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TRUST AFFECTION MODEL APPLICATION FOR SOCIAL ISSUES

NETRVALOVA, Arnostka, SAFARIK, Jiri, (CZ)

Abstract. The paper deals with application of Trust Affection Model Framework for modelling social issues. Terms trust, phenomenal trust as a modification of impersonal trust, and trust representation are introduced and model of trust affection is presented. Model design using multi-agent system is described and applied to real data. These data deal with the public opinion poll of social impact assessment of economic crisis. Survey was acquired from websites articles of the Institute of Sociology of the Academy of Sciences of the Czech Republic.

Key words. Trust, trust modelling, impersonal trust, trust affection

Mathematics Subject Classification: Primary 93A30, 94A17; Secondary 03B42.

1 Introduction

Many studies coming from psychological or social sciences describe the meaning and characteristics of trust [7], [2], and [3]. Computational models for exploration of trust formation were created e.g. in [8] and [5]. Wide-spreading of e-service [6], e-commerce, e-banking, etc., raise question of human machine trust. Further, trust plays an important role in peer-to-peer networks, and multi agent systems [9], where humans and/or machines have to collaborate. The aim of our work is simulation of the trust evolution under intentional trust affection applied to social issues.

2 Trust and Trust Representation

The acceptation of the term trust is wide [1]. Based on Gambetta [3], we interpret trust as a confidence in the ability or intention of a person to be of benefit to trustworthy something or someone at sometime in future. Trust in our model is represented by a value from continuous interval ⟨0, 1⟩. Value 0 represents complete distrust and value 1 means blind trust. Trust evolves not only within personal relations, i.e. personal trust, but person can trust to a phenomenon, so called phenomenal trust, that is the modification of impersonal trust. In this case, trust is formed towards the exclusive values of a given phenomenon, e.g., into possible products of the same kind from different producers.

Consider a group of n subjects represented as the set $S = \{s_1, s_2, \ldots, s_n\}$, and a phenomenon of m products represented as the set $P = \{p_1, p_2, \ldots, p_m\}$. Trust of subject s_i, $i = 1, \ldots n$, to product p_k, $k = 1, \ldots, m$, is denoted as follows

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

3 Intervention Model

The general model of information intervention effect is depicted in the Figure 1 (Vavra F., University of West Bohemia, personal communication) will be applied.

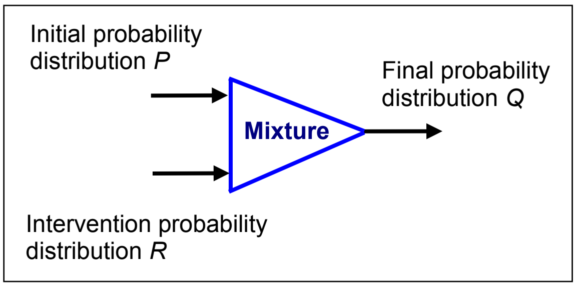

Figure 1 Trust Probability Distribution Mixture

Suppose 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. The intervention is modeled by probability distribution $R(x)$. The simple method for joining initial probability and intervention probability is their mixture

$$Q(x) = (1-\lambda)P(x) + \lambda\, R(x) \tag{2}$$

where $0 < \lambda \leq 1$, 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 of probability mass functions are known

$$\lambda = \frac{\sum_{x \in X} (Q(x) - P(x))(R(x) - P(x))}{\sum_{x \in X} (R(x) - P(x))^2} \tag{3}$$

3 Phenomenal Trust Affection Model

Further, the presented intervention model will be applied for trust affection. We will define the dominant product p_d as a product a subject $s \in S$ trusts mostly. This trust is called t_d^s,

$t_d^s = \max t(s, p_k)$, $k = 1,..., m$. Values of subject's trust in other products are modeled by $t_i^s=(1-t_d^s)/(m-1)$, $i \neq d$. Obviously, each value $t_d^s > 1/m$ makes a product dominant. The higher is value of t_d^s, the higher is trust of the subject in the dominancy of a product. Values t_d^s in each product are supposed to have approximately normal distribution in the population. Then, the population S can be divided into preferential classes according to the dominant product. Population's dominant product is the product, which is trusted mostly by the whole population.

