MENTORing Affectively the Student to Enhance his Learning

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Abstract

In this paper a Web-Based Adaptive Educational System to support personalized distance learning, which is named MENTOR is presented. The main purpose of MENTOR is to support learner’s actions during the learning process in an affective way. To achieve this MENTOR incorporates an affective module which enhances the traditional learning practices with an affective dimension. The affective module makes use of an ontological approach in combination with the Bayesian Network model in order to provide learner with the properly affective guidance. In this way the foremost goal of MENTOR, which is to supply the learner with a personalized and emotional awareness learning environment, is achieved.

1. Introduction

Recently, research in computer science has begun to take emotions into account, because their influence in perception, reasoning, decision-making and learning is considered catalytic. A new field, that is located in the scientific area in the intersection of artificial intelligence, cognitive psychology and physiology, has come to surface with the promise to cover this deficiency and offers a wide range of methods, techniques and applications which take into account affectivity. This field is called affective computing and owes its name to Rosalind Picard who studied and developed in her book “Affective Computing” [8] methods and techniques related to the computer’s capability to recognize, model, respond, and express emotions in order to interact effectively with users. These features which are basic components of human emotional intelligence remain today major concerns of the designers of affective machines. Especially in education, the appropriate emotional background constitutes an important factor and a significant requirement for the accomplishment of learning goals.

On the other hand, the Internet is the ideal environment for the promotion of the personalized learning according to the student needs. Various educational systems such as the Adaptive Educational Systems (AES) and lately the Web Based Educational Systems (WBES) have been developed to this direction. Many Web learning designers realize that the omission of the affective aspect from the educational systems deprives the learning process from a very important pedagogical dimension. As a result, a notable few contemporary educational systems designers began to consider their operation under an affective perspective with the aim of modeling the emotional processes which are taking place during the educational session. Work conducted by Conati [1] and Oren and Ghasem-Aghaee [6], correspond to affective techniques are being incorporated more frequently in educational systems with the aim of recognizing student’s emotions, mood and personality.

In this paper we first introduce the basic concepts of our framework which are related to Affective Computing, Ontologies and Bayesian Networks. In the next section we present the architecture of the MENTOR which is an Affective WBES for personalized learning [5]. Then the proposed method for the student’s affective support is analyzed. In the following section an experimental study and its results are presented in detail. Finally, conclusions and future plan of our research are discussed.

2. Background and Motivation

The term Affective Computing involves the intention of Artificial Intelligence researchers to model emotions in intelligent systems. According to Picard [8] an affective system must be capable of recognizing emotions, respond to them and react “emotionally”.

Personality determines all those characteristics that distinguish one human being from another. It is related to his behaviour and mental processes and has a permanent character. The most known model of personality is the Five Factor Model (FFM) and results from the study of Costa and McCrae [2]. It is a descriptive model with five dimensions: Openness, Conscientiousness, Extraversion, Agreeableness, and
Neuroticism. Due to these dimensions the model is also called OCEAN model. The descriptive character of FFM and the particular characteristics that accompany each type of personality (traits) allow us to model the student’s personality [6] and use this information in educational applications [1].

Although many efforts have taken place there is not an explicit definition for the emotion. It is easy to feel, but it is hard to describe it. According to Scherer [9], emotion is the synchronized response for all or most organic systems to the evaluation of an external or internal event. Nevertheless, various attempts have been made, but the cognitive theory of emotions, known as OCC model, which formulated by Ortony, Clore and Collins [7], keeps a distinctive position among them. The three authors constructed a cognitive theory of emotion that explains the origins of emotions, describing the cognitive processes that elicit them.

