AN ARCHITECTURAL PLATFORM TO PROVIDE INTEGRAL CARE FOR COGNITIVE IMPAIRED CHILDREN THROUGH NEUROPEDAGOGICAL METACOGNITION

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Abstract: Some children require special education due impairment from deafness, blindness, abuse or mental disabilities. This necessity must be carefully tracked, early and throughout their lives so to provide assistance at critical life stages. An integrated education can largely benefit from a consistent architecture, where many specific needs are catered for, while maintaining a fair base of commonalities. This work describes a meta-architecture which has been employed to develop several neuropedagogical portals. This architecture offers fine grained neuroinformatic data acquisition and processing, online educational game development support with neuropsychological profiling. Neuropedagogical education offers a scientific approach to the development of leaning abilities and the proposed architecture encompasses a guide to achieve metacognitive design as an important asset in the installation of a rule-forming epistemic mind.

1 INTRODUCTION

Neuropedagogy is a recent science targeting the correct development of mental abilities and integral activation of all brain functionality. Inadequate brain development can occur whit children suffering from physiological impairment such as deafness and blindness, traumatic experiences of abuse, violence, negligence or even insufficient education. Whichever are the reasons, the consequences are usually severe and mostly irreversible, ranging from cognitive underdevelopment to brain damage from deactivated cerebral regions. All these risks to child integrity must be accounted for, early detected and promptly reacted upon to ensure that appropriated measures are taken in due time to avoid compromise of child future.

The cognitive functions are fundamental structures that serve as foundation for all mental operations. Thus, they are the essential components for intellectual activity. These functions enable us to understand, develop and express information. These functions emerge from a careful trimming of brain connections mainly through the process of learning. The cognitive functions are the framework of thought are continually being be structured, adapting and accommodating the different modes of interaction with the environment. Cognitive functions are the key to observe, track and nurture mental development, and every child, especially from the risk groups should be provided with a thorough program capable of assess and assist its mental development.

Mental development is, however, very peculiar to each individual and a general health program capable of dealing with all the mental condition details could incur in heavy investments in specialized human resources, training and maintenance. This is the point where neuroinformatics can be applied to great avail, delivering widespread cognitive testing, mental development assistance and assessment of therapeutic proceedings. Cheap computer stations can make good use of non specialized local staff, which with little training can conduct a whole

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computerized health program. This program can cover basic demographic and pediatric data, collecting cognitive testing information, forwarded to eliciting processes and returning therapeutic interventions prescribed by specialists.

This work describes the neuroinformatic architecture proposed jointly by a partnership of the Laboratory of Cognitive Neuropsychology and Neuroscience (NEUROLAB-INES) and Neuroinformatics Laboratory at the Electronic Computing Center of the Federal University of Rio de Janeiro (Neurolog-REDE-NCE/UFRJ). This architecture is being applied to several neuroinformatic platforms for mental health care such as TUIA (abused children) NEUROLOG-IBC (blind) NEUROLOG-INES (deaf) and ESGRIMA (public education). The platforms are fitted with demographic data for children and support neuropsychological testing and gaming for neuropedagogical intervention. Those specialized software programs are being developed as several M.Sc. and B.Sc. works that follow and make use of the architectural specifications.

The cognitive functions are fundamental structures forming the base to whole mental operations. So that, they are essentials components to intellectual activity. Those functions qualify us to perceive, to elaborate and express information. The cognitive functions are the outline of the thought and are continually structuring, adapting and accomodating in the different interaction manners with the environment.

Since cognitive styles are particularly configured in each person, a wide plethora of learning strategies should be considered for cater to each individual requirement. In substitution to this costly approach, psychological research has brought forward metacognition as a more efficient solution. Metacognition is a innate mental process controlling the acquisition of knowledge and can be fairly developed across individual particularities of cognition process. This work proposes a metacognitive architecture to convey neuropedagogical interventions and improve the cognitive development through metacognitive design guidelines (Kirsh, 2005) and cognitive modelling (Bandura).

