



encode all admitted causes of change. The nonmonotonic reasoning is done by the human who wrote the axioms. Explanation closure is not *elaboration tolerant*; introducing new actions or new conditions for the success of actions requires surgery on the explanation closure axioms. This is ok as long as the scientific or practical objectives are sufficiently limited. Human-level AI or even reasonable elaboration tolerance will require the computer to do nonmonotonic reasoning.

2. In my opinion many variants of nonmonotonic reasoning that have been introduced, e.g. Vladimir Lifschitz's pointwise circumscription, have been insufficiently studied.

3. (McCarthy 1986) introduces *simple abnormality theories* in which a single predicate *ab* is minimized while all other predicates are varied. Lifchitz and McDermott respectively showed that particular simple abnormality theories for the blocks world and the Yale shooting problem suffered from unintended models. It remains possible that a simple abnormality theories with different predicate symbols and axioms could handle these problems. I conjecture that this won't work; certain so far unstated limitations apply to all simple abnormality theories.

4. I think minimization of predicates, i.e. circumscription, is here to stay, but this doesn't cover all possible future developments in nonmonotonic reasoning.

5. (McCarthy 1980) mentions such entities as "things wrong with the boat" and suggests minimizing them. No formulas are given, but I think such abstract entities will be needed even for a proper treatment of the missionaries and cannibals problem.

## References

- McCarthy, J. 1976. Epistemological Problems in Artificial Intelligence<sup>1</sup>. reprinted in (McCarthy 1990).
- McCarthy, J. 1980. Circumscription—A Form of Non-Monotonic Reasoning<sup>2</sup>. *Artificial Intelligence* 13:27–39. Reprinted in (McCarthy 1990).
- McCarthy, J. 1982. Common Business Communication Language<sup>3</sup>. In A. Endres and J. Reetz (Eds.), *Textverarbeitung und Bürosysteme*. R. Oldenbourg Verlag, Munich and Vienna.
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- McCarthy, J. 1990. *Formalizing Common Sense: Papers by John McCarthy*. Ablex Publishing Corporation.

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<sup>1</sup><http://www-formal.stanford.edu/jmc/epistemological.html>

<sup>2</sup><http://www-formal.stanford.edu/jmc/circumscription.html>

<sup>3</sup><http://www-formal.stanford.edu/jmc/cbcl.html>

<sup>4</sup><http://www-formal.stanford.edu/jmc/applications.html>