

Visualization of Social Relationship for Analyzing NFC User Regarding SNS

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Abstract

Most of the previous works of social network analysis depend on node graph and adjacency matrix in connection with an aspect of social network topology. However, the representing node and matrix are difficult to understand a relationship between SNS users, because the user's interaction is presented by a complicated node graph. In order to overcome this limitation, this paper proposes a new visualization method to represent hierarchy relationship of SNS users for analysis of social network with respect to NFC users. The proposed method uses fuzzy relational product to construct dynamic hierarchy relationship which can intuitively understand user's interaction. Besides, it can focus on personal relation on SNS which is modeled using user activities of Twitter (i.e., microblogging) by visualizing relationship among users regarding NFC users. Also, we propose analyzing scenario regarding NFC access information using the proposed algorithm

Keywords: Hierarchy relationship, SNS, Fuzzy relational product, Twitter, NFC

1. Introduction

NFC (near field communication) is a new radio technology which finds special application in the field of mobile consumer electronics for contactless communication technology. It is designed for bidirectional data transmissions over a distance of up to 10 cm and a maximum data rate of 424 kB/s. NFC technology works at an operating frequency of 13.56 MHz. NFC is standardized as ISO/IEC 18092 and ECMA-340/ECMA-352 respectively. NFC has three operating modes: peer-to-peer mode, reader/writer mode and card emulation mode. The peer-to-peer mode is an operating mode specific to NFC and allows two NFC devices to communicate directly with each other. The reader/writer mode can access contactless smartcards with regard to RFID transponders and NFC tags. The card emulation mode emulates a contactless smartcard which can communicate with existing RFID readers [1-3].

All information in today's world can mostly be found online, which has increased the online social networks (i.e., file exchanges, chat, blogs, and collective development such as Wikipedia and Open-Source Software projects). According to the increment of online social activities, the necessity of social network analysis (SNA) has been a growing area of the social sciences. The analysis can be automatically instrumented and analyzed for discovering terrorist networks, monitoring outbreaks of diseases, commercial activities, etc. Many of these social networks are large, complex and continuously changing which need an effective approach to help social science researches. Information visualization can well display relationships between users and present their findings to others for SNA [4].

Recently, the approaches of visualizing social networks including node-link (NL) based [5], matrix graph based representations (MAT) [6], and a hybrid based representation with NL and MAT [4] have been proposed. The NL based approaches can be usefully displayed by the overall structure of a network however details about dense sub-graphs is difficult to read [4, 5]. The MAT based approaches are poor for path-finding tasks [4, 6]. The hybrid based approaches also showed that makes relationship between users difficult to understand [4-7].

In order to resolve the limitation of the graph and matrix based visualization approaches, this paper proposes a user-focused relationship visualization method which uses the fuzzy relationship product and external relation score of social networks. The proposed method can well represent user-focused hierarchy relationship of users on social networks in connection with NFC users by using the fuzzy relationship. Besides, the importance of users reflects into a relationship hierarchy by exploiting external relation score. So, our proposed method can well understand the relationship between users to represent hierarchy relationship of user on social networks. In addition, we propose analyzing scenario regarding NFC access information using the proposed algorithm.

This paper is organized as follows: Section 2 reviews the related works regarding fuzzy relational product; Section 3 presents the proposed construction hierarchy social; Section 4 shows the clustering NFC access information scenario; Section 5 shows the performance evaluation and experimental results of the proposed method. Finally, in Section 6 concludes this paper.

2. Fuzzy Relational Product

We have previously defined the dynamic category hierarchy reconstruction method [8]. In this section, we give a brief introduction to the Fuzzy Relational Products that are used in the Dynamic restructuring of Category Hierarchy. The fuzzy set is defined as follows:

Definition 1. α -cut of a fuzzy set A, denoted by A_α , is a set that contains all elements whose membership degrees are equal to or greater than α . $A_\alpha = \{ x \in X \mid \mu_A(x) \geq \alpha \}$.

$$\begin{aligned} a \rightarrow b &= (1 - a) \vee b = \max(1 - a, b), \\ a &= 0 \sim 1, b = 0 \sim 1 \end{aligned} \tag{1}$$

A fuzzy implication operator is an extended crisp implication operator applied in the fuzzy theory. A crisp implication operator is defined as $\{0,1\} \times \{0,1\} \rightarrow \{0,1\}$, while a fuzzy implication operator is defined as $[0,1] \times [0,1] \rightarrow [0,1]$ to be extended in multi-valued logic. We use the implication operator defined as follows [9]:

