Trust modeling based on Capra cognitive framework

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Abstract

Trust is needed to facilitate cooperation and delegation among agents in a multi-agent system. This paper proposes a trust model based on Capra cognitive framework. This framework explains social phenomena from the four perspectives of structure (agent), pattern (network), process, and meaning. We assume trust as "meaning" in the proposed model. Every agent has properties such as personality, responsibility, and specialty. Interaction among agents is based on friendship network. OODA, as a general process for decision making, is used for updating the trust in the simulation run.

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1. Introduction

Recently, many researchers have been interested in the concept of trust, its modeling and simulation. This interest is due to its high importance in various applications and domains such as Net Centric Organizations (NCO), electronic commerce, as well as distributed, decentralized, and multi-agent systems. From the viewpoint of artificial intelligence, creation and development of trust is necessary to form concepts such as cooperation, coordination, collaboration, and delegation among agents (Fetanat & Feshareki Naghian, 2010; Gambetta, 1988; Josang, Ismail, & Boyd, 2007; Marsh, 1994).

Trust became a topic of research by Diego Gambetta. According to him “Trust (or symmetrically distrust) is a particular level of the subjective with which an agent will perform a particular action, both before he can monitor such action (or independently of his capacity to monitor it) and in a context in which it affects his own action”. Gambetta’s definition of trust is a good starting point. Also, this definition for trust modeling was used with mathematical view (Marsh, 1994). Castelfranchi expanded on Gambetta’s work on trust. In Castelfranchi's definition of trust, two critical extensions were identified. First, only cognitive agents can trust other agents. Second, goals and beliefs are essential to trust those agents (Castelfranchi & Falcone, 1999). Castelfranchi’s view on trust is cognitive. In this view trust is made up of underlying beliefs.

As we mentioned above, another view for trust modeling is mathematical view, as in Marsh's trust model. This view uses a trust metric based on variables such as perceived competence, perceived risk, utility of situation for the agents involved, importance of a situation, etc (ElSalamouny, Krukow, & Sassone, 2009; Marsh, 1994; Seo & Han, 2009).

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Hybrid approaches can also be used. Esfandiari and Chandrasekharan (2001), for example, consider trust in both cognitive and mathematical perspectives. However, there is a controversy over the concept of trust. Researchers have presented different definitions and each definition utilizes certain features of trust. Different studies use an approximate or hypothetical definition based on the scope of expectations. Lack of a common definition has made precise discussion about trust more difficult.

Agent and multi agent system (MAS) is a conventional approach for analyzing, modeling, and simulation of trust. In general, the agent concept is a tool for understanding complex concepts such as trust. Multi agent systems are made of a set of agents that interact with each other for problem solving. In other words, such systems solve a problem with a distributed and decentralized approach (Weiss, 2001). There are various definitions and interpretations for multi agent systems. Most researchers, however, agree that multi agent systems consist of several agents interacting with each other to achieve a certain goal (Bernon, Cossentino & Pavon, 2005; Stone & Veloso, 2000; Weiss, 2001). Today, MAS is used as an advanced method for modeling and simulation. This method provides the testbed for examining models and theories from different perspectives (Gilbert & Troitzsch, 2005). Likewise, in trust modeling, agent is a basic concept that serves as a trustor or a trustee having his own intentions, cognitive abilities, and knowledge on how to fulfill its requirements. Today, most trust models have been developed based on MAS because two essential concepts for trust modeling are agents and interactions among them that can be described in this approach.

In this paper, trust dynamics has been modeled based on Capra cognitive framework. The paper is organized as follows. First, Capra cognitive framework is introduced. Next, we explain the proposed model. Then, the related work is described, and finally we have conclusion and future works.

2. Capra Cognitive Framework

Capra cognitive framework is based on new definition of cognition. Cognition is the process of knowing in life; knowing how and what capabilities are used for survival. With this definition, the smallest living organisms such as cells are cognitive phenomena that use cognition for survival in life. Definition of cognition based on biological view enables us to use the cognition concepts in a wide range to explain the behavior of living organisms. Capra has presented a unique framework for understanding the biological and social phenomena in four perspectives. Three out of four perspectives is about life and the fourth one is meaning (Capra, 2002). The first perspective is pattern that includes various relations among system components. Structure, the second perspective, is defined as the material embodiment of system pattern. The structure of a living organism evolves in interaction with its environment. The third perspective is the life process integrating the pattern and the structure perspectives. When we try to extend new understanding of cognition to the social life, we immediately encounter many misleading phenomena - rules of behavior, values, goals, strategies, intentions, designs, and power relations - that often do not have a role in non-human world, but they are essential for human social life. For extending life to the social domain, meaning perspective is added to three other ones. Thus, we can understand social phenomena from four perspectives: pattern, structure, process, and meaning. Culture, for instance, has created and preserved a network (pattern) of communication (process) with embedded meaning. Material embodiment of culture includes art and literary masterpieces (structure) that transfer meaning from one generation to another.

According to Capra cognitive framework, any complex phenomena such as trust can be studied in four perspectives. In order to close these four perspectives to the terminology of trust modeling, we replace "pattern" with "network" and "structure" with "agent". Pattern perspective is the relationship between components, thus network is a good terminology. Structure is a set of features that evolves during life. These features together will make the agent concept. Therefore, Capra cognitive framework is redefined in four perspectives: network, agent, process, and meaning (Figure 1).
3. The Proposed Model

For trust modeling, we assume trust as meaning in Capra cognitive framework. In order to create the desired meaning (trust) in this framework, we design trust model based on the three perspectives of agent, network, and process. Therefore, our model is based on these three perspectives (Figure 2).

