Interpersonal Trust Relationship Model in Restricted Domain of Literary Works

Liqun Liu, Dequan Zheng, Tiejun Zhao
MOE-MS Key Laboratory of Natural Language Processing and Speech
Harbin Institute of Technology
Harbin, China
liqunhit@gmail.com

Mengda Yang
Institute for Interdisciplinary Information Science
Tsinghua University
Beijing, China
mengda.yang@gmail.com

***Abstract*—Interpersonal trust relationship is an important dimension of interpersonal relationships. With new introduced plots of literature, we can evaluate the environment of characters and predict plot development to some extent. This paper proposes a representation of interpersonal trust relationship based on the fuzzy set theory in the restricted domain of A Dream of Red Mansions. Interpersonal trust degrees are obtained by the comprehensive evaluation based on the fuzzy analytic hierarchy process. This paper proposes a thought that solves the divergences of domain experts, and proposes an approach that establishes the initial trust degree between characters. Based on above, this paper analyzes the trust bias and overall trust degree between characters and mines the relationship between characters and content of the whole trust network of characters. The experiments show that the model is efficient in reflecting the interpersonal trust relationship of A Dream of Red Mansions. The interpersonal trust relationship of A Dream of Red Mansions is modeled and analyzed by the fuzzy set theory, which provides a novel thought on mathematical study of interpersonal trust relationship in literary works.**

Keywords-Interpersonal Trust relationship; Fuzzy comprehensive evaluation; Trust bias; Cluster analysis; A Dream of Red Mansions.

I. INTRODUCTION

A Dream of Red Mansions, also known as the story of the stone, written by Cao Xueqin, is regarded as the greatest masterpiece of Chinese fictions. This paper chooses it as our research object. Three reasons we consider. First, relationships between characters in literary works totally depend on the text, which shows all of the evidence-based evaluation of them. Second, it creates a series of characters and the relationships between them are complex. Third, it is an incomplete great literary work, and its true outcome is unknown. So there are lots of domain researchers and their opinions vary a lot. This paper focuses on the opinions of domain experts to conduct our research.

Interpersonal relationship is an important relationship in social life. Digital modeling of international relationship has been researched by some researchers [1]. Interpersonal trust relationship is usually researched from the aspects of sociology and psychology [2-3]. Chinese family connections are more complicated than those in other nations and have attracted some researchers. Modeling research of family connections in literary works, for instance, the family tree of A Dream of Red Mansions is studied from the perspective of networks in [4]. It is also widely used in other domains, like network security [5]. There are lots of researches on trust management in the domain of network security [6], the approaches of which are based on the concept of interpersonal trust relationship. There are researches of interpersonal relationship based on the fuzzy theory. Reference [7] puts forward the idea of exploring the structure of interpersonal relations in small groups through the fuzzy comprehensive evaluation and clustering analysis with reference system of small groups. Researches on interpersonal trust relationship haven't been found yet.

This paper summarizes some approaches in those domains and models the interpersonal trust relationship based on the fuzzy set theory in the restricted domain of A Dream of Red Mansions. A complete model is established about interpersonal trust relationship through formalized representation, comprehensive evaluation and mining analysis. Our experimental results show that the model is efficient in reflecting the interpersonal trust relationship in A Dream of Red Mansions.

This paper proceeds as follows. In section II, the interpersonal trust relationship in A Dream of Red Mansions is represented based on the fuzzy set theory. Fuzzy comprehensive evaluation on it is discussed in Section III. Trust bias and overall trust degree between characters are defined and mining analysis based on them is presented in Section IV. Experimental design and results analysis are presented in Section V. Finally, Section VI presents conclusions and discusses future directions.

