The MR Tutor: Computer-based Training and Professional Practice

M. Sharples, J.B.H. du Boulay
B.A. Teather, D. Teather, N. Jeffery
G.H. du Boulay

CSRP 393

his paper was published in the proceedings of the World Conference on Artificial Intelligence and Education AI-ED 5), Washington, USA, 1 5, 42 -436.

November 1995

ISSN 1350–3162

UNIVERSITY OF

Cognitive Science
Research Papers

The MR Tutor: Computer-based Training and Professional Practice

M. Sharples, J.B.H. du Boulay
School of Cognitive and Computing Sciences, University of Sussex,
Brighton, BN1 9QH, U.K.
Tel: +44 (0) 127 606755 Email: rad@cogs.susx.ac.uk

B.A. Teather, D. Teather, N. Jeffery
Medical Systems Research Group, School of Computing Sciences,
De Montfort University, Leicester, LE1 9BH, U.K.

G.H. du Boulay
(*Visiting Professor at the Medical Systems Research Group, De Montfort University*)
Institute of Neurology, Queen Square,
London, WC1N BG, U.K.

Abstract

The MR Tutor is intended for use by radiologists who are being trained to interpret MR images of the brain, particularly images presenting diseases that are acknowledged to be hard to differentiate. We have developed an image description language for MR images of the head suitable for a wide range of image sequences. The language is image-based, not pathology-based, and is used to describe the images as they present themselves rather than to classify the pathology which may be indicated in the image. We have established a dedicated archive of cases that illustrate a range of pathologies. This archive provides a substantial part of the domain knowledge for the MR Tutor. This paper is concerned with accounts of professional practice and skill development, and how these provide requirements for the design of the MR Tutor and similar systems.

Developing an effective computer-based system for professional training poses many additional problems compared to computer-aided instruction in an educational setting. A central difficulty is that of gaining the confidence of the trainee. The trainee must be convinced that it is worthwhile investing time in learning and operating the

We have already developed a detailed MR image description language suitable for a wide variety of image sequences. This language, with each case described in terms of a vector indicating the presence of absence of image features, provides the domain knowledge for the MR Tutor. The Tutor under-development deals with two distinct training issues: (i) training radiologists to view and describe an MR image set of the brain in a systematic manner, and (ii) training radiologists to make reliable diagnoses, especially in the case of confusable diseases.

The MR Tutor is currently being implemented using HiPWorks, a multimedia extension to the Poplog programming environment, running under X-Windows on Sun workstations.

This paper is concerned with the process of designing the MR Tutor, in particular with the ways in which accounts of professional practice and skill development are providing requirements for system design. A companion paper describes how theories of categorisation and concept teaching have provided us with a further set of guidelines for the design of the MR Tutor, and how these guidelines have been realised in the prototype system (Sharples et al., 1994).

1 Professionalism

Professionalism is both an ideology and a practice (Eraut, 1994). Seen as an ideology, a profession is a means of providing services that the general public are not competent to practice or evaluate. The emphasis is on careful recruitment to the profession, shared knowledge, and agreed standards of skill and behaviour. From the classroom to the police interview room, professionals must not only be competent, but also publicly accountable, and they need to protect themselves against misinformation and carelessness.

One means of providing accountability is to develop a more structured approach to the task, and to ensure that activities are recorded and can be evaluated by colleagues. Such an approach should lead to the establishment of guidelines for best practice based on a core of shared procedures and common terminology and thus restrict maverick behaviour.

As a practice, professionalism is situated in the confusion and uncertainty of the everyday world. Professionals sometimes work to tight schedules and cannot always afford to gather 'crystalline' evidence to support their decisions: "One whose work requires practical application to concrete cases simply cannot maintain the same frame of mind as the scholar or scientist." (Friedson, 1971 cited in Eraut, 1994).

This is the central tension of professionalism: the work is situated in a complex environment, relying on partial knowledge and requiring time-pressured decisions, but the results of that work must be made accountable in a well-structured form to clients, colleagues and the law. Nowhere is this tension stronger than in the medical professions.

