MULTI AGENT MODEL OF TRUST AFFECTION

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ABSTRACT

The paper deals with construction of a platform for trust modeling extended by intentional affection of trust using a multi-agent system. Terms trust, phenomenal trust as a modification of impersonal trust, and trust representation are introduced, and model of trust affection is presented. Design of corresponding multi-agent system is described and applied to real data. These data deal with the public opinion poll of chosen ecological problems. Survey was acquired from websites articles of the Institute of Sociology of the Academy of Sciences of the Czech Republic.

INTRODUCTION AND RELATED WORKS

Many studies coming from psychological or social sciences describe the meaning and characteristics of trust (Luhmann 1979; Fukuyama 1995; Sztompka 1999; Gambetta 2000). Computational models for exploration of trust formation were created (Mui 2002; Lifen 2008). Wide-spreading of e-service, e-commerce (Zhang et al. 2008; Sathiyamoorthy et al. 2009), e-banking, etc., raise question of human machine trust. Further, trust plays an important role in peer-to-peer networks, ad hoc networks, grid computing, semantic web, and multi agent systems (Indiramma et al. 2008; Samek et al. 2009; Sathiyamoorthy et al. 2010), where humans and/or machines have to collaborate. The aim of our work is simulation of the trust evolution under intentional trust affection. This is common real situation, e.g. when bank affects the clients to trust it.

TRUST AND TRUST REPRESENTATION

The acceptation of the term trust is wide (Fetzer 1988). Based on Gambetta (Gambetta 2000), we interpret trust as a confidence in the ability or intention of a person to be of benefit to trust something or someone at sometime in future. Trust in our model is represented by a value from continuous interval $\langle 0, 1\rangle$. Value 0 represents complete distrust and value 1 means blind trust. Trust evolves not only within personal relations - personal trust, but person can trust to a phenomenon – phenomenal trust. In this case, trust is formed towards a phenomenon, e.g. to certain product from a set of products of some kind or to a political party.

Considering a set of m products, the distribution of person's trust can be described by trust values t^k , $0 \le t^k \le 1$, $k = 1, \dots ,$ m, and their sum is one.

INTERVENTION MODEL

The general model of information intervention effect (Vavra F., University of West Bohemia, personal communication) will be applied. Let finite set of events X with the probability distribution mass function $P(x)$, $x \in X$ on the input represents the state before intervention, e.g. initial probability of specific product preferences from a set of products of some kind. Probability distribution $Q(x)$ on the output describes the state after intervention activity and the intervention is modelled by probability distribution $R(x)$. The simple method for joining initial probability and intervention probability is their mixture

$$Q(x) = (1-\lambda)P(x) + \lambda\, R(x) \qquad (1)$$

where $0 < \lambda \le 1$, represents intensity of the intervention.
Given probability mass functions $P(x)$, $R(x)$, $Q(x)$, the intensity λ can be found by the method of the least squares when all probability mass functions exist.

PHENOMENAL TRUST AFFECTION

Further, we will cope with an intentional trust intervention applying presented intervention technique to phenomenal trust. Consider a group of n subjects represented as the set $S = \{s_1, s_2, \dots, s_n\}$, and a group of m exclusive products of some kind represented as a set $P = \{p_1, p_2, \dots, p_m\}$ that constitutes the phenomenon. Trust of subject s_i, $i = 1, \dots n$, to product p_k, $k = 1, \dots , m$, is denoted as follows

$$t_i^k = t(s_i, p_k),\ t_i^k \in \langle 0, 1\rangle, \text{ and } \sum_{k=1}^{m} t_i^{\,k} = 1 \qquad (2)$$

The dominant product p_d is defined as product a subject $s \in S$ trusts mostly. This trust is called t_d, $t_d = \max t(s, p_k)$, $k = 1,\dots, m$. The population S can be divided into the preferential classes according to the dominant product the individual subject trusts. Population trust to dominant product is denoted by T_d. The example of subject (t) and population (T) trust distributions to five products of a phenomenon is shown in the Figure 1. It illustrates a possible situation, when the dominant product in whole population (p_3) differs from dominant product of specific individual (p_4).