3.1. Agent

Agents that model people in society can be represented by vectors of properties. Three important properties of specialty, responsibility, and personality have been used in this model (Figure 3). The first two properties are from zero (lack of the property) to one (having the property completely).

We use binary numbers for personality property to compare it with the equation 1. For single bit, two personality properties, for two bits, four, and for n bit, $2^n$ personality property is defined for agents. In this equation, $P_A$ is personality of agent A and $P_B$ is personality of agent B.

$$disSimilarity(P_A, P_B) = \frac{\sum_{i=1}^{n} |P_A - P_B|}{n}$$

$$Similarity = 1 - (disSimilarity)$$
3.2. Network

This model is also based on interaction among agents which is very important in MAS. Interaction concept in the proposed model is friendship that is modeled as friendship network (Figure 4). If service is needed, each agent sends its request to a friend or a familiar agent based on this network. Such a network not only expresses relationship but also its strength. Thus, network is described as a weighted matrix. The strength of relationship can be interpreted as the amount of trust one agent has on another. The more trust, the higher the probability of delegating a service to an agent.

![Friendship Network](image)

Figure 4. Friendship Network

3.3. Process

Given trust is a decision making process for trust; therefore, the main process in trust is decision making. When two agents with no prior knowledge of each other want to engage in an interaction (for example, electronic commerce transaction), they must each ask themselves “Should I trust this agent and engage in this interaction (or not)?”. The problem arises when each agent must choose the indicators that should be used for this decision making and request it from the other agents. When an agent is faced with these complex questions, trust can be a tool to simplify decision making. Moreover, it can guide an agent in a certain direction and limit the number of decisions that has to be considered (AL-Mutairi, 2007; Stranders, 2006).

Decision making can be related to trust by considering the opponent. For example, an agent needs to decide whether or not to delegate a task to another. To do this, the decision model needs to know the agent's goals and risk-profile regarding to trust.

Trust can be the result of decision making and we should decide whether to trust or not. In this process, the assessments are compared to a threshold. If they are higher than the threshold we trust, otherwise we do not. The threshold value depends on decision making type (or agent type). In an optimistic decision making, for instance, this value is lower and in a pessimistic decision making, it is higher.

In the proposed model for process perspective (Figure 2), OODA loop is used (Figure 5). OODA is a general process for decision making (Yang, 2006). Each agent in this process observes the environment (Observe) and makes knowledge from the observation (Orient). Decision-making is based on knowledge (Decide), and finally this decision is executed (Act). These four stages are the main stages of simulation cycle of the proposed model. Trust is formed incrementally and distrust catastrophically.
Social manner includes three different kinds of trust. Interpersonal trust is the direct trust that an agent has on another. Impersonal trust deals with the trust within a system that is perceived through different properties. And finally, dispositional trust is the general trusting attitude. The proposed model focuses on interpersonal trust more and evaluates the influence of friendship network, similarity, specialty, and responsibility in developing trust. In other words, the simulator developed based on the proposed model examines several different scenarios as "What ... If ...". For example, if most of the agents providing service are specialists, how will trust develop? Scenarios can be defined regarding the number and diversity of parameters in a given model. This paper examines two scenarios among many.

**Scenario 1:** More than 50% of agent service providers have specialty and responsibility above 0.7 in this scenario. The simulation results indicate that trust increases gradually with 500 iterations (Figure 6-a).

**Scenario 2:** In this scenario, more than 50% of agent service providers are specialists but not responsible. The results show fluctuations (Figure 6-b).

4. Related Work

Like other works on trust modeling, our framework model focuses on the main concepts of trust making conceptually. It determines and models the main concepts and components and relationships among them. Some
framework models have studied trust in WEB and some other have used framework as application. There are a number of researches that study trust as a framework model.

In their paper, Weth and Bohm (2006) propose a framework for behaviour-based trust models for open environment based on a relational representation of behavior-specific knowledge. Trust-policy algebra is used in this framework. Sun, Yu, Han, and Liu (2006) present an information theoretic framework to quantitatively measure trust and model trust propagation in ad hoc networks using entropy-based model and probability-based model. Chen, Zhang, Cohen, and Pin-Ho (2010) introduce a trust-based message propagation and evaluation framework in vehicular ad hoc frameworks where peers share information regarding road condition or safety, and others provide opinions about whether the information can be trusted. Fung, Zhang, Aib, Boutaba, and Cohen (2009) develop a simulation framework that incorporates different components namely expertise model, deception model, attack model, and evaluation metrics to compare existing trust models. Schultz (2006) proposes a framework model that includes the situational trust model, the trust transaction, and the trust equation. The situational trust model relates the trustor, the trustee, the trust object, and the trust environment. Gao and Houben (2010) present a framework for trust establishment and assessment on the web of data.

5. Conclusions and Future Work

As trust is a complex concept, it has various definitions, interpretations, and models in different areas. In this paper, a model is proposed based on Capra cognitive framework. This model assumes trust as cognitive dynamics. A value is calculated based on friendship, similarity, and prior trust and then it is compared with the threshold. As trust concept is closely related to decision making, we use OODA decision making loop in this model. OODA process also provides the update mechanism for trust. The simulation of the examined scenarios shows that the specialty and responsibility of service providers lead to an increase in trust. On the other hand, trust can not develop if the specialists are not responsible.

In our proposed, agent, network, and process are used as the main concepts for trust making or meaning perspective in Capra Cognitive Framework. Depending on the given domain and application, we can extend each of three perspectives. In other words, future works can extend agent's parametric model with more properties, include other networks besides friendship network, and improve the decision-making process.

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