From Figure 1, we can see that expert h_1 , expert h_3 and expert h_4 make a comment on expert h_5 . Expert h_5 is supported by three experts in general. Expert h_3 and expert h_4 also make a comment on expert h_2 . Similarly, expert h_2 is supported by two experts in general. Therefore, the *PR* value of expert h_5 is greater than the *PR* value of expert h_2 . Expert h_2 only makes a comment on expert h_1 , expert h_2 has attitudes to expert h_1 from neutral to support. Expert h_1 has attitudes to expert h_3 from oppose to support, so the support degree of expert h_1 is greater than expert h_3 and the *PR* value is so. Because expert h_4 does not express viewpoints, so the *PR* value is minimum.

- (2) In the Second discussion, more experts participate in the discussion. there are ten experts $H = \{h_1, h_2, h_3, h_4, h_5, h_6, h_7, h_8, h_9, h_{10}\}$ participating in the discussion, their weights are $W = (w_1, w_2, w_3, w_4, w_5, w_6, w_7, w_8, w_9, w_{10}) = \{0.15, 0.1, 0.05, 0.15, 0.1, 0.05, 0.1, 0.15, 0.05, 0.1\}$, the digraph is shown in Figure. 3, the semantic relations among experts as follows:

$$\begin{aligned}
 A_{12} &= \{a_1 = O, a_2 = N, a_3 = N, a_4 = N, a_5 = S\}, A_{15} = \{a_1 = IO, a_2 = O, a_3 = O\}, \\
 A_{17} &= \{a_1 = O, a_2 = N, a_3 = S, a_4 = S\}, A_{21} = \{a_1 = IO, a_2 = O, a_3 = N\}, \\
 A_{24} &= \{a_1 = N, a_2 = N, a_3 = S, a_4 = S, a_5 = S\}, A_{25} = \{a_1 = O, a_2 = S, a_3 = IS\}, \\
 A_{29} &= \{a_1 = O, a_2 = N, a_3 = S\}, A_{31} = \{a_1 = O, a_2 = N, a_3 = S, a_4 = S\}, \\
 A_{34} &= \{a_1 = O, a_2 = N, a_3 = S\}, A_{37} = \{a_1 = IO, a_2 = O, a_3 = N\}, \\
 A_{38} &= \{a_1 = O, a_2 = O, a_3 = N, a_4 = N\}, A_{45} = \{a_1 = IO, a_2 = N, a_3 = N, a_4 = S, a_5 = S\}, \\
 A_{58} &= \{a_1 = O, a_2 = O, a_3 = N, a_4 = N, a_5 = S\}, A_{62} = \{a_1 = IO, a_2 = IO, a_3 = IO, a_4 = N, a_5 = N\}, \\
 A_{64} &= \{a_1 = IO, a_2 = IO, a_3 = N, a_4 = N\}, A_{78} = \{a_1 = IO, a_2 = O, a_3 = O, a_4 = N, a_5 = N\}, \\
 A_{74} &= \{a_1 = O, a_2 = O, a_3 = N, a_4 = N\}, A_{81} = \{a_1 = O, a_2 = N, a_3 = S\}, \\
 A_{92} &= \{a_1 = N, a_2 = N, a_3 = S\}, A_{93} = \{a_1 = O, a_2 = N, a_3 = N, a_4 = S\}, \\
 A_{910} &= \{a_1 = IO, a_2 = O, a_3 = N, a_4 = N\}, A_{101} = \{a_1 = N, a_2 = N, a_3 = S, a_4 = S, a_5 = IS\}, \\
 A_{103} &= \{a_1 = O, a_2 = O, a_3 = N, a_4 = N\}, A_{109} = \{a_1 = O, a_2 = O, a_3 = N\}.
 \end{aligned}$$

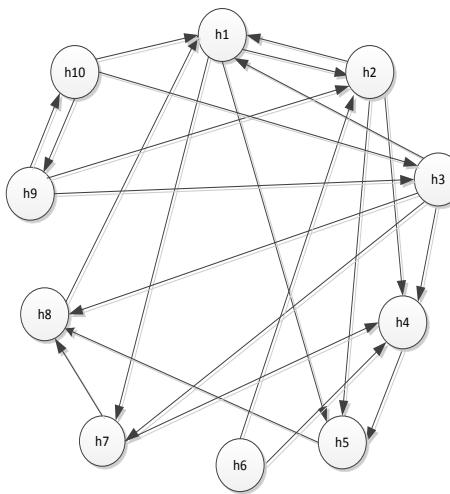


Figure 3. The digraph of discussion information in many experts

According to equation (2), the support degrees among the experts are shown in Table 3.

Table 3. Support degrees among experts

Expert	Support Degree	Expert	Support Degree	Expert	Support Degree
$h_1 \rightarrow h_2$	$\frac{2}{15}$	$h_1 \rightarrow h_5$	$-\frac{7}{12}$	$h_1 \rightarrow h_7$	$\frac{3}{10}$
$h_2 \rightarrow h_1$	$-\frac{1}{3}$	$h_2 \rightarrow h_4$	$\frac{2}{5}$	$h_2 \rightarrow h_5$	$\frac{7}{12}$
$h_2 \rightarrow h_9$	$\frac{1}{6}$	$h_3 \rightarrow h_1$	$\frac{3}{10}$	$h_3 \rightarrow h_4$	$\frac{1}{6}$
$h_3 \rightarrow h_7$	$-\frac{1}{3}$	$h_3 \rightarrow h_8$	$-\frac{3}{20}$	$h_4 \rightarrow h_5$	$\frac{7}{30}$
$h_5 \rightarrow h_8$	$\frac{1}{15}$	$h_6 \rightarrow h_2$	$-\frac{3}{10}$	$h_6 \rightarrow h_4$	$-\frac{3}{10}$
$h_7 \rightarrow h_4$	$-\frac{3}{20}$	$h_7 \rightarrow h_8$	$-\frac{7}{30}$	$h_8 \rightarrow h_1$	$\frac{1}{6}$
$h_9 \rightarrow h_2$	$\frac{1}{4}$	$h_9 \rightarrow h_3$	$\frac{3}{20}$	$h_9 \rightarrow h_{10}$	$-\frac{1}{5}$
$h_{10} \rightarrow h_1$	$\frac{7}{30}$	$h_{10} \rightarrow h_3$	$-\frac{1}{5}$	$h_{10} \rightarrow h_9$	$-\frac{1}{4}$

According to the known support degrees to calculate the *PR* values by equation (3), after several iterations, the ultimate stability of the *PR* values as shown in Table 4.

Table 4. The PR values of experts

Expert	PR	Expert	PR
h_1	0.15321	h_2	0.15044
h_3	0.14947	h_4	0.15005
h_5	0.15315	h_6	0.15000
h_7	0.15142	h_8	0.14913
h_9	0.14894	h_{10}	0.14958

From Table 4, the current rank among experts can be seen:
 $h_1 > h_5 > h_7 > h_2 > h_4 > h_6 > h_{10} > h_3 > h_8 > h_9$.

Conclusions

Real-time and accurately understanding of current viewpoints ranking in order to improve the efficiency of experts in HWME. Therefore, in this paper, viewpoint ranking method on PageRank is proposed, based on information organization model, designing the computational methods of support degrees and PageRank values to rank the experts' viewpoints. The *PR* value is used to solve the ranking problem of divergent discussion. Finally, examples are used to validate the validity and practicability of the method. The next step will focus on the relevance of experts' comments and discussion topics, in order to prevent the drift of viewpoints and improve the efficiency of discussion.

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