

Local search for computing normal circumstances models (Abstract)*

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Abstract. In this paper, a new method is introduced to check several forms of logical consistency of nonmonotonic knowledge-bases (KBs). The knowledge representation language under consideration is full propositional logic, using “Abnormal” propositions to be minimized. Basically, the method is based on the use of local search techniques for SAT. Since these techniques are by nature logically incomplete, it is often believed that they can only show that a formula is consistent. Surprisingly enough, we find that they can allow inconsistency to be proved as well. To that end, some additional heuristic information about the work performed by local search algorithms is shown of prime practical importance. Adapting this heuristic and using some specific minimization policies, we propose some possible strategies to exhibit a “normal-circumstances” model or simply a model of the KB, or to show their non-existence.

Keywords: local search, tabu search, nonmonotonic reasoning, common-sense reasoning, SAT, consistency checking

Extended Abstract

Assume that a knowledge engineer has to assemble several logic-based propositional knowledge modules, each of them describing one subpart or one specific view of a complex device. In order to make fault-diagnosis possible in the future, each knowledge module describes both normal functioning conditions and faulty ones. To this end, the ontology is enriched with McCarthy’s additional “Abnormal” propositions (noted Ab_i) allowing default rules to be expressed together with faulty operating conditions. For instance, the rule asserting that, under normal circumstances, when the switch is on then the lights should be on is represented by the formula $switch_on \wedge \neg Ab_1 \Rightarrow lights_on$, and in clausal form by $\neg switch_on \vee Ab_1 \vee lights_on$. In this very standard framework, Ab_i propositions are expected to be false under normal operating circumstances of the device. The knowledge based system (KB) is expected to be used in a nonmonotonic

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way, in the sense that conclusions can be inferred when they are satisfied in some preferred models of the KB where Ab_i are **false**. Also, model-based diagnosis can be performed in order to localize faulty components in the presence of additional factual data.

The specific issues that we want to address in this framework is the following one. How can the knowledge engineer check that the global KB is consistent? Also, how can he exhibit (or show the non-existence of) one model of the KB translating normal functioning conditions of the device? We would like these questions to be answered for very large KBs and practical, tractable, methods be proposed.

Actually, consistency checking is a ubiquitous problem in artificial intelligence. First, deduction can be performed by refutation, using inconsistency checking methods. Also, many patterns of nonmonotonic reasoning rely on consistency testing in an implicit manner. Moreover, ensuring the logical consistency of logical KBs is essential. Indeed, inconsistency is a serious problem from a logical point of view since it is global under complete (standard) logical rules of deduction. Even a simple pair of logically conflicting pieces of information gives rise to global inconsistency: every formula (and its contrary) can be deduced from it. This problem is even more serious in the context of combining or interacting several knowledge-based components. Indeed, individually consistent components can exhibit global inconsistency, due to distributed conflicting data.

Unfortunately, even in the propositional framework, consistency checking is intractable in the general case, unless $P = NP$. Indeed, SAT (i.e., the problem of checking the consistency of a set of propositional clauses) is NP-complete. Recently, there has been some practical progress in addressing hard and large SAT instances. Most notably, simple new methods that are based on local search algorithms have proved very efficient in showing that large and hard SAT instances are consistent. However, these methods are logically incomplete in that they cannot prove that a set of clauses is inconsistent since they do not consider the whole set of possible interpretations.

However, we have discovered the following phenomenon recently. When the work performed by local search algorithms is traced when they fail to prove consistency, a very powerful heuristic can be extracted allowing us to locate probable inconsistent kernels extremely often. Accordingly, a new family of powerful logically complete and incomplete methods for SAT has been proposed.

In the full paper, we extend this previous work in order to address nonmonotonic propositional KBs, using the above “Abnormal” propositions that are expected to be false under normal circumstances. Using this preference for normal conditions, we guide the local search towards a possible “normal circumstances” model. When such a model is not found, several issues can be addressed. First, using the above heuristic and assuming that normal circumstances are satisfied, we propose a technique that allows us to prove (very often) the absence of such a model and to exhibit an inconsistent kernel. Then, dropping the special status of “Abnormal” propositions to several possible extent, we introduce various strategies for showing the consistency or inconsistency of the KB.