P-log : combining nonmonotonic logical and probabilistic reasoning

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P-log is a knowledge representation language, obtained by augmenting Answer Set Prolog with constructs for representing causal probabilities in the spirit of [3]. In addition to ordinary rules of Answer Set Prolog, a P-log program may contain the following statements: The random selection rule $[r]\ random(a(t) : \{X : p(X)\}) \leftarrow B$ which says that if B were to hold, then the value of $a(t)$ would be selected at random from the set $\{X : p(X)\}$ by experiment r, unless this value is fixed by a deliberate action; the pr-atom $pr_r(a(t) = y|_c\ B) = v$ which says that if B were to be true, then experiment r would cause $a(t) = y$ with probability v; the observation $obs(l)$ which says that l occurred; and the action $do(a(t) = y)$ which says that the value of function a is set to value y by a deliberate action.

Consider the following program, T, representing knowledge about whether a certain rat will eat arsenic today, and whether it will die today.

[1] $random(arsenic)$. [2] $random(death)$.
$pr(arsenic) = 0.4$.
$pr(death\ |_c\ arsenic) = 0.8$. $pr(death\ |_c\ \neg arsenic) = 0.01$.

The above program entails that the rat is more likely to die if it it eats arsenic. Not only that, the intuitive semantics of the *pr*-atoms expresses a belief that this correlation between death and arsenic-eating stems from *arsenic causing death*. Consequently, for example, the probability of death goes up if arsenic-eating is observed *or* fixed to be true (say, by feeding the rat arsenic); while the probability of arsenic-eating increases if death is observed but not if death is fixed to be true (say, by shooting the rat with a pistol).

The following is a list of accomplishments of the language.

- P-log generalizes the notion of probabilistic updates, by allowing updates which add or modify possible worlds, change the probability measure, add logical rules or definitions, defeat default rules. The notion of an update in P-log is provably more general than those available in classical probability theory [1].
- P-log elegantly axiomatizes Pearl's do operator, by giving its semantics in terms of statements of Answer Set Prolog (as opposed to operations on graphs).

- P-log formalizes the Bayesian philosophy that all probabilities are conditional (viz., on a knowledge base).
- P-log achieves good performance on well known benchmark problems, by applying logical solvers to prune the probabilistic sample space[2].
- P-log allows probabilistic diagnosis of challenging practical problems related to Space Shuttle control.

An experimental P-log system can be obtained from http://www.cs.ttu.edu/∼wezhu.

References

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[2] Gelfond, M., Rushton, N. and Zhu, W.: Combining Logical and Probabilistic Reasoning. AAAI Spring Symposium (2006) 50–55.

[3] Pearl, J. Causality: models, reasoning, and inference. Cambridge University Press. (2000)