A KNOWLEDGE ACQUISITION EXTENSION TO NOTECARDS

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Abstract: There is a danger that the narrow concepts of 'knowledge' currently prevalent in computer science will result in knowledge acquisition tools tools that do not allow experts to express their knowledge naturally and without distortion. Hypermedia systems provide a technology for the construction of knowledge bases that allows a much greater variety of forms of knowledge to be incorporated than has been considered in the development of knowledge bases to date. It is attractive to use such systems for the initial elicitation of knowledge from experts in a very free and open-ended fashion, and to supplement them with structured knowledge acquisition tools based on entity-attribute elicitation and object hierarchy derivation. This paper describes KC0, an extension of the *Notecards* hypergraphic system with KSS0-like structured elicitation tools.

INTRODUCTION

In developing interactive knowledge acquisition systems for the rapid prototyping of expert systems there is a danger that the narrow concepts of 'knowledge' currently prevalent in computer science and implemented in 'knowledge-based systems' will result in tools that do not allow experts to express their knowledge naturally and without distortion. Even if hierarchical, object-oriented systems prove to give a representation of much human knowledge that is adequate for its operationalization and computer-based application, this does not imply that their data structures are a natural format for human knowledge expression. Indeed, one can argue (Gaines 1987a) that human knowledge in general is anarchical, unstructured and non-algorithmic, whereas knowledge-based system research has focused only on the well-ordered nature of some knowledge. The use of the term 'knowledge' to mean 'those aspects of human knowledge that can be formally represented and processed' is a major restriction of its usual meaning 'acquaintance with ascertained truths facts or principles' (Oxford English Dictionary).

Knowledge acquisition systems based on personal construct psychology allow experts to chose entities and develop attributes using their own vocabularies in a very free and open-ended fashion, translating this into hierarchical, object-oriented structures as as later phase (Shaw & Gaines 1986, 1987, Boose 1985, 1986, Boose & Bradshaw 1987, Gaines 1987b). However, even these systems require that experts submit to their entity-attribute structure from the start. It is easy to argue that experts soon accept this structure and find it a natural one within which to express their knowledge. However, it is known that the initial entity selection is both critical to the utility of the technique, problematic for users, and difficult to aid through the computer.

It is always appropriate in computer-based system design to take a step outside the technology and ask 'how would we perform the task without the computer?' The image will probably come to mind of the person attempting to communicate knowledge scribbling furiously surrounded by scraps of paper. We make notes on our ideas, draw sketches, re-write, re-draw, change the order of presentation, bring fragments into juxtaposition, and so on. This happens in knowledge engineering sessions—it happens with computer-based structured interviewing—and it is a computer-supportable activity.

This paper describes the initial development of a system, KC0 (Knowledge Cards Zero) that extends the Xerox Notecards system (Halasz, Moran & Trigg 1987) with some of the knowledge elicitation and analysis facilities of KSS0 (Gaines 1987b). KC0 provides a knowledge acquisition environment that supports the relatively unstructured elicitation of knowledge through a hypergraphic system as a precursor to relatively structured elicitation through entity and attribute elicitation.

HYPERTEXT, HYPERGRAPHIC AND HYPERMEDIA SYSTEMS

The concept of a *hypertext* system as a computer-based alternative to books allowing knowledge to be stored with multi-dimensional access links can be traced back to Bush's (1945) *Memex* concept which led to Engelbart's (1963) *NLS* and Nelson's (1980) *Xanadu* systems. The advent of low-cost graphic workstations made it feasible to store and link text, graphic and pictorial material and resulted in the development of *hypergraphic* systems such *Notecards* on the Xerox 1109 Lisp machine. The availability of videodiscs and CD-ROMs has made it attractive to extend the concept to include material on computer-controlled media and talk of hypermedia systems (Young 1986, Gassée 1987).

The key concepts underlying hypermedia systems (Gaines 1987c) are that:

- knowledge is stored in a completely free and open-ended form;
- a linkage structure is embedded in the material;
- paths through the material are generated by a user following parts of the linkage structure;
- a *gateway* is a link within material to other material;
- a *perspective* is the viewpoint into the material that is built up through access to it.

