

The Method of Inferring Trust in Web-based Social Network using Fuzzy Logic

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Abstract— This paper proposes the approach for inferring trust between users in the web-based social network using fuzzy logic. User would construct social network making direct connection and indirect connection through the several users. If user make connection without any consideration in such social network, it should cause decreasing reliability of whole network. Consequently, this paper suggests the method of inferring trust between users in web-based social network information retrieval system using fuzzy logic for reliable information retrieval and user's trust deduction.

Index Terms—Social Network, Trust, Fuzzy Logic

I. Introduction

Since late 1990's, research and technologies of information retrieval have been rapidly developing thanks to the development and commercial applications of the Internet. These days, the volume of information available in the Web has sharply increased and information in various fields is complicatedly interconnected. As a result, technical development has been focused on finding information quickly and accurately [10]. However, one-dimensional information retrieval that simply offers the search results of keywords is difficult to provide accurate information that meets the needs of information searchers.

Recently, in an effort to move away from such one-dimensional information retrieval, there has been active technical developments in customized information retrieval that is exactly tuned to user requirements. In order to tune in to user requirements, you must first accurately analyze users including user information and tastes [6]. But it is not easy to understand the needs of users or to make judgments on users as a whole in order to provide personalized information retrieval.

In this situation, an information retrieval system using social network service (SNS) is emerging lately which approaches from a different perspective the analysis of user requirements as a prior process of personalized information retrieval. This system searches other users who have a similar situation, tastes, and preferences as the user who needs information and finds relevant information from them [7]. The first challenge that this system faces is how the user who needs information can

II. Related Studies & Background

A social network is a social structure that consists of individuals or groups who have one or more interdependent relationships [11]. As these social networks express interpersonal relationships on the network, various application technologies are being developed. This paper proposes a method to infer trust between people in a social network. Trust between users of a social network is very important because the reliability of the total network would drop if the members of a social network could exchange information without any restrictions.

Jennifer Golbeck proposed a method to quantitatively infer trust between users for a recommendation system in a Web-based social network [1, 2]. She suggested a method to combine the trust levels of all users in the path from a user to the target user to receive information, and applied it to the film recommendation system to run in an actual application.

Also, she proposed a method to infer trust based on users' reputation instead of similarity of preferences in a semantic web-based social network [4]. She suggested a method for inferring trust in consideration of the trust that users have on the next user in the path from a user to the target user, and applied it to a web e-mail system to infer the trust of e-mails received from specific users.

In this paper, trust is similar to the reputation of a specific user rather than the similarity of preferences and profiles between users. As motioned above, social networks express interpersonal relationships as a network. Users give subjective trust values to users who have a direct connection with themselves, and the trust value is a float value between 0 and 10. Users can get to know other users through the users whom they know, and the accuracy and expertise of information exchanged in a social network can be judged by the trust for a specific user. We propose a method for users to infer trust for other users whom one get to know through the users who are related to themselves.

III. Technologies of Method

A. Fuzzy Logic

We use fuzzy logic [8, 9] to infer the trust between two nodes. Boolean expressions such as trust or not trust is not appropriate for trust between users in a social network. We use fuzzy logic to infer trust values

in consideration of various factors, and the following three fuzzy descriptors to establish the methodology for inferring trust:

1. Direct connection trust
2. Distance
3. Mean trust

The above fuzzy descriptors have important influence on inference of trust between users and each factor allows us to infer the appropriate trust between users.

1. Direct connection trust

Direct connection trust refers to the trust that is given to a node that is directly connected to the user node in the path from the user to the target user.

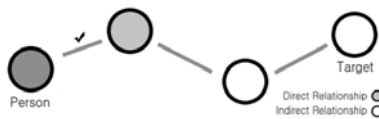


Figure 1. Direct Connection Trust

When the path in Figure 1 has been found and the user and target user have been defined, the direct connection trust is the trust for the next user who has direct relationship with the person. Because this direct connection trust is the trust on a user that the person knows, it greatly affects the trust on the target user. Actual users determine their trust on a target user depending on who introduced the target user to the themselves. We can reflect this fact through the direct connection trust.

