A Qualitative Model of Automated Decision Making: The Answer Set Programming Approach

Abstract

In the field of decision making, there are two main groups of approaches: quantitative (classical) models and qualitative models of decision making. The former group relies on the notions of utility and probability as representations of a decision maker preferences and beliefs. The latter applies qualitative counterparts of these functions, where the numbers reflect nothing more than positions of the given alternatives.

Logic programming approach, presented in this thesis, belongs to the latter group. The idea is to simplify the issue of knowledge acquisition and representation, enabling easier and more intuitive modeling of decision problems by use of declarative programming language. Another benefit is to provide a way of representing and reasoning over complex knowledge, where preferences and outcomes are not given explicitly.

In the first part of the thesis, the properties of the language are studied, demonstrating its ability to represent and reason over combinatorial preference and knowledge structures. Then, application of the approach to 4 problem domains is presented: (1) decision making under uncertainty, (2) multicriteria decision making, (3) combinatorial voting and (4) game theory.

The framework assumes replacing numerical preferences and probabilities with linear orderings, encoded by ordered disjunction (invented by Brewka [2002b]). A decision problem is represented as a logic program, while answer sets of the program represent possible acts scenarios. The answer sets are ranked according to degrees of satisfaction of the preference and belief rules. The optimal act is defined in terms of preferred answer set of the program.

In case of combinatorial multicriteria decisions, hierarchy of criteria is represented by a meta-preference relation on the rules. Moreover, a semi-qualitative extension of the approach is proposed, allowing intensities of preferences to be represented.

In case of combinatorial voting, logic programs with ordered disjunction are used to represent problems, in which the set of candidates has a combinatorial structure. Several well-known vote rules are qualitatively defined in terms of preferred answer sets of a logic program with ordered disjunction; in addition lexicographic extensions to the selected rules is proposed, providing higher decisiveness and efficiency.

In the last chapter, a qualitative model of normal form of games is presented. Logic programs are used for representing the structure of a game, and the preferred strategies of players of a game. Instead of a payoff function, the ordered disjunction is applied for encoding preference ordering of possible strategies of each player, given the actions of the remaining players. Several solution concepts are defined in the framework, such as dominant strategy equilibrium, Nash and Pareto equilibrium