Children usually present learning problems at schools due to (among other reasons) the low development of cognitive processes (Barkley, 2002), (Rotta, 2006). This way, the construction of a computer tool focused on the development of cognitive processes (Eyesenck, 2005) is an essential component in the psychopedagogic process and in the total development1 of the child.

2 GOALS

This paper proposes a software architecture and an efficient computer environment that helps children among 7 to 12 years old with problems in cognition's full development. Neuropedagogical intervention largely relies on metacognition. This works study metacognitive design as source of learning acceleration and rule formation.

The metacognitive design becomes a crucial tool in the construction of any computer environment where the goal is to achieve metacognition, because it is the individual's first contact with the environment, becoming the essential link for the conducting thread. A neuropedagogical intervention based on these design principles, align itself with the metacognition's goals.

Several educators have already highlighted the importance of the child game as a help on the development and child education. The game is a great resource of development (Vygotsky, 2007), since in the game universe the child smartens his/her curiosity, models his/her acting, takes initiatives, develops self-confidence, language, thoughts and concentration. Activities with games permit to work the liberty of choice, in which the child chooses for living in some situation, works the imagination, creativity, agility, reasoning, limits and language. We rarely find a child who is not ready to participate in a game, being it individual or in group, or in a physical or mental activity. Nowadays it is defended in a franc way that games are great stimulators of mind and suggest a large cognitive commitment since activate a diversity of sensorial and motor cortexes (Johnson, 2005). This way, games propel the construction and reorganization of cognitive functions. Such interaction allows that the cognitive functions (Papalia, 2000) be practised with more intensity, favouring the discovery of new knowledge ways (Piaget, 1971).

But how to outline the best design to compose this structure? Which elements we could search to understand the necessities of this space? Which is the best computer architecture to sustain such mechanism? Such questionings lead us to the proposition of a system design and architecture of system, as a way of reaching the individual metacognition.

2.1 CHI and Interaction Design

In the original concept of human machine interface it was seen as a hardware device and the software with which the human being and the computer could communicate each other (Rocha, 2003). In short, the interface was the link that made the communication possible.

With the maturing o computing, a study area was formed to produce an efficient model of communication with the user. This was the starting point to the area of Computer-Human Interaction (CHI). This area studies the bridge (interface) between electronic data and the human mind (Figure 1). Its purpose is to turn this communication as natural as possible, as if it was a conversation with another person (Amstel, 2004). The purpose of CHI area is to create friendly interfaces (or user-friendly).

The CHI is a multidisciplinary area involving the knowledge of areas such as Computer Science, Psychology, Human Factors, Linguistic and other ones. The CHI does not have in its body the goal of studying the man or the computing, but the communication between these two entities.

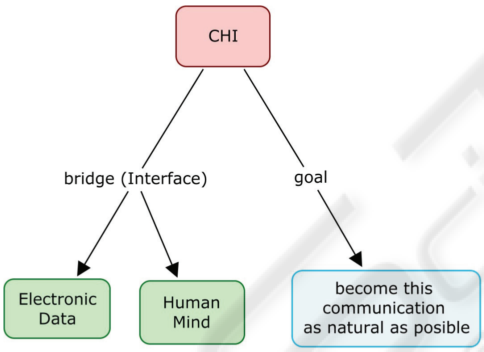

Figure 1: CHI - Computer-Human Interaction.

Going further, we find another approach that tries to think over the effervescence of technology in which nowadays we find us inserted, that is the Interaction Design. Such approach goes beyond the traditional CHI, because in this context the quest is for experiences that target to improve and widen the manner through which people communicate. This way, interaction designers and usability engineers get together to develop interactiveness for a new generation of technologies. Managing such task requires a set of varied abilities in areas like Psychology, CHI, Web design, Computer Science, Information Systems, Marketing, Entertainment and Business (Figure 2) (Preece, 2005).