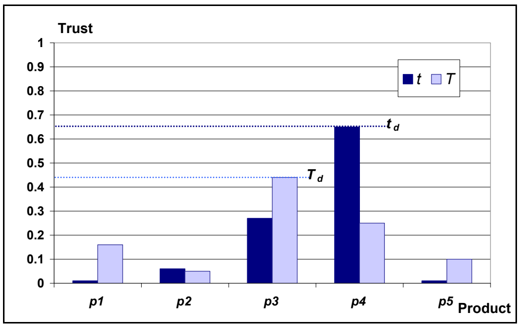

Figure 1: Population and Subject Trust Distributions Example

Now, consider affection of trust in favor of selected product in order to gain or even increase dominancy. This is modeled by mixture of intervention distribution I and current trust distribution to the products of individuals. Then, new trust probability distribution is given by values t'^{k}_{i}

$$t'^{k}_{i} = (1- \lambda_i^k)\, t_i^k + \lambda_i^k\, I_i^k, \qquad (3)$$

where $0 \le t_i^k \le 1$, $0 \le I_i^k \le 1$, $\sum_{k=1}^{m} t_i^k = 1$, and $\sum_{k=1}^{m} I_i^k = 1$

The formula (3) means that some part of previous trust is transformed into intervened trust.

TRUST INTERVENTION MODEL FRAMEWORK

Agent model structure is hierarchical and covers four sets of subjects. The first set is called Consumers, the second Producers, next Analyzer (set of one or more agents), and the last is Dominator (set of one agent). The model hierarchy is shown in the Figure 2.

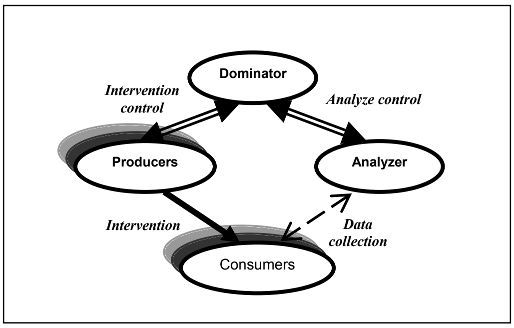

Figure 2: Model Hierarchy

Dominator is the highest element in the hierarchical structure, has the control function of the whole intervention process, sets the input parameters, and evaluates the impact of the intervention. Analyzer and Producer represent the next lower hierarchic level. Intervention is realized through chosen Producers on the whole set of the Consumers or its subset. Analyzer is advisory service agent, which requests and collects data on trust changes of the Consumers, analyzes the intervention process, and sends the results to Dominator. Producers authorized by Dominator are charged with the task to perform the intentional intervention on selected Consumers. Consumer is the lowest element in hierarchy that is able to change his phenomenal trust distribution to products depending on Producer's intervention, and sends the messages about trust changes to Analyzer. The phenomenal trust model is implemented (Hruska 2010) exploiting Java Agent DEvelopment Framework JADE (JADE 2010).

CASE STUDY

To illustrate trust evolution under affection, we took data obtained from the reports on the portal websites of the Institute of Sociology of the Academy of Sciences of the Czech Republic (IS 2009). The data deal with an opinion on growing genetically modified farming products (Global ecological problems by Czech public eyesight published in May 2009). The respondents answered the question: "Tell us, please, what is your view of growing the genetic modified farming products?", and 22% respondents considered growing the genetic modified farming products as big, 31% quite and 21% as small problem, 19% didn't know, and 7% saw no problem. For simplicity, data are reduced into two values. First three answers in "big problem" and the last two ones in "no problem". Then, dominant trust value of an individual needs to be higher than 0.5. The higher trust the stronger belief in dominantly trusted value. Choosing the mean of belief, we generate the population having dominant trust distribution approximately normal.