II. REPRESENTATION

A. Concept Definition

Interpersonal trust is a quite complicated concept in sociology and psychology, there is no generally accepted definition until now. Interpersonal trust relationship is an important dimension of interpersonal relationships, in [8], if two persons know much about each other or they share similar life experience, they are considered more concerned and there is more trust between them. The viewpoint only considers interpersonal relationship as intimacy, which is too simple to describe Chinese interpersonal trust relationship as mentioned in [9]. Interpersonal trust relationship is only reflected by the text of literary works, so the factors of restricted domain are less than those in the open domain. This paper sees interpersonal trust relationship in literary works as a character's subjective overall views to another character.

B. Fuzziness of Concept

The factors that influence the interpersonal trust relationship are uncertain and involve multiple factors in different levels. With the development of the plot, it has a very

978-1-4673-0089-6/12/$26.00 ©2012 IEEE

large unrepeatable uncertainty. So we think the research of interpersonal trust relationship belongs to the category of fuzzy theory, rather than the probability theory.

Interpersonal trust relationship in literary works is a reflection of real social interpersonal trust relationships, so it is also fuzzy. The interpersonal trust relationship in A Dream of Red Mansions is different from that in real society. First, it does not change or changes little with time. Second, it is simpler and factors are less than those in real society. Third, its evaluation totally depends on the opinions of domain experts.

C. Representation Based on the Fuzzy Set Theory

1) Representative characters selecting

This paper selects 15 representative characters from A Dream of Red Mansions as our research objects. Fig. 1 shows Semantic network of those 15 characters' family connections.

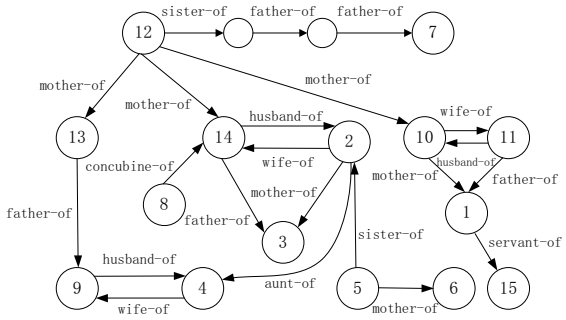

Figure 1. Semantic network of characters' family connections.

The connections of those representative characters include three important relations in family: blood relationship (mother-of, father-of, sister-of and aunt-of), relation by marriage (wife-of and concubine-of) and master-servant relationship (servant-of). We map the characters' names {Lin Daiyu, Wang Furen, Jia Baoyu, Wang Xifeng, Xueyima, Xue Baochai, Shi Xiangyun, Zhaoyiniang, Jia Lian, Jia Min, Lin Ruhai, Jiamu, Jia She, Jia Zheng, Zijuan} with 1 to 15. Here, the names of characters are represented in the form of Chinese pinyin.

2) Relationship representation

Let the universe U represent all the characters of A Dream of Red Mansions, then for a fuzzy relation T on $U \times U$, interpersonal trust relationship of all characters can be represented as follows:

$$T = \begin{bmatrix} t_{11} & t_{12} & \cdots & t_{1n} \\ t_{21} & t_{22} & \cdots & t_{2n} \\ \vdots & \vdots & & \vdots \\ t_{n1} & t_{n2} & \cdots & t_{nn} \end{bmatrix}$$

T is called international trust relationship matrix. T is a three-dimensional matrix and represents international trust relationship in A Dream of Red Mansions. In this paper, n=15. t_{ij} is called the trust relationship vector between character i and character j, $t_{ij} = (v_1, v_2, \cdots, v_m)$, $i, j = 1, 2, \cdots, n$. The number of elements in comment set is m, v_i represents the membership degree of the i^{th} element, $0 \le v_i \le 1$.

Diagonal elements of T represent a self trust relationship vectors for characters. Although trust relationship is mutual between two characters, their trust relationship vectors may not be same, namely, T is not symmetric.

III. Comprehensive Evaluation

A. General Process

Basic idea of fuzzy comprehensive evaluation is considering each factor of evaluating object and making a reasonable comprehensive evaluation using fuzzy linear transformation and maximum membership degree law. There are four basic elements about it [10].