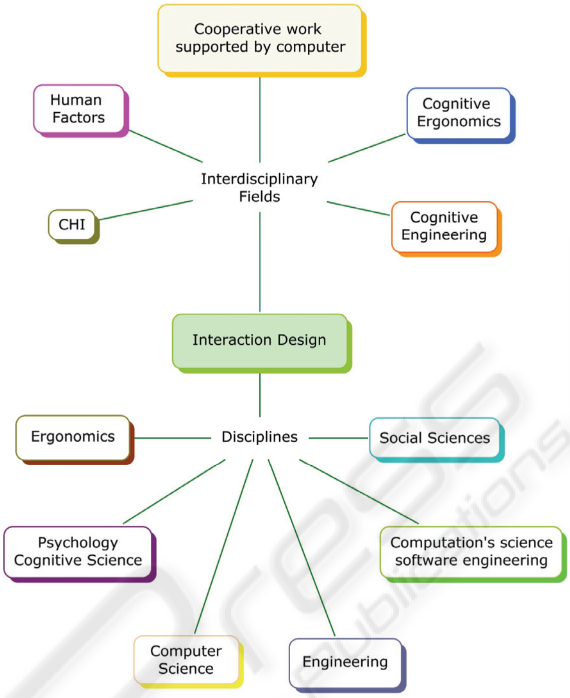

Figure 2: Interaction Design, Disciplines.

Interaction design is proposing ergonomic solutions but not yet reached a point that has a focus to objectively promote metacognition.

2.2 Metacognitive Design

A good design project tries to use efficient tools in order to enable the manipulation of the complexity that any virtual environment requires.

Jonassen (Jonassen, 1998) has already described that the use of the computer as a cognitive tool, assumes it as a mean of extracting what they know, and endeavouring them in a critical thought about the content worked. The designers help the users providing tools, support, advertisements, and a content of high quality. The success of a virtual environment depends much on how the tools, contents and support are implemented and visually presented, not only being enough the simple fact of being there (Gonçalves, 2005). A good visual design can facilitate the learning, since it can improve the metacognition (Kirsh, 2005).

Metacognition is seen much more as a process that occurs isolatedly in the brain, than an interactive process. Cognition and metacognition belong to a continuous, and both are highly interactive (Figure 3).

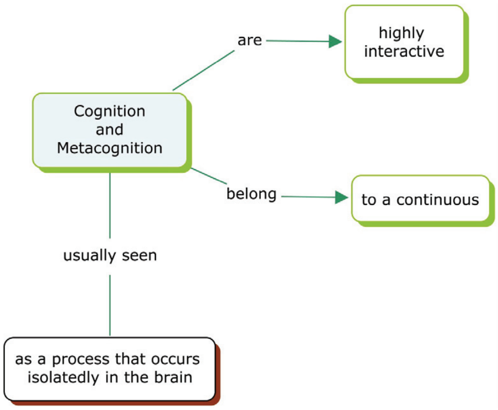

Figure 3: Cognition's and metacognition's process.

The way the suggestions are structured and the way the interaction is designed, can make an important difference in the facility and efficiency of cognition and metacognition (Kirsh, 2005).

The art of the design is to restrict the visual clues in each screen to a smaller set, in way that it signs the next step to the user (Weinman, 1998). The wisest do not reduce the complex processes to the same levl of simplicity and intuition, however they share the same goal. Designers must understand how to fragment a system that is functionally complex in a collection of systems functionally simple. It requires ability and careful planning. The visual and interaction design are related, because the final purpose is to control how the user registers the next step (Kirsh, 2005).

David Kirsh (Kirsh, 2005) defends that a well designed layout facilitates the metacognition, and enumerates some arguments, see below:

1 – Metacognition, as a first order cognition, is a kind of established cognition; the interaction individual-world can be more or less complex.

2 – The rhetoric of metacognition is about the internal regulation, but the designers practice focus on external sources.

3 – Good visual projects are cognitively efficient. Good designs help managing the student attention, and training to predict clues semantically important, such as topic-phrases or useful summaries since they are visually prominent. Good designs are good because they are cognitively efficient.

4 – A good visual design establishes a good work flow. Starting from the point that the user has multiple tasks to do, he/she must be trained to use the learned tools, as well as his/her expectations of acknowledgment through exposition to environments which are quite established.

5 – A good visual design is related to the projection of a indicative structure. The clues are more complex than the visual attractive. Some of them serve as indicators, permitting the user to know when he/she is close to his/her purposes.

