INTERACTION PROCESSING OF A COGNITIVE EDUCATIONAL SYSTEM

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Keywords: Intelligent educational systems, User interface, Cognitive tutoring.

Abstract: This paper briefly describes some of the modelling work of intelligent web-based educational systems with cognitive monitoring. Specifically, it focuses on the interaction process consisting of a processor based on mental models and several interaction environments related to interface devices. Both systems work together to regulate the student learning process through controlling working memory load, focusing attention and presenting knowledge in conceptual-semantic format. These features require an object-oriented rich web interface.

1 INTRODUCTION

User interfaces of educational systems have followed a parallel development to the information and communication technologies improving their capability of interaction and presentation. The old interfaces with command-line textual interaction were replaced by GUI/WUI (Graphical User Interfaces / Web User Interfaces) with hypermedia interaction. The complexity of new requirements for higher interaction, adaptability and student monitoring has changed the interface designs from traditional Web browser to the more sophisticated Rich Internet Applications (RIA). These interface applications enable the deployment of new features like conversational agents (Rus & Graesser, 2006; Tarau & Figa, 2004; Cassell et al., 2000), 3D navigational environments and physical agents, which reduce the ambiguity of linguistic communication through additional emotional information (Zakharov et al., 2008; Forbes-Riley et al., 2008; Prendinger & Ishizuka, 2005).

Diversification of media devices (Internet, Mobile, PDA) and content globalization has promoted integration initiatives as the Edit@ project (www.proyectoedita.org), mainly devoted to the creation of specifications for resources and user synchronization such as: SMIL (Synchronized Multimedia Integration Language), AAIML (Alternate Abstract Interface Markup Language), AUIML (Abstract User Interface Markup Language), UIMLA (User Interface Markup Language) , XIML (eXtensible Interface extensible Markup Language), Swing and XUL (XML-based User-interface Language).

This paper presents a generic interaction architecture in the context of intelligent web-based educational systems, especially those focused on cognitive control (Arrabales & Sanchis, 2008; Chong et al., 2007; Pinker, 2007; Lehman et al., 2006; Huss et al., 2006; Bach, 2003; Anderson & Corbett, 1997). The model must be scalable, interoperable and designed to monitor mental processes involved in the teaching-learning process. This work is part of an ontology modelling project called COES (Cognitive Ontology of Educational Systems), implemented on two different intelligent educational systems: TIX and MAP. The first approach is a traditional adaptive web-based educational system while the second one is an adaptive rich-interface educational system with cognitive tracking. The TIX system is used to obtain baseline data to be compared with that from the MAP system.

In the following section, the COES model of interaction is introduced. Sections 3 and 4 describe the main components of the interaction domain in the MAP architecture: a mental processor and a conceptual interface.

Caravantes A. (2010).
INTERACTION PROCESSING OF A COGNITIVE EDUCATIONAL SYSTEM.
In *Proceedings of the 2nd International Conference on Computer Supported Education*, pages 387-390
DOI: 10.5220/0002771603870390

2 INTERACTION MODEL

The traditional Intelligent Educational Systems (IES) architecture keeps a functional division in which a processor uses the rules of a pedagogical/adaptive model to select content from a domain model depending on a student model. In COES proposal we have opted for architecture composed of three functional domains as shown in Figure 1. The educational domain encodes knowledge involved in the teaching-learning process. The personal domain estimates the characteristics and state of the student, and simulates his behaviour. The interaction domain, subject of this paper, facilitates communication with the user and includes the user interface and the control unit.

Dynamics of web-base educational systems requires dividing the interaction domain into two subsystems (Figure 1): an environment that interacts on sensory level with the user (IE-Interaction Environment) and another subsystem (IP-Interaction Processor) that processes all communication with educational and personal domains, and regulates the interaction with the user applying perception laws and cognitive control. Typically, IE and IP run on separate computers linked by some kind of logical connection. This functional division allows having a single processor (IP) for multiple environments (IE) and thus adapting the teaching-learning process to the physical display constraints and allowing ubiquitous-learning.

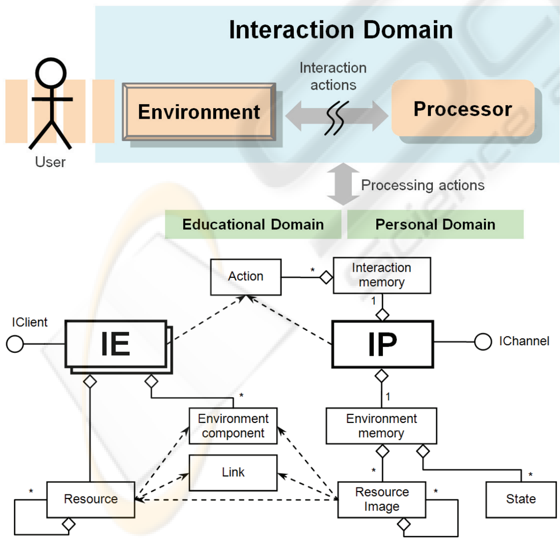

Figure 1: Scheme of COES architecture focused on the interaction domain.

Wide system communication takes place via an action-based protocol. Depending on the direction of the communication we have two interaction types: *Activators* come from the environment and are generated by the user behaviour and *Actuators* generated as responses by the processor.

