KNOWLEDGE-BASED SYSTEM DESIGN FOR THE GRAPHIC ARTS

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Abstract: Most graphic arts products have a fairly complex structure. The design systems need to be flexible and intelligent and cover the publication level comprehensively. Application of knowledge engineering (KE) and knowledge-based (KB) systems is reviewed and some preliminary results are discussed. The discussion includes mainly prepress and publishing systems. Examples of our own projects from 1986 to 1990 are given. So far they range from design and positioning of items on pages (publication-wide) to various expert systems (ES) for evaluation, advisory, diagnostic or control problems in various graphic arts environments.

Introduction

The first few applications of the knowledge engineering (KE) were reviewed and reported three years ago in our TAGA paper (1). Only some progress has been reported since then in the graphic arts literature. One might even say that the early applications of KE in the graphic arts were not aimed properly.

As we first decided – way back in 1985–86 – to launch these it was clear from the very beginning that these systems would take more time to mature than most other new technologies do. For three years – from 1987 to 1990 – we have had a research group of 3 to 4 experts working on a number of well-chosen KE-tools in which we invested between 1986 and 1989 and which have not yet become obsolete . They will be reviewed briefly in this paper.

Figure 1. briefly gives the knowledge engineering approaches of our laboratory. Only a few have been used in production and it is too early to report any major cost or time savings. It seems that the KB systems will be used in solving problems (in graphic design, control, automation and measurement) which are difficult or impossible to be solved with other methods. A typical "unsolved" problem was

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Knowledge-Based System Design & Research in the VTT/GRA between 1986-90

A. Pagination & design

* Yellow page system AI-CATALOGUE
* AI-PAGE system
* AI-Composing system
* Newspaper layout and page design
* Links to press line-up
* Knowledge-based analysis for lineart (e.g. map lineart)
* Colour-repro module for the PrintSim (TM) (Level V)

B. Database and expert evaluation systems

* Expert system for data on projects EPMAP (Project data evaluation)
* Presentation of news and other factual information
* Database information export and re-editing

C. Materials and process applications

* Texture analysis of paper structure: Adaptive and automatic classifications
* Expert system for litho and web-offset materials (ESWOM)
* INK-ES : Composition, properties & behaviour (newspaper web-offset)

FIG. 1 Research and system design using KE tools on Unix and LISP workstations and on various PCs. The KE-tools have been KEE, Level V and Nexpert

the top-down design (or CAD) of newpaper pagination (Ylä-Jääski and Ahonen, 1990).

We have worked in the three main areas listed in Figure 1. In one particular case a system for real production could be developed. This was the case of the yellow page ads (Ahonen and Viertiö, 1989), the AI-CATALOGUE system. We have also a general tool for the automatic positioning of classified items in page structures which we call the AI-PAGE system – reported in the refs. (Ylä-Jääski and Ahonen, 1990, Ahonen, 1989, and Ahonen and Viertiö, 1989).

In a number of other projects (Viertiö, 1989, Juntunen et alii, 1988, EPMAP, 1989, Jäntti, 1990) KE has helped us develop knowledge capture from the research environment (always abounding in facts, attributes, models, rules and data) to some practical evaluation, advisory or diagnostic problems in the graphic arts processes.

This paper deals with the background and principal results of our work. KE tools are widely accepted in our research groups. Not only the Knowledge Engineering Group but also other VTT/GRA's Groups e.g. those of Simulation, Paper Technology and Process Automation today have some experience in KE applications.

Knowledge-based systems

Graphic arts applications contain complex information processing tasks. Tools generated by the research of artificial intelligence seem to be very useful in developing systems for such tasks. The methods originally developed to describe human intelligence provide us practical means of presenting data and knowledge needed to perform complicated reasoning tasks.

Artificial intelligence and more specifically knowledge-based methods offer a new viewpoint to graphic arts problems, since they enable us to solve the problems by constructing direct models and making descriptions of the applications instead of first translating them into some separate computer representations. We can also use concrete tools to solve problems and to build systems. There are symbolic programming languages (LISP, Prolog, object oriented languages), software tools to build knowledge-based systems such as KEE (a trademark of Intellicorp), ART (a trademark of Inference), Nexpert (a trademark of Neuron Data), and KRS (a trademark of Knowledge Technologies), as well as special hardware for symbolic processing (LISP machines). These "classical" AI tools are today complemented or partly replaced by new products and computer platforms, e.g. in the form of object-oriented languages, hypermedia tools, Unix workstations, and personal computers.

