Knowledge Management for the Applied Sciences

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Abstract

Expert systems are usually built from knowledge elicited from domain experts. However, knowledge in applied science domains is grounded in published sources like research reports, text books, articles and so on. This corpus of knowledge is typically inconsistent, dated, dispersed, etc. The project described in this paper aims to construct a putative Knowledge Management System. The core of the system is a knowledge server which represents each publication and expert as a separate knowledge base, and a meta-knowledge base to allow different kinds of access to the server. Different client systems can be connected to the knowledge server to meet different user needs such as forecasting, advice, explanation, education, and training. The server can also be a resource for researchers and research managers, by allowing hypothesis testing and review of the literature. Knowledge re-engineering is not necessary, as the system simply embodies what is in the domain. The test domain is viticulture, the work being supported by Australia's Cooperative Research Center for Viticulture.

Introduction

Before the knowledge created by applied science research can form a normal part of industrial practice, it must be published, presented at conferences and seminars, built into training and education courses and slowly 'percolate' through the community. This process takes a deal of time and much detail is lost or misinterpreted along the way. The Cooperative Research Centre for Viticulture (CRCV) in Australia is investigating methods of building applied research results into a knowledge-based system *as a matter of course* so that new knowledge can be put to use in the grape growing industry. Such a system would provide a vehicle for quick and complete promulgation of research results. We envisage a future where knowledge created in the laboratory and in the field can be reported to a knowledge-based system and become immediately effective in viticultural practice.

The project described here aims to find ways of representing applied research papers and reports directly in a knowledge management system (KMS) and of establishing the "meta-knowledge" necessary to properly mobilise the knowledge embedded in the literature. Such a system will enable multiple kinds of access to the knowledge, by decision support systems or computer-aided education systems for example, which will use the knowledge in different ways, for advice, forecasting, education and training, explanation and so on. It will also be a resource for researchers in hypothesis testing and research management. A prototype KMS is being built in the irrigation of grapevines as a means of evaluating the KMS approach.

The Problem

Human knowledge takes two forms: private and public (Kemp, 1976). Private knowledge is that held in and used by the minds of all humans. In its public form, knowledge is published as periodical articles, research papers, conference proceedings, technical reports, textbooks, and so on. The applied sciences create public knowledge through research and publication, but current methods of organising and mobilising this knowledge are inadequate. Considered as a whole, the applied science literature is :

Dispersed: It is scattered across different kinds of literature; books, periodicals, research papers, technical reports, proceedings, etc. located all over the globe. It is possible that research is unwittingly being duplicated because the original was not found in the literature review.

Dated: Some knowledge created long ago has been superseded by more recent work, but still remains in the literature with a potential to mislead.

Under-utilised: Studies indicate that no more than 20 percent of the knowledge available in research institutes is really being used (Mühlemann, 1995). Therefore the full weight of current human knowledge is not brought to bear on problem solving.

Expanding rapidly: The quantity of knowledge is increasing at an exponential rate.

Variable in quality: The reliability of the public knowledge is complex. Bauer's knowledge filter theory (Rauscher, 1993) mentioned that "Textbook Science" is more reliable than primary (eg. research papers) and secondary literature (eg. review articles). Furthermore, knowledge that is reliable in one context may not be so reliable in another.

Inconsistent: Considerable contradictions have been found within the published knowledge and between the published knowledge and expert opinion (McDonald & Ellison, 1994).

Incomplete: There are considerable gaps between the published knowledge and expert opinion. For example, in the development of the AusVit module (McDonald & Ellison, 1994) to deal with the disease caused by *Botrytis cinerea* a number of questions arose which had a great bearing on advice being given by the system but for which there were no answers in the literature.

Slow to be published and applied: Publication in scientific journals can take 12 to 18 months after acceptance, which may have taken a year itself. This will lead to a delay factor in decision making. The path from applied science research to decision making in the field can be long and inefficient.