Ontology is a formal way to represent the specific knowledge of a domain, providing an explicit and extendable framework to describe it. It is a technique of describing formally and explicitly the vocabulary of a domain in terms of concepts, classes, instances, relations, axioms, constraints and inference rules. The necessity for Ontologies has been widely recognized during the development of the Semantic Web. As a result, a wide range of applications that incorporate ontological approaches has been produced because of their beneficial feature to be shared specifications of conceptualizations [10] and to encourage in this way the collaboration of different experts. In our model we take advantage of the ontological representation to set the vocabulary, properties, and relationships for learning and pedagogical concepts under an af
c
tective perspective. These schemas can be defined in a machine-accessible way so as to be suitable for sharing among various systems, understandable between humans and machines and appropriate for meta-data and semantics encoding. In this way the educational objects of the MENTOR’s learning environment accumulate more meaning by the relationships they hold and the possible inferences that can be extracted by these relationships.

Bayesian networks (BN’s) is a graphical data structure which provides us the formal way to represent the dependence between variables and to give a concise specification of the joint probability distribution [4]. BN’s have been successfully used to model knowledge under conditions of uncertainty within Intelligent Tutoring and Adaptive Educational Systems. Also methods have been developed from data combination and expert system knowledge in order to train these systems. In this way an information system can easily process the knowledge which is encoded formally in a BN representation. Thus, making use of BN’s, we can handle efficiently conditions of uncertainty and facilitate human understanding with computational models which can perform effectively actions of reasoning and inference.

3. The Architecture of MENTOR

MENTOR is an “affective” Web-based educational environment which aims to recognize the emotions of the student and thereafter to provide him with a suitable learning strategy [5]. The operation of MENTOR is based on the FFM [2] and the OCC model [7]. The architecture of the MENTOR is designed appropriately in order to provide the system with the essential “emotional” information to determine the strategy of learning in collaboration with the cognitive information.

The architecture of MENTOR is presented in Figure 1. The MENTOR has three main components: The Emotional Component (EC), the Teacher Component (TC) and the Visualization Component (VC), which are respectively responsible for: a) the recognition of student’s personality, mood and emotions during the learning process, b) the selection of the suitable teaching and pedagogical strategy and c) the appropriate visualization of the educational environment. The combined function of these components “feeds” the AES with the affective dimension optimizing the effectiveness of the learning process and enhancing the personalized teaching. The main purpose of MENTOR is to create the appropriate learning environment for the student, taking into account particular affective factors in combination with cognitive abilities of the student offering in this way personalized learning.

The architecture of the MENTOR is designed with equal respect to the cognitive and the emotional dimension of teaching as well. So, we consider that the Teacher Component which is in charge of the formation of teaching consists of two subcomponents, the Teaching Generator and the Pedagogical Generator which are responsible for providing the cognitive and emotional tactic respectively. Therefore, we use the term Affective Tactic (AT) so as to denote that the learning method which is suggested by the Teacher Component is a two-dimensional combination of cognitive and emotional guidance and support. The AT’s are presented by a set of “if-then-else” rules which allow the MENTOR to establish a suitable affective guidance for the student.
In this way, a traditional instructional tactic is enhanced with a motivational one and this would be proved beneficial to the student from two aspects. The first concerns the planning of the teaching strategy and the educational content, which and what topic will be taught to the student next and which method will be used for it. The second is more related to the delivery planning, how this topic will be taught.

Figure 1: The basic architecture of MENTOR

4. Representation and Selection of the Appropriate Affective Tacticts

In order for the MENTOR to represent appropriately the AT’s and to select the most suitable according to the affective style of a student a two-dimensional technological method is proposed in this paper. The first aspect of this method adopts an ontological approach, so that the affective information can be represented. The second makes use of the BN model to choose the AT which fits better to student’s particular needs. In this way an Ontology-based BN is formed which stores the affective information of MENTOR, as well as the transitions between situations in order to reason efficiently about the most appropriate affective guidance.