The key concept in our approach is knowledge. This is used in a wide sense, including detailed knowledge of the system components in an application as well as more or less vague knowledge of current conditions and habits in the environment of the application.

The inherent power of knowledge-based systems is derived from expressive knowledge representation schemes and efficient reasoning mechanisms. Knowledge representation schemes allow us build conceptual models for our applications. Two types of representations are used, sometimes separately but often combined. In the first type concepts are organized in the form of hierarchical object representations. The hierarchy tells us how the objects are related. We can for example describe how advertisements in a newspaper consist of several classes of advertisements. Some of them will be placed before the editorial material. Some are bound to certain topical sections while some form classes of classified ads. Each object class has specific properties which are common to all the members of the class. There may also be members with some exceptional properties. For example, the size of an individual classified ad may exceptionally exceed the standard dimensions.

The hierarchical knowledge representation scheme allows us to specify attributes describing object classes and individual objects. Objects inherit all their attributes from the classes with the help of special inheritance mechanisms. We can also give objects exceptional attributes by explicitly overriding an inherited attribute. An object can communicate with other objects by sending messages, which can e.g. change some attributes of the receiving objects.

Another important knowledge representation scheme is based on the use of rules. We can write rules to tell how the system components are mutually related, how they can change or how they react to changes in the environment. We can thus describe the behaviour of the system under the prevailing conditions.

The two main knowledge representation schemes are often connected together. Some parts of the domain knowledge are naturally represented with objects (e.g. the structure of a newspaper), while others are better expressed in the rule form (e.g. the constraints for placements of ads). This possibility of combination is essential in the so called hybrid knowledge representation tools. An example of hybrid tools is the KEE system mentioned above.

Our research work consists of building models and prototypes for selected applications. The work is mainly done in the symbolic processing environment with Symbolics artificial intelligence workstations and KEE permitting rapid prototyping and experimenting with several alternatives. This approach makes it, however, often necessary to convert or rewrite the developed systems when taking

them outside the laboratory. Even though there are versions of KEE on several platforms like personal computers and Unix workstations, we sometimes need to adapt our applications to other environments as well.

The current development in the standardization of LISP offers a viable solution to our applications development. The object-oriented extension of the well-standardized Common Lisp, CLOS (Common Lisp Object System) (Keene, 1989) makes it possible to write portable systems with an object-oriented knowledge representation scheme. The portability extends also to the user interfaces of the prototypes. They need not be fully rewritten, since the emerging CLIM (Common Lisp Interface Manager) standard allows us to design their central parts in a portable manner.

Heuristic page layout design

Page layout design is often rather far from the artistic work typical of the production of newspapers and magazines. We only need to think of the design of catalogues and directories. Even newspapers contain parts, e.g. the sections of classified ads, which are assembled with very little artistic ambition. This does not mean that the automation of these tasks would be very simple, since it is very difficult to save space while keeping up the order and the good appearance.

Our first version of page layout design systems was produced to handle one of such simple layout design tasks, the design of yellow page directories (Ahonen and Viertiö, 1989). In Finland the directories contain a large number of display ads in variable sizes, whereas the line ads are of a minor importance. Thus the task to be handled by our system differs from that of the systems built in the U.S. (Amdocs, 1989, Pegasys, 1986). We call the system product AI-CATALOGUE.

Our system may be considered semiautomatic. The system was intended to assist a human designer not to replace him. AI-CATALOGUE proposes a preliminary layout by automatically designing a given number of double pages. These can be evaluated and corrected by a human designer with the interactive tools provided by the system. The main user interface is in Figure 2.

The user interface contains five windows. The two top windows give an overview of the proposed double page layouts and the values of the evaluation parameters. The large window on the left shows one double page with mouse-sensitive ad boxes which may be moved about on the double page or removed from the double page and moved into the working area (on the right). The small window on the right od a control panel for various user operations.

