DIVISION OF COMPUTER SCIENCE

MODEMA - A Knowledge Based Browsing System to Facilitate the Employment of People with Disabilities

Jill Hewitt
John Sapsford-Francis
Greta Bolstad
Olav Eftedal
Philip Halford
Dirk Vervenne
Michael Verheyen

Technical Report No.192

March 1994

MODEMA - A Knowledge Based Browsing System to Facilitate the Employment of People with Disabilities

Jill HEWITT, John SAPSFORD-FRANCIS
University of Hertfordshire, Hatfield, Herts, ENGLAND
Greta BOLSTAD, Olav EFTEDAL
SINTEF Unimed, N-7034 Trondheim, NORWAY
Philip HALFORD
Compris Consulting Limited, 56 Boycroft Avenue, London, ENGLAND
Dirk VERVENNE, Michael VERHEYEN
BIKIT, Plateaustraat 22, 9000 Ghent, BELGIUM

Abstract. This paper describes the stages of the MODEMA project which have been carried out to establish the user requirements for a computer system and to implement a prototype version. Sections describe the Market and User Analysis, the Knowledge Extraction methodology, modelling and implementation and the evaluation procedures. Finally, potential exploitation possibilities and future developments are discussed

1. Introduction

The MODEMA group is building a computer based system to assist with the integration of people with disabilities into paid employment. It is intended to provide help to three categories of user - employers, employment advisors and people with disabilities who are seeking work. The knowledge to be encapsulated in the system includes legislation and advice relevant to people with disabilities seeking employment, as well as details of specialist equipment to augment the abilities of 'differently able' people in various employment tasks. The system utilises multimedia technology to provide video and photographic information to enhance its information base. While supporting general database browsing facilties, the system also offers a task and user-profiling structure which provides a guided route through the data bases to enable the user to home in rapidly on the required information and to browse through relevant areas via a hypertext facility.

In the early stages of the project, a market and user analysis was carried out to establish the potential market for the system and the existence of relevant information in the participating countries. In order to ensure that diverse user requirements were met by the system an iterative prototyping approach was followed, allowing maximum exposure of the emerging system to potential users and enabling evaluations to be carried out throughout the project. The knowledge embodied in the system was captured through a program of structured interviews and questionnaires, designed to capture both general knowledge about working environments and the more detailed and diagnostic knowledge held by disability experts.

2. Market and User Analysis

In the process of collecting and compiling information which could serve as background information for subsequent knowledge extraction for the computer based system as well as describing the potential market for such a model, it became evident that the relevant data were either lacking or only available in a form not adequate for the MODEMA system. Data

describing the number and distribution of people with various types of disabilities, their level of education, current employment rate, legislation concerning disabled people as well as information on various available services, were collected in England, Belgium, Spain, Portugal and Norway, by the respective partners in the consortium. The initial aim of the work was to compare these data, treat them statistically and present them in a manner suitable for comparing living and working conditions for disabled people with those of the corresponding able-bodied populations in the five countries. However, it was apparent that available data suffered from various weaknesses.

In most of the five countries important information, such as level of education and annual income, was lacking. Other types of data may exist, but were not suited to be compared with corresponding data from other countries because the underlying basis and/or the statistics were not comparable. Even when based on the same survey, different publications may report different numbers describing the same topic. For instance for Spain, three different publications report that 7.6, 10 and 14.98% of the total population are disabled [1,2,3]. One report [4] argues that the number of people with reduced functions defined by fairly objective criteria is considerably larger than the number of people who acknowledge that they are disabled when asked about it. The information collected has been fed into a database, but due to the inconsistencies in the available data, the results are presented separately for each of the five countries.

The aim of the user analysis was to identify and describe the various categories within the frame of the project. Two main groups of user were identified: 1) users of the workplaces, i.e. the disabled person applying for work, and 2) users of the computer model. Potential users of the computer model may be: Advisors for and employers of disabled people, equipment producers or the disabled themselves. The informaiton collected through the user analysis is focussed on physical characteristics and performance and perception abilities for the different user categories. A brief discussion on how these characteristics and abilities may influence the funcitonal abilities of the person is also included, to help decide which tasks the particular disabled person may or may not be expected to perform adequately.