Consider affection of trust in favor of some product in order to gain or even increase dominancy. This is modeled by mixture of intervention distribution I and initial trust distribution to the products of individuals. So, new trust probability distribution of an individual is given by values t'^k_i

$$t'^k_i = (1- \lambda_i^k)\, t_i^k + \lambda_i^k I_i^k, \tag{4}$$

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

Affection of trust distribution in the population is modeled using multiagent system. The model is hierarchical and covers four sets of subjects. The first set is called Consumers, second Producers, next Analyzer (set of one or more agents), and the last is Dominator (one agent). 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 (authorized by Dominator) 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. Consumer is the lowest element in hierarchy that is able to change his phenomenal trust distribution to products depending on intervention, and sends the messages about trust changes to Analyzer.

4 Case Study

To demonstrate trust evolution under affection, we used data obtained from the reports on the portal websites of the Institute of Sociology of the Academy of Sciences of the Czech Republic [4]. The data deal with an opinion on effect of economic depression (Economic crisis by Czech public eyesight published in April and May 2009). The respondents answered the question: "Tell us, please, what are your view of economic crisis effect and its impact on your personal situation?" The answers of the respondents are written down in Table 1.

Table 1 Opinion on Effect of Economic Crisis from April to May 2009 [%]

ANSWER	04/2009	05/2009
DECIDEDLY AFFECTION	25	29
SUSPICIOUSLY AFFECTION	37	40
SUSPICIOUSLY NO AFFECTION	23	21
DECIDEDLY NO AFFECTION	4	4
DON'T KNOW	11	6

In the model, the phenomenon values, i.e. products, are respondent's individual views on crisis having five values.

For simplicity, data are reduced into three following phenomenon values - first two answers in "affects", second two ones in "doesn't affect", and the last one in "don't know" (Table 2). As the initial probability distribution, the values from April 2009 and as the final probability distribution the values of trust from May 2009 are taken for the study introduced below (Subsection 4.1). The dominant product value in the population is "affects" in both cases, what is obvious from data in Table 2.

Table 2 Phenomena Values from April to May 2009 [%]

PHENOMENA VALUE	04/2009	05/2009
AFFECTS	62	69
DOESN'T AFFECT	27	25
DON'T KNOW	11	6

4.1 Study of Population Trust Dependence on Intervention Intensity

Several studies of model behavior have been performed. Presented study is accomplished for all products. Number of consumers, i.e. $n = 1000$, is chosen proportionally to the number of respondents which was 1038. The data acquired in April 2009 are used at the beginning of trust development simulation and the situation in May 2009 should be reached by intervention. This means that in the beginning 620 individuals dominantly believe the crisis affected their personal situation, 270 individual dominantly believe the crisis does not affected their personal situation a 110 individuals do not have dominant opinion.

The values of dominant trust of individuals' t_d^s were generated with approximately normal probability distribution using mean value 0.5 and deviation 0.05 keeping $t_d^s > 1/3$ ($m=3$). Values of intervention probability distribution for intended increase of population trust into dominant product are $I_{\text{AFFECTS}} = 0.7$, $I_{\text{DOESN'T AFFECT}} = 0.15$, and $I_{\text{DON'T KNOW}} = 0.15$ in this study. The population trust dependence on intervention intensity λ produced by the simulation is shown in the Figure 2.