A range of systems is being developed for a diversity of applications, from simple hypertext systems such as Learning Tool (Kozma & Roekel 1986) and Guide (Owl 1986), through electronic books (Weyer 1982) and encyclopedias (Weyer & Borning 1985), through programmable hypergraphic systems such as NoteCards (Halasz, Moran & Trigg 1987), through complex, multi-media systems for literary studies (Yankelovich, Landow & Cody 1987) to knowledge-based, multi-media systems for expert system development (Neuron 1986), computer-integrated manufacturing (Gaines 1986) and sports coaching (Vickers & Kingston 1987).

The hypermedium concept is significant in capturing the computer-supported, open-ended access to a diversity of media that offers so many attractive possibilities for creative thinking, problem solving and networking by individuals and dispersed groups. It provides a basis for the integration of the very wide variety of resources offered by information technology within a coherent but non-restrictive framework. Data-processing, simulation, information retrieval, text processing, presentation graphics, databases, knowledge bases, expert systems, knowledge acquisition, and so on, may all be regarded in a significant sense as particular aspects of hypermedia systems.

STRUCTURED KNOWLEDGE ACQUISITION IN HYPERMEDIA

Hypermedia systems seem to provide a technology for the construction of knowledge bases that allows a much greater variety of forms of knowledge to be incorporated than has been considered in the development of knowledge bases to date (Gaines & Vickers 1987). In particular, they provide an interesting vehicle for knowledge acquisition since the expert can enter data in a very free form and then annotate it with a variety of cross-linkages. VanLehn (1985) has reported on a successful experiment in large-scale knowledge structuring using Notecards, and claimed that it led to the generation of structures which would otherwise have been missed. He used the programmability of Notecards to extend it with special formats and linkage structures related to the development, expression and validation of lines of argument.

We have extended Notecards in a similar fashion to include structured knowledge acquisition based on entity-attribute elicitation. Knowledge Cards Zero is intended to provide a knowledge support environment in which an expert can use:
- Notecards' data entry facilities to emulate an enhanced form of 'scribbling notes on paper;'
- Notecards' hypergraphic linkage capabilities to begin to organize the raw notes through annotation and aggregation of related material;
- structured elicitation to construe the organized material in entity-attribute terms;
- inductive analysis to derive an object hierarchy from the entity-attribute relations.

The primitive element in Notecards is a "notecard" which can contain text, graphics, any mixture of these, and gateways linking to other notecards. Special-purpose notecards are defined within the systems, such as *browsers* that show a map of the linkage structures between notecards, and *fileboxes* that group sets of notecards together. Notecards is written in Lisp and provision is made for its extension through the addition of other special-purpose notecards whose functionality is programmed in Lisp. This programmability is an important feature that is lacking on current commercial hypergraphic systems for personal computers such as the Macintosh.

KC0 is a port of the knowledge acquisition functionality of KSS0, a knowledge support system, from Pascal on the Macintosh into Lisp in the Notecards environment on the Xerox 1109/1186. The structured knowledge elicitation is implemented as a set of special-purpose notecards that provide:
- a status card showing the purpose of the elicitation and naming the classes of entities and attributes (Figure 1);
- an entities card listing the entities considered (Figure 2);
- an attributes card listing the attributes elicited (Figure 3);
- a triadic elicitation choice card prompting the elicitation of attributes (Figure 4);
- a rating card allowing attributes to be entered and entities to be rated on attributes (Figure 5);
- the rating card with entities trated on attributes by spatial click and drag (Figure 6);
- various forms of entity-attribute structure analysis such as ENTAIL allowing object hierarchies to be derived.

These special purpose notecards are currently being integrated into the full Notecards environment so that gateways may be generated: from normal hypergraphic material to elicitation notecards; and from elicitation notecards into normal hypergraphic material. This will allow users to chose entities in the normal material and link them to elicitation, and also to use Notecards to annotate the elicitation process, for example, with explanations of the meaning of attributes.