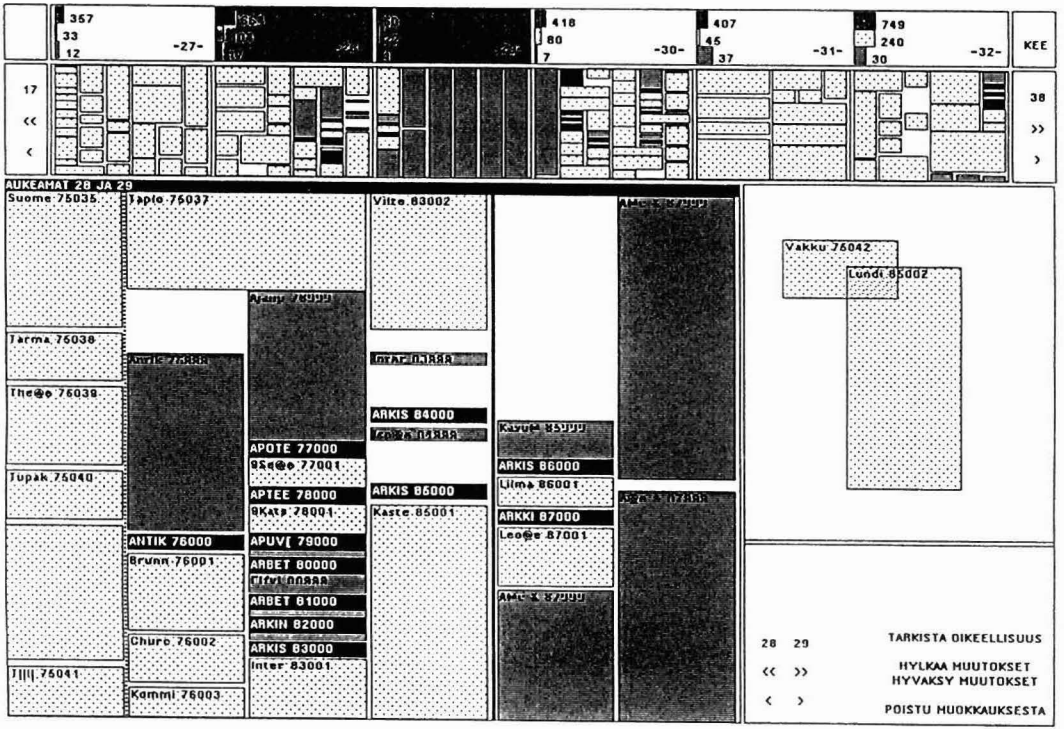

Figure 2. The user interface of the yellow page layout system.

The knowledge behind the operations of the yellow page system incorporates some of the knowledge of human designers, including the choice of the active scope of work, the restrictions in repaginating, and the method of making room for large ad boxes by removing smaller boxes which have already been placed. The method for finding a good page layout may be considered a heuristic search method instead of a strict optimization procedure. The user can also decide how much automation or manual interaction the product may need.

The yellow page system has been developed with KEE and Symbolics LISP machines. The final production version also runs under KEE, but the machine environment is a Unix workstation. It is possible to create a version in which KEE is no longer needed.

The work has been expanded into newspaper layout as well. (Ahonen, 1989, Ylä-Jääski and Ahonen 1990). The produced system, AI-PAGE, is a general tool for automatic placement of classified ads. Compared with AI-CATALOGUE, the yellow page system, this system introduces more flexibility into the original page. The number of columns, the order of the display ads and the positioning of the items on the page can be more variable. The two systems, AI-CATALOGUE and AI-PAGE, are examples of our efforts to produce universally applicable modular solutions.

Design of newspaper structure

Currently there are in newspapers separate design systems for information management, page layout and text composition. The latest systems of this type, the desktop publishing systems, come from the world of personal computers.

We believe that design of a newspaper and other mass media publications is not done in the best possible way with DTP systems. The main reason is that DTP systems were developed for pagewise processing and therefore do not support the management of large amounts of material. The overall design of a publication with a DTP is difficult and sharing the work between several people is not easy.

A current project in our laboratory aims at developing tools for the global design of a newspaper. This includes all the relevant aspects of newspaper production starting from the configuration of the printing press and ending with the time schedules for mailing and distribution. An early similar project was reported in (CSI, 1986), but, as far as we know, it was not finished.

We formulate the newspaper design problem in terms of goals and restrictions. The goals are both economical and esthetical. Economical goals are for example the use of print colours and page area. Esthetical goals include, e.g. the balanced distribution of ads on the pages. The restrictions come from the properties of the material to be positioned and from the production environment. Property-related restrictions are the requirements for the ad colours and the placing of ads. The production equipment determines the structure of the publication, whereas the production process fixes the schedules for the different phases of work.

