Chapter VIII

Knowledge Engineering in Adaptive Interface and User Modeling

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ABSTRACT

This chapter presents the issues of user modeling and its role in adaptive human-computer interface (HCI). Particularly, it focuses on knowledge acquisition and representation in user modeling. Several related problems in the traditional user modeling systems are also identified and discussed.

ADAPTIVE INTERFACE AND USER MODELING

The concept of an adaptive human-computer interface (HCI) has been recognized as a very promising and challenging area for both research and applications (Norcio and Stanley, 1989). The objective of an adaptive interface is to adapt system responses to the user effectively in a complex computer-based task. In the context of human computer interaction, the relationship between a human and a computer involves many factors such as the computing environment, the nature of the tasks to be performed, as well as various characteristics of the users. The effectiveness of a human-computer interface system is influenced greatly by its ability to adapt to these factors.

As the functionality of computer systems becomes more complex and users’ tasks vary, users must adjust their behavior and problem solving strategies to the systems. This situation is often made worse because users lack the knowledge and experience to be effective. A well-designed interface can provide much more helpful information in a more appropriate manner during the interaction, especially for those users who have limited experiences. Therefore, an adaptive interface is not only beneficial for users but also for system resources management since the tasks and the related resources are better allocated between user and the computer.

Generally, an adaptive interface should be able to offer an effective interaction and allocate tasks dynamically between the user and the computer system. It is not unusual that users are frequently confronted with an overwhelming amount of information in interacting with computers. Users must decide what information to request and use. In these situations, it has been found that users do not usually perform optimally (Card, Moran and Newell, 1983). In addition, users may not have the necessary information or expertise to adjust their
behavior. The adaptability of an interface is helpful for the users with different backgrounds, because the interface system can individualize its responses. An adaptive interface can increase user proficiency with a new system and allow novices and experts to use the system with equal ease.

To adapt to a user effectively and correctly, an interface system must be able to characterize and distinguish individual users. User modeling, a process of establishing a collection of the system’s beliefs about various users’ characteristics, has become an important component in adaptive interface systems. An interface equipped with user modeling component is able to tailor its responses to individual users. Generally, an adaptive interface has the following advantages:

- **Economy of the interaction:** The dialogue may be short, more precise, better focused and understandable. Since system responses can rely on default knowledge already stored in the user model, the system knows what the next optimal response should be to help the user perform the task.
- **User acceptability:** The dialog is individually tailored. Thus, it becomes more acceptable to the user. In addition to providing a clearer dialogue, a user model can provide the basis of explanations of the solution to users. It can also detect the user’s misconceptions in the task performance; and therefore, it can provide justifications for the adaptation.
- **Effectiveness and efficiency of use:** The access to the target system and its use may become more effective and efficient, in terms of both quality and cost of the performance.

Research in the field of user modeling dates to the early seventies (Self, 1974; Bruce, 1975; Allen and Perrault, 1978; Cohen, 1978; Rich, 1979). It is widely recognized that computer systems should adapt to users in an intelligent and cooperative manner. It is also evident that computer systems can acquire these capabilities on a large scale only if they have the knowledge about users and the tasks that the users are performing. Constructing, maintaining, and utilizing user models has become an active research area. Since the mid-eighties, user modeling research has focused on four different but interrelated domains: human-computer interface (Murray, 1987; Dede, 1986; Botman et al., 1987), natural language dialog systems (Wahlster and Kobsa, 1989), intelligent tutoring systems (Self, 1974; Kass, 1989; Selker, 1994), and information retrieval (Daniel, 1986; Allen, 1990; Kramer et al, 2000). From the viewpoint of system functionality, user modeling can be considered as a component of the interface for optimizing human-computer interactions.

Some studies of user interface management systems (UIMS) partially address adaptation of information displays based on features of the system’s operation (Eberts and Eberts, 1989). With the UIMS approach, the interface becomes an important and separate system component to which software engineering techniques are applied. The UIMS approach facilitates interface design by providing a set of tools. A UIMS provides a definition language for representing the dialogue required and a generator that automatically produces the necessary code from a source definition in this language. A UIMS typically includes screen generation tools, a graphics package, and editors for help messages, error messages, prompts, forms, icons, and so on. The typical runtime functions are management of multiple windows and conversion of task output to user representation. However, the characteristics of users and tasks to which the system needs to adapt are not emphasized. The UIMS approach provides a flexible and reliable interface design strategy, but fails to make the interface adapt dynamically because the underlying cognitive models
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