- Factor set $F = \{u_1, u_2, \cdots, u_k\}$.
- Comment set $C = \{c_1, c_2 \cdots, c_m\}$. This paper represents elements of comment set with natural language. We set $C =$ {full trust, extreme trust, strong trust, moderate trust, neutral, moderate distrust, strong distrust, extreme distrust, full distrust}.
- Factor comprehensive evaluation matrix.
- Factor weight set $W = \{w_1, w_2, \cdots, w_n\}$.

B. Comprehensive Evaluation

If there are lots of factors influencing the problem, it is hard for domain experts to consider all the factors comprehensively, thus implicit contradictory data may be proposed [11]. We divide the complicated factors into several levels, thus evaluation on each level will be relatively easier. This paper proposes a comprehensive evaluation approach based on [12].

1) Establishing hierarchical structure of factors

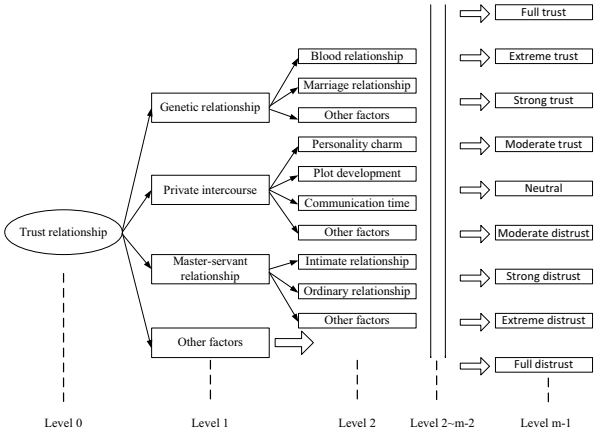

Figure 2. Factors' hierarchical structure of interpersonal trust relationship between two characters.

Fig. 2 shows the factors' hierarchical structure of interpersonal trust relationship between two characters. The number of levels is determined by domain experts, m levels we assume. The first level (Level 0) is our evaluation target, which represents the trust relationship degree between two characters. The elements of comment set constitute the last level (Level m-1). Other levels (Level 2~ Level m-2) represent the factors that are divided by domain experts. The number of factors and what they are in each level are also determined by domain experts.

The weight of each factor is very small if the number of factors is large in some level. In this case, it is difficult for domain experts to evaluate a significant and distinguishing weight value. An approach of solving this problem is that

clustering the factors of each level, which makes the factors to small classes, then making fuzzy comprehensive evaluation on those classes will be easier [1].

2) Establishing the fuzzy judgment matrix

For factors of each level, Tab. shows the numeric scale of comparing factors we set for this model [12].

TABLE I. NUMERIC SCALE OF TWO FACTORS

Numeric Scale	Definition	Explanation
0.5 0.6 0.7 0.8 0.9	Equal importance Moderate importance Strong importance Very strong importance Extreme importance	The numeric scale represents the relationship of two factors that are compared.
0.1,0.2, 0.3,0.4	Converse comparing	$r_{ji}+r_{ij}=1$ (r_{ij} is the result of comparing a_i with a_j).

If the opinions of domain experts are inconsistent, number scale could not be determined uniquely. There are lots of methods to solve this problem [13-15]. The approach proposed by [15], which first makes decision individually, then integrates and weights at last. This paper holds that this approach is suitable for the domain of A Dream of Red Mansions. Of course, to reflect opinions of different domain experts better, comprehensive evaluation could be carried out on every single domain expert.

3) Seeking weight vector

If the fuzzy judgment matrix is consistent, then:

$$r_{ij}=0.5+a(w_i-w_j), i,j=1,2,\cdots,n \tag{1}$$

Where $0<a\le 0.5$, a is a measure of the degree of object's difference that is perceived by domain experts.

