DIVISION OF COMPUTER SCIENCE

Validating Knowledge Models Across Multinational Boundaries

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Technical Report No.184

March 1994

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The issue of validation in knowledge engineering has always been problematic and approximate. The requirements of the Modema project create even greater problems for the validation process. This paper reviews exisiting approaches to the validation of computerised knowledge models. The special requirements that the Modema project has for validation are explored and the validation approach that has been developed to meet these requirements is discussed.

Introduction

Validity testing is an essential part of the development of any computer system, or the development of any useful model. This principle holds particularly for knowledge based systems.

Traditionally in software engineering validation has meant testing the product against the requirements specification. However most knowledge extraction processes do not start with a requirements specification. A general area of expertise is established at the outset, but the process is more one of simultaneous exploration of the area of expertise and the requirements for the knowledge based system that is to be produced. For this reason the validation of knowledge based systems and their models is problematic and approximate. Partridge (1986) for example says "AI programs are not correct or incorrect: they are at best adequate....the ultimate test for an adequate approximation is that it displays no major inadequacies within its intended application environment"

Traditional methods of knowledge model validation

Mostly the validation of knowledge based systems has been limited to testing the system and evaluation of the output. In the worst cases the evaluation is carried out by the main knowledge engineer testing the system output on cases drawn from the data that provided the knowledge that the system embodies (MacGraw & Harbison-Biggs 1989).

The main methods of validation in use at present are:

- Simulation
- Testing
- Scenario testing
- Turing Test
- Walkthrough
- Review by expert or expert panel
- Review by end users.

The validation requirements of the Modema project

Modema: a pan-european project concerned with the development of a knowledge based system to support decision making, by three very different user types, in the area of the employment of people with disabilities, is described more fully in Hewitt and Sapsford-Francis (1992). The requirements of this project differ markedly from those prevailing in most knowledge based system developments. In the development of Traditional knowledge based systems there are relatively few experts within which the knowledge to be modelled is concentrated. Knowledge is usually extracted from these experts in an intense knowledge extraction process that may go on for a very long time indeed. For example Vervenne (1992) describes a range of methods that may be employed in context oriented knowledge acquisition they include:

- Familiarisation: which is concerned with establishing a relationship with the expert and integrating the knowledge extractor into the expert environment.

- Document analysis: here documents generated and used by the experts are used to provide a view of the expert domain. This method provides access to declarative knowledge about the domain of expertise.

- Field observation: experts are observed in their performance of daily tasks in the expert environment. This provides compiled and procedural knowledge about the domain of expertise.

- Interview methods: here the expert is approached directly to provide declarative and some compiled knowledge about the domain of expertise.

- Multi-dimensional methods: such as reprertory grids, card sorting etc. enables detailed elicitation of domain concepts providing both compiled and declarative knowledge about the domain of expertise.

The process of knowledge extraction is normally intensive and lengthy focussing on a highly restricted group of experts.

The Modema project faces a challenging scenario. The expertise is highly distributed. Indeed there is no truly integrated compilation of information on the employment of the disabled. This is one of the reasons that the project was initiated. There are no experts on the employment of the disabled. There are a large number of people with narrow bands of expertise. These narrow band experts can be grouped into three main types: the disabled themselves, potential employers, and those who advise the disabled in employemnt. Each of these narrow band expert types is also a potential main user type of the finished knowledge based system. As a user they would primarily be concerned in gaining access to the knowledge that the other narrow band expert types might have.

Additionally these narrow band expert types live in a five different countries. Geographical limitations mean that the task of knowledge extraction and subsequent knowledge validation must be carried out at a distance by practioners who do not normally do this kind of work. Consequently the validation approach must: be portable across international boundaries, be sufficiently well defined for non-expert practioners to use it and have an inbuilt method of consolidating results from a wide variety of sources and resolving conflicts.

The knowledge model

Knowledge extraction and modelling has produced an extremely complex knowledge structure, however a simplified view of the knowledge structure can be obtained by focussing consideration on seven main clusters of knowledge and the interrelationships between them (see figure 1).

