PROJECT PRAIA
PEDAGOGICAL RATIONAL AND AFFECTIVE INTELLIGENT AGENTS

Patrícia Jaques[3], Edilson Pontarolo[4], Magda Bercht[1], Rosa Vicari[1], Sylvie Pesty[2]

[1]PGIE/Universidade Federal do Rio Grande do Sul (UFGRS)
[2]Laboratoire D'Informatique de Grenoble (LIG)
[3]PIPCA/Universidade do Vale do Rio dos Sinos (UNISINOS)
[4]Universidade Tecnológica Federal do Paraná (UTFPR)

pjaques@unisinos.br, epontarolo@utfpr.edu.br, bercht@inf.ufrgs.br
rosa@inf.ufrgs.br, sylvie.pesty@imag.fr

Abstract. *This paper describes the ongoing research of the project Capes/Cofecub PRAIA. The project aims at studying how to handle users' emotions in intelligent learning environments. A collaborative reasoning game is proposed as platform to test and validate the developed research. In this game, we use a psychologically grounded model to infer peer-related emotions that will be used by an Embodied Conversational Agent to improve collaboration between students.*

1. Introduction

This article aims at describing some partial results from the project PRAIA: a cooperation project between researchers from UFRGS (in Brazil) and LIG and LIMSI (in France). PRAIA (http://gia.inf.ufrgs.br/praia/) is an interdisciplinary project involving three main areas of research: Education, Computer Science and Cognitive Science. Education and Computer Science because we are interested in developing computational solutions for a more effective learning, and Cognitive Science because we aim at handling the emotions in intelligent learning environments.

The field of the Computer Science that studies the potential use of computing resources in learning is called Computer in Education. Some researchers of Artificial Intelligence (AI) interested in Education study the possibility of using techniques of AI in order to turn the educational software more customized to the user. Pedagogical theories and sophisticated techniques of user modeling have been investigated.

On the other hand, little attention has been paid to the role of the affect in cognition. However, some recent works of psychologists and neurologists have pointed out the important role of the emotions in some cognitive activities such as, for example, decision taking [Damásio 1994] and learning [Goleman 1995].

Thus, researchers of Artificial Intelligence have considered the emotions in intelligent systems modeling, appearing thus a new field of research in AI: "Affective Computing" (AC). Picard [Picard 1997] defines AC as "computing that relates to, arises from or deliberately influences emotions". This area is divided in two major branches of research interest. The first one studies mechanisms to recognize human emotions or to express emotions by machine in human-computer interaction. The second branch investigates the simulation of emotion in machines (emotion synthesis) in order to discover more about human emotions and to construct more realistic robots.

In the first one, the researchers are mainly interested in recognizing the users' affect and to respond emotionally to them with the goal of adapting the system to the users, in this case, to their emotions. The systems that are part of this branch have the capacity of *recognizing* and *expressing* emotions. The proposed project is mainly situated in this first branch of research in Affective Computing.

Aiming at contributing to the works in affective computing applied to education, the project PRAIA has as main goal to develop models, methodologies, techniques and tools that handle the users' emotions in intelligent learning environments. A platform was defined in order to test and validate the research developed in this project. It consists in a collaborative game, called "Collaborative Sudoku", and is a multi-user version of the popular logic-based number placement puzzle, which requires basically simple spatial reasoning. We are employing this game to study empirically what happens in terms of peer-related emotions when this kind of simple reasoning task is addressed collaboratively. In the game, a team collaborates through a web-based interface. Supported by a game server, the partners interact, negotiating and coordinating actions in order to construct a shared solution to each proposed reasoning problem. They seek to complete the task faster than an adversary team, matched by the server at random.

We also have developed an affective model to recognize the specific emotions students feel towards their peers during collaboration. Our modeling follows an approach based on cognitive psychology, i.e. the students' emotions are inferred based on their interactions with the system's interface and the produced outcomes, evaluated according to cognitive criteria. More specifically, the model is based on the OCC psychological model of emotions [Ortony *et al.* 1988]. The model is focused on inferring four OCC "attribution" emotions: pride, shame, admiration and reproach.

In order to develop different affective models applied to education, we are also working in affective states like mood [Longhi *et al.* 2008], adopting the researches developed by Scherer [Scherer, 2001].

The information about users' emotions is used by an Embodied Conversational Agent (ECA), which will be integrated to this platform. ECAs are intelligent agents with a humanlike representation that are able to engage in a conversation with humans [Cassel and Sullivan 2000]. In a learning environment, recognizing the students' emotions can increase the believability of an ECA by making possible to maintain a more credible dialog with the students [Lester and Stone 1997]. As a consequence, the ECA will have a more effective base to support collaboration.

