Adaptive TEL based on Interaction Traces

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Abstract. The scientific objective of this work is to develop an Adaptive Technology Enhanced Learning System (TEL) able to observe, by various means, the learner's actions in order to understand his/her behaviour and to response in real time by adequate reactions taking into account people with disabilities. Indeed, in most current computer systems, the interactions between the learner and the system are usually specified by the designer in the conception process and do not take into account the history of the learner and its evolution. The approach we advocate in this work is to use Interaction Traces as Knowledge Sources that can be discovered and exploited by the system. The Interaction Traces here are defined as a history of learner's actions collected, in real time, from his/her interaction with a computer system.

Keywords. Adaptive Systems, Interaction Traces, Technology Enhanced Learning, Accessibility, Disabilities.

Introduction

Adaptive Interactive Systems are characterized by the ability to adapt themselves to the user and use context. Among the factors that motivate this form of adaptation: personalization of interaction, flexibility of use, etc. Traditionally, we distinguish two kinds of adaptation, namely:

- Content adaptation according to knowledge and goals of the user,
- Interface adaptation according to preferences and skills of the user.

The limitations of most existing approaches concern mainly the lack of consideration of cognitive and physical capacities of the user. Indeed, on the one hand, user capacities have a strong influence on his ability to efficiently carry out his tasks. On the other hand, they determine the way in which the user can interact with the system or perceive its state. This information is essential, particularly for taking into account people in "disability situations" and, more broadly, is potentially useful to everyone (eg a person aged, a person in a situation where his hands his eyes are embarrassed or occupied).

In this area, the question we are concerned with is how a computer system can progressively learn from its interactions with users, including people with disabilities. The approach we advocate is to use the Interaction Traces as Knowledge Sources that can be exploited by the system in order to adapt its reaction to users. It consists in generating adaptive scenarios, suitable interaction modalities, personalized interfaces,

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etc. according to needs, profile and behaviours of each user. The proposed scope of our project focuses in improving TEL accessibility for people with disabilities.

This paper is organized as follows. The next section presents and discusses related work on adaptive systems. Section 2 describes the principle of our architecture. The use of interaction traces for improving adaptive behaviour of system is detailed in section 3. Finally, section 4 presents the conclusion and perspectives.

1. Related work

According to Oppermann [3] a system is called adaptive "if it is able to change its own characteristics automatically according to the user's needs". Adaptive systems consider the way the user interacts with the system and modify the interface presentation or the system behaviour accordingly. So, the adaptive systems receive the information about the user from observations of the user. Several work on adaptive systems, in various application area, have been developed. For example, [6] proposes an Adaptive environment of Interactive Educational Games for Autistic Children, [5] developed Nomadic Radio System that dynamically selects the relevant presentation for incoming mail, voice mail, hourly news broadcasts, or personal calendar events based on message priority, user activity and the level of conversation in the environment. NetCoach system [8] provides a way to assess the users' prior knowledge and to adapt the course in different ways.

In these systems and in the majority of existing approaches, the architectures basically consist of three main components as pointed out by [9]:

- The user model represents the system's beliefs about the user (learner model, profile model, psychological model…),
- The domain model defines the aspects of the system and the world that are important for inferences, e.g., functions that might be altered.
- The interaction model handles the dialog between the user and the application.

However, to our knowledge, there is no model that proposes an adaptive approach, based on Interaction Traces, which takes into account the history of the user and his evolution. The history is a diary of activities suggested by system and the results carried out by user. It allows tracking of the evolution of the user and is also at the origin of many rules of decision.

2. General architecture

The figure 1 shows the general architecture of the system. Initially, the expert feeds the system with the domain knowledge. It is a set of scenarios related to the training objectives. Thus, this knowledge and the user profile will be used, in a reasoning process based on Case-Based Reasoning [6], to generate an adaptive learning scenario taking into account the suitable interaction modalities. For example, the system can read a text for blind people, enlarge the font size for visually impaired people, etc.

During the interactions between the user and the system, all the user actions are stored in an Interaction Traces. A Traces Management System (TMS) uses in real-time these traces as sources of knowledge in order to control the scenario execution. TMS allows also using interaction traces to update domain knowledge and user profile, which are represented by a Dynamic Bayesian Network.

