2. Calderwood, R., Crandall, B., & Klein, G. A., (1987). *Expert and novice fire ground command decisions* (KATR-858(D)-87-02F). Yellow Springs, OH: Klein Associates, Inc. Prepared under contract MDA903-85-C-0327 for U.S. Army Research Institute, Alexandria, VA.

3. Collins, H. M., Green, R.H., & Draper, R.C., (1985). Where's the expertise?: Expert systems as a medium of knowledge transfer. In M. Merry (Ed.), *Expert systems '85*. NY, NY: Cambridge University Press.

4. Crandall, B., & Klein, G. A., (1987). *Key components of MIS performance*. Yellow Springs, OH: Klein Associates, Inc. Report prepared for Standard Register, Dayton, OH.

5. Hoffman, R .R., (1987). The problem of extracting the knowledge of experts from the perspective of experimental psychology. *AI Magazine*, 8, 53-67.

6. Klein, G. A., (1988). *The development of knowledge elicitation methods for capturing military expertise* (KATR-863-88-08F). Yellow Springs, OH: Klein Associates, Inc. Prepared under contract MDA903-86-C-0170 for the U.S. Army Research Institute for the Behavioral and Social Sciences, Alexandria, VA.

7. Klein, G. A., Calderwood, R., & Clinton-Cirocco, A., (1986). Rapid decision making on the fire ground. *Proceedings of the Human Factors Society 30th Annual Meeting*, 1, 576-580. Dayton, OH: Human Factors Society.

8. Klein, G. A., Calderwood, R., & MacGregor, D., (In press). Critical decision method for eliciting knowledge. *IEEE Transactions on Systems, Man, and Cybernetics, Special Issue.*

9. Taynor, J., Klein, G. A., & Thordsen, M., (1987). *Distributed decision making in wildland firefighting* (KATR-858(A)-04F). Yellow Springs, OH: Klein Associates, Inc. Prepared under contract MDA903-85-C-0327 for U.S. Army Research Institute, Alexandria, VA.

Knowledge Acquisition From Repertory Grids Using A Logic of Confirmation

Kenneth Ford
Department of Computer Science
University of West Florida
Pensacola, FL 32514

Frederick Petry
Department of Computer Science
Tulane University
New Orleans, LA 70118

Introduction

This research involves a continuing effort aimed at the development and unification of the prerequisite underlying theoretical foundations for an adequate approach to knowledge elicitation from repertory grid data. The repertory grid is a sorting test in which a list of elements are judged based on a set of constructs, essentially mapping elements onto constructs. Thus knowledge elicitation is performed by the expert's assigning of ratings to elements on the given constructs. The repertory grid is based on the personal construct psychology of Kelly. This theory assumes that people typically use cognitive dimensions - termed *constructs* - to evaluate their experience where each construct represents a single bipolar distinction.

A theory of non-quantitative confirmation was evolved incorporating personal construct theory into the logic for the determination of relevance. This was needed for an adequate probabilistic interpretation of quantitative confirmation. This logic is consistent with personal construct psychology as it produces epistemic probabilities by the measurement of overlap of a person's constructs. Bundy's incidence calculus was extended and applied to the measurement of partial entailment, affording a degree of rigor and formality. Here the degree of confirmation is characterized by epistemic probabilities arrived at by measuring the overlap between the constructs' extensions represented as binary bit strings. This interpretation of the probability calculus permits a uniform, truth functional method for measuring the degree of entailment associated with a proposition and provides a sound basis for the assignment of numeric values to expert system rules.

These theoretical developments are then applied to the representation and analysis of repertory grid data. The concept of an alpha-plane is introduced as a binary decomposition of repertory grid data, that furnishes the necessary realization of construct extensions (or ranges of convenience) needed to determine the range of relevance of a particular generalization or hypothesis. In addition, they provide the uniquely determined string of incidences required by any application of Bundy's truth functional incidence calculus. This incidence calculus enjoys numerous advantages in comparison with other mechanisms proposed for the automated handling of uncertainty in expert systems, but has previously had the difficulty that, although domain experts are able to provide a numerical certainty for a rule, they cannot assign the required string of incidences.

Finally, the approach evolved in this group have been applied to the design and construction of NICOD - a semi-automated medical knowledge acquisition system. In particular, the system has been successfully employed in the capture of valuable heuristic radiological knowledge (mammography) that the domain experts (radiologists) were otherwise unable to articulate.

Some current areas of research include further medical/radiological applications, use of parallel processing to generate rules, neural nets, capture of imprecise knowledge, and use of multiple experts.

Other investigators involved in this interdisciplinary group include Jack Adams-Webber from Brock University and Paul Chang a radiologist from Stanford University. See reference list for additional publications on this subject.

References

Chang, P. J., K. M. Ford, and F. E., Petry (1987). "The production of expert system rules from repertory grid data based on a logic of confirmation," *Seventh International Congress on Personal Construct Psychology*, Memphis, TN.

Ford, K. M., and F. E. Petry (1987). "An approach to the acquisition of fuzzy production rules," *Proceedings of NAFIPS 87*, May 4-7, Purdue University.

Ford, K. M. (1987). *An Approach to the Automated Acquisition of Production Rules from Repertory Grid Data*, Ph.D. dissertation., Tulane University.

Ford, K. M., and J. R. Adams-Webber (1989). "The structure of personal construct systems and the logic of confirmation," *International Journal of Personal Construct Psychology*.

Ford, K. M., and P. J. Chang (1989). "An approach to automated knowledge acquisition founded on personal construct theory," In: *Advances in Artificial Intelligence Research*, M. Fishman (Ed.), Greenwich, CT: JAI Press.

Ford, K. M., F. E. Petry, J. R. Adams-Webber, and P. J. Chang (1989). "A probabilistic approach to the automated acquisition of production rules from repertory grid data," *Second International Workshop on Artificial Intelligence and Statistics*, January 4-7, Ft. Lauderdale, FL.

The Design Of An Automated Assistant For Acquiring Strategic Knowledge

Thomas Gruber
Knowledge Systems Laboratory
Stanford University
701 Welch Road, Building C
Palo Alto, CA 94304

Paul Cohen
Department of Computer Science
University of Massachusetts
Lederle Graduate Research Center
Amherst, MA 01003

The Problem: Acquiring Strategic Knowledge

Knowledge acquisition is the transfer and transformation of expertise from knowledge sources in the world (mainly people) into a form that can be executed by a knowledge-based system to perform an expert task. It is widely acknowledged that the knowledge acquisition problem is a significant barrier to the development of knowledge-based systems. The research reported here focuses on the problem of acquiring *strategic knowledge*: knowledge used by an agent to decide what action to perform next, where the actions are external events that effect both what is believed by the agent and the state of the world.

Strategic knowledge is an important source of expertise in application tasks where managing the *process* of problem-solving (repeatedly choosing the next action to take) is intrinsic to performance. For example, although diagnosis is often modeled as a pure classification task - that of matching data and hypotheses - in medical diagnosis the decisions about which questions to ask and tests to run require strategic expertise to balance costs and