If the fuzzy judgment matrix is inconsistent, least square method is used to compute the weight vector $W=\{w_1,w_2,...,w_n\}$, namely, constrained programming problem is solved as follows:

$$\begin{cases} minz=\sum_{i=1}^{n}\sum_{j=1}^{n}[0.5+a(w_i-w_j)-r_{ij}]^2 \\ s.t.\sum_{i=1}^{n}w_i=1, w_i\ge 0, (1\le i\le n) \end{cases} \tag{2}$$

From (2), we can get the weight vector $W=\{w_1,w_2,...,w_n\}$.

Using this approach to compute from the last level to the first level, we can get the interpersonal trust vector between two characters. The process is repeated for all characters, we can get the interpersonal trust vectors between all characters, and all of the vectors constitute the interpersonal trust relationship matrix.

4) Establishing initial trust degree

Initially, a three-dimensional matrix is established to represent interpersonal trust relationship, the size of this matrix is $n\times n\times m$, where n represents the number of characters, and m represents the number of elements in comment set. Then, let the first element's value of a self trust relationship vector for a character equal to 1, and others equal to 0. For other trust relationship vectors, let all value equal to 0 except the membership degree of "neutral" equals to 1.

With the plot developing, there are two cases, when a new event occurs, if there exist characters related, domain experts make comprehensive evaluation on the degree of trust between these characters, and update the interpersonal trust relationship matrix. When a new character appears, comprehensive evaluation on all the characters that have relations with this character should be done, thus a new matrix of interpersonal trust relationship is obtained.

With the plot continuous developing, interpersonal trust relationship matrix constantly changes. It reflects the changes of the interpersonal trust relationship between the characters in a period. In other words, a sequence of interpersonal trust relationship matrix is calculated with the development of the plot. The matrixes in this sequence are the notes and signs of interpersonal trust relationship changes between characters with the plot developing. Through researching and analyzing the sequence, we can get an intuitive profound understanding of whole story of A Dream of Red Mansions. The sequence can be mined and analyzed deeply to get more information about interpersonal trust relationship of A Dream of Red Mansions.

IV. MINEING ANALYSIS

A. Trust Bias Analysis

Based on trust relationship vector between two characters, this paper defines the trust bias degree between character i and character j as the cosine distance between vector t_{ij} and t_{ji} subtracted by 1 as followed.

$$t\_bias(i,j)=1-\frac{\sum_{k=1}^{9}t_{ij}(v_k)\cdot t_{ji}(v_k)}{\sqrt{(\sum_{k=1}^{9}[t_{ij}(v_k)]^2)(\sum_{k=1}^{9}[t_{ji}(v_k)]^2)}} \tag{3}$$

Where $t\_bias(i,j)$ represents the trust bias degree between character i and character j. Where $t_{ij}(v_k)$ represents the k^{th} element of t_{ij}. Thereupon, we get trust bias matrix between all characters as follows:

$$T\_bias=\begin{bmatrix} t\_bias_{11} & t\_bias_{12} & \cdots & t\_bias_{1n} \\ t\_bias_{21} & t\_bias_{22} & \cdots & t\_bias_{2n} \\ \vdots & \vdots & & \vdots \\ t\_bias_{n1} & t\_bias_{n2} & \cdots & t\_bias_{nn} \end{bmatrix}$$

Trust bias reflects nonequivalence extent of trust between two characters. If trust bias degree equals to 0, it represents the two characters trust each other with no bias. Diagonal elements' values equal to 0, because they represent a self trust relationship vector for characters. If trust bias degree between two characters is smaller, these two characters trust each other with less bias, otherwise, it shows that these two characters trust each other with more bias.

The trust bias of two characters is a negative factor for interpersonal trust relationship. Analyzing trust bias degree between a single character and other characters can assess nonequivalence of interpersonal trust environment of this character. The network of trust bias of all characters could be assessed by statistics and analysis on all trust bias degrees between all characters.

