Belief Network Algorithms: a Study of Performance

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This abstract gives an overview of the work described in (Nicholson & Jitnah 1996). We present a survey of Belief Network algorithms and propose a domain characterisation system to be used as a basis for algorithm comparison and for predicting algorithm performance.

Belief Updating Algorithms

There are several algorithms for exact belief updating, for example, the polytree algorithm, clustering (Pearl 1988) or the Jensen tree method (Jensen, Lauritzen, & Olesen 1989). However, approximate methods are often preferred because the complexity of exact updating is NP-hard. Approximate updating is usually done by stochastic simulation (Pearl 1988). Variants include likelihood weighting, survival-of-the-fittest and Markov Chain Monte Carlo methods.

Another approach to complexity reduction is to approximate the model by simplifying the network. Some of the existing methods do this by state-space abstraction, removal of weak links, replacing small probabilities with zero and graph pruning. Such procedures may be applied individually or in combination.

Domain Characterisation

We characterise a problem by obtaining measurements, prior to each experiment, on the network as a whole and on instantiated and queried nodes. The measurements are then used for comparison of algorithm performance.

Measurements taken for the network relate to the numbers of nodes and arcs, the connectedness, path lengths, overall skewness of the conditional probability distributions (CPDs), sizes of the CPDs and the numbers of states of nodes. If using clustering or the Jensen method, we also record the clique network or the Jensen tree respectively.

For each instantiated or queried node, we record its location, the skewness of its CPD, its distance from root and leaf nodes, the clique network nodes or Jensen tree nodes which it belongs to. For the set of instantiated nodes, we record the size of the set, the distribution of evidence, the overall skewness of the CPDs, the total number of states and the probability of the evidence. For the set of queried nodes, we record the size of the set, the distribution of queries, the overall skewness of the CPDs and the total number of states. We also measure the distance between instantiated and queried nodes.

Implementation and Results

A range of problems are selected using various networks and evidence. We compare the time and accuracy of some exact and approximate algorithms on this range of problems. We also apply some model approximation procedures to the networks and evaluate the performance of the algorithms on the resulting models.

The results of our comparisons provide a means of predicting algorithm performance given a problem domain. Hence, the complexity issue can be tackled by designing efficient special-case solutions for particular problems, rather than by searching for general solutions.

References

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