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Extensions of Equilibrium Logic by Modal Concepts

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Résumé : Here-and-there (HT) logic is a three-valued monotonic logic which is intermediate between classical logic and intuitionistic logic. Equilibrium logic is a nonmonotonic formalism whose semantics is given through a minimisation criterion over HT models. It is closely aligned with answer set programming (ASP), which is a relatively new paradigm for declarative programming. To spell it out, equilibrium logic provides a logical foundation for ASP: it captures the answer set semantics of logic programs and extends the syntax of answer set programs to more general propositional theories, i.e., finite sets of propositional formulas. This dissertation addresses modal logics underlying equilibrium logic as well as its modal extensions. It allows us to provide a comprehensive framework for ASP and to reexamine its logical foundations.

In this respect, we first introduce a monotonic modal logic called MEM that is powerful enough to characterise the existence of an equilibrium model as well as the consequence relation in equilibrium models. The logic MEM thus captures the minimisation attitude that is central in the definition of equilibrium models.

Then we introduce a dynamic extension of equilibrium logic. We first extend the language of HT logic by two kinds of atomic programs, allowing to update the truth value of a propositional variable here or there, if possible. These atomic programs are then combined by the usual dynamic logic connectives. The resulting formalism is called dynamic here-and-there logic (D-HT), and it allows for atomic change of equilibrium models. Moreover, we relate D-HT to dynamic logic of propositional assignments (DL-PA): propositional assignments set the truth values of propositional variables to either true or false and update the current model in the style of dynamic epistemic logics. Eventually, DL-PA constitutes an alternative monotonic modal logic underlying equilibrium logic.

In the beginning of the 90s, Gelfond has introduced epistemic specifications (E-S) as an extension of disjunctive logic programming by epistemic notions. The underlying idea of E-S is to correctly reason about incomplete information, especially in situations when there are multiple answer sets. Related to this aim, he has proposed the world view semantics because the previous answer set semantics was not powerful enough to deal with commonsense reasoning. We here add epistemic operators to the original language of HT logic and define an epistemic version of equilibrium logic. This provides a new semantics not only for Gelfond's epistemic specifications, but also for more general nested epistemic logic programs. Finally, we compare our approach with the already existing
semantics, and also provide a strong equivalence result for EHT theories. This paves the way from E-S to epistemic ASP, and can be regarded as a nice starting point for further frameworks of extensions of ASP.