B. Clustering Analysis

To get a distinguishing trust degree measurement, a constant vector $w=(4,3,2,1,0,-1,-2,-3,-4)$ is introduced as

a weight vector. This paper defines overall trust degree from character i to character j as follows:

$$trust_{ij} = \sum_{k=1}^{9} t_{ij}(v_k) \cdot w_k \quad (4)$$

Where $t_{ij}(v_k)$ represents the k^{th} element of trust relationship vector between character i and character j, $k = 1, 2, \cdots, 9$. w_k represents the k^{th} element of weight vector. According to the definition, $trust_{ij} \in [-4.0, 4.0]$. $i, j = 1, 2, \cdots 15$.

Based on above representation and compute, interpersonal trust relationship matrix is converted to a two-dimensional matrix as follows:

$$TRUST = \begin{bmatrix} trust_{11} & trust_{12} & \cdots & trust_{1n} \\ trust_{21} & trust_{22} & \cdots & trust_{2n} \\ \vdots & \vdots & & \vdots \\ trust_{n1} & trust_{n2} & \cdots & trust_{nn} \end{bmatrix}$$

$TRUST$ is a matrix, an element of which represents a single metric of trust degree from one character to another. The matrix meets $trust_{ii} = 4.0, i = 1, 2, \cdots, 15$. From the definition, $TRUST$ is not symmetric.

To represent the overall trust degree between two characters, a new measurement needs to be defined. We present overall trust degree matrix between all characters, which is represented as a matrix as follows:

$$T\_overall = \begin{bmatrix} t\_overall_{11} & t\_overall_{12} & \cdots & t\_overall_{1n} \\ t\_overall_{21} & t\_overall_{22} & \cdots & t\_overall_{2n} \\ \vdots & \vdots & & \vdots \\ t\_overall_{n1} & t\_overall_{n2} & \cdots & t\_overall_{nn} \end{bmatrix}$$

This paper uses a linear equation to define overall trust degree between two characters as follows:

$$t\_overall(i, j) = a \cdot min\{trust_{ij}, trust_{ji}\} - b \cdot t\_bias(i, j) \quad (5)$$

Where $t\_overall(i, j)$ represents overall trust degree between character i and character j, $min\{trust_{ij}, trust_{ji}\}$ the minimum value between $trust_{ij}$ and $trust_{ji}$. a and b are real numbers parameters that are determined by domain experts.

Now $T\_overall$ is a symmetric matrix, the value of diagonal elements of which is all equal, so it can be converted to a fuzzy similar matrix easily. Note that $T\_overall$ does not possess transitivity, which means the trust degree can't transfer through an intermediary character.

The appropriate measure of clustering is selected by the domain experts. The aggregation relationship of the characters may be mined out by comparing usual personal network of the character with the collection of characters obtained through clustering. It can also evaluate the quality of interpersonal relationships. Many conclusions and much information could be mined through analysis on clustering set of characters. If all the clustering sizes are very small, it is a dangerous signal to the whole family to some extent, otherwise, the family unity is very good. Making a new comprehensive evaluation after the introduction of new events can predict the future development of the family. With the development of the plot, we can learn the relationship between the overall change of the trust relationship and plot development from the analysis on interpersonal trust clustering results.

V. EXPERIMENTAL ANALYSIS

To make the experiment analysis convenient, we choose the first eight characters from the fifteen representative characters, the numbers of which is from 1 to 8. We choose one domain experts to conduct our experiment. Initially, the domain expert selects and layers the factors that influence the system, then determine the digital scales. Comprehensive evaluation is done on this basis. Assuming above processes have been completed, and we have obtained the data, which are shown in Tab. Ⅱ.