In set theory, " $A \subseteq B$ " is equal to " $\forall x, x \in A \rightarrow x \in B$ ", and it is also equal to " $A \in \wp(B)$ ". Here $\wp(B)$ is the power set of B. Thus, in the fuzzy set, the degree of $A \subseteq B$ is the degree of $A \in \wp(B)$, so it is denoted by $\mu_{\wp(B)}A$ and defined as follows:

Definition 2. Given the fuzzy implication operator \rightarrow , a fuzzy set B of a crisp universe set U, the membership function of the power set of B, $\mu_{\wp(B)}A$ is $\mu_{\wp(B)}A = \bigwedge_{x \in U} (\mu_A x \rightarrow \mu_B x)$.

Definition 3. Let U_1, U_2, U_3 be finite sets, R be a fuzzy relation from U_1 to U_2 , and S be a fuzzy relation from U_2 to U_3 . That is, R is a fuzzy subset of $U_1 \times U_2$ and S is a fuzzy subset of $U_2 \times U_3$. Fuzzy relational products are fuzzy operators that represent the degree of fuzzy relation from a to c for $a \in U_1, c \in U_3$. The fuzzy triangle product as a fuzzy relation from U_1 to U_3 , \triangleleft is defined as follows. This is called Fuzzy Relational Products.

$$(R \triangleleft S)_{ik} = \frac{1}{N_j} \sum_j (R_{ij} \rightarrow S_{jk}) \quad (2)$$

Definition 4. The fuzzy implication operators vary in the environments of given problems. The afterset aR for $a \in U_1$ is a fuzzy subset of U_2 such that y is related to a , for $y \in U_2$. Its membership function is denoted by $\mu_{aR}(y) = \mu_R(a,y)$. The foreset Sc for $c \in U_3$ is a fuzzy subset of U_2 such that y is related to c , for $y \in U_2$. Its membership function is denoted by $\mu_{Sc}(y) = \mu_S(y,c)$ for $y \in U_2$. The mean degree that aR is a subset of Sc is meant by the mean degree such that the membership degree of $y \in aR$ implies the membership degree of $y \in Sc$, so it is defined as follows:

$$\pi_m(aR \subseteq Sc) = \frac{1}{N_{U_2}} \sum_{y \in U_2} (\mu_{aR}(y) \rightarrow \mu_{Sc}(y)) \quad (3)$$

Here, π_m is a function to calculate the mean degree ♦

The above mean degree denoted by $R \triangleleft S$ can be regarded as the mean degree of relation from a to c [8].

3. Proposed Method

This study proposes construction hierarchy social relationship method for an analysis method of SNS using internal relation score of fuzzy relation product and external relation score. The proposed method consists of three phases: preprocessing, calculating relationship, and constructing hierarchy relation, as shown in Figure 1. In the subsection below, each phase is explained in full.

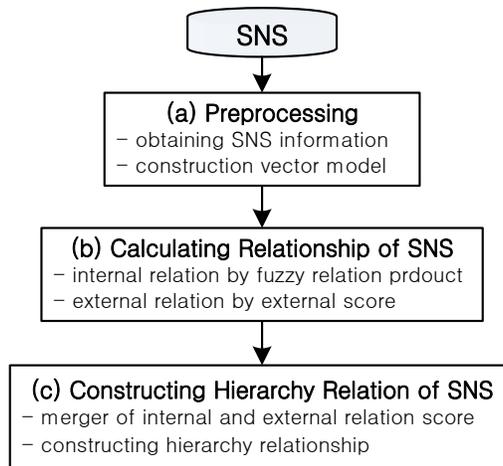


Figure 1. Construction of Hierarchy Social Relationship Method

3.1. Preprocessing

In preprocessing phase of Figure 1(a), SNS information is obtained for next phase of relation score. This paper explains an example to apply our proposed method using a SNS of Twitter. Table 1 shows the obtained information from Twitter. The preprocessing phase consists of two steps.

First step preprocess the contents of Twitter for internal relationship as follows. After the given obtainment results of Tweet are decomposed into individual users, the stop words are removed using Rijsbergen's stop words list, and word stemming is removed using Porter's stemming algorithm [10]. Then the term user frequency matrix T is constructed from the users set. Let T be $m \times n$ terms by users matrix, where m is the number of terms and n is the number of user. The element of matrix T , T_{ij} represents i 'th term frequency of j 'th user [11].

In second step, the information of network topology of Twitter is extracted for external relation score.

