Higher Order Uncertainty and Evidential Ontologies

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- Evidential reasoning has been extensively analyzed, in particular by David Schum. In particular, he identifies the following source-dependent factors as essential:
  1. The source credibility (believability)
  2. The relevance of the evidence
  3. The inferential weight of the evidence
- Reasoning with evidence is inherently uncertain.

An Example

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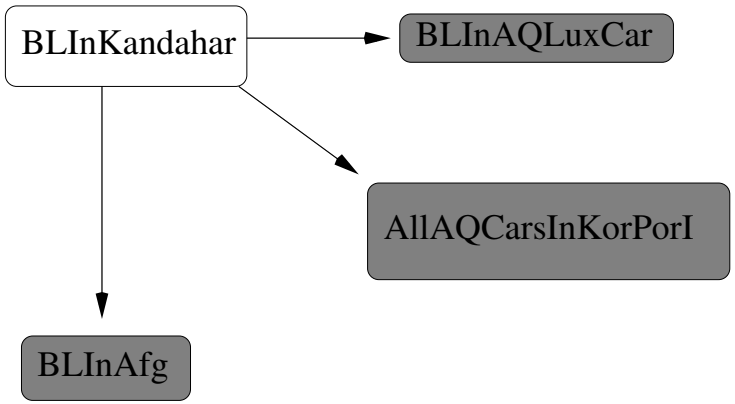
  2. "the only luxury cars used by al-Qaeda are in Kandahar, Parachinar, or Islamabad"
  3. "bin Laden was recently seen in an al-Qaeda owned luxury car"

Bayesian Network



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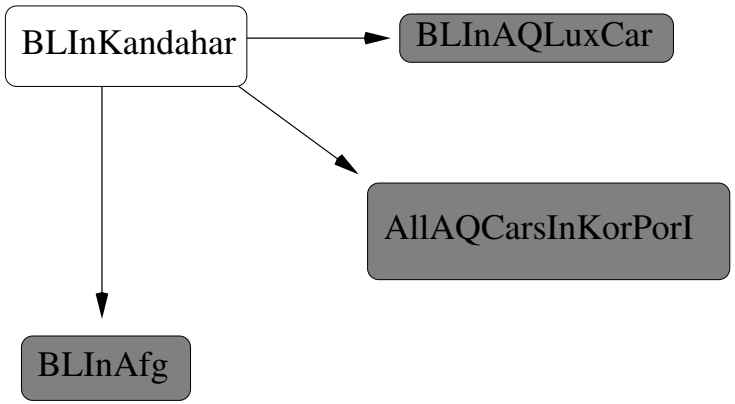
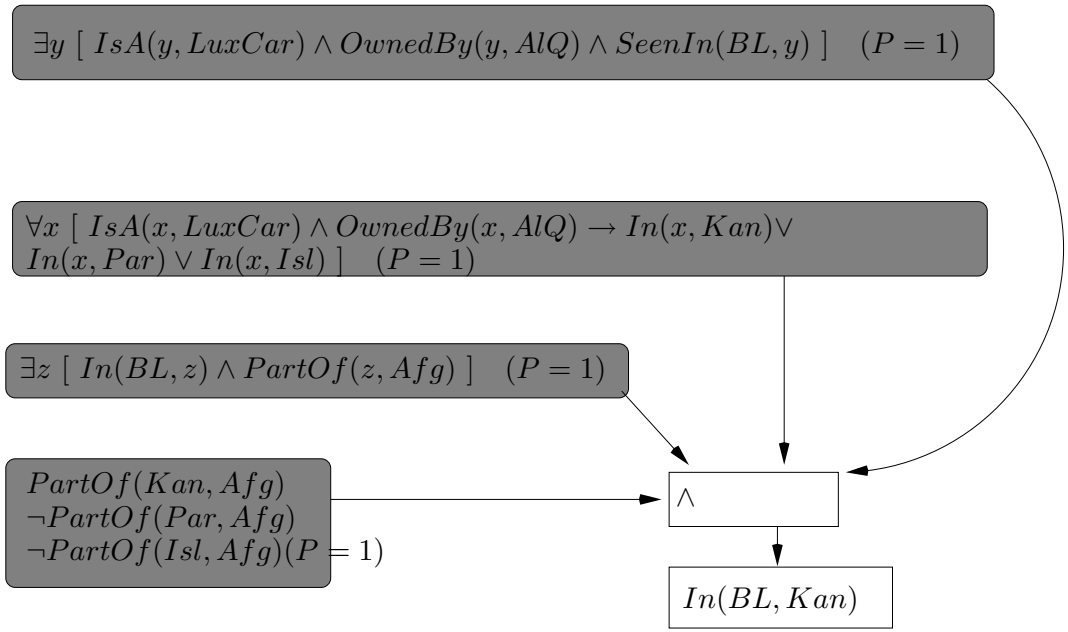