TABLE II. TURST RELATIONSHIP VECTORS BETWEEN CHARACTERS

Trust relationship vectors between characters	Character 1~Character 8
Character 1	(1,0,0,0,0,0,0,0,0)(0,0,0,0,0,0,0,1,0.4,0.4)(0.8,0.1,0,0,0.1,0,0,0,0) (0,0,0,0,0,0.1,0.1,0.1,0.7) (0,0,0,0.1,0,0,0,0.2,0.7) (0,0.5,0.2,0,0,0,0,0.3,0) (0.7,0.3,0,0,0,0,0,0,0) (0,0,0,0,0,0,0,0,1)
Character 2	(0,0.1,0,0.2,0.1,0.3,0.3,0,0) (1,0,0,0,0,0,0,0,0) (1,0,0,0,0,0,0,0,0) (0,0.8,0.2,0,0,0,0,0,0) (0,0.9,0.1,0,0,0,0,0,0) (0,0.9,0.1,0,0,0,0,0,0) (0.8,0.2,0,0,0,0,0,0,0) (0,0,0,0,0,0,0,0,1)
Character 3	(1,0,0,0,0,0,0,0,0) (1,0,0,0,0,0,0,0,0) (1,0,0,0,0,0,0,0,0) (0,0,0,0,0,0,0,0,1) (0,0.5,0.2,0,0,0,0.3,0,0) (0,0.7,0.3,0,0,0,0,0,0) (0.9,0.1,0,0,0,0,0,0,0) (0,0,0,0,0,0,0,0,1)
Character 4	(0,0,0,0.1,0,0.2,0.3,0.4,0) (0,0,0,0,0,0,0,0,0) (0,0.8,0.2,0,0,0,0,0,0) (1,0,0,0,0,0,0,0,0) (0,0,0.7,0.3,0,0,0,0,0) (0,0,0,0.7,0.3,0,0,0,0) (0,0,0,0,0.5,0,0,0,0) (0,0,0,0,0,0,0,0.2,0.8)
Character 5	(0,0,0,0,0.1,0.3,0.1,0,0.6) (0.9,0.1,0,0,0,0,0,0,0) (1,0,0,0,0,0,0,0,0) (0,0.3,0.1,0,0,0.2,0.4,0,0) (1,0,0,0,0,0,0,0,0) (1,0,0,0,0,0,0,0,0) (0.7,0,0,0,0,0,0,0.3,0) (0,0,0,0,0,0,0,0.2,0.8)
Character 6	(0.8,0.1,0.1,0,0,0,0,0,0) (0,0.5,0,0,0,0,0,0.5,0) (1,0,0,0,0,0,0,0,0) (0,0,0,0,0,0.1,0.2,0.3,0.4) (1,0,0,0,0,0,0,0,0) (1,0,0,0,0,0,0,0,0)(0.9,0.1,0,0,0,0,0,0,0) (0,0,0,0,0,0,0,0.1,0.9)
Character 7	(1,0,0,0,0,0,0,0,0) (0.9,0,0.1,0,0,0,0,0,0) (1,0,0,0,0,0,0,0,0) (0,0,0,0.2,0,0,0,0.2,0.6) (0.8,0.2,0,0,0,0,0,0,0) (0.9,0.1,0,0,0,0,0,0,0) (1,0,0,0,0,0,0,0,0) (0,0,0,0,0,0,0,0.2,0.8)
Character 8	(0,0,0,0,0.5,0,0.5,0,0) (0,0,0,0,0.5,0,0,0,0.5) (0,0,0,0.3,0.5,0,0,0,0.2) (0,0,0,0.4,0.2,0,0,0,0.4) (0.8,0,0,0,0,0,0,0,0.2) (0.3,0,0,0,0,0,0,0,0.7) (0,0,0,0,0.5,0,0,0,0.5) (1,0,0,0,0,0,0,0,0)

According to (3), trust bias matrix is obtained using the data in Tab. . The computing results are shown in (6).

