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AI Approach forIntegration of Engineering Knowledge: WaterResources Case Studies

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ABSTRACT

The real value of AI software systems for various engineering applications lies in the integration of different sources of knowledge and information. An approach to integration is presented, based on a two level architecture: software components and object based models for integration. Two applications of the proposed approach are presented, related to water resources problems.

INTRODUCTION

In solving real world problems, the engineering profession requires different and heterogeneous sources of knowledge and information. A significant example is the problem of managing the safety of important civil structures, such as dams through data interpretation.

In this example, it is important to examine different sources of information such as quantitative data coming from automatic monitoring systems and qualitative data from visual inspections carried out by human operators. The interpretation may use numerical models (statistical or deterministic), but many physical phenomena cannot be adequately represented at present with numerical models. Therefore, the use of qualitative models and engineering judgement based on experience, may be required. In addition, other types of information such as pictures or design documents may be necessary.

The task of the engineer consists of using these tools, with appropriate strategies, to make decisions in an environment of uncertain and incomplete data and knowledge.

It is clear that in this framework the key to solving the problem does not lie in a specific type of knowledge or data, but in the availability and integration of many different types.

AI AND KNOWLEDGE INTEGRATION

Software systems may be viewed as containing three types of components:

1. models of the physical world
   For example, a component modelling the flow of water in a river, or a data base modelling the river basin are models of systems existing in the physical world;

2. models of human reasoning
   We may see for example the statement "IF the goal is a rapid estimate then run physical model A, otherwise run model B". This simple fragment of code does not model the structure or the behaviour of a physical system, (i.e., a natural or a technical system). It describes the behaviour of a reasoning agent and models a simple human decision process;

3. communication mechanisms
   The code representing a data time history on a screen in graphical form or a man/machine interface are mechanisms used to implement communications between physical models and reasoning agents inside the computer and reasoning agents outside the computer.

[…]

KNOWLEDGE MODELLING

The integration approach requires:

1. identification of the different types of knowledge;
2. choice of the appropriate modelling techniques for each type;
3. choice of the related implementation techniques;
4. use of a suitable integration approach and technology.

[…]

INTEGRATION CONCEPTS AND TECHNOLOGY

In the case studies presented in the following sections we used a common conceptual approach and technology. The basic idea is that a software system designed and implemented around the integration concept is made of two layers.

A first layer contains the software components to be integrated. For example in this layer we can find data bases, procedures, sets of rules, qualitative causal models, images or programs producing graphical representations.

The second layer is a model based integrator [4]. This is a software tool whose aim is to provide an environment where specific components can be encapsulated.

[…]

THE IDRO SYSTEM

The first case study is the decision support system IDRO [5]. The aim of IDRO (Fig 2) is to support a technician collecting, managing and processing hydrometric data. The current prototype is focused on the phase of stage-discharge curves definition.

The system offers the ability to manage the hydrometric data related to different rivers through the integration of a data base. It is possible to locate different cross-sections and for each cross-section the system provides two different approaches: *manual processing* and *supported processing*.

[…]

The system runs in a SUN workstation. The integrator is written using C++ and the toolkit InterViews under X-Window. The integrated components are written using C, FORTRAN, GKS and NEXPERT *OBJECT* (for the rule based language).

THE DAMSAFE SYSTEM

The second case study is the DAMSAFE [6] system. DAMSAFE is a system for assisting engineers in the management of safety of dams (fig.3).

The aims of the system are to:

- integrate qualitative and quantitative data arising from inspections and monitoring respectively;
- identify the state of the dam system (the structure and the near environment) in terms of attributes and behaviours from the evidence manifested in data and observations;
- assist the engineers in comparison of the data and identified state with the reference models for normality;
- identify how the present state may develop in the future and also the possible causes of the present state.

[…]

The different types of knowledge are integrated (fig.3) using a hierarchical software model describing, through objects, the main components of the system (model of data, model of dam, reasoning agents). The user, interacting with this model, may expand the components in a hierarchical way accessing the objects models and running the reasoning agents. As for the previous case study, DAMSAFE runs on a SUN workstation platform, using the same integration environment.

The integrated components are written, for the main part, in C++. Graphical components written using GKS are included and the system may access an existing data base storing monitoring data coming from dams.

CONCLUSIONS

An approach used to integrate different types of engineering knowledge has been described and two case studies to exemplify it have been presented. This approach may help in developing software systems required for engineering tasks where the availability and co-operation of diverse types of knowledge are important.

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