Guest Editors: David Heckerman, Abe Mamdani, and Michael P. Wellman

Real-World Applications of

Bayesian Networks
Facilities for handling uncertainty have long been an integral part of knowledge-based systems. In the early days of rule-based programming, the predominant methods used variants on probability calculus to combine certainty factors associated with applicable rules. Although it was recognized that certainty factors did not conform to the well-established theory of probability, these methods were nevertheless favored because the probabilistic techniques available at the time required either specifying an intractable number of parameters or assuming an unrealistic set of independence relationships.
Today, methods based firmly in probability theory have once again begun to gain acceptance in the computer-science and uncertain-reasoning communities. The "breakthrough" was a graphical modeling language for representing uncertain relationships. Although Bayesian networks have gained widespread use in knowledge-based systems relatively recently, they are based on modeling ideas that have been around for some time. The representation was actually first introduced in 1921 by the statistician Wright [16] for the analysis of crop failure, and reinvented by many researchers [4, 5, 9, 14, 15] under various names, such as "causal network," "belief network," and "influence diagram."

A Bayesian network is an annotated directed graph that encodes probabilistic relationships among distinctions of interest in an uncertain-reasoning problem. The representation rigorously describes these relationships, yet includes a human-oriented qualitative structure that facilitates communication between a user and a system incorporating the probabilistic model. With the advent of small, powerful computers and GUI interfaces, modeling tools based on Bayesian networks are seeing frequent use in real-world applications, including diagnosis [2, 3, 7], forecasting [1, 6], automated vision [10], sensor fusion [8, 13], and manufacturing control [12].

This special section contains a small sampling of these applications. Burnell and Horvitz show how Bayesian-network and logical approaches can be married for program understanding and debugging. Fung and Del Favero describe an application of Bayesian networks to information retrieval. Finally, Heckerman et al. show how Bayesian networks can be used for troubleshooting system failures, including software and hardware problems as well as mechanical failures of cars and jet engines.

These three papers are indicative of the increasing use of probabilistic methods in knowledge-based systems and artificial intelligence more generally. Interested readers are invited to learn more about the technology by reading the tutorial "Bayesian Networks" included here, and to follow up with a more in-depth exploration of the literature, starting from the references listed. Additional applications and technical advances in Bayesian networks (as well as uncertain reasoning more broadly) are showcased at the annual Conference on Uncertainty in Artificial Intelligence [1].

References

About the Authors:
DAVID HECKERMAN is a senior researcher in the Decision Theory Group at Microsoft Research. email: heckerma@microsoft.com.

E.H. "ABE" MAMDANI is a professor in the electrical engineering department of Queen Mary & Westfield College, University of London. email: e.h.mamdani@qmw.ac.uk.

MICHAEL P. WELLMAN is an assistant professor in the department of electrical engineering and computer science at the University of Michigan. email: wellman@eeng.ummich.edu.

Permission to copy without fee all or part of this material is granted provided that the copies are not made or distributed for direct commercial advantage, the ACM copyright notice and the title of the publication and its date appear, and notice is given that copying is by permission of the Association for Computing Machinery. To copy otherwise, or to republish, requires a fee and/or specific permission.