Table 1. Basic Information of Twitter

	item	description
Profile	name	User name
Tweet	tweet	Text-based posts of up to 140 characters
	time	Post time
Mention	Sender	User of sending message
	Receiver	User of receiving message
Retweet	Retweetee	Referenced user of tweet
	Retweeter	User refer to tweet

3.2. Calculating Relationship

In the calculating relationship phase in Figure 1(b), this phase consists of internal relationship and external relation score for constructing hierarchy relationship of SNS. The internal relation score represents the relationship between users to be derived from the contents of user's post. The external relation score means the relationship between users on social network topology.

3.2.1. Internal Relationship

We use fuzzy relation product to calculate internal relationship from the content of user's post. The relationship between users can be decided by inducing relevant information from the relationship between terms of post and users. A user can be regarded as fuzzy set, consisting terms in the posts in that user. The relationship of two users can be decided by calculating the average degree of inclusion of a fuzzy set to another one using the fuzzy relational products. An average degree of fuzzy set inclusion can be used for making a similarity relationship between users. By using this, similarity relations of users can be obtained dynamically.

The fuzzy implication operator has to be presented differently according to the needs of each application. In this paper, the formula referred to above (1): Kleen-Diense fuzzy implication operator is used. By applying the Kleen-Diense fuzzy implication operator to the fuzzy relational products of the formula (2), we can get the average degree of fuzzy sets inclusion for users, $\pi_m(U_i \subseteq U_j)$. We interpret this degree as the similarity relationship degree of U_i to U_j , it is the degree to which U_i is similar to U_j , or we interpret it as the fuzzy hierarchical degree of U_i to U_j , or the degree to which U_j can be a sub user of U_i . Attention is required from the fact that the hierarchical ordering is reverse to the concept of set inclusion in that U_j is the superset of U_i , but U_j is the hierarchical sub user of U_i . Intuitively, it is

conjectured that the user comprising many indices likely inherits the properties from the super-class users. However, $\pi_m(U_i \subseteq U_j)$ have some problems representing the fuzzy hierarchical degree of U_i to U_j . That is, if U_i had many elements x 's of which membership degrees, $\mu_{C_i}(x)$, are small, we could have a problem in which the fuzzy relational products tend to converge to 1 regardless of the real degree of fuzzy sets inclusion of $U_i \subseteq U_j$. Thus, we define Restricted Fuzzy Relation Products as follows to calculate the real degree of fuzzy sets inclusion of two categories, $\pi_{m,\beta}(U_i \subseteq U_j)$.

$$\pi_{m,\beta}(U_i \subseteq U_j) = (T^T \triangleleft_{\beta} T)_{ij} = \frac{1}{|C_{i,\beta}|} \sum_{K_k \in C_{i,\beta}} ((T^T)_{ik} \rightarrow T_{kj}) \quad (4)$$

where, K_k is k 'th user. U_i, U_j are each, the i 'th and j 'th user. $U_{i,\beta}$ is U_i 's β -restriction, that is, $\{X \mid \mu_{U_j}(X) \geq \beta\}$ which means we only choose the elements with values higher than β . $|U_{i,\beta}|$ is the number of elements in $U_{i,\beta}$. R is a $m \times n$ matrix such that R_{ij} is $\mu_{U_j}(K_i)$, that is, the membership degree of $K_i \in U_j$. T^T is the transposed matrix of T such that $T_{ij} = T^T_{ji}$. $(T^T)_{ij}$ is as follows:

$$(T^T)_{ij} = \begin{cases} 0 & \text{if } T_{ij} < \beta \\ R_{ij} & \text{if } T_{ij} \geq \beta \end{cases} \quad (5)$$

3.2.2. External Relation Score

This section calculates an external relation score to exploit the mention and resending scores of SNS. Mention score reflects direction between sender of post and receiver of post. If the amount of post message is increased from sender to receiver, the mention score is also increased. In addition, the latest post message has higher score than previous one. The mention score, $ES()$, is as follows.

$$ES(U_x \rightarrow U_y) = \frac{nm}{tn} \times \sum_{i=1}^{tn} \frac{pp_i}{td} \quad (6)$$

where, U_x and U_y are the x 'th and y 'th of user, respectively. \rightarrow is direction from sender to receiver, nm is the number of mention by one user, tn is the number of mention and resending posts, pp is the number of date of the mention and resending posts, and td is the number of total date of the mention and resending period.