One way to address this problem is to provide a shared 'conceptual framework' for the profession: a set of publicly available terms, structures and techniques that provide a means of communicating knowledge to colleagues, and a common language with which to record activities and justify decisions. The medical profession is devoting great effort to developing standard terminologies to describe symptoms, pathologies, and the content of medical images (e.g. Rector et al., 1994; du Boulay et al., 1994). The computer can play an important part by providing a means of storing and accessing the shared language, with the terms cross-referenced and accompanied by definitive examples.

Another approach to squaring the demands of professional practice with the need for competence and accountability is to promote the "reflective practitioner" (Schön, 1983), by encouraging professionals to reflect on their work and to develop strategies for evaluating and restructuring their actions. This can take place on the job (reflection-in-action), usually prompted by a breakdown in routine or an abnormal event, or after the job has finished when the professional attempts to make sense of the experience and learn from it. Again, the computer can contribute, by providing cases and events for comparison — along with strategies for repairing breakdowns — and an environment that simulates working practice but in a more structured, controllable form, to assist reflection and experiment.

Computer-based 'coached practice' environments such as SOPHIE (Brown et al., 1982), SHERLOCK (Lesgold et al., 1992), the Recovery Boiler Tutor (Woolf et al., 1986) and IDM (Fink, 1991) are examples of successful systems for training in complex skills. The theory of cognitive apprenticeship (Collins et al., 1989) that underlies these systems is appropriate to training in the professions, but it needs to be supplemented by a more specific set of requirements for system design. Eraut (1994) suggests that any framework for promoting and facilitating professional learning will have to take account of:

- an appropriate combination of learning settings (on-the-job, near the job, home, library, course, etc.);
- time for study, consultation and reflection;
- availability of suitable learning resources;
- people who are prepared (i.e. both willing and able) to give appropriate support;
-