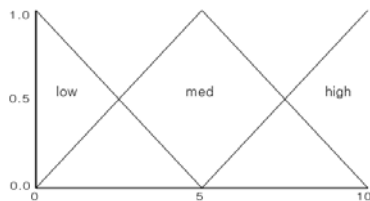


Figure 2. Direct Connection Trust Fuzzy Set

Figure 2 shows the judgment graph of the fuzzy descriptor of direct connection trust. As shown in this graph, direct connection trust is divided into low, medium, or high depending on the trust value from 0 to 10. For example, if the direct connection trust is 4, it has 80% medium and 20% low and judged as the medium level because it is determined by the highest value.

2. Distance

Distance refers to the distance of the path from the person to the target user.

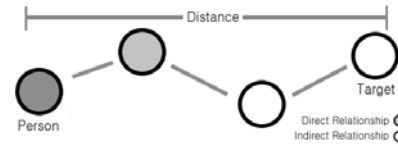


Figure 3. Distance

In a path such as the one in Figure 3, the number of users between the person to the target user is the distance. The farther the distance, the farther the relationship between the person to the target user, and the after the relationship, the lower the trust level. Users judge the trust of a target user by reflecting the distance from themselves to the target user. The proposed method reflects this through the distance element.

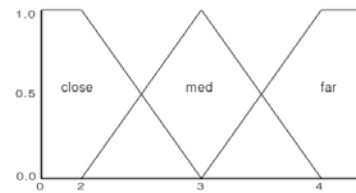


Figure 4. Distance Fuzzy Set

Figure 4 shows the judgement graph of the fuzzy descriptor of distance. Distance is divided into close, medium and far depending on the number of users in the path to the target user including the target user. The criterion for dividing these three levels is based on the study of Stanley Milgram which claims that anyone is connected to another person in the world through up to six related persons [12].

3. Mean Trust

Mean trust refers to the mean value of trust that a target user receives from other users who are directly connected to themselves.

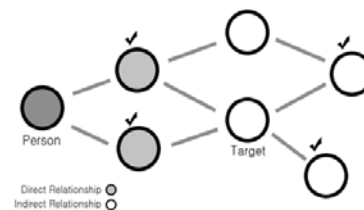


Figure 5. Mean Trust

As shown in Figure 5, the mean value of the trust levels that the target user receives from four directly connected users (checked) is the mean trust. The mean trust factor determines how much trust the directly connected users have on the target user. Because only the directly connected users can directly evaluate the target user, mean trust can provide a measure of how much trust the target user receives.

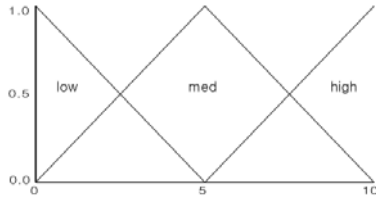


Figure 6. Mean Trust Fuzzy Set

Figure 6 shows the judgment graph for the fuzzy descriptor of mean trust. As can be seen from this figure, mean trust is divided into low, medium, and high depending on the trust value between 0 and 10 like the direct connection trust.

B. Adjustment factor

Because the direct connection trust, distance and mean trust in our proposed method cannot reflect the changes of trust in the searched path, the reliability of the inference method drops in such situations as shown in Figure 7.

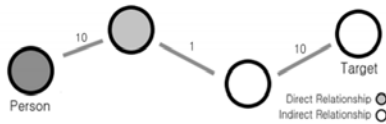


Figure 7. Weak Point Example

In Figure 7, although the direct connection trust and mean trust are very high, the trust between users in the path is very low. In this case, the direct connection trust is high (100%), the distance is medium (100%), and the mean trust is high (100%). By the fuzzy rule, this case belongs to very high (100%) and the inferred quantitative trust becomes 10. To reflect this kind of situations, we added an adjustment factor.

