Abstract

Real time domains like aerospace, military, and process monitoring require expert systems to possess capabilities for handling continuous streams of data, temporal knowledge and provide reactive response. Traditional expert systems fail to meet these requirements. In this thesis, techniques for temporal data and knowledge representation, continuous reasoning, matching and interference analysis for multiple rule firing are developed. An object oriented real time asynchronous production system architecture based on an extended Petri net model, incorporating the above techniques is proposed.

Data in real time domains are multi faceted. A structured and efficient data management scheme is required to capture the semantics of real time data. Knowledge about temporal events and their relationships has to be represented in real time expert systems. This requires a suitable representation formalism. A unified object oriented data and knowledge representation scheme which can capture these properties is presented. An augmented rule structure is defined to represent knowledge about temporal properties. Three rule types viz. Autonomous rules, Clock Synchronised rules and Spanning rules are defined to represent different kinds of knowledge. Clock synchronised rules represent knowledge about temporal relationships between events. Spanning rules pertain to trends in historical data.

The reactive response behaviour of real time expert systems, depend on the efficiency of the reasoning process. Since data is continuously arriving the latest data values invalidate the earlier data values. This property is used in the design of the REX match algorithm. The evaluation of the premises in the rule base is modelled as Select and Join operations on the working memory. The evaluation of Spanning premises is modelled as the evaluation of an aggregation query on a set of object instances. The Match process is designed to accept external data when available and handle the Clock synchronised rules and Spanning rules efficiently.
The match algorithm performs linear number of premise evaluations per attribute update.

Expert system architectures with single rule firing per inference cycle, cannot handle all simultaneously occurring events in the external world. Therefore, multiple rule firing in a single inference cycle has been adopted in REX. In a multiple rule firing model, integrity of working memory has to be ensured. This is achieved through interference analysis. Techniques proposed in literature are compute intense, deadlock prone and specific to OPS5. We have proposed a new technique for interference analysis. This algorithm is deadlock free and less compute intense. The algorithm is not specific to REX and can be applied even to OPS5 like systems. The asynchronous rule firing scheme is presented next. This is followed by discussions on the significant implementation aspects. Finally, a summary of the work and the scope for further work are presented.