Non Prioritized Reasoning in Intelligent Agents

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1 Introduction and Background

The design of intelligent agents is greatly influenced by the many different models that exist to represent knowledge. It is essential that such agents have computationally adequate mechanisms to manage its knowledge, which more often than not is incomplete and/or inconsistent. It is also important for an agent to be able to obtain new conclusions that allow it to reason about the state of the world in which it is embedded.

It has been proven that this problem cannot be solved within the realm of Classic Logic. This situation has triggered the development of a series of logical formalisms that extend the classic ones. These proposals often carry the names of *Nonmonotonic Reasoning*, or *Defeasible Reasoning*. Some examples of such models are McDermott and Doyle's Nonmonotonic Logics, Reiter's Default Logic, Moore's Autoepistemic Logic, McCarthy's Circumscription Model, and Belief Revision (also called Belief Change). This last formalism was introduced by Gärdenfors and later extended by Alchourrón, Gärdenfors, and Makinson [1, 4].

In particular, *Belief Revision* has as its main objective to model the dynamics of knowledge, that is, the way in which an agent's knowledge must be updated when it encounters new information. In other words, in what way must an agent's model of the world be updated when its sensors obtain up to date information about the environment? In this sense, it is in the field of *Cognitive Robotics* where belief revision finds its most appropriate application. Agents (be them physical or software) must have the necessary flexibility in order to change their beliefs because they are the main motivators of their actions. The idea of belief revision finds an example close to our basic intuitions in the legal environment, where the promulgation of a new law demands that some of the rest be "revised" and others removed to keep the set of laws consistent. In this example, the three basic operations of belief revision known as *expansion*, *contraction*, and *revision* are mapped into promulgation, derogation, and amendment of laws. These same ideas are also applicable to environments that are closer to the computational realm, such as the use of communication protocols where new protocols can be added (expansion), withdrawn (contraction), or a set of them be replaced by one or more (revision).

Revisions are the most commonly used change operators because they allow a sentence α to be included into a set K, generating a new set K', preserving consistency in the new set. The traditional revision models are *prioritized*, that is, they give priority to new information over the information that is already part of their knowledge. This property does not seem plausible in the real world, because in many cases it is not reasonable to give priority to information just because it is new.

In *non prioritized* models, it is possible for new information not to be accepted. Such new information can be rejected or accepted only after a debate process. In this sense, there exists a variety of different non prioritized belief revision models, among which are David Makinson's Screened Revision [7, 6], Sven Ove Hansson's consolidation and semirevision operators [5], André Fuhrmann's merge operations [3] and Falappa's [2] recently formulated revisions by sets of sentences. In this last work, a new kind of nonprioritized revision operator based on the use of explanations is presented. It is argued that an agent, before incorporating information which is inconsistent with its knowledge, should request an explanation that supports this information. An explanation is characterized as being composed of an *explanans* (set of sentences supporting a certain belief), and an *explanandum* (the final conclusion).

A classic example of this situation is the following: Suppose that a person believes that (α) *all mammals can jump* and (β) *Titus is a mammal.* Thus, he will believe (δ) *Titus can jump.* Later on, another person states that *Titus cannot jump.* If δ is dropped, then α or β will have to be dropped as well. However, it does not seem to be rational to incorporate external beliefs without pondering them. An explanation should be required in order to incorporate such information, especially in the case where it contradicts the previously maintained set of beliefs.

In our case, the person should demand an explanation for $\neg\delta$. One possibility is that he is given an explanation such as: *Titus cannot jump because he is an elephant*, and *elephants are mammals, but they cannot jump.* Now, the sentences in the explanans can be used to evaluate the new piece of information before it is incorporated.

2 Objectives

This research is directed towards the definition of *non prioritized belief revision* operators in knowledge based systems, using a declarative programming language as a representation language and inference mechanism. Once formally defined, these operators will be implemented in knowledge based systems, information systems, knowledge bases, etc. Their implementation is focused on learning the computational problems associated with this type of operators.

The theory of belief change assumes that an agent's beliefs are represented by *belief sets* (sets of sentences closed under logical consequence) or belief bases (arbitrary sets of sentences). It is clear the, in computational applications, one must opt for finite belief bases. New information, which is called *epistemic input* is sometimes represented by a sentence of the language or an arbitrary set of sentences.

The revision operator proposed in [2] allows a non prioritized revision in the following way:

- The epistemic input is a single sentence with an explanation for it.
- The explanation (a set of sentences with some constraints) is added to the original set, maybe resulting in a temporarily inconsistent set.
- Then the consistency is restored by a contraction by falsum.

This mechanism could be applied in some real life situations or dialogs between agents. The goal of our investigation is to develop new operators of this type for multiagent systems.

For example, suppose an agent wishes to make an investment of up to $20.000, so he goes out and scouts the market to see where he can invest his money. A variety of salesmen offer him: a car for $16.000, a piece of land for $21.000, and an apartment for $30.000. Now, the agent has to make a decision among the three options (if any); each of the salesmen gave him good reasons to buy their item:

- The car is a good bargain, but its disadvantage is that it loses value by the day.
- The piece of land could be worth double what is being paid just a few years from now; nevertheless, if the agent is not planning on investing more money on the land after buying it, it may not be the best option.
- The apartment is very appealing: even though its value is not likely to go up, the agent can make money out of it by renting it to others. It has a disadvantage though: its price is well over the amount the agent initially expected to spend.

The agent is now faced with a revision of his knowledge. Before he went shopping, he expected to spend $20.000, even though he actually has $28.000 to spend. There are two possible situations that can arise when the agent revises his beliefs:

- He decides not to change his spending limit.
- He decides to rise his spending limit to try and buy one of the more expensive offers.

In the first case, once the salesmen see that the agent will not take the offer, they will also revise their knowledge, which can lead to a better offer for the agent and a good profit for the salesmen.

In the second case, the agent may decide that he wants to buy the apartment. Even though this is initially inconsistent with his knowledge (he has $28.000, and the apartment costs $30.000), he adopts the wish anyway, because he is also planning on bargaining with the salesman in order to get a better price.

References

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