

ADVANCED METHODS OF REASONING UNDER UNCERTAINTY

Judea Pearl

Computer Science Department
University of California, Los Angeles, CA 90024-1596, USA

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ABSTRACT

The ultimate aim of this research is to develop computer systems capable of operating autonomously in dynamic and uncertain environments. The objectives of the current project were to conduct theoretical and experimental studies in the following areas:

1. Learning and utilizing causal structures, including the identification of hidden causes and feedback mechanisms using optimal combination of observations and manipulations, and the evaluation of actions from past performance records.
2. Information fusion, diagnosis and planning under uncertainty using qualitative approximations of probabilities, utilities, and causal relationships.

SUMMARY OF RESULTS

- A formal model has been developed, based on dynamic structural equations, which generalizes and unifies the structural and counterfactual approaches to causal inference, explicates their conceptual and mathematical bases and resolves their technical difficulties. A simple rule was devised for translating a problem between the structural and counterfactual representations, and choosing the one most appropriate for analysis.
- It has been proven that the structural and counterfactual formalisms are equivalent in recursive causal models (i.e., systems without feedback) but not when feedback is considered possible.
- Formal semantics have been developed for the probability that event x was a *necessary* or *sufficient* cause (or both) of another event y .
- Conditions have been explicated under which the probability of necessary and sufficient causation can be learned from statistical data.

- It was shown that data from both experimental and nonexperimental studies can be combined to yield information that neither study alone can provide.
- Formal semantics has been developed for the notion of “actual cause” (or single-event causation), based on a combination of the necessity and sufficiency components of causation.

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