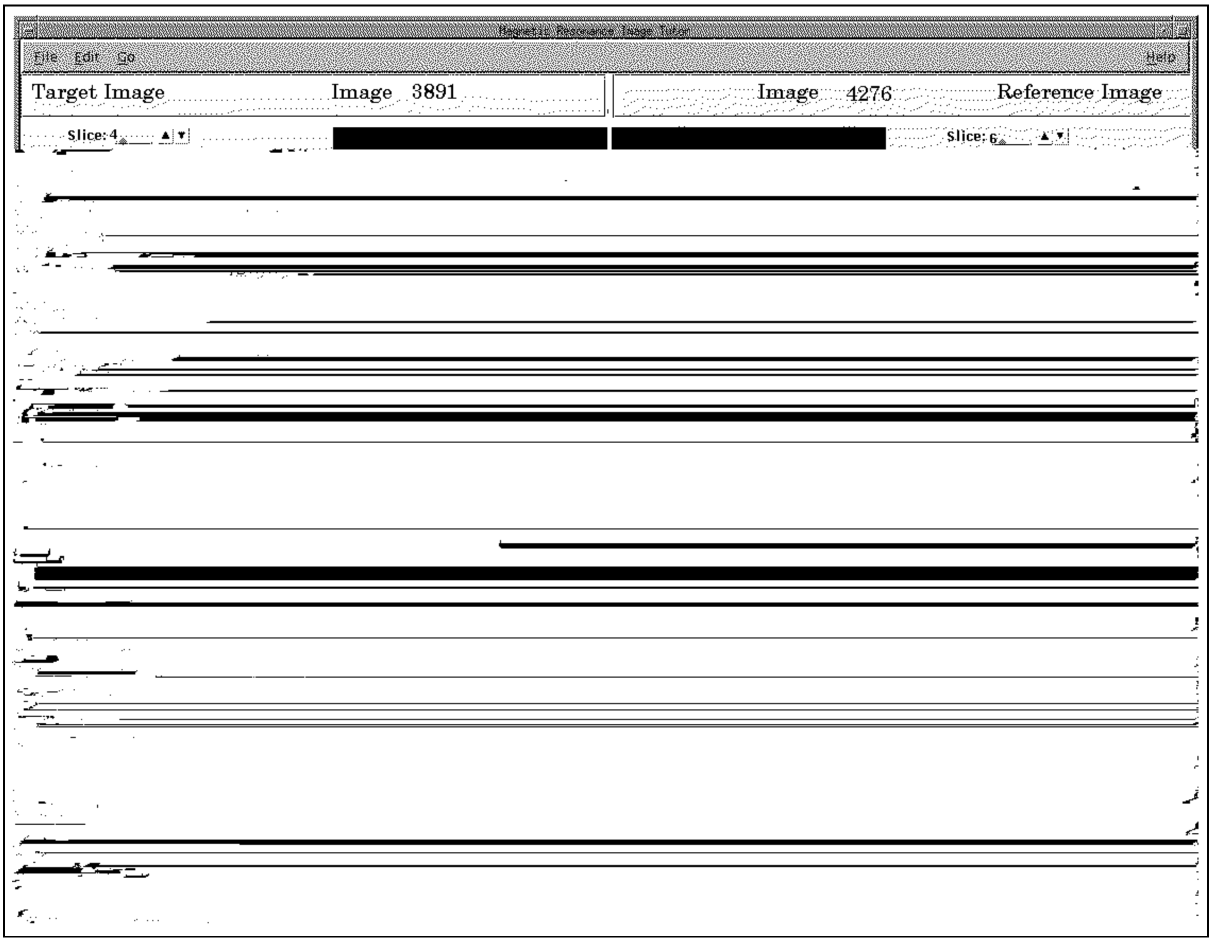

Figure 1: Interface for image description

3.1 Authentic and up-to-date material

We have developed an *image description* language for MR images of the head suitable for a wide range of image sequences. The language is image-based, not pathology-based, and is used to describe the images as they present themselves rather than to classify the pathology which may be indicated in the

```
Margin
     Mainly sharp
     Graded
Shape
     Rounded
     Irregular
             Area: sq. cm.
     Conforming to an anatomical feature
Interior Pattern
     Homogeneous
     Heterogeneous
     Containing a distinct focal structure
```

Figure 2: A portion of the Simplified Image Description Language relating to the appearance of a lesion

vides a canonical set of feature descriptors. These are being implemented in the MR Tutor as a frames system in which the features are represented by slots whose fillers indicate feature values.

3.2 Appropriate presentation of learning materials

There is an issue in providing tutoring material based on complex images, of how to give the trainee an overview of the entire image archive. Can we provide an index to the images based on visual appearance? How can the Tutor select images for teaching in an ordered sequence according to typicality, similarity and probability of category membership? This is part of a more general problem of storing and accessing visual material for picture archives, on-line reference libraries and multimedia presentations.

MR images for a particular 'sequence' (i.e. images generated according to a particular menu of gradient currents etc.) are organised into a stack where each image corresponds to a 'slice' through the head. A complete stack in a particular orientation will normally consist of more than twenty slices. A case will often consist of more than one stack of images generated under a different sequence or at a different orientation.

Each image stack in the MR Tutor archive is associated with a full expert description using the terms of the image description language. The set of descriptions form a 'feature space' where points in the space indicate exemplar cases and regions represent categories (pathologies). The statistical technique of Multiple Correspondence Analysis can take a high-dimensional space of nominal descriptors and display them as a two-dimensional scatter plot, or 'overview space', that represents as much of the variability of the feature space as possible. The technique makes no assumptions about independence of feature values. The space can be scaled so that the typicality of a case is proportional to its distance from the centre of the plot, and the similarity of any two cases is proportional to their nearness in the plot (Teather et al., 1994). By 'typicality' we mean 'central tendency' of a category rather than 'frequency of occurrence' of a case.

An example of an 'overview space' is shown at the lower right of Figure 1. This shows 17 cases for a particular pathology, where each case is indicated by a small circular point. The circle for the fairly typical case, currently the subject of tutoring (number 3891), is shown darker than the rest. The circle for a similar reference case (number 4276) is shown lighter than the rest. One image from the stack or series available for this case is displayed in the reference image window and was selected for display by 'clicking' on the point in the overview space.

The trainee can see at a glance which are typical cases (nearer the centre) and which are atypical or can select similar cases by directly clicking on adjacent points in the overview space for that pathology. The contours in the overview space indicate the degree of typicality. The training can thus incorporate appropriate exposure to both typical and atypical cases — the former otherwise sometimes being overshadowed by the latter in training (Schmidt and Boshuizen, 1993). When the trainee is choosing a feature value for an image (see lower left hand side of Figure 1) the overview space can light up those points which have the same feature value, thus providing a ready indication of which other images in the