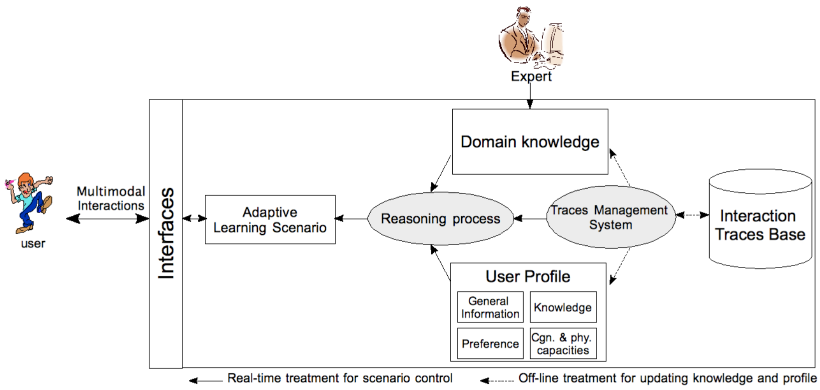

Figure 1. General architecture

The idea of our approach, based on *k-means* clustering algorithm, is to update the structure of the Bayesian Network (BN) by analyzing the values of observed variables (the evidence variables of BN) in order to create/modify node(s) or relation(s) between nodes.

3. Adaptive behaviour based on Interaction Traces

The scientific objective here is to illustrate the close links between the Interaction Traces and Knowledge Discovery in the adaptive systems area. In this section, the transition from interaction traces to knowledge discovery is studied in depth and we present mechanisms used for personalizing user interfaces using multimodal interactions.

1.1. From traces to knowledge discovery

The Interaction Traces are defined as a history of learner's actions collected, in real time, from his/her interaction with a computer system. Formally, a trace is represented by a sequence of observed values generated from the interaction user-scenario. The scenario is a set of observable nodes generated by reasoning process from Bayesian Network.

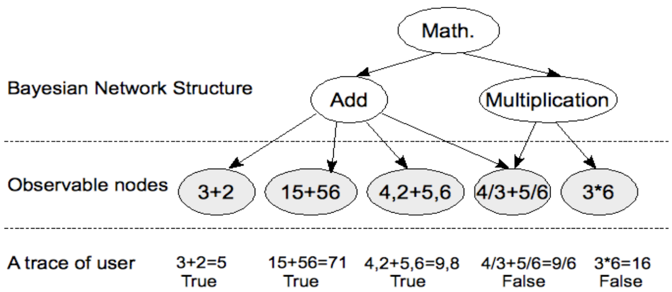

Figure 2. Example of Bayesian Network and interaction trace

The Interaction Traces of each user can be used by the system in order to adapt the learning scenario to the user and also to update the knowledge domain and the user profile. The figure 2 shows an example of a Bayesian network and the corresponding trace. The analyse of the trace of the user allows, on the one hand, to draw conclusion on the user profile concerning the basic arithmetic operations. On the other hand, the reasoning process can generate exercises more difficult on addition and other activities that explain the multiplication.

These interaction traces can also be used by the user for analyzing his productions (See for example [1]). By doing this, we add a reflexive dimension to the user's activity, intended to help him apprehending its environment, making a better usage of it, and then improving the productivity of its activity.

1.2. Multimodal user interfaces for improving systems accessibility

According to Oviatt [4], multimodal interfaces have the potential to accommodate a broader range of users than the traditional interfaces. As a result, providing to the users systems with fine tailored, personalized multimodal interfaces will improve systems overall accessibility, all the more for people with disabilities [7].

The difficulty of taking into account multimodal interfaces, in Adaptive Interactive systems area, is mainly due to the choice of appropriate modalities, i.e. that best suit cognitive and physical capacities of the user. To do this, we plan to use special mechanisms for setting user preferences (see [2] and ISO/IEC 24751-2:2008[2]) according to the type of educational content that can be specified using ISO/IEC 24751-3:2008[2]. Generally speaking, it consists in comparing the properties of each modality with cognitive and physical capacities of the user in order to detect possible incoherence and to determine the preferred interaction modalities. For example, the presence of a disability that affects ability to use the computer with a gestural mode of interaction, or visual impairments that require the use of screen readers, etc.

Interaction traces are used here to adjust user preferences, detecting the habits of the user concerning content presentation, content scanning, etc. Concerning presentation for instance, if a user, with a given visual impairment, often zooms in to enlarge size of specific fonts, system analyse of these interaction traces can result in a better adjustment of fonts or/and font sizes that will be used. Moreover, the system in some cases can suggest a bimodal presentation of the content, e.g. a visual presentation and an audio presentation.

4. Conclusion

This paper presents an approach of adaptive TEL based on Interaction Traces. It consists in taking into account the history of the user's actions in order to adapt in real-time the system reaction, particularly, the learning scenarios and user interfaces using multimodal interactions.

The proposed representation of interaction traces allows to update the knowledge domain and user profile that are represented using a Dynamic Bayesian Network. The idea of the approach is to use *k-means* clustering algorithm in order to update the Bayesian network structure.

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[2] http://www.iso.org/

The first obtained results by simulation are interesting and promising. However, more experiments are needed to validate the proposed models and architecture, particularly a TEL environment area.

Future works include the verification of the scenarios coherence. Indeed, the adaptive scenarios may cause some inconsistencies in the overall logic of the learning session.

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