CONCLUSIONS

An extension of Notecards has been described which allows the freedom and flexibility of hypergraphic knowledge elicitation to be combined in an integrated fashion with more structured entity-attribute elicitation leading to object hierarchy derivation. It is suggested that this combination provides an attractive knowledge support environment for experts in the rapid prototyping of expert systems. A hypermedium shell can provide a useful framework in which many other forms of more structured elicitation can be embedded.

ACKNOWLEDGEMENTS

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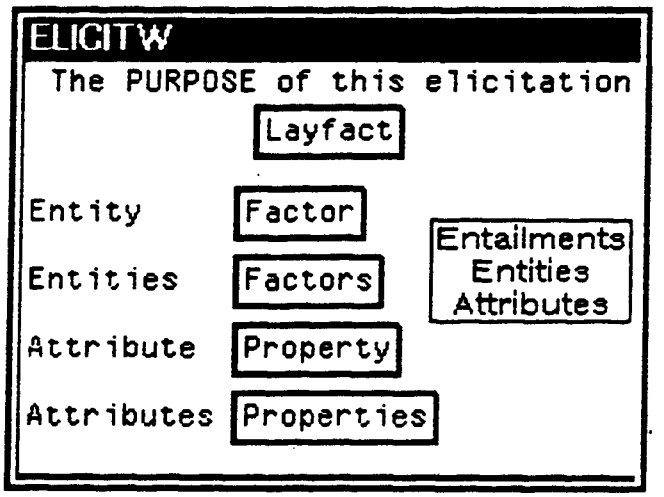

Fig.1 A status card showing the purpose of the elicitation and naming the classes of entities and attributes —menu of options showing on right

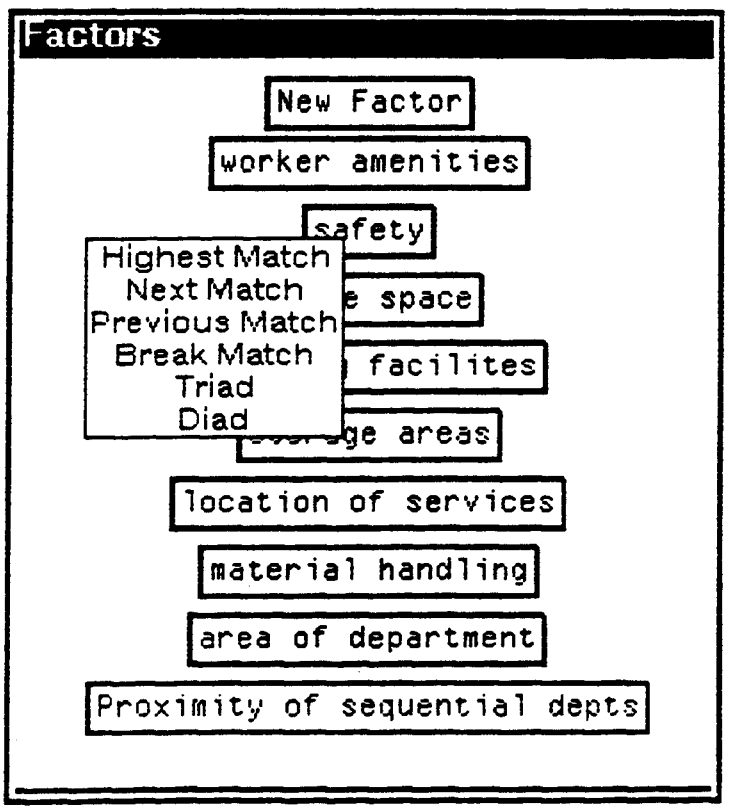

Fig.2 An entities card listing the entities considered —menu of options showing on left