The character 1 and character 7 are taken as an example. Statistics on the trust bias degree between character 1 and other characters show that this character has trust bias of all other characters. There are four characters in seven having a large trust bias degree with character 1, which shows that character 1 is in a bad environment of trust bias. The

situation of character 7 is opposite. It has a very small trust bias degree with all other characters except character 4, so we think character 7 is in a good environment of trust bias.

$$T\_bias = \begin{bmatrix} 0.00 & 0.86 & 0.02 & 0.77 & 0.17 & 0.86 & 0.08 & 1.00 \\ 0.86 & 0.00 & 0.00 & 1.00 & 0.89 & 0.30 & 0.04 & 0.29 \\ 0.02 & 0.00 & 0.00 & 1.00 & 1.00 & 1.00 & 0.01 & 0.68 \\ 0.77 & 1.00 & 1.00 & 0.00 & 0.83 & 1.00 & 1.00 & 0.35 \\ 0.17 & 0.89 & 1.00 & 0.83 & 0.00 & 0.00 & 0.11 & 0.76 \\ 0.86 & 0.30 & 1.00 & 1.00 & 0.00 & 0.00 & 0.01 & 0.09 \\ 0.08 & 0.04 & 0.01 & 1.00 & 0.11 & 0.01 & 0.00 & 0.31 \\ 1.00 & 0.29 & 0.68 & 0.35 & 0.76 & 0.09 & 0.31 & 0.00 \end{bmatrix} \quad (6)$$

According to (4), we get the matrix of overall trust degree of one character to another as follows:

$$TRUST = \begin{bmatrix} 4.00 & -3.00 & 3.50 & -3.40 & -3.30 & 1.00 & 3.70 & -4.00 \\ -0.40 & 4.00 & 4.00 & 2.80 & 2.90 & 2.90 & 3.80 & -4.00 \\ 4.00 & 4.00 & 4.00 & -4.00 & 1.30 & 2.70 & 3.90 & -4.00 \\ -1.90 & 4.00 & 2.80 & 4.00 & 1.70 & 1.70 & 0.00 & -3.80 \\ -2.90 & 3.90 & 4.00 & 0.10 & 4.00 & 4.00 & 1.90 & -2.40 \\ 3.70 & 0.00 & 4.00 & -3.00 & 4.00 & 4.00 & 3.90 & -3.90 \\ 4.00 & 3.80 & 4.00 & -2.80 & 3.80 & 3.80 & 4.00 & -3.80 \\ -1.00 & -2.00 & -0.50 & -1.20 & -2.40 & -1.60 & -2.00 & 4.00 \end{bmatrix} \quad (7)$$

According to (5) and (7), set $a = 1.0,\ b = 1.0$, we get the overall trust degree matrix between all characters as follows:

$$T\_overall = \begin{bmatrix} 4.00 & -3.86 & 3.48 & -4.17 & -3.47 & 0.14 & 3.62 & -5.00 \\ -3.86 & 4.00 & 4.00 & 1.80 & 2.01 & -0.30 & 3.76 & -4.29 \\ 3.48 & 4.00 & 4.00 & -5.00 & 0.30 & 1.70 & 3.89 & -4.68 \\ -4.17 & 1.80 & -5.00 & 4.00 & -0.73 & -4.00 & -3.80 & -4.15 \\ -3.47 & 2.01 & 0.30 & -0.73 & 4.00 & 4.00 & 1.79 & -3.16 \\ 0.14 & -0.30 & 1.70 & -4.00 & 4.00 & 4.00 & 3.79 & -3.99 \\ 3.62 & 3.76 & 3.89 & -3.80 & 1.79 & 3.79 & 4.00 & -4.11 \\ -5.00 & -4.29 & -4.68 & -4.15 & -3.16 & -3.99 & -4.11 & 4.00 \end{bmatrix} \quad (8)$$

Clustering operation is used to analyze the aggregation of all characters. Statistics on the number of trust and distrust relationship, we get 34 trust degree connections and 30 distrust degree connections. It shows the family's interpersonal trust relationship network presents balance.

We take characters 7 and character 8 as an example. Statistics on the overall trust degree between character 8 and other characters show that this character has a large distrust degree with all other seven characters. It shows the interpersonal trust relationship environment of character 8 is bad, and we can also infer that character 8 is unwelcome in the whole family characters to some extent. However, statistics on overall trust degree of character 7 show an opposite result.