Editorial systems

By editorial systems we mean systems which help writers to recall relevant facts when they write their stories. The facts stored in the systems are of different types and need different types of representation. Exact facts may be stored in a database like form, whereas descriptions of complicated relations may require structural definitions, which represent everyday common sense knowledge behind the relations. The information may also be stored in a multimedia form, e.g., in the form of graphics, an image or in sound representations. Knowledge representations for the design of selected items such as composition, type or graphics, may also be used.

Editorial background information systems encourage us to look for new approaches utilizing knowledge-based methods. "Classical" databases or recently developed hypertext (Nelson, 1967) and hypermedia (Yankelovich et al., 1988) tools are not sufficient for editorial systems.

Databases are not flexible enough, since the information the writers need is seldom well structured and therefore cannot be stored and retrieved by some logically defined keywords. People who are not experts in database management cannot install and update strictly organized databases.

Keeping personal records is the most effective way of recalling past events and respective background information. Hypertext systems and their extensions, hypermedia systems, support this by allowing the user to form links between separate information blocks. Their disadvantage is, however, that the links are not necessarily well organized and keeping track of them may be difficult. This means that after a time the writer's notes may include a lot of irrelevant details and the system is used ineffectively. Hypertext and hypermedia systems are almost too flexible, as they do not give the user overall support in the organization of his data. They may however, be useful personal tools when the structural definitions are under control.

We have studied the problem by starting from the knowledge representation schemes which can be gradually extended by copying and editing existing structures. Our approach therefore emphasizes the possibility to change structural definitions without unvaliditating the information already stored in the system. Another important feature is to allow the user to recall facts by using several points of views and by making associations between different facts.

Archiving systems

The amount of material and its versatility cause many problems in newspaper archiving systems. Neither the full-text systems nor databases are sufficient. The full-text systems are too "flat", since the data retrieval based on invidual words and their combinations is too time-consuming and inexact. The databases have too stringent structural restrictions with their predefined fields and data sizes. This causes problems in "conventional" database applications and people have begun to seek new solutions by combining database methods with knowledge-based methods (Brodie et al., 1984).

The situation is somewhat similar to that of editorial systems. We need systems in which the user can flexibly give descriptions of the stored material (copy and edit) and in which the information retrieval can be based on conceptual dependences and associations between facts. We need extensive concept-based query processing to solve the ambiguities of natural language. We need for example tools to handle temporal clauses ("the former president of the United States"), inexact expressions like "Europe is changing rapidly" or metaphors like "He has a heart of stone". We need also tools to avoid misunderstandings in the interpretation of the answers given by information systems. A classical example of this is the answer "No" to the question "Is John divorced?" if John happens to be a bachelor.

The practical problems of archiving systems are a real challenge to knowledge-based systems. The systems could assist the user in choosing a proper level of abstraction when handling the vast amount of concepts and facts. They can propose structural definitions already stored in the system as models for new structures and they can assist the user to give background information to the articles stored in the system. They could even remind the user of facts assumed to be known to the reader.

Database project evaluator

In a recently finished subproject of the EPMAP Project (EPMAP, 1989) we (VTT) managed to solve a project evaluation problem by configuring a typical expert system (Viertiö, 1989) on top of a large database. The host of EPMAP Project is the IEPRC (a mem-

ber-based service of PIRA, UK) which is an association of publishers and other companies interested in new electronic publishing (EP). The EPMAP Project of the IEPRC includes a large database of research and development projects or early product launches in EP.

To asses the potential success of the projects the collected data was pre-evaluated and judged by a certain hierarchy of criteria. After this the expert system can be used to produce a rapid quantitative evaluation, i.e. a score on a relative scale.

This very simple expert system was able to rank projects in a way that was rather satisfactory compared to an assesment made by experts of EP companies who were in this case chosen from EPMAP and IEPRC member companies. Confidential reports (available to the members of the EPMAP) can be requested – on standard membership terms – from PIRA and from Dr Richard McArthur, the project manger. The EPMAP Project is still continued.

Expert system for web-offset materials

Most frequent applications of KE are various expert systems with diagnostic or advisory nature. A good example is a recent portable prototype called ESWOM (Expert System for Web-Offset Materials) which runs on MS-DOS computers and can be distributed on a diskette. It uses the Level V, an ES environment, and includes about 300 rules. It aims to advise production managers in their urgent and frequent choices of web-offset materials for a specified job and press (Jäntti, 1990).

Essential for this particular expert system is that it forces to take an adequate number of relevant factors into consideration but it can give hints according to incomplete input data as well. The factors input include the process variables (press type, plates, dampening solution, rubber blankets, inking, speeds), print variables (print quality, faults, tolerances), and material variables (paper and inks).