Because of these principles (metacognitive design), we have to look for an architecture model that stands the requirements of the suggested environment. Such environment needs to assure the user a view which contains the metacognitive design paradigms. This construction permits the existence of a chapter focused on the development of the access interface to the user. Such chapter does not interfere on the control of appliance, nor on the flow of appliance information.

Due to that, the best architecture to this case is a model that fits three models that possess independence, and also interact harmonically between them along the process.

2.3 Proposed Architecture

In this paper we want to show the construction of a neuroinformatic architecture translated from a preexistent neuropedagogic model. Such model is the basis for all the games that compound the Attention Metacognitive Room, since all of them are built through the principles of Guided Elaboration, having as basis the Conducting Thread (Seminério, 1987). The Guided Elaboration is a technique of metaprocess development of human cognition lead through a mental flow named Conducting Thread. This mental flow surrounds every possible transformations that obey to the principles of inflexible reasoning. This neuropedagogic process was developed along twenty years of experimental research by Professor Franco Seminério (Seminério, 1987).

The neuropedagogic modeling is made through architecture based on the standard of Model View Control (MVC) (Figure 4). MVC is an architecture of development which purpose is separate the logic of application (Model) from the interface of information access to the user (View), and besides that, from the application information flow (Controller) (Gamma, 2005). This architecture allows that the same logic of business can be accessed, and even visualized for several interfaces.

The model entity is formed by elements that represent the application data, that is, the game rules based on Guided Elaboration e performed by the Conductive Thread. These two parts that compound the entity (5 – Game Rules and Conductive Thread), they self-regulate according to the feedback received from the player (3), or the Applier (4). This self-regulation made by the Control entity is essential in

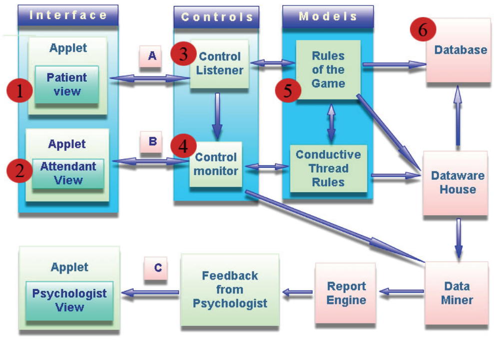

Figure 4: Proposed Architecture.

order to keep a lock on the activity target, configuring this way the main goal of the neuropedagogic process. This target is transcribed to the neuroinformatic model: work the necessities of each player with the Guided Elaboration following the principles of the Conductive Thread.

The model is installed to the player/child as metacognitive games of attention using the principles of metacognitive design. The View's goal is to accomplish the presentation of these data and capture the user's events. So, the essential self-regulation to the process is installed on the Client through API A, and this way, we can say that all Cases of Study are not merely lead by the system functionality, but by the neuropedagogic purpose of the whole process.

The Control entity makes the connection between the Model and the View, accomplishing the treatment of the events, acting on Model, and modifying the View to represent the situations required by the neuropedagogical process.

The events captured by the API A are:

1 - Register of the date of Protocol Execution

2 - Time of Reaction (before being initiated the first section)

3 - Time of Response (after the beginning of the action up to the response)

4 - Number of correct answers

5 - Number of mistakes

6 - Number of perseverances (repetitive wrong answers or number of repetitions)

7 - Order of answers execution

8 - Handling order of game's piece

9 - Number of plays (how many times the player started the game)

10 - Register any kind of waive (observation: the player may not want to start the game, stop in the middle of any phase or not pass to the next phase).

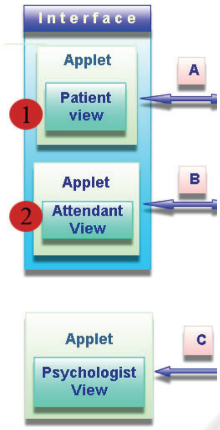

Figure 5: client-patient and client-attendant.

2.3.1 Requirements Description

1) Application client-patient - It is divided in four phases according to the principles of Guided Elaboration.