Clearly, there is a large knowledge management problem to be addressed here. Current approaches to the problem come from either information management technology (document indexing and bibliographic databases which store and deliver papers) or expert systems technology (advice giving systems built from consensus knowledge of domain experts). The former requires a person to make knowledge from the information delivered while the latter is often pervaded by imprecision and/or uncertainty (Grabot 96).

The research project described here aims to employ knowledge based technology to deal more effectively with the knowledge management problem. The KMS under development will collect and consolidate knowledge in a form that is explicit and accessible, while still preserving the context of each research publication. By avoiding some of the problems in current knowledge management the KMS will be a powerful tool for technology transfer, allowing more complete, unbiased and justifiable responses to industrial problems and for research management. In the future, research results will be input to the KMS as though they were data. Of a parallel domain, forest science, McRoberts et al. (1991) say:

> *Computerised database management systems have been accepted as essential aides to the human mind for decades now. No one would dream of trying to manage a large forest inventory on paper or in the minds of humans any more. Computerised knowledge base management systems are making it equally wasteful to manage forest science knowledge in paper journals and books, or in the minds of human scientists. The volume is too large and, thanks to the advances in AI, the computer can now cheaply store and retrieve knowledge as easily as it can store and retrieve data. (p20)*

A KMS system has the possibility of incorporating and integrating new knowledge that is being created in applied research projects around the world.

A Prototype KMS

A prototype KMS, based on the public knowledge in viticulture literature, is being constructed with two components. The first is a set of knowledge bases each representing the knowledge in a particular research paper or report. In the KMS each publication is treated like a small single and independent knowledge base, with its own domain knowledge. The second is a meta-knowledge base which represents the aspects of research publications that influence the selection of which knowledge base is applicable in a particular instance.

The KMS will be used by a range of interface systems which will employ the KMS in different ways. For example, a decision support system will use the KMS as a model of a domain to allow scenario processing. An expert system will give advice using the KMS as a knowledge base and justify the advice on the basis of the publications from which the KMS has been built. A Computer Aided Instruction (CAI) interface would allow the KMS to form the basis of courses in the domain. Researchers and research bodies can use the KMS as a source for literature reviews and hypothesis testing. Each of these interface systems would have specific systems components suitable to their purposes but would rely on the KMS as the source for their domain knowledge.

As each new research report becomes available it is represented as a new document-related knowledge base and so participates immediately in the various uses to which the system is being put. Figure 1 shows the KMS architecture.

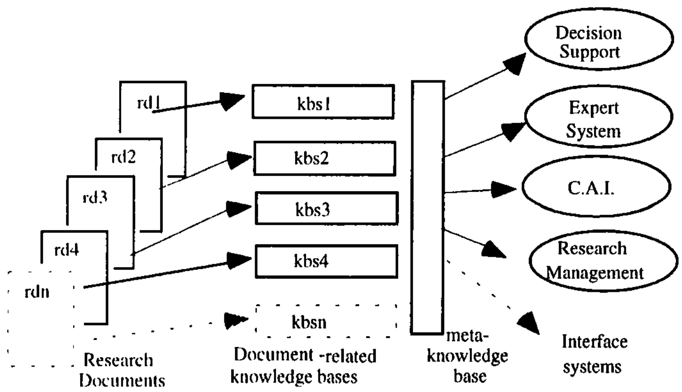

Figure 1: Knowledge Management Systems Architecture

The research involved in the construction of the KMS centers on the development of methods for knowledge extraction from literature, knowledge representation in conceptual graphs (Sowa, 1984), knowledge query, and access to KMS by the interface systems mentioned above.

