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Using Knowledge-Based Intelligent Reasoning to Support Dynamic Equipment Diagnosis and Maintenance

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ABSTRACT

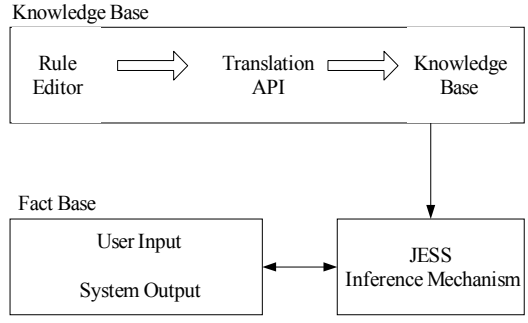
This research focuses on the development of a rule-based intelligent equipment trouble-shooting and maintenance platform using JAVA Expert System Shell (JESS) technology. A prototype system is designed and developed combining rule-based knowledge system and inference engine to support real-time collaborative equipment maintenance across geographical boundary. The main modules of the system include diagnosis knowledge management, project (or case) management and system administration. The knowledge management module consists of key functions such as knowledge type definition, knowledge component definition, document definition, mathematical model definition, rule and rule-set management. The project management module has key functions such as project definition, project's role management, project's function management and project's rule-set execution. Further, a Thin-Film Transistor Liquid-Crystal Display (TFT-LCD) production equipment diagnosis and maintenance system is designed and implemented to demonstrate the intelligent maintenance capability. The prototype system enhances agility of TFT-LCD collaborative manufacturing processes with real-time equipment diagnosis and maintenance.

Keywords: *expert system; intelligent support system; knowledge-based system; knowledge management*

INTRODUCTION

In modern factories, production equipment maintenance represents a very significant and important task to ensure that equipment continues to function properly. Research has shown that up to 20% of the cost is wasted in non-realized revenue due to poor maintenance decisions (Bengtsson, 2003). Hence, there is an urgent need to develop intelligent diagnosis and maintenance systems to prevent equipment failures and reduce the chances of breakdowns. Intelligent maintenance and diagnosis

Figure 1. The architecture of a rule-based expert system



systems have been developed for a variety of domains, such as trouble shootings of electrical and/or mechanical equipment, identification of software/hardware problems and integrated circuit failures, as well as fault-detection in nuclear power systems (Balakrishnan & Honavar, 2003). It is desirable for the intelligent system to identify the possible causes that could explain the symptoms and propose suitable solutions. In order to perform the tasks, an intelligent system must collect adequate domain knowledge constantly (Balakrishnan & Honavar, 2003) and dynamically emulate human reasoning and decision making based on the most updated knowledge. The system must also support collaborative maintenance in real-time and remote geographical locations. In this research, an intelligent equipment maintenance system platform using cyber-enabled JESS technology is designed and developed to demonstrate how the tasks can be realized and implemented effectively in the maintenance domain and related applications.

LITERATURE REVIEW

This section provides a brief overview of JESS technology and rule-based expert system. The challenges of developing an intelligent equipment maintenance system and some related research literatures are also reviewed.

Rule-Based Expert System

Based on the advances in artificial intelligence and information technology, Expert System (ES), also called Knowledge Based System (KBS), has been widely applied in a variety of domains to solve problems and support decision making (Cai & Xu, 2000; Lamma, Maestrami, Mello, Riguzzi, & Storari, 2001). An architecture of rule-based expert systems, including knowledge base, fact base and inference mechanism, is shown in Figure 1. The knowledge base contains domain knowledge useful for problem solving in rule formation (Buchanan & Shortliffe, 1984; Roesner, 1988). The facts database, that is, the working memory, contains a set of facts, which can be entered by user or created automatically by the system. Facts must be presented in the working memory in order for a rule to become available for activation (Preece, Grossner, & Radhakrishnan, 1996). Inference mechanism, an interpreter of rule-based expert systems, compares rules in knowledge base with fact base, selects rules for firing, and executes the actions associated with the rules. In order to reduce the effort for constructing a rule base, a rule base can be built up with rule-based knowledge system tools, such as Java Expert System Shell (JESS) (Menken, 2002).

The basic operations of a knowledge base are to manipulate facts and rules in the