In a session with this system a production manager can not only find recommended compatible combinations but also prognose likely problems and the reasons for these.

Conclusion

Knowledge engineering (KE) and knowledge-based (KB) systems consist of a wide range of tools and methods. It seems that they may be applied in many ways to solve editorial and production problems in the graphic arts. We all know how complex commercial publications (e.g. newspapers, magazines, catalogues and books) may be, including conceptual, temporal, point-of-view, personal, subjective and contextual problems in the choice of the contents or design. Many routines like spelling, proofing, layouting, correcting,

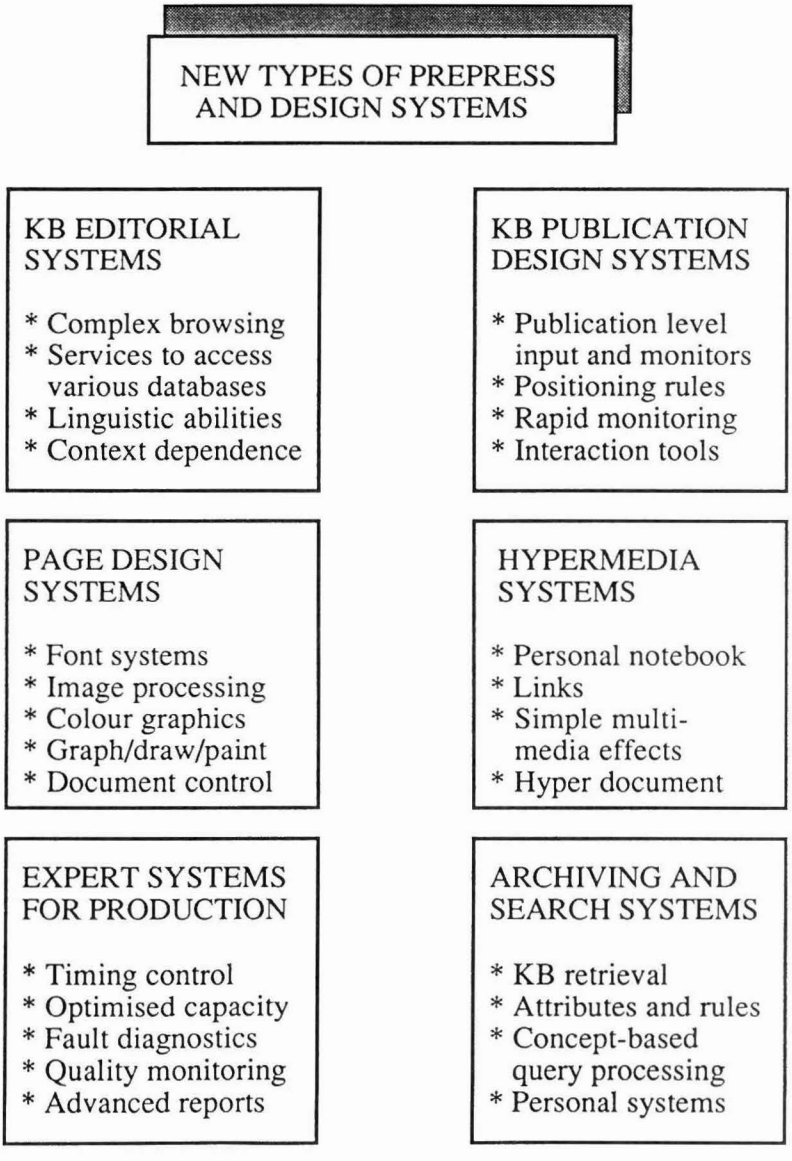

Fig. 3 Knowledge-based (KB) systems for prepress

copying and making changes will be more systematic and economic with the aid of advanced KB systems.

Daily production takes place in a number of design, editorial and productional stages and often in several offices or on remote sites. It is always group work and the group may sometimes be big and scattered (e.g. newspaper sections, editors, remote reporters and correspondents). The time constraints are many and vary over the editorial and production staff. It is evident that DTP and other personal tools are simply inadequate and only able to solve the problems of subsystems. They may in time do jobs that higher knowledge-based systems push down.

In graphic production, from pagination to printing and distribution, expert systems and KB systems will be equally useful (in ambiguous solutions) as they have proven to be in editorial applications. Our experiences with the research and applications of KE in the graphic arts are encouraging.

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