In figure 1, each box represents a cluster of knowledge. The links between the boxes represent the mappings between the knowledge items in one box and an items of knowledge in another. These mappings also represent knowledge.

There follows a brief description of the mappings numbered in figure 1

1   for a given set of characteristics of an employee with a disability, it is possible to provide advice on how work functions may be carried out in general.
2   for a given type of work it is possible to specify a range of likely tasks that would be generally performed.
3   For a specific task it is possible to supply advice on how that task may be performed by an employee with a particular disability (1)

Given general advice for a specific task and a specific disbility profile it is possible to gain further and more specific advice on:

4   how to carry out tasks within the workplace
5   relevant legislation
6   relevant compensatory equipment

Given a particular disability profile it is also possible to access specific information on:

7   how to carry out tasks within the workplace
8   relevant legislation
9   relevant compensatory equipment

Fig 1 Modema High Level Knowledge Structure (Design Model)

```
  ┌─────────────────┐        ┌──────────────┐
  │   Employee      │        │   Type of    │
  │ Characteristics │        │    Work      │
  └─────────────────┘        └──────────────┘
                                     │ 2
              1                ┌──────────────┐
                              │     Task     │
                              └──────────────┘
                                3
        ┌───────────────────────────┐
        │ General Advice on Work    │
        │ Functions for disability  │
        │ Type                      │
        └───────────────────────────┘
      4                5                6
 ┌──────────────┐ ┌──────────────┐ ┌──────────────┐
 │ Detailed     │ │  Legislation │ │ Compensatory │
 │ Advice on    │ │              │ │  Equipment   │
 │ disability   │ │              │ │              │
 │ and          │ │              │ │              │
 │ Employment   │ │              │ │              │
 └──────────────┘ └──────────────┘ └──────────────┘
      7                8                9
```
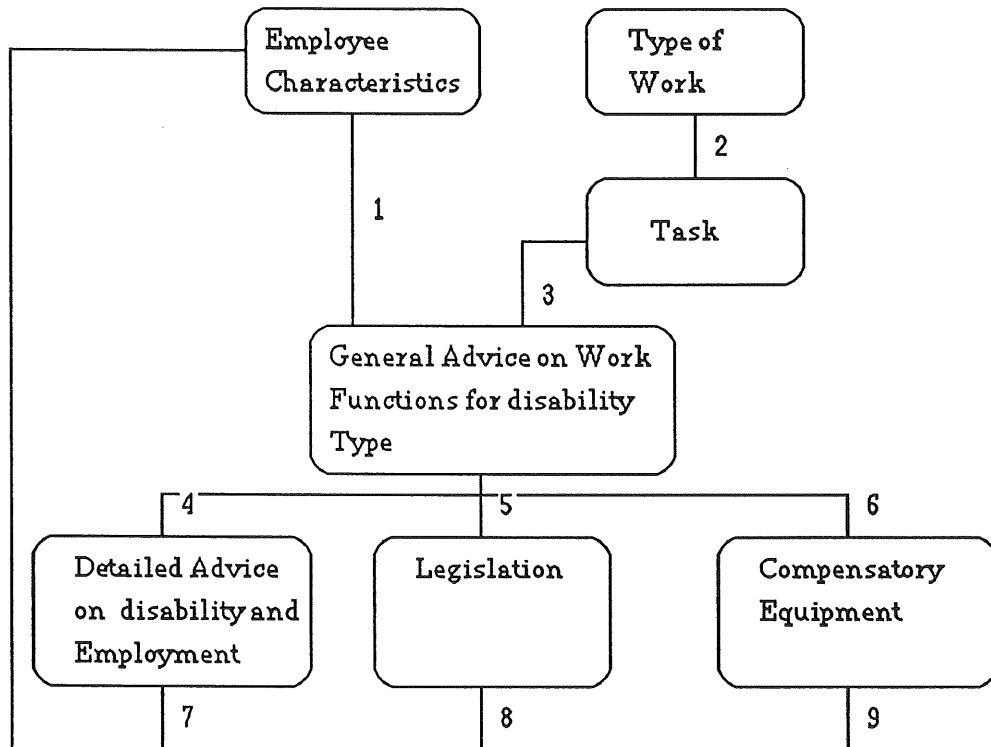
Figure 1 and its accompanying explanation represents the knowledge model that needed to be validated.

