Diagnosis and Prognosis: From Rule-Based Systems to First-Order Graphical Models

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Abstract:
In this talk I summarize the primary approaches the Artificial Intelligence community has taken to diagnostics and prognostics over the past twenty years. We begin with some simple examples of rule-based expert systems, but mostly to try to understand when and how this approach failed. Full Bayesian-based reasoning systems were seen as an alternative, but these in turn had their own shortcomings, primarily related to complexity issues. Directed graphical models were first created through insights Judea Pearl described in 1988. I will describe and give several simple examples of the most important of these, the Bayesian belief network. Our own research has extended this class of graphical model to be first-order and turning complete. First-order means that general variable-based relationships can be represented within a graphical model. Turing complete means that this system can reason over potentially infinite classes of problems. Because we use Pearl's loopy belief propagation inference scheme, our models naturally implement a form of expectation maximization for parameter learning. We give several examples of our system reasoning about applications, including a hidden Markov model approach to analyzing rotor failures for the US Navy. We end the presentation with thoughts about future important issues in this research area, including model induction