Intervention distribution adjustment

We start with the very neutral situation modeling the state before the discussion on growing genetically modified farming products started. The opinion in population is evenly distributed with rather low belief due to the lack of information. The May situation corresponds to intervention I_d between 0.7 and 0.8 in favor of big problem. We explored how the trust under these values will change depending on the intensity of interventionλ. Results of this study are shown in the Figure 3.

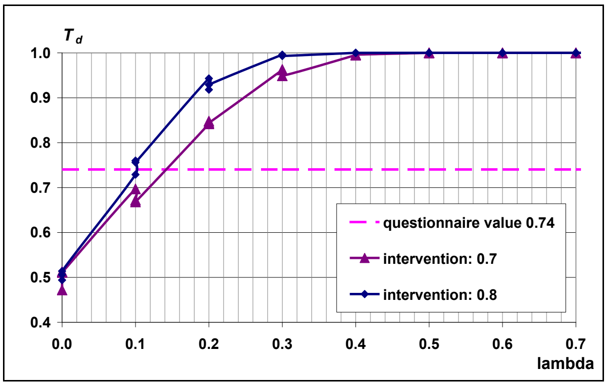

Figure 3: Study of Intervention Distribution Adjustment

In the graph, a curve connects the computed discrete values denoted by different marks. A vertical distance of the same mark represents the population trust dispersion value computed in simulation runs. The value acquired from the questionnaire is depicted by dashed line. The values gained by the intersection points with the questionnaire value range from 0.1 to 0.14. According to expectation, the higher intervention value I_d the lower intensity λ is needed. The reason for relatively low intensity value can be overall situation in the society, when concerns grew slightly.

The new questionnaire results were published at the beginning of July 2010. The rate between "big problem" and "no problem" products changed only a little, from 74:26 to 73:27, which is in concordance with small media attention in the last year. Using formula (3) and according to small decrease of trust to dominant product, the required intervention distribution I_{dComp} was computed with trust value change from 0.74 to 0.73 using value of intensity $\lambda = 0.14$ (see Figure 3, I_d = 0.7). The computed value I_{dComp} = 0.67 corresponds to our simulation result for I_d = 0.7.

Expected value influence

Next, we studied how the intensity λ needed to reach today's state depends on the mean value μ of belief to the dominant value. Following values of mean values were chosen: μ = 0.6, 0.7, 0.8, and 0.9 instead of neutral 0.5. The results of this study are shown in the Figure 4.

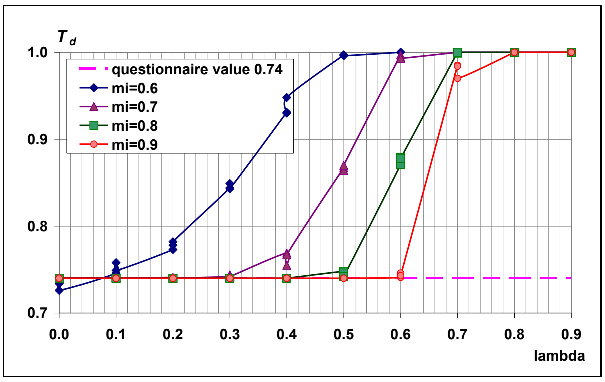

Figure 4: Study of Expected Value Influence

The value acquired from the questionnaire is depicted by dashed curve. The parameter λ increases with growing mean μ to accomplish the same trust. This result is in good concordance with human behavior, when we expect more effort to change somebody's opinion, in which he believes strongly.

CONCLUSION

We developed the phenomenal trust model integrating intentional affection of trust evolution. The model itself is deployed in the agent based trust management model. We demonstrated its application to the real data. The model confirmed expected sociological behavior, moreover some its aspects can be quantified. Upcoming model modification will allow covering the effect on benefit of more products in several time series.

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