According to the knowledge models of KDM-CS, representational primitives and transformation rules of MLKAM are defined and stored in the acquisition support knowledge base of each layer of MLKAM. DCSL primitives are defined based on the first knowledge model of KDM-CS, and KRSL primitives are also defined based on the second and third knowledge models of KDM-CS.

In DCSL, end users (requirements definers) describe their requirements by using graph structured representational primitives (templates) with interview facilities. Missing or inconsistent information is detected and corrected through the interviews of DCSL. Basically, those interviews are extracted from representational templates. In KRSL, initial requirements collected in DCSL are analyzed and transformed into the formal representations of requirements/specifications by designers of requirements specifications. Control structure of requirements/specifications, such as a sequence of virtual commands, are also mixed with initial requirements in this layer. Final descriptions of requirements/specifications are stored in the frame-based knowledge base of MLKAM.

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A Grid-Based Tool For Knowledge Acquisition: Validation With Multiple Experts

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Introduction

Knowledge Support System Zero (KSS0) is a system providing an integrated set of tools for knowledge acquisition for knowledge based-systems. *Elicit* provides facilities for eliciting the important dimensions of an expert's thinking on a topic; *Exchange* extends this to share entities and attributes between experts and elicits differences in perspective and terminology as well as disagreements on the topic. *SOCIO* processes results from several experts to reveal the similarities and differences in the concept systems of different experts, or the same experts at different times, construing a domain defined through common entities or attributes. It can be used to focus discussion between experts on those differences between them which require resolution, enabling them to be classified in terms of differing terminologies, levels of abstraction, disagreements, and so on. It provides a framework for identifying *consensus*, *correspondence*, *conflict*, and *contrast* in a knowledge acquisition system with multiple experts.

KSS0 has been evaluated against a model for a knowledge support system and experiments are reported in knowledge acquisition of spatial interpolation techniques for contour maps. Results are described on validation experiments to show the extent to which this system can replace standard interviewing techniques: 1) Does an expert always use the same terminology? 2) Do experts agree on their terminology in talking about a topic? 3) To what extent to experts agree among themselves about the topic? 4) To what extent does each expert agree with the knowledge at a different time? 5) To what extent does an expert find the generated rules meaningful?

KSS0 provides facilities to combine information from a number of different sources, including text, expert interviews, expert decision-making using a variety of different techniques including text analysis, entity and

attribute elicitation, clustering and inductive rule generation. At the heart of KSS0 is an object-oriented knowledge base in which knowledge is formally represented as a multiple-inheritance digraph of classes, objects, and properties. Such a structure generalizes the entity and attribute grids used in several early knowledge acquisition systems (Shaw and Gaines, 1983).

The following briefly describe the tools which comprise the KSS0 system:

Elicit accepts specifications of entities within a specified domain and provides an interactive graphical elicitation environment within which the experts can distinguish entities to derive their attributes. The resultant class is continuously analyzed to provide feedback prompting the expert to further enter additional entities and attributes.

Exchange allows interactive exchange and comparison of entities and attributes from multiple experts in a domain.

FOCUS hierarchically clusters entities and attributes prompting the experts to structure the domain through the addition of high-level entities.

PRINCOM spatially clusters entities and attributes within a domain prompting the experts to add higher-level entities structuring the domain.

ENTAIL induces logical entailments enabling the attributes of an element or the evaluations of a decision-making process situation in a domain to be derived from other attributes.

SOCIO compares the structures for the same domain generated by different experts, the same expert at different times, or from varying perspectives.

**An extended version of this paper is available from the authors.

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Automated Design Data Capture Using Relaxation Techniques

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Introduction

A method that converts a Computer Aided Design (CAD) database description of a process control system into a frame-oriented knowledge base for an automated diagnostic control system is introduced. The system is unique in that relaxation labeling techniques borrowed from research in computer vision are used to resolve the functional composition of the diagnostic frames. The target system for the automated knowledge generation process uses frames to represent structure and function data at the component level and does not use inference rules. Failure detection is performed by constant analysis of the output functions. Diagnosis of failure is performed via functional inversion of the component transfer function represented in the component frame. Capture of the functional knowledge of a component is the most difficult task in the building of this type of knowledge base. A CAD database constructed for a particular process control system contains all the structural information required to describe the system, but little or no functional data. A functional description can be inferred in some cases from the CAD data, however, the complexity of such a system for a domain as large as process control is extensive.

The diagnostics system we are using is identified by the acronym KATE, which stands for Knowledge-Based Autonomous Test Engineer. KATE was developed by NASA at the Kennedy Space Center for use in shuttle ground support operations and was preceded by an earlier diagnostic system called LES, for Liquid-Oxygen Expert System [1]. LES was designed to monitor real-time data during shuttle fueling cycles (although it must be noted that the system was never employed on line) and respond accordingly if problems developed. In the design of LES, the development team found that, although the traditional rule based systems worked well with incorrect and incomplete data, they tended to hide the basic structure of the domain. In an effort to develop an inferencing mechanism that analyzed the domain in the same fashion