On the revision of informant credibility orders

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A R T I C L E   I N F O

A B S T R A C T

In this paper we propose an approach to multi-source belief revision where the *trust* or *credibility* assigned to informant agents can be revised. In our proposal, the credibility of each informant represented as a strict partial order among informant agents, will be maintained in a repository called *credibility base*. Upon arrival of new information concerning the credibility of its peers, an agent will be capable of revising this strict partial order, changing the trust assigned to its peers accordingly. Our goal is to formalize a set of change operators over the credibility base: expansion, contraction, prioritized, and non-prioritized revision. These operators will provide the capability of dynamically modifying the credibility of informants considering the reliability of the information. This dynamics will reflect a new perception of trust assigned to the informant, or extend the set of informants by admitting the addition of new informant agents.

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1. Introduction

In this paper we will consider a set of deliberative agents that participate in a multi-agent system; each agent may play the role of an informant for other agents in the system. In this scenario, each agent could receive information from multiple sources, and the agents' subjective attribution of trust or credibility to a particular informant can be related to the trust attributed to others. Thus, when different agents provide conflicting information, or an agent gives information in conflict with the information the agent maintains, the credibility of the informants can be used to obtain a prevailing conclusion that will allow the agent to update its stored information.

In Multi-Source Belief Revision (MSBR) [10,15,49], a single agent can obtain new beliefs from multiple sources of information. Some proposals found in the literature of MSBR assume an order among sources (or informants), and use this order to decide which information prevails when a contradiction arises.

In this paper we propose an approach to MSBR where the *credibility* assigned to informant agents can be revised. To attach some degree of *informational* or *epistemic trust* to data received as information from an external source [45], is a common social device for human agents. We are drawing a distinction between epistemic trust and practical trust, making a suggestive analogy with epistemic and practical reasoning; the former being reasoning about what to believe and the latter being reasoning about how to act. Epistemic trust is therefore about the degree of acceptance an agent is willing to attach to a piece of information coming from another agent. Following the analogy, practical trust can be considered as trust in that an agent will act as she has promised to act. Notice that in this case, this is a form of subjective trust or

credibility, *i.e.*, trust as perceived and stored by an agent. Here, we will assume that the information received from an agent is as credible as the agent that provides it; this is a simplifying assumption that will be lifted in future investigations. We will also limit the present research to single topic credibility.

Furthermore, we can distinguish two types of MSBR. *Unitary MSBR* where an agent can receive from different informant agents an atomic piece of information (a sentence or a belief); and *Conjunctive MSBR* where the received information is a set of objects, probably provided by one or more sources. Our paper is focused on the first approach. Other works are focused on the second approach where the new information is a set of beliefs. For a more detailed comparison, *cf.* Section 8.

We will favor the use of the word credibility to refer to this characteristic of informant agents as this particular word carries an intuitive sense that helps to understand the related problems. We chose to represent credibility as a strict partial order in the set of agents; this choice will give us the capability of representing cases where the credibility of two agents is not related because it has not been established. The examples introduced below will show the usefulness of having this possibility.

The credibility relation of an agent and its informants will be maintained as a *credibility base* that will keep the current state of this particular strict partial order relation. As new assessments regarding the credibility of its informants are effected, an agent will be able to change this partial order relation, and in that manner, revise the credibility assigned to its peers accordingly.

Our goal is therefore to formalize change operators over the credibility base. These operators will provide the capability of dynamically modifying the credibility of informants to reflect a new perception of the informant's trust, or extend the set of informants by admitting the arrival of new informant agents. We will develop an expansion operator for a credibility base, then a contraction operator and finally two versions of revision: prioritized and non-prioritized. Contraction and revision operators will be based on the *reliability* of the information. Thus, the main contribution is the definition of different belief change operators that use the reliability of the information in order to make decisions regarding what information prevails. Following the approach presented in the AGM model [1], these operators are defined through constructions and representation theorems.

We will adopt an epistemic model where beliefs are provided by some informant(s). If the agent considers that *Informant*$_1$ *is less credible* than *Informant*$_2$ then, in case of conflictive information, the information received from *Informant*$_2$ will be preferred over the information received from *Informant*$_1$. That is, the *trust* assigned to *Informant*$_2$ is higher than the trust assigned to *Informant*$_1$; hence, in our proposal, the *reliability* of a piece of information will reflect the credibility assigned to the informant.

A common approach to the analysis of the reliability of information is obtained by integrating different sources that rely on the use of some form of a majority principle (see Section 8). In some of those approaches, and oversimplifying the description of the decision mechanism they introduce, when two or more sources provide the same piece of information α, and a single agent gives $\neg\alpha$, then α will be preferred. It is clear that using majority in the process of deciding is a very useful and computationally efficient approach for many situations, but it might not be appropriated in some complex scenarios that require a qualitative analysis of the information; in domains where there exists an order among informants, it is natural to prefer the information of the more credible one. As an example, consider the situation where an agent seeks information on a particular topic in an internet children's health forum. Reading the forum the agent finds out that four participants provide information α on the subject; but later the agent's pediatrician provides $\neg\alpha$. If the agent assigns a higher credibility to the pediatrician than the perceived credibility of the other four; then, clearly in this case $\neg\alpha$ should prevail. Thus, our approach can be considered as complementary to those that use majority for taking decisions. This complementarity is important since majorities not always are right; the previous example and our motivating example below is intended to show precisely that.

Lately, the importance of having trust models have been emphasized in the literature. As stated in [44], two elements have contributed to substantially increase the interest on trust: the introduction of the multi-agent system paradigm and the evolution of e-commerce. The study of trust has many applications in Information and Communication technologies.

It is clear that some form of trust model is needed in any problem where the adoption of a critical decision depends on the credibility (informational trust) assigned to the information received from other agents. A crucial activity in multi-agent system is the agent's interaction, and through this interaction agents can share different types of information. Significatively, they can share information about the credibility or informational trust they have assigned to their peers; hence, through this interaction, the credibility assigned to their peers could change. In this work we will propose change operators for handling the dynamics in the credibility information.

In Sabater and Sierra [44], a set of relevant aspects to classify trust models is proposed. In our proposal, we will take into consideration only two of these aspects: *information sources* and *trust reliability measure*. They suggest that, sometimes knowing how reliable is the trust value reported, and its relevance to the decision making process, is as important as the value itself. In the model that we will propose, we provide this kind of information through agent identifiers which are the information sources.

Although there exist relevant works in Multi-Agent Belief Revision [35,30,15,10] and in Trust and Reputation [44,43,14, 4,45], their combination in one formalism and its formalization through representation theorems is novel. Our approach can be applied in any system requiring that trust or credibility of informants will be taken into consideration. For instance, the partial order of informants and the belief change operators we will introduce can be used as a complement for the model of MSBR proposed in [49] where informant agents are used, but a fixed total order was assumed among them. Thus,