1.1) First Phase - the child plays.

1.2) Second Phase- the attendant asks the child to explain how did she/he played

1.3) Third Phase A (manipulating objects) - the objects are shown exposed in a screen, and the child has the possibility to move the characters/pranks the way he/she desires. Child interactions are stored in a data bank in order to be analysed later.

1.4) Third Phase B – the attendant asks the child to tell what he/she did on the third phase (previous)

1.5) Fourth Phase (or mediation to the induction of the rule) – the attendant through mediation will ask the child to the play game in spoken words.

2) Application client-attendant - the attendant has the possibility to register:

2.1) Child reactions along the game.

2.2) Record texts of comments according to what is observing.

2.3) Make stimuli and to do interactions with the child through the NPC (Non-player character) picture during the game. All information are stored in the data bank for a late analysis.

3 and 4) Server application-controls and offers all services to the applications clients through a Servlet, and call the components that treat the game rules and persist on data bank.

The game engine is handled by the Phidias library (http://code.google.com/p/phidias), a byproduct of this architecture, designed to develop neuropedagogical games. This library incorporates a sprite engine with techniques that permit the visual objects placed in the scenery game being sensitive

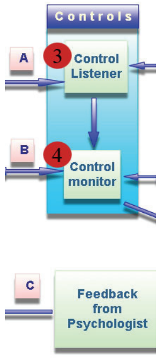

Figure 6: Control Listener and Control Monitor.

to the mouse stimuli. The events occurred during the game, that is, the interactions from the patient with the game are captured through mouse stimuli inside the game scenery, and also the actions with sprites. According to the game phase in which the player is, the events can be captured or not. The captured ones are sent to the attendant view in order he/she can monitor the patient's moves.

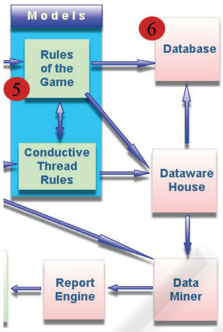

Figure 7: Rules of the game and Database.

Between the server and the applet clients the communication is made through the HTTP protocol, using Java Servlet technology.

The architecture of the platform follows the schemata shown previously on picture 4. They are three client applicatives: one to the patient who will play, another to the attendant, and the third one to the psychologist who will analyse the patient results later.

The developed platform defines engines that will be used by the games to be developed. There is one engine to games with bidimensional images, that is already prepared to the treatment of events, and one engine of forms that will be used by the attendant to follow the patient session. Besides that, the structure to data collecting and processing is defined in the architecture, and will be added with a analysis of each game, to interpret the stored data.

3 IMPLEMENTATIONS ASSESSMENT

The Phidias's framework is a open-source client-server platform that is being oriented as thesis M.Sc. associated with this work. Its development was based on the architecture described in this work whose purpose is to promote metacognition.

The Phidias is composed of a set of packages (Figure 8) with the task of making possible the conduction of metacognitive interaction.

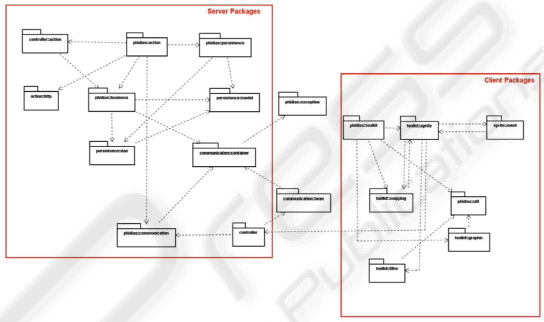

Figure 8: Diagram Package.

The games developed by Project Kuarup 2008 (http://kuarup2008.pbwiki.com) have as a goal to work cognitive function of attention (Figure 9). These games have been implemented with the framework Phidias.