1. Trust Error Frequency

Trust Error Frequency was introduced to complement the proposed method. It is the frequency of trust errors in the path exceeding the set value. In the example in Figure 7, if we define the set value as 5, and calculate the errors of trust between three persons in the path, the total number of comparisons is two and both cases exceed the set value 5 ($|10 - 1| = 9$, $|1 - 10| = 9$). Therefore, the trust error frequency of the example in Figure 7 becomes 100%. According to this value we lower the levels of the Direct Connection Trust. According to this value we lower the level of the fuzzy descriptor; Direct Connection Trust.

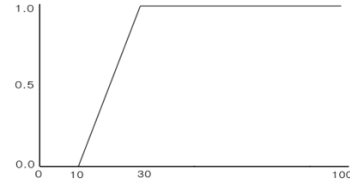


Figure 8. Trust Error Frequency

We defined the trust error frequency to be calculated as shown in the graph in Figure 8. The direct connection trust is lowered by one level if the trust error frequency has a value between 10% and 30%. A path has the value of 1.0 if the trust error frequency is greater than 30% in which case the direct connection trust is lowered by two levels. As described above, the direct connection trust is the trust for the searched path. Thus, if the trust level of a path is low, it should affect the direct connection trust.

C. Fuzzy Logic Representation

As described above, we defined three fuzzy logic descriptors: direct connection trust, distance, and mean trust. Table 1 shows the fuzzy rule base that is generated through the fuzzy sets defined as shown in the following figures. The trust level that a user can have on the target user is inferred through judgements on each fuzzy descriptor. The total number of cases listed in this table is $3^3 = 27$. We can adjust the value of trust by judging the trust level in each of the 27 cases in total.

We infer the appropriate trust level using the fuzzy sets defined in Table 1. After the values of the fuzzy descriptors are determined for each case of the fuzzy rule base in Table 1, we can have seven results: very low, low, rather low, medium, rather high, high, and very high. In this way, we can determine the trust of a user for the target user in seven levels.

	Direct Connection Trust	Distance	Mean Trust	Trust
1	low	far	low	ysmall
2	low	far	med	small
3	low	far	high	small
4	low	med	low	ysmall
5	low	med	med	small
6	low	med	high	rsmall
7	low	close	low	small
8	low	close	med	small
9	low	close	high	rsmall
10	med	far	low	small
11	med	far	med	rsmall
12	med	far	high	med
13	med	med	low	rsmall
14	med	med	med	med
15	med	med	high	rlarge
16	med	close	low	med
17	med	close	med	rlarge
18	med	close	high	large
19	high	far	low	rlarge
20	high	far	med	large
21	high	far	high	large
22	high	med	low	rlarge
23	high	med	med	large
24	high	med	high	vlarge
25	high	close	low	large
26	high	close	med	large
27	high	close	high	vlarge

Table 1. Fuzzy rule base (rsmall = very small, rsmall = rather small, rlarge = rather large, vlarge = very large)

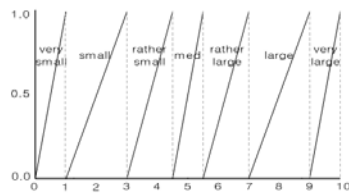


Figure 9. Result values

We use the graph in Figure 9 to determine the inferred trust value between 0 and 10 from a user to the target user. The seven levels are converted to the values of 0-1 for very low, 1-3 for low, 3-4.5 for rather low, 4.5-5.5 for medium, 5.5-7 for rather high, 7-9 for high, and 9-10 for very high. These values are combined with the weight (%) of each fuzzy descriptor to determine the result value. In this way, we can infer the quantitative trust level from a user to the target user.

IV Conclusions and Future Studies

This paper proposed a method to infer trust which is important in information retrieval system using a social network service (SNS). Trust is an essential element in reliable information retrieval in SNS and will be the most fundamental element required for application of off-line interpersonal relationships to on-line interpersonal relationships. The method we propose derive reliable

results by considering the relationships of users with and the trust of users for other users and contribute to the development of reliable information retrieval systems in web-based social network services as well as to the improvement of reliability of the entire social network.

The adjustment of considerations suggested in this paper and the reflection of other considerations require further research. In addition, we need to keep studying the method of selecting target users which we have not explored in this paper.

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