The Case Study - Australian Viticulture Adviser, AusVit

Currently AusVit is an expert system which is part of the technology transfer program of the CRCV in Australia. The system provides advice to vineyard managers and grape growers about pest and disease risk in their vineyards and what appropriate action might be taken. The advice is based on vineyard profile data, data from weather stations and user input from vineyard monitoring, all of which is interpreted by a series of disease simulators and a rule-based expert system. A chemical database provides details of the active components in agricultural chemical products, their application and registration information. The components of the system are shown in Figure 2.

The rule base has been built using the traditional expert systems approach (Travis, 1992). The CRCV is interested in transforming AusVit from a traditional expert system to a KMS. Its aim is to ensure that the results of the applied viticulture research it commissions are transferred to industry and sees the KMS as a vehicle to demonstrate that transfer explicitly. A pilot study of building a knowledge base from the literature was conducted in the *Botrytis Cinerea* module of AusVit (McDonald & Ellison, 1994) and over the next two years the expert rule bases and simulations in one module of AusVit will be replaced by a KMS.

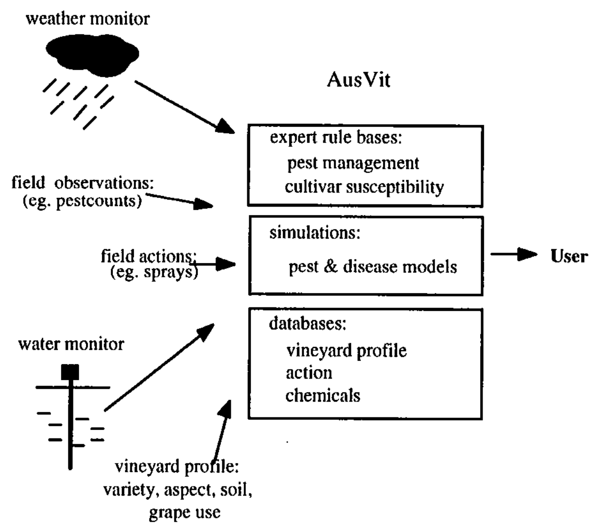

Figure 2. The inputs and components of AusVit

The Potential

As a KMS, the re-engineered AusVit has the potential to become an effective vehicle for technology transfer and knowledge management. It will have :

Up to date knowledge: Because AusVit will contain the most recent research results as well as a full history of non-obsolete research it will be complete and up to date. As new research is entered the advice that the system gives will change.

Flexible knowledge application: To apply knowledge to a problem AusVit will weight the applicability of each of the various literature sources according to its match with the vineyard profile and prevailing conditions.

Explanation: Giving useful explanations of their advice has been a difficult issue for expert systems, in part because of the disassociation of the explanation facility from the actual reasoning in expert systems, and in part because experts can not explain how they know something. Explicitly basing both reasoning and explanation in the literature has the potential to add a new dimension to explanation.

Research implications: The pilot study of building a knowledge base from the literature revealed a number of questions which had a great bearing on advice being given by the system, but for which there were no answers in the literature. It also found contradictions between sources. Such gaps and contradictions in the literature can generate new research projects. The knowledge-based system will become a source of information for researchers, much like a data base (eg. the Global Climate change Knowledge Base (Rauscher, 1993)), but one that holds active knowledge rather than passive information. It would, for example, allow hypothesis testing (Davis, 1990). This raises an issue for applied science funding bodies like the CRCV - given the bodies' strong industry orientation, if the results of one of its research project cannot be built into a KMS, or if it is built in but has no impact on the advice given by the system, was it really applied science research?

Educational uses: The possibilities for using the system in education and training are clear, especially if the system captured complete literature sources and had a range of computer-based learning facilities (eg. interfaces, programmed instruction, concept maps).

Summary

AusVit is a part of a growing trend to manage scientific knowledge using computer systems. Information technology has an extraordinary rate of change and its ability to deal with highly complex and voluminous data is increasing rapidly. It is already the primary vehicle for recording information and it will become the primary vehicle for mobilising knowledge. Systems builders of the future will have to come to grips with the issues of knowledge management rather than knowledge engineering.

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