Resending score is calculated by the number of resending post and the number of date of resending period, since a resending post is only identified by resending user. The resending score, $RS()$, is as follows.

$$RS(U_x \rightarrow U_y) = \sum_{i=1}^{tn} \frac{rpp_i}{trd} \quad (7)$$

where, rpp is the number of date of the resending posts, trd is the number of total date of the resending period.

The external relation score, $ERS()$, is as follows.

$$ERS(U_x \rightarrow U_y) = ES(U_x \rightarrow U_y) + RS(U_x \rightarrow U_y) \quad (8)$$

3.3. Construction Hierarchy Relation

In this section, we construct hierarchy relationship between users of social network to use the internal relationship and the external relation score for analysis of SNS. The hierarchy relationship of user's sociality improves the performance of analysis, because it reflects the internal relationship of user's posts by fuzzy relation product and the external relation of user's social topology by user's activity.

This phase as in Figure 1(c) can be described as follows. In the first step, the calculated internal relationship between users using Equation (4) is transformed to crisp values using α -cut value. The elements of internal relationship lower than α -cut value are transformed to 0, and the others to 1. The hierarchy relationship is created by using the transformed results. Besides, the hierarchy is dynamically reconstructed to control α -cut value. In other words, the α -cut value can control the important of hierarchy relationship. In the second step, external relation score applies the hierarchy relationship to adjust relationship between users, which enhances the analysis performance of SNS.

4. Analyzing Social Relationship regarding NFC Users

Figure 2 shows the analyzing Social Relationship regarding NFC user scenario using Visualization of SNS. Figure 2 consists of three components: the smart phone equipping with NFC, the NFC tag, the analyzing SNS server. The smart phone (*i.e.*, NFC device) has application which handles NFC access information and SNS analyzed information. The NFC tag has accessing information (*i.e.*, URL) in connection with website regarding the tag relevant information. In Figure 2(b), NFC device receives the tag relevant information by touching NFC tag. The tag relevant information is preprocessed for analyzing SNS. In Figure 2(c), NFC device sends the analyzing request to analyzing SNS server. The analyzing server retrieves the relevant information with respect to tag content information from social networks. The analyzing server visualizes the retrieved information into relationship hierarchy with relation to tag information by the proposed algorithm. The Visualization of relationship hierarchy is sent from analyzing SNS server to smart phone.

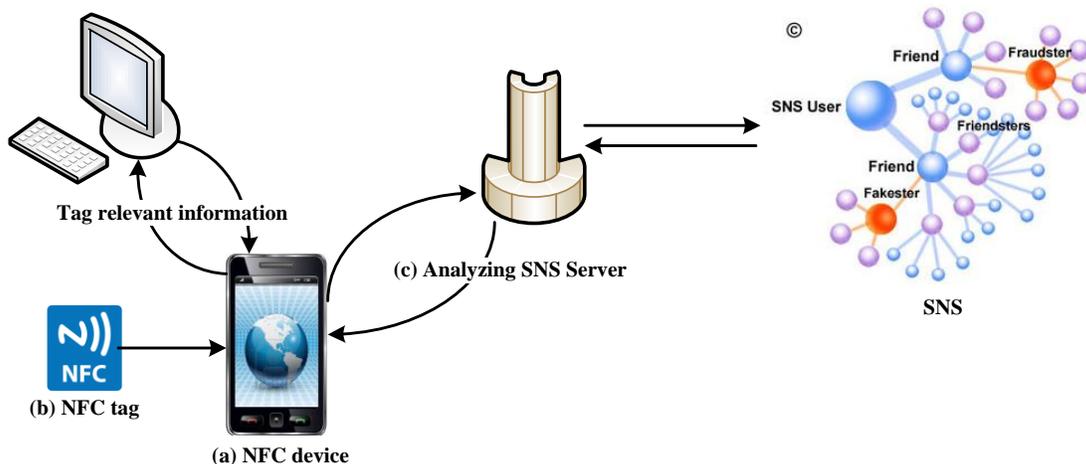


Figure 2. Scenario of Clustering NFC Access Information

5. Conclusions

In visualizing social networks for analyzing one generally uses a node graph based and a matrix based approaches. However, these approaches are difficult to understand a relationship between users on SN, because the user's interaction is large, complex and continuously changing. In order to overcome this limitation, this paper proposes a new visualization method to represent hierarchy relationship of SNS users, which uses fuzzy relational product and external relation score to construct dynamic hierarchy relationship. The constructed hierarchy relationships can well understand the relationship between users to represent hierarchy relationship with regards to user importance. In addition, analyzing scenario regarding NFC users is shown by the NFC access information and the proposed algorithm.

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