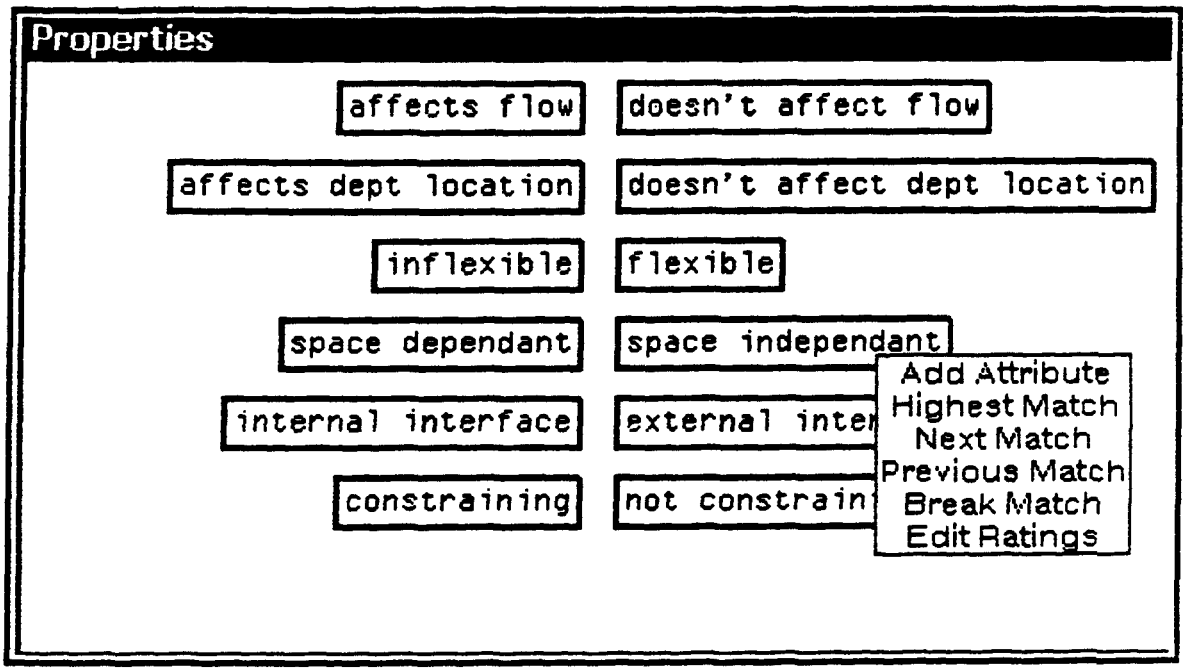

Fig.3 An attributes card listing the attributes elicited —menu of options showing on right