The structure of the proposed Ontology is comprised of one main class the System_Affective class. The System_Affective class is divided into four sub-classes which are, the Student_Affective_Model, the Student_Personality, Emotional_State and the Affective_Tactic sub-classes. The last sub-class represents the twenty AT’s that have been already implemented in MENTOR. Every of these AT’s is represented as a second layer sub-class, into these sub-classes. For instance, the System_Affective_Model is described as follows:

(System-Affective-Class
(SUBCLASSES
(VALUE (STUDENT-AFFECTIVE-MODEL, STUDENT-PERSONALITY, EMOTIONAL-STATE, AFFECTIVE-TACTIC))
(IS-A

Table 1. The Affective Tactics of MENTOR

| AT1: Congratulate the student | AT6: Express admiration |
| AT2: Reassure the appropriateness of help | AT7: Play a game with student |
| AT3: Express unhappiness after an unsuccessful help | AT8: Open a dialogue with the student |
| AT4: Express sympathy in case of fail | AT9: Present a part of a movie |
| AT5: Explain the need for help | AT10: Play a video clip |

In Table 1 some of the implemented AT’s are exemplified. In this way, the formal and flexible representation of an AT can be achieved in relation to the learning goal of a student. The proposed Ontology was implemented with the Protégé tool and its hierarchy is shown in Figure 2.

Figure 2. An Excerpt from the Affective Ontology of MENTOR

We use the DL-OWL (Description Logic – Ontology Web Language) as a reasoning and inference mechanism to obtain the essential production rules, as well as analyze the domain knowledge and interaction data. In order for the MENTOR to select the appropriate AT, the Ontology is mapped with the BN with the following technique. Every AT and personality type is modeled as node of the BN, while its arcs correlate the influential probability to transit from one AT to another according to the current emotional state and the personality of the student. We consider as $P_{in}(E_i), i=1,2,\ldots,10$ the probability of each emotional situation at a given period of time $t_i$ which is related with the transition from one emotional state $s_a$ to another emotional state $s_b$ and as $P_{tr}(s_a|s_b, E_i), a\neq b$ the probability of this transition. The following formulas denote this probability:

\[
\sum_i P_{in}(E_i) = 1, i=1,2,\ldots,10 \quad (1)
\]

\[
\sum_i P_{tr}(s_a|s_b, E_i) = 1, i=1,2,\ldots,10 \quad (2)
\]
Given the previous mapping method the system is capable of using the Ontology and updating the suggested AT, during the learning process. The initial data set, namely the implicit evidence, had been already gathered from the initial personality and assessment tests. In this way, the Ontology not only populated initially but it is being updated continuously during the learning process. Simultaneously, taking into consideration the transitional probability of the BN’s arcs, we can validate and hence training suitably our model. Taking these probabilities into account the Conditional Probability Table (CPT) of the BN is constructed. The CPT is a crucial parameter because the inference in the BN relies on the values of this table which are assigned with each node of the BN (Figure 3). Therefore, the initialization of the CPT incorporates the uncertain information and as a result, the creation of the BN from the Ontology is completed. When the MENTOR loads the Ontology-based BN, the Ontology will be converted to a suitable BN and the choice of the appropriate AT can be made. In this way, a set of “if-then-else” rules is defined and allow us to determine the proper affective tactic for the student.

Figure 3. An example from the decision process of the BN

Let us examine, for example, the case of a student whose personality belongs to the Conscientiousness category and he fails to accomplish a given task. Then negative emotions such as sadness or disappointment can appear. He seems to be less confident in the current session and there is the danger of giving up the trial. He fears maybe that he has not got the ability to deal with a project that was assigned to him and he will not live up to his teacher’s expectations. According to Table 1, there are pedagogical actions which can be applied in order to eliminate the student’s negative emotions. For instance, the system may praise him for his effort, give him help and encourage him to try again. Then the Mentor Component presents him an easier problem to reinforce his confidence and to foster positive emotions. In this way, the student has great chances to resolve the problem, so that his confidence would be regained and positive emotions such as happiness or satisfaction can preserve an upbeat to the student’s mood. The following are two of a rules’ set which are triggered to handle this educational event.

If exercise.accomplish <> done Then
    Show_message(personality_type, type_of_message)
    Give_help(personality_type, task_type, type_of_help)
    Motivation(personality_type, task_accomplish, task_type)

If (Personality_Type = Conscientiousness ) And
    ((Educational_Event Or Learning_Activity) = Success) And
    (Student_Response = Positive) Then AT is Appropriate

5. Experimental Study and Results

In order to evaluate our proposal and to validate