A six-valued logic for modeling incomplete knowledge

by Massoud Kazem Moussavi

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Abstract

One of the difficulties in building intelligent systems is developing an inference mechanism for incomplete information. Another area of difficulty involves the passage of time during the reasoning process. Classical logic as a tool for knowledge representation and reasoning has a number of limitations. For example, it does not provide a way of representing incomplete or uncertain information, its inference rules are monotonic, and it is timeless.

This study explores the use of multivalued logics to represent unknown or incomplete information. In particular, a novel six-valued logic (M6) is developed for this purpose. This logic distinguishes temporarily unknown propositions (due to lack of complete information at the present time) from eternally unknown propositions (no possibility for acquiring a true or false vale exists). This logic allows better knowledge representation than the existing multivalued logics such as Kleene's three-valued logic or Belnap's four-valued logic when dealing with incomplete knowledge that is refined over time. The existing multivalued logics do not distinguish different kinds of unknown information and represent the lack of knowledge with a single value “unknown.”

The study formalizes M6 and investigates its properties. The proposed logic belongs to a family of logics with similar mathematical properties. These logics can be considered as generalized Kleene's logic and directly relate to the concept of bilattices.

The study concludes that the proposed logic provides a suitable logical framework for rule-based systems that represent incomplete knowledge. To demonstrate this, the study implements forward-chaining and backward-chaining inference engines, based on this logic, in programming languages Lisp and Prolog. These implementations apply the logic to a rule-based question-answering system. The study additionally investigates the logic’s applications to digital circuit modeling.