VI. CONCLUSIONS AND FUTURE DIRECTIONS

This paper uses the fuzzy set theory to research interpersonal trust relationship in restricted domain of A Dream of Red Mansions. Through Representing and making comprehensive evaluation on interpersonal trust relationship, an approach to establish initial trust degree of characters is proposed. This paper proposes three definitions of interpersonal trust relationship, which are trust bias, overall trust degree of one character to another and overall trust degree between characters. Based on above, this paper mines the relationship between characters and content of the whole trust network of characters in a slight level. The experiments show that this model is effective in reflecting the interpersonal trust relationship in A Dream of Red Mansions. This model can also be applied to other similar restricted domains of literary works.

Many areas of future work remain. There is no evaluation on the model we established, so the metrics of reliability and effectiveness are needed. Data about interpersonal trust relationship are important, more authoritative data of experiment need to be acquired from the domain experts. Another area of our ongoing work lies in the mining analysis on interpersonal trust relationship in deeper level.

ACKNOWLEDGMENT

This work is supported by the national natural science foundation of China (No. 61073130) and the project of National High Technology Research and Development Program of China (863 Program) (No. 2011AA01A207).

REFERENCES

[1] Wu Gang, “An approach of digital modeling and searching on personal relationship and event,” Chinese Patent: CN101963990A, February 2011.

[2] Yang Zhongfang and Peng Siqing, “Conceptualization of Chinese Interpersonal Trust: One Viewpoint of Interpersonal Relationship,” Sociological Studies, February 1992.

[3] Ding Daoqun and Shen Mowei, “Relationships among Personality Traits, Online Social Support, and Online Interpersonal Trust,” Psychological Science, vol. 2, 2005, pp. 300–303.

[4] Xuewei Cui, “Study of stability of deterministic complex networks,” Wuhan: Huazhong University of Science and Technology, June 2009.

[5] Tang W and Chen Z, “Research of Subjective Trust Management Model Based on the Fuzzy Set Theory,” Journal of Software, vol. 8, 2003, pp. 1401–1408.

[6] Beth T, Borcherding M and Klein B, “Valuation of trust in open networks,” In: Gollmann D, ed. Proceedings of the European Symposium on Research in Security(ESORICS). Brighton: Springer-Verlag, pp. 3–18, 1994.

[7] Liu Jing, “Application of the Fuzzy Mathematical Model to Interpersonal Relations Research in Small Groups,” Acta Psychologica Sinica, vol. 4, 1988.

[8] Daniel J. McAllister, “Affect and Cognition-based Trust as Foundations for Interpersonal Cooperation in Organizations,” Academy of Management Journal, vol. 38, No.1, 1995, pp. 24–59.

[9] Yang Zhongfang, “Relationship and Conceptualization of Human Feelings,” Fourth National Social Psychology conference, Fragrant Hill, Beijing, October 1998.

[10] Chen Shuili, Li Jinggong and Wang Xianggong, Fuzzy Set Theory and Application. Beijing: Science Press, 2005, pp. 187–234.

[11] Hu Baoqing, Fuzzy Theory Foundation, 2nd ed., Wuhan: Wuhan University Press, 2010, pp. 351–358.

[12] Zhang Jijun, “Fuzzy Analytical Hierarchy Process,” Fuzzy Systems and Mathematics, vol. 2, 2000.

[13] Bardossy A, Duckstein L and Bogardi I, “Combination of Fuzzy Numbers Representing Expert Opioions,” Fuzzy Sets and Systems, vol. 57, 1993, pp. 173–181.

[14] Hsu H M and Chen C T, “Aggregation of Fuzzy Opinions under Group Decision Making,” Fuzzy Sets and Systems, vol. 79, 1996, pp. 279–285.

[15] Wang Genjie, “Aggregation of Expert’s Opinion with Dynamic Weight for Fuzzy Group Decision-making,” Nanning: College of Mathematics and Information Science, GuangXi University, 2008.