3. Knowledge Extraction

Three types of knowledge model were required for the system - models of working environments and their adaptation for people with disabilities, models of 'expert' knowledge relating to all aspects of the integration of disabled people, and models of the potential user groups. In each case, it was important to use a knowledge extraction technique suitable for the task in hand and to develop a method which would:
- be portable across international boundaries
- allow knowledge extraction by practitioners with varying degrees of expertise
- be usable in a wide variety of settings
- be capable of testing existing hypotheses about the knowledge base
- capture knowledge in a form that is readily convertible for input to the computer system

To build generic models of working environments, it was important to cover a wide range of scenarios in all the participating countries, and a task checklist approach - TOX [5] was considered appropriate since this gave a broad but shallow coverage of many work places. The elicitation of an expert's knowledge however could not be undertaken without an in-depth interview, so it was recognised that a smaller number of cases would be studied, but in much more depth. The models of users were developed through the prototyping and evaluation cycle, which are discussed in sections 4 and 5.

3.1 Task Oriented Cross Referencing (TOX)

This method utilises an iterative approach to building a generic model and is designed to be operated over several iterations, using a checklist that has been refined where necessary to better reflect the generic model. In addition to the checklist, a short questionnaire is provided

to elicit such details as job title, disability, length of employment, type of organisation etc.

A preliminary task analysis is carried out for a specified environment to develop a set of hypothesised generic objects and actions. These are represented on a "cross referenced checklist" which is used in subsequent knowledge capture interviews. The left hand side of the checklist contains lists of typical actions, grouped according to the 'role' to which they belong, so for example 'supervise staff' comes under the managerial role, whereas 'take minutes' and 'arrange meetings' is under 'administrative'. The role headings are there for guidance, but in practice most office jobs involve tasks from a number of roles, although they tend to cluster around one or two. In the shop floor environment, some jobs involve only a single task (e.g. 'counting'), although others such a 'maintenance engineer' encompass many different activities. Along the top of the form are a list of typical tools used to carry out the tasks, e.g. telephone, pen & paper, typewriter, memo etc. - but in the case of disabled employees these may need to be augmented by compensatory equipment - recorded on the right-hand side of the form.

Once the forms have been completed they are sent back to the 'expert' knowledge elicitors who use the information to refine and build the generic models of the workplace, and where necessary to amend the forms for the next knowledge extraction round. After the first knowledge extraction round it was decided to prioritise tasks on a scale of 1 to 5 rather than just marking them as core or peripheral. In addition, the vertical columns were discarded in favour of free-format text describing tools used for the job. The analysis of these forms is currently taking place.

The revised models of the working environments are fed into the prototype computer system which is used to validate the model against the knowledge of the end users.

3.2 Knowledge Extraction from 'Experts'

Two methods of recording an expert's knowledge were used for this project. The first, based on ADESCIRA [6] is designed to be used in conjunction with a fast prototyping approach. It uses a rule-based approach to create dependency trees and rule tables from raw interview transcripts. The steps of the method are as follows:
- **chunk** the information and if necessary pretreat any graphical data
- build a **topic tree**, which is useful for offering an overview of content and making a list of reference points useable in later phases
- build an **object-attribute-value** table - this is the main database of the model and records all entities with their prime functions their attributes and attribute values
- build an **object hierarchy** from which inheritance relationships can be derived
- build a **dependency tree** which shows interdependence between objects
- build a **rule table** to express the protocol's knowledge in the form of rules
- build a **lexicon** which defines all terms used in the model

This method is suitable for use on experts with extensive knowledge of a particular area - e.g. legislation relating to the disabled, however there was not enough time available in the project to use this method widely, so a second method based on a structured interview format was used to get a wider but shallower coverage of experts' knowledge in the major aspects of the system domain, these are the following:

Legislation: All aspects concerning legislation related to the integration of disabled people. e.g. What is the employment quota of disabled people?

Financial support: All aspects concerning grants related to the integration of disabled people. e.g. What grants are available to help an employer to adapt the workplace and buy compensatory equipment?

Service Institutions:All aspects concerning services and support related to the integration of disabled people. e.g. Which are the experts in the field who could advise?

Training and education: All aspects concerning training and education related to the integration of disabled people. e.g. What training courses can be followed?

4. Modelling and Implementation
At the heart of the system are currently three databases - compensatory equipment, legislation

and advice. These can be browsed in 'normal' database mode, but the strength of the system lies in the fact that it allows a multiperspective view of the information, based on the task models of the working environment and disability profiles. In this mode, a user will:

- select a disability profile (e.g. severe visual handicap)
- select a working environment (e.g. office)
- select a task from the list of tasks presented (e.g. arrange meetings)
- be presented with a list of activities related to this task for which further information is offered for the selected disability (e.g. reading, writing, telephone use)
- select an activity (e.g. reading)
- be presented with a page of free text (the equivalent of an expert's knowledge) with hypertext words which can be selected to take them to relevant parts of the information base.