The processor (IP) controls system running along all domains and performs the following functions: origin detection and validation, execution control by priorities, response monitoring and process-time control.

3 MENTAL PROCESSOR

The processor (IP) of the MAP system is composed of interconnected units called nucleus working in parallel. These cells set an architecture based on mental processing to enable the learning monitoring by simulation. An interaction response is made by a 3-stage sequential process laid out by the following subsystems (Figure 2):

– **Sensory System.** It processes the inputs from the environment using 3 nuclei: Origin, Trace and Message. The first identifies the user and focuses the attention of the system. The second processes all actions in the environment to refresh the memory of remote monitoring. Finally, the message nucleus transforms student communications into internal signals.
– **Processor System.** It keeps track of pending processing internal signals of the working memory called gaps, and controls its processing priorities. It is composed of three main nuclei: Attention, Memory and Control. The first focuses and fills internal signals in the working memory. The second accesses, updates and reinforces the content of the working memory. Finally, the control nucleus regulates execution through the selection of pending gaps. During processing, these nuclei activate other ones in complementary subsystems like cognitive, perceptual, emotional, and behavioural.
– **Motor System.** It converts logical actuators generated by the processor system into physical actuators and motor actions that are sent to the environment. This conversion is based on parameters of cognitive load and attention capability of the user.

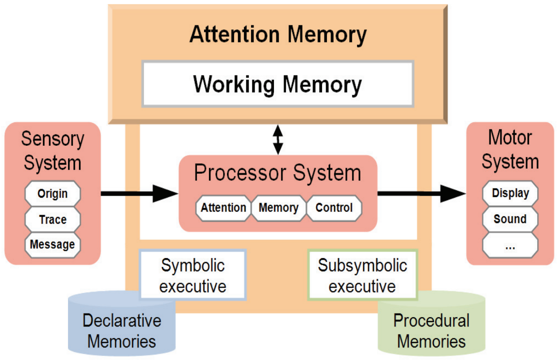

Figure 2: Functional scheme of interaction processor.

4 CONCEPTUAL INTERFACE

The interaction environment of the MAP system is a RWI/OOUI (Rich Web Interface / Object-Oriented User Interface) application, focused on content presentation of multichannel conceptual format (text, image and audio). The MAP system interacts with students by sending motor actions that dynamically change environment elements called SIC (Structural Interaction Components). The environment synchronizes and executes motor actions on the client computer, runs the SICs, controls remote system connections and logs actions and reactions.

Designers and developers can design new SICs adapted to the client device. They should always be derived from one of the 5 generic SIC types (samples in Figure 3):

– *Dialog*. Interpellation component (e.g. Message, Identification, Query…)
– *Stimulus*. Sensory component (e.g. Background, Text, Image...)
– *Entity*. Abstract component (e.g. Icon, Object ...)
– *Relation*. Association component (e.g. Implication, Succession, Group ...).
– *Stage*. Conceptual component that serves to focus attention.

SIC components have the following common characteristics:

– Configurable aspect through parameters.
– Scalable sizing and positioning through percentage values.
– Auto-inclusion. A SIC can contain several SICs.
– Transformable through transitions like moving, scaling, rotation and flash.
– Active links than include communication options for the user. Each SIC usually has an intercommunication button that appropriately reacts to the mouse-over event.
– Internal control of perception time. Learning monitoring systems need to know when the student perceives a SIC.
– Public state for synchronization consisting of presentation (Permanent/Transient), perception (Present/Past), blockade (Yes/No), duration (Initiated/Ended), sound (Active/Stop).

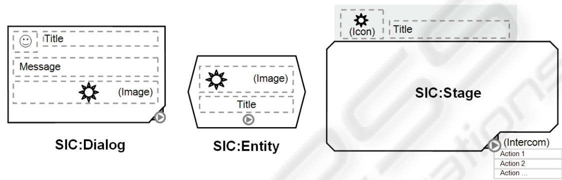

Figure 3: Samples of SIC components.

5 DISCUSSION

This article briefly describes an interaction architecture focused on cognitive tracking, called MAP.

The modelling approach was evaluated through a course about *Web Design*. 32 students participated in the study, 17 of them used the TIX system and the reminder used the MAP system. Academic performance (P_a) and time spent (T_s) are dependent variables of the study. P_a is obtained from students' responses to a final questionnaire ranging 0-100. T_s is estimated by the time students remain logged into the system.

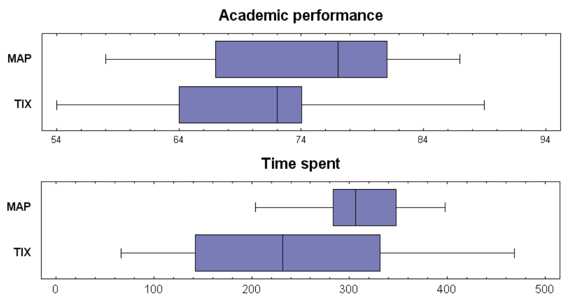

Figure 4: Comparative of students' performances.

The initial analysis of the results (Figure 4) show similar academic performance between groups, lightly higher among users of the MAP system. Time spent by students in the TIX system exhibits high variability and a lower average than that recorded in the MAP system. This fact is justified because the TIX interface focuses on textual contents. Many students prefer to print documents and read them offline thus reducing logged time. Further analysis has begun on the student satisfaction degree and the level of knowledge acquisition.

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