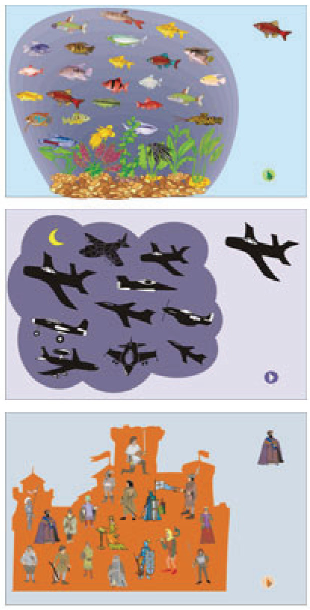

Figure 9: Kuarup's Project games.

The first requirement for development of these games was to build an interface based on the principles of metacognitive design (Kirsh, 2005). The visual project supported its construction in a number of client packages of Phidias, which supports the development of an appropriate interface to metacognition. All the elements that composes the scenario of the game (parts and board) have been implemented using the Graphic package. In Phase 1 of the Guided Elaboration all visual elements are placed on the screen (Figure 10). This is the first contact with the child's game. The applicator starts the mediation of the game guided by the principles of Guided Elaboration. It makes contact with the child through the NPC figure of fun. The NPC is that the means the attendant has to target and stimulate the child.

In Phase 1 of the Guided Elaboration (Seminério, 1987) the NPC asks the child to start the game.

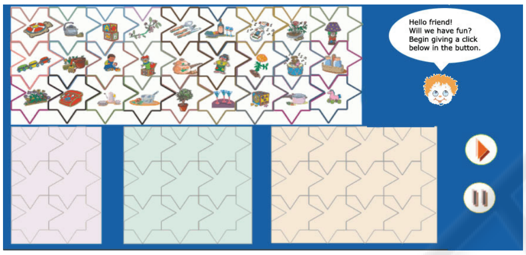

Figure 10: Botocudos's game (Kuarup's Project 2008) in Phase 1 of the Guided Elaboration.

The Graphic package provides the static elements of the game in order to compose the scene, which may conflict or not with the sprites. The term Sprite is well known in the business of game development. Sprite is a term used to refer to an element composed of a visual image, which can be moved by the player across the screen independent of other elements. The sprites of the games are implemented by the Sprite client package. Each element is coupled to a set of sprite events, such as: identification of the sprite selected, the sprite dragging time interval, the withdrawal of sprite handling by the child, the sprite collision with another static element or other sprites, position where the player left the sprite in the scenario (Figure 11), etc. The events identified are captured and stored in the database t for future analysis. The Phidias platform is highly customizable and flexible. This makes possible that new events are mapped for future neuropedagogical needs.

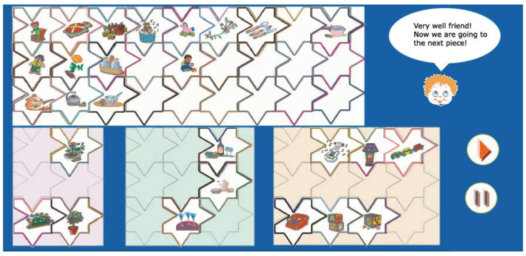

Figure 11: Moving parts of the board in Phase 1.

There is a possibility that every visual element that make up the scenario run through some treatment, so that it is in accordance with the requirements of metacognitive design. This can be done through the Filter client package. This package offers options for treatment of the image, such as: zoom, brightness, contrast and size.

Throughout the implementation of the conductive thread the client captures the data and forwards to the server for storage, receiving an adequate stimulus in response. That dynamic is carried through a protocol of communication between the Client and Server. The Client and Server communicates through its agents (Java agent). The Client agent layer capture data to be stored in a relational database. In turn, the agent in Server stores this information in the database, does the analysis and returns the client feedback to the agent, so that it can interpret and generate some stimulus. This set of actions is done through the Control layer, responsible for bidirectional communication between the client and server agents.

4 CONCLUSIONS

The main goal of this study is to develop and apply this metacognitive platform all around Brazil, since it was the result of a long term research on brazilian children reality.

The building of the Neurolab-INES platform makes possible the study of attention problems in deaf children, who before this initiative did not have adapted tools for such purposes, leaving this specific population forgotten for this health care.

The advantage of this environment being constructed in a computer system is making easier the usage/application of it, offering a certain kind of cognitive training non existent before to the population of deaf children.

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