The knowledge structure is also separable into a number of regions or domains. These domains represent knowledge that is restricted in relevance in some way, for example to a particular user type, a particular locale or a particular country.

Methods of knowledge validation used in the Modema project

As described elsewhere (Hewitt and Sapsford-Francis 1992) one of the main methods of knowledge extraction used in the Modema project was the TOX method. This method builds upon the Generic Reference Model Approach to modelling working environments (Hewitt, Hobson and Sapsford-Francis 1990). To some extent the method provides a means of validating the existing knowledge model, however a broader approach to validation was required.

This broader approach was a scenario driven, prototype validation. This has brought its own problems in the form of internationalisation of the prototype software. In some of the participating countries use of the English language prototype has created too great a barrier for the potential evaluators -the narrow domain experts. How the issue of internationalisation of the prototype was handled is described in Halford, Hewitt and Weaver 1992.

The validation took place in each of the five participating countries. It was essential, therefore, that the validation procedure would be applied uniformly. Accordingly validation organisers for each country attended a validation workshop. Here the method of validation was explained and the organisers participated in an example validation session.

An early decision in the project was that validation and evaluation should be carried out by

samples taken from the population of the narrow domain experts that provided the expert knowledge in the first place. The confirmatory bias of hypothesis testers is well established (eg. Sanford 1987, Baron 1988). One way of avoiding this bias is to have the validation carried out by people who did not generate the hypotheses. We have seen that these knowledge sources are numerous and wide spread and that to carry out an effective validation narrow domain experts in all participating countries would have to be approached. Furthermore an adequate selection from the the three main types of narrow domain experts should be apporached: people with disabilities, employment advisors and employers. Access to experts has provideed a major bottle-neck in this project. Accordingly it was decided that knowledge extraction would proceed in tandem with system evaluation and validation.

An important part of scenario based validation is the selection of appropriate and representative scenarios. To use a scenario that has been the source of current knowledge does not adequately test the validity of a knowledge model. For this reason test scenarios were collected, independantly of the main knowledge extraction process, from local contacts. Scenarios provide rich contexts that enable problem solvers to access knowledge that may otherwise be hard to reach (eg. Sapsford-Francis, Britton and Brown 1992). It was also important to select appropriate sections of the knowledge model for validation. Appropriateness of a section of the knowledge model was determined by three main factors: the main user type of the narrow band expert validator, the narrow band expert validator's nationality and the locale within that particular national boundary.

Within each validation session three short scenarios were used to train the validators to use the prototype. They were then asked to carry out three specified test scenarios and comment on the usefulness and accuracy of the information provided. The validation session finished with the completion of a structured interview designed to ensure the validators views were captured as accurately as possible. Transcripts of the validator's responses were collated along with validator's name, experience, area of expertise, any useful background information, country and locale of testing, name of the validation organiser, date and version of the prototype.

The integration of this mass of data from five countries presented something of a challenge. Conflict resolution can be a serious problem when extracting knowledge from multiple experts, on the whole however, conflict resolution has not been a problem in the Modema project. The key to effective conflict resolution was the maintenance of audit trails to enable us to trace knowledge representation decisions back to the knowedge extraction or validation processes that gave rise to those decisions and the main factors that influenced those processes (the narrowness of each narrow abdn expert's expertise was also a relevant factor). To maintain and use these audit trails the following were important:

- recording the characteristics of the validator: name, experience, area of expertise, nationality and locale on which that expertise is based.
- recording the characteristics of the validation session: name of the validation organiser, date of the validation and version of the prototype.
- documenting all conclusions drawn from validation reports and referencing them to the reports on which they were based.
- documenting all decisions about changes to the knowledge structure nad cross referencing them to the conclusions above.
- all documents were annotated with counterindications from validation and knowledge extraction sources.
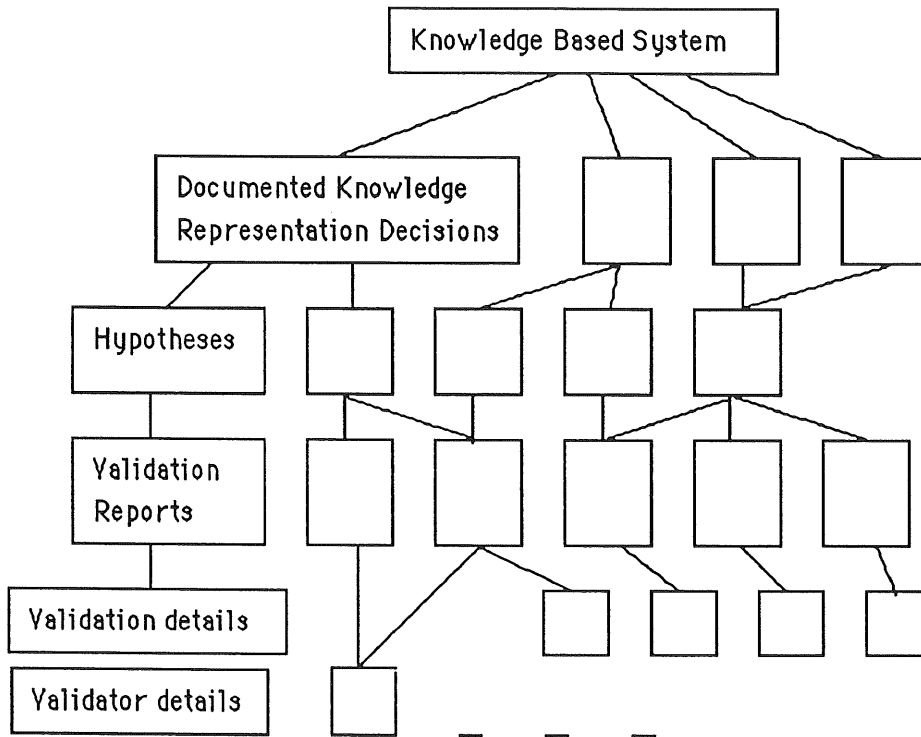
In the event of discovering conflicting knowledge the audit trail allowed us to to backtrack to the source documents and correlate factors such as: a particular validator, validation session, validation organiser, location, country or a version of the prototype (see figure 2). Thus it was possible for us to detect and rectify any problems with the validation process. In early validations a suprising range of errors were reported. Many of these apparent errors were found to be caused by variations in local practice: either in the way that local organisations and facilities catered for the disabled or in the way the validation was carried out. Where there was a conflict that was hard to resolve the subject of the conflict was made an explicit goal of the next phases of knowledge extraction. Later scenario testing allowed the targetting of specific experts for longer scenario based testing.

Currently we are investigating the incorporation of an annotation facility in the prototype system. This facility will allows users and validators of the system to annotate any screen giving their comments on the accuracy of the information or indeed filling in any gaps themselves. These annotations will be coded by user, date and country and after a given period will be read off into a

separate file and returned to the main validation organisers for collation.

Figure 2 The extended audit trail

Links can be followed upwards or downwards. This allows backtracking to source documents as well as forward tracking the consequences of lower level inputs.

Knowledge Based System

Documented Knowledge Representation Decisions

Hypotheses

Validation Reports

Validation details

Validator details

Conclusion

The demands of a knowledge extraction process that requires expertise from a large number of narrow domain experts from several different countries makes traditional approaches to the validation of knowledge based systems of dubious value. The Modema project team has developed an validation approach based on scenario driven prototype validation over distributed test sites. The approach depends on careful collection of information about validators and the circumstances surrounding the validation as well as the validation results themselves. All documentation is carefully cross referenced to support the detection of sources of conflicting knowledge by following audit trails.

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