- Probability theory provides a rigorously grounded framework for working with uncertainty.
- Bayesian networks provide a practical way with working within a probabilistic context, provide there is a sufficient degree of *conditional independence*

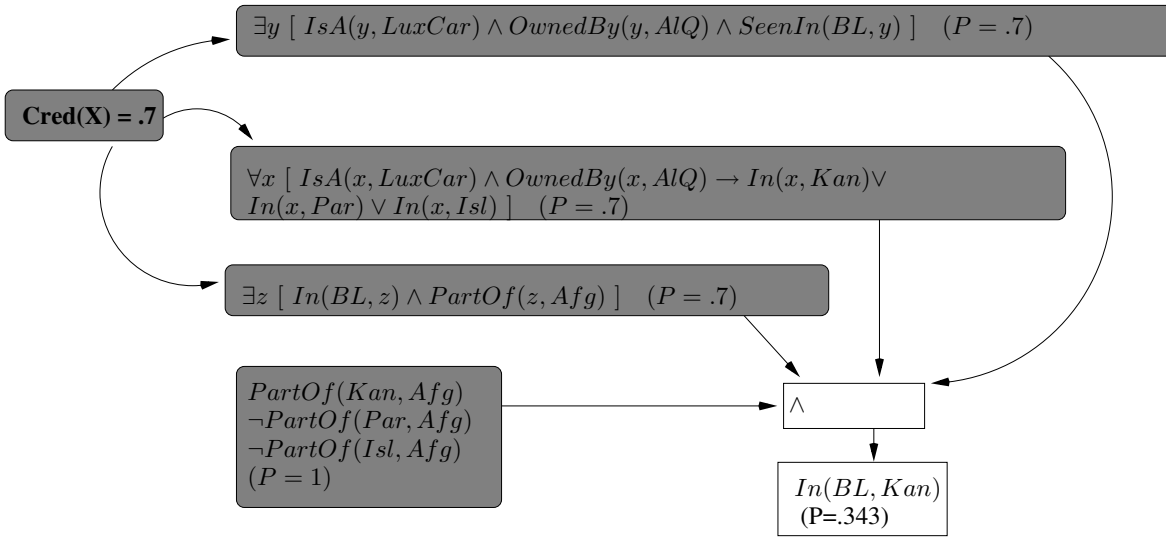
MEBN

We can get better structural representation by combining Bayesian networks with first-order logic.



Credibility

As mentioned previously, we might not have complete confidence in Xs assertion. We can therefore attach credibility level to his assertion and adjust our confidence accordingly.



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- The uncertainty around these kinds of questions is as great as that around the questions of basic relationships between real objects of the world.
- Because this uncertainty is about network structure rather than objects of the world, we call it *higher order*. Because of the complexity involved, coming to terms with this kind of uncertainty is as amenable to computer-aided analysis as any other.

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- Gaifman embeds his operator with a system of propositional calculus and shows that nested applications of the $Pr(\cdot)$ operator are eliminable. He views his construction as being analogous to a modal logic.

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- This will allow the network to encode hypotheses about various assertions, and ultimately learn about higher order uncertainty through evidence.

An Example

Consider the following simple rule that gives a partial coding of how we might deal with an agent X making an assertion a while under duress:

- If the assertion is inconsequential, then the credibility is unaltered
- Otherwise, monetary duress combined with a belief by X that he will be paid for his information should result in the credibility of the assertion being decreased by some parameter α
- A consequential assertion made while under physical duress should result in a decrease by the parameter β if X is deemed insufficiently competent to judge a.

Syntax and Semantics

- We code the rule: "A consequential assertion made while under physical duress should result in a decrease by the parameter β if X is deemed insufficiently competent to judge a."

$$(\text{Consequential}(a) \geq \chi) \wedge (\text{DuressType}(X) = \text{Physical}) \wedge (\text{CompetenceToJudge}(X, a) < \theta) \rightarrow (\Delta(\text{Cred}(a)) = -\beta)$$

Syntax and Semantics

Suppose in this scenario that we learn that agent X has asserted "bin Laden is in Afghanistan" while under physical duress. This might be represented as:

$$\begin{aligned} &\mathit{Asserts}(X, a) \\ &\qquad \wedge \mathit{PropCont}(a) = "\exists y\ [\ \mathit{In}(BL, y) \wedge \mathit{PartOf}(y, \mathit{Afg})\ ]" \\ &\qquad \wedge \mathit{UnderDuress}(X) \wedge \mathit{DuressType}(X) = \mathit{Physical} \end{aligned}$$

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The semantics should be defined so that the credibility of the corresponding assertion is decreased, and the whatever rules we have for applying credibility to assertions would be applied.

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- Generally work out the details of a possible modification to MEBN.
- What computational cost would come with deductions in the new system?
- What quantifier complexity is necessary?
- Proof theory for added operator
- Can we guarantee logical *and* probabilistic consistency (e.g. avoid "Dutch booking")
- Do a more general cost/benefit analysis.