The prototype systems are written in Knowledge Pro to run under Microsoft Windows on any standard PC. Photographs of equipment are included in the equipment database, and video clips show compensatory equipment in use in working environments. Case studies relating to disabled employees can be accessed to provide further insight into various aspects of the knowledge base.

5. Evaluation

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

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 e.g. [7,8]. One way of avoiding this bias is to have the evaluation carried out by people who did not generate the hypotheses. We have seen that these knowledge sources are numerous and widespread 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 three main types of narrow domain experts should be approached: people with disabilities, employment advisors and employers. Access to experts has provided a major bottleneck in this project since there are relatively few experts and each one typically has expertise in one aspect of the field. Accordingly it was decided that knowledge extraction would proceed in tandem with system evaluation and validation.

An important part of scenario based evaluation 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, so for this reason test scenarios were collected from local contacts independantly of the main knowledge extraction process. Scenarios provide rich contexts that enable problem solvers to access knowledge that may otherwise be hard to reach (e.g. [9]).

Within each evaluation 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 evaluation session finished with the completion of a structured interview designed to ensure the evaluator's views were captured as accurately as possible. Transcripts of the evaluator's responses were collated along with the evaluator's name, experience, area of expertise, any useful background information, country and locale of testing, name of the evaluation organisor, 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 resoultion 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 track knowledge representation deceisions back to the knowledge extraction or validation processes that gave rise to those decisions and the main factors that

influenced those processes. To maintain and use these audit trails, the following were important:

- recording the characteristics of the evaluator: name, experience, area of expertise, nationality and locale on which that expertise is based
- recording the characteristics of the evaluation session: name of the organiser, date of the evaluation and version of the prototype
- documenting all conclusions drawn from evaluation reports and referencing them to the reports on which they were based
- documenting all decisions about changes to the knowledge structure and cross referencing them to the conclusions above
- all documents were annotated with counterindications from evaluation and knowledge extraction sources.

6.0   Exploitation and future developments

By the end of the project, the team will present a working demonstrator system with the following features:
- customised interfaces for the three user groups, to take into account expert and novice modes
- specialist interfaces for blind and motor handicapped users
- examples of all types of information, with approporiate photographs and video clips

If the funding becomes available, the work of MODEMA will be extended to provide a system that will support pan-European information flow. This will incorporate Structured Annotation to allow users to update information, support for management of the data by domain experts, the further development of non-standard interfaces for use by people with disabilities, and a generic system that will assist in the translation process for data input to the system, facilitating translation by language experts with no system domain or computer expertise.

In order to implement such a system, there is a need to establish an infrastructure for a pan-European information system, based on centres of expertise, with clusters of sites attached to each centre.

7.0   References

[1]   Ministerio de Asuntos Sociales: Las personas con minusvaia en Espana, Madrid, 1989.
[2]   The United Nations: The United Nations Disability Statistics Microcomputer Data Base (DISTAT), Version 1, 1988.
[3]   Alfonsin E.T, Ferruelo M.G: Survey of impairments, disabilities and handicaps in Spain, in: International Journal of Rehabilitation Research, Vol. 12, No. 2, HVA. Edition Schindele, 1989.
[4]   Fredriksen J, Martin M, Puig de la Bellasca R, Von Tetzcner S : The use of telecommunication: The needs of people with disabilities. Fundesco and Telefonica, COST 219, Madrid 1989.
[5]   Hewitt, J. and Sapsford-Francis, J. 1992 A Knowledge Extraction approach for capturing dispersed knowledge and its application to the modelling of working enviornments for people with disabilities. International Cybernetics Conference, Namur.
[6]   Vandamme, F. Vervenne, D. 1991, The Adescira versus KADS/SKE KT Methodology. BIKIT Library Bulletin Vol 5. nr. 6 pp 98-103
[7]   Sanford, J. 1987 The Mind of Man, The Harvester Press.
[8]   Baron, J. 1988 Thinking and Deciding, Cambridge.
[9]   Sapsford-Francis, J. Britton, C. and Brown, J. 1992 Problem Solving (..in Computer Science) ISTIP '92, Proceedings of the 5th UK Conference.