Chapter 8
A Bayesian Belief Network Methodology for Modeling Social Systems in Virtual Communities: Opportunities for Database Technologies

Ben K. Daniel
University of Saskatchewan, Canada

Juan-Diego Zapata-Rivera
Educational Testing Service, USA

Gordon I. McCalla
University of Saskatchewan, Canada

ABSTRACT

Bayesian Belief Networks (BBNs) are increasingly used for understanding and simulating computational models in many domains. Though BBN techniques are elegant ways of capturing uncertainties, knowledge engineering effort required to create and initialize the network has prevented many researchers from using them. Even though the structure of the network and its conditional & initial probabilities could be learned from data, data is not always available and/or too costly to obtain. Further, current algorithms that can be used to learn relationships among variables, initial and conditional probabilities from data are often complex and cumbersome to employ. Qualitative-based approaches applied to the creation of graphical models can be used to create initial computational models that can help researchers analyze complex problems and provide guidance/support for decision-making. Once created, initial BBN models can be refined once appropriate data is obtained. This chapter extends the use of BBNs to help experts make sense of complex social systems (e.g., social capital in virtual communities) using a Bayesian model as an interactive simulation tool. Scenarios are used to update the model and to find out whether the model is consistent with the expert’s beliefs. A sensitivity analysis was conducted to help explain how the model reacted to different sets of evidence. Currently, we are in the process of refining the initial probability values presented in the model using empirical data and developing more

DOI: 10.4018/978-1-60566-814-7.ch008
INTRODUCTION

Bayesian networks, Bayesian models or Bayesian belief networks (BBNs) can be classified as part of the probabilistic graphical model family. Graphical models provide an elegant and mathematically sound approach to represent uncertainty. It combines advances in graph theory and probability. BBNs are graphs composed of nodes and directional arrows (Pearl 1988). Nodes in BBNs represent variables and directed edges (arrows) between pairs of nodes indicate relationships between variables. The nodes in a BBN are usually drawn as circles or ovals. Further, BBNs offer a mathematically rigorous way to model a complex environment that is flexible, able to mature as knowledge about the system grows, and computationally efficient (Druzdzel & Gaag, 2000; Russel & Norvig, 1995).

Research shows that BBN techniques have significant power to support the use of probabilistic inference to update and revise belief values (Pearl, 1988). In addition, they can readily permit qualitative inferences without the computational inefficiencies of traditional joint probability determinations (Niedermayer, 1998). Furthermore, the causal information encoded in BBNs facilitates the analysis of actions, sequences of events, observations, consequences, and expected utility (Pearl, 1988).

Despite the relevance of BBNs, the ideas and techniques have not spread into the social sciences and humanities research communities. The goal of this chapter is to make Bayesian networks more accessible to a wider community in the social sciences and humanities, especially researchers involved in many aspects of social computing. The common problems, which can prevent the wider use of BBN in other domains, include:

- Building BBNs requires considerable knowledge engineering effort, in which the most difficult part of it is to obtain numerical parameters for the model and apply them in complex, which are the kinds of problems social scientists are attempting to address.
- Constructing a realistic and consistent graph (i.e., the structure of the model) often requires collaboration between knowledge engineers and subject matter experts, which in most cases is hard to establish.
- Combining knowledge from various sources such as textbooks, reports, and statistical data to build models can be susceptible to gross statistical errors and by definition are subjective.
- The graphical representation of a BBN is the outcome of domain specifications. However, in situations where domain knowledge is insufficient or inaccurate, the model’s outcomes are prone to error.
- Acquiring knowledge from subject matter experts can be subjective.

Despite the problems outlined above, BBNs still remain a viable modeling approach in many domains, especially domains which are quite imprecise and volatile such as weather forecasting, stock market etc. This chapter extends the use of BBN approaches to complex and imprecise constructs. We use social capital as an example of showing the modeling procedures involved. The approach presented in the chapter help experts and researchers build and explore initial computational models and revise and validate them as more data become available. We think that by providing appropriate tools and techniques, the process of building Bayesian models can be extended to ad-