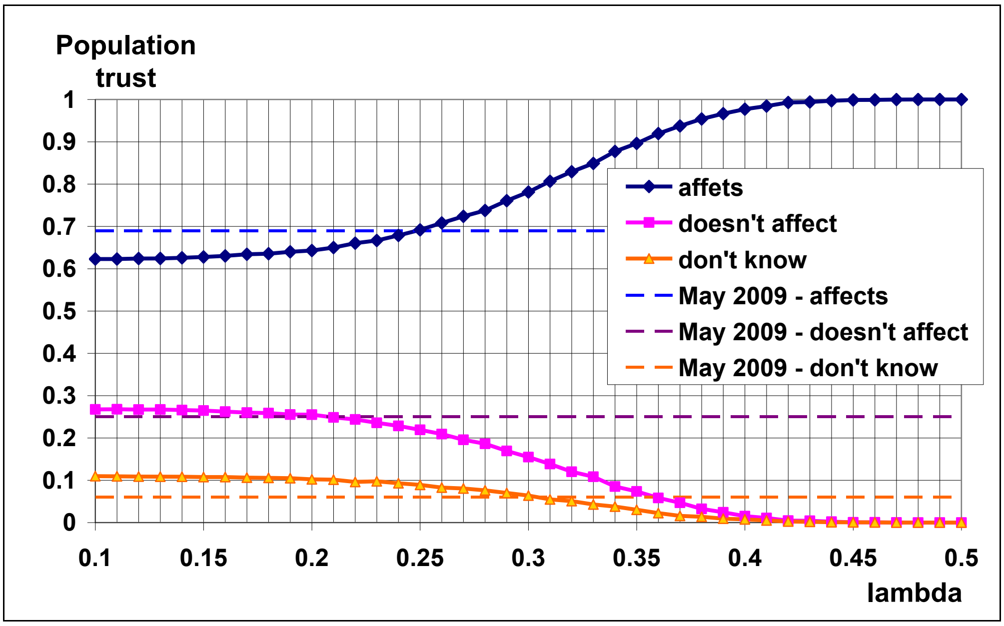

Figure 2 Dependence of Population Trust on Intervention Intensity λ

In the graph, a curve connects the computed discrete values denoted by different marks. The values acquired from the questionnaire are depicted by dashed lines. Value of intervention intensity λ needed to reach final population trust distribution determined by simulation is $\lambda = 0.25$. The maximum increase rate of population trust is for $\lambda \in \langle 0.2; 0.4 \rangle$. The graph can be utilized e.g. to forecast population trust evolution if similar situation in the future occurs.
The values for other products gained by the simulation are 22% for "doesn't affect" and 9% for "don't know". The values acquired by the questionnaire were 25% for the first one and 6% for the second one. The fact that caused these divergences is the uniform distribution trust probability between two reminded products in the model and this lead to slight undervaluation and overvaluation of trust into these products.

4.2 Model Results Verification

To validate trust intervention simulation results, we computed intervention intensity λ using formula (3) from the data of the questionnaire. The computed results are shown in Table 3. Thus, computed value of intervention intensity ($\lambda_{COMP} \approx 0.27$) is close to that gained by the simulation. Small dissimilarity can be explained by the fact that initial in the simulation, population trust was generated randomly.
In addition to intervention intensity computation, the values of probability distribution entropies $H(T_{\mathrm{APRIL}})$, $H(I)$, and $H(T_{\mathrm{MAY}})$are shown in Table 3. These entropies are computed by classic information entropy formula. Entropy decreased from April to May, i.e. from value 1.2879 to 1.1129 one, what indicates that trust probability distribution among the products in April is more uniform than in May. Indeed, population trust into dominant product grew in May and population trust into other products dropped.

Table 3 Computed Results: Data of Questionnaire (from April to May 2009)

PHENOMENA VALUE	T_{APRIL}	I	T_{MAY}	$H(T_{\mathrm{APRIL}})$	$H(I)$	$H(T_{\mathrm{MAY}})$
AFFECTS	0.62	0.70	0.69	0.4276	0.3602	0.3694
DOESN'T AFFECT	0.27	0.15	0.25	0.5100	0.4105	0.5000
DON'T KNOW	0.11	0.15	0.06	0.3503	0.4105	0.2435
Σ	1.00	1.00	1.00	**1.2879**	1.1813	**1.1129**
λ_{COMP} = **0,2679**						

5 Conclusion

We developed the trust affection model for trust evolution. The model itself was deployed in the agent based trust management model. We demonstrated its exploitation for real data from social domain. The model confirmed expected sociologic behavior, moreover some its aspects can be quantified.

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Current address

Arnostka Netrvalova, Ing, Ph.D.
University of West Bohemia, Faculty of Applied Sciences,
Department of Computer Science, Univerzitni 22,
306 14 Plzen, Czech Republic
Direct Tel. +420-37-763-2425
e-mail: netrvalo@kiv.zcu.cz

Jiri Safarik, prof., Ing., CSc.
University of West Bohemia, Faculty of Applied Sciences,
Department of Computer Science, Univerzitni 22,
306 14 Plzen, Czech Republic
Direct Tel. +420-37-763-2439
e-mail: safarikj@kiv.zcu.cz