The first part of our work was dedicated to the development of an emotions inference model applied to the context of collaborative learning environments, which is described in more detail in the next sections. This affective model is the result of Edilson Pontarolo thesis supervised by Rosa Vicari and Patricia Jaques, and with a sandwich with Syvie Pesty. The ECA is being developed in the context of the PhD work of Michelle Leonhardt. The latter will be explored in another paper submitted to this same colloquium [Leonhardt *et al.* 2009].

2. Cognitive-based Inference of Emotions in Computing Systems

In order for a computing system to recognize users' emotions, two main steps are necessary. First, the system should be able to catch some users' data from which it

could infer their emotions. Nowadays, emotional states can be recognised by the following source of data: (*i*) voice (prosody); (*ii*) facial expressions; (*iii*) physiological signs (blood volume pulse, muscle tension, skin conductivity, breathing), and (*iv*) behavioural data, i. e. user's actions and choices in the system interface (for example, chosen options and typing speed). Second, the system should have a user model that is able to infer her/his emotional states from past emotions and also from the caught data. The capacity of the computational system to model the user's affective states is known as Affective User Modeling (AUM) [Elliott *et al.* 1999]. The affective user model must be dynamic enough to consider the changes in emotional states, since emotion is an ephemeral process.

In a well-defined context (for example, a learning environment), the users' **behavioral data** may be a path to predict, recognize and interpret their affective states. In this case, the system is conceptually grounded on a psychological model of emotions that follows a cognitive approach in order to infer the users' emotions from their actions and choices in the computing system. This approach was denominated **Cognitive-Based Affective User Modeling (CB-AUM)** [Martinho *et al.* 2000]. One of the most employed cognitive-based psychological models for inference of emotions in computing environments is Ortony, Clore and Collins Cognitive Structure of Emotions [Ortony *et al.* 1988], generally called the OCC model. The OCC model aims at explaining the appraisal, the cognitive process that elicits an emotion, of 22 types of emotions.

In the next section, we describe the proposed model, which is grounded on the OCC model for the inference of emotions.

3. The Peer-related Affective Student Model

We have developed an affective model to recognize the specific emotions students feel towards their peers during collaboration. Our modeling follows an approach based on cognitive psychology, i.e. the students' emotions are inferred based on their interactions with the system's interface and the produced outcomes, evaluated according to cognitive criteria. More specifically, the model is based on the OCC psychological model of emotions [Ortony *et al.* 1988]. The model is focused on inferring four OCC "attribution" emotions: pride, shame, admiration and reproach.

These peer-related emotions are inferred by representing the student's cognitive appraisal of her/his own collaborative interactions (giving rise to pride or shame), as well as the appraisal of her/his partner's collaborative interactions (giving rise to admiration or reproach). The praiseworthiness of collaborative interactions is evaluated according to student's goals-related standards, i.e. her/his assumed prototypical models of behavior. In both situations, the model assumes that the student applies the same set of standards, based in the fact that people tend to believe that other people have the same knowledge as theirs.

Some examples of collaborative interactions are "make a justified (or an unjustified) proposition", "agree (or disagree) with a proposition", and "send a positive/encouraging (or a negative/discouraging) message". Some examples of behavioral standards are "the student prefers a quite negotiated solution to a more individualist one", and "the student believes that it is important to keep the partner motivated to solve the problem".

The chosen modeling technique relies on Bayesian Networks [Jensen 2001]. Some conceptually derived causal dependencies among students cognitive and affective variables were mapped and related by means of conditional probabilities. This knowledge representation allowed us to deal with the uncertain domain of cognitive-based emotions recognition and is suitable to be refined through controlled experiments, by learning the conditional probability tables between the random variables. The initial assumption of multivalued independence among the random variables simplifies a lot the task of learning the probability density distributions and keeps an acceptable level of generalization. We have started to evaluate the model using a collaborative game test-bed prototype we have developed called "Collaborative Sudoku".

4. Conclusions

The proposed model is already developed and additional information about its functioning and validation can be found in [Pontarolo *et al.* 2008]. As a future improvement, the group aims at aggregating a face-based inference of emotions tool that is already being developed [Oliveira and Jaques 2008]. The ECA is an ongoing work of the PhD student Michelle Leonhardt and its description can be found in more details in [Leonhardt *et al.* 2009].

5. References

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