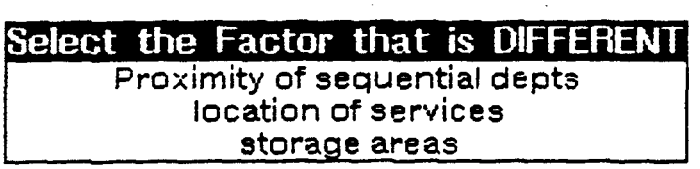

Fig.4 A triadic elicitation choice card prompting the elicitation of attributes

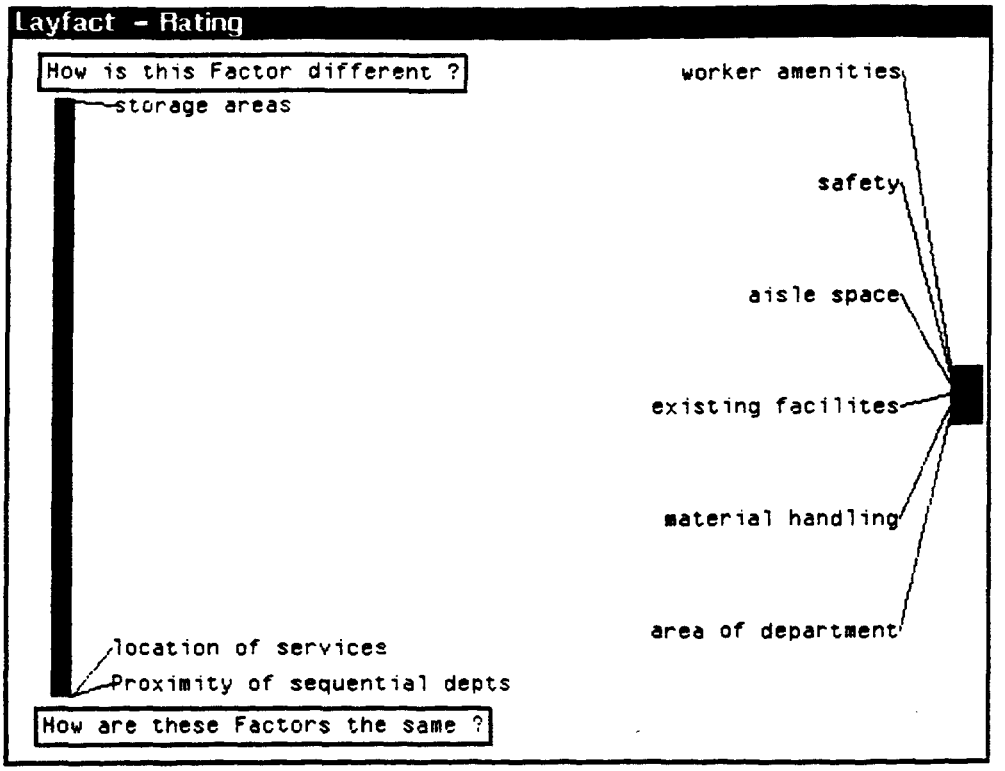

Fig.5 A rating card allowing attributes to be entered and entities to be rated on attributes

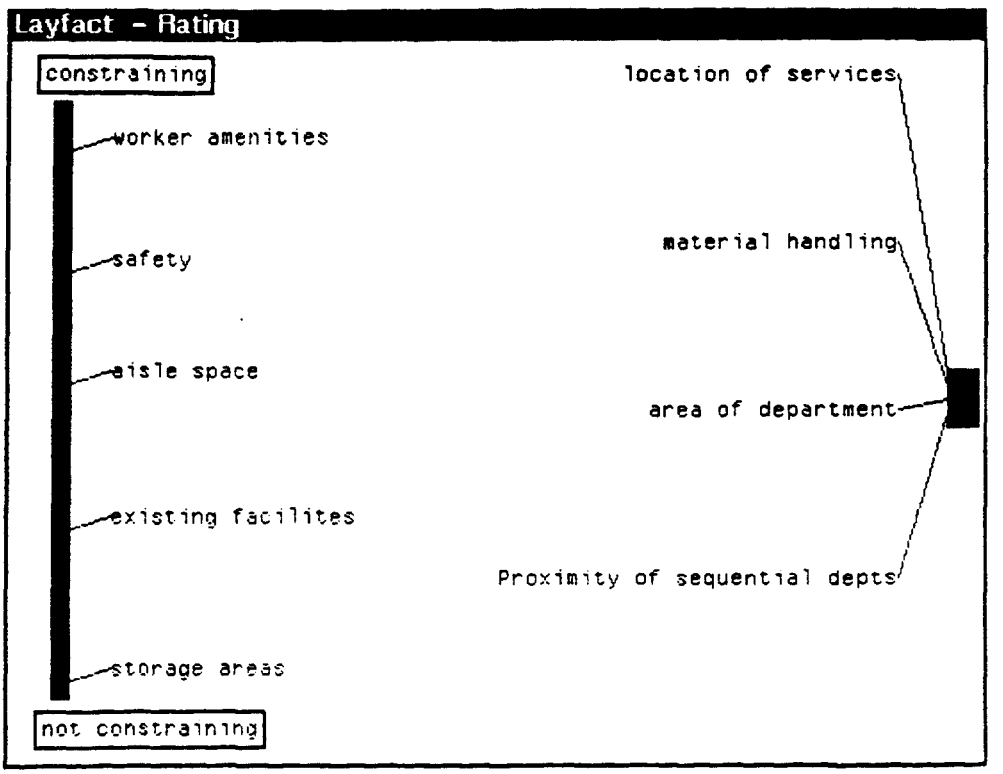

Fig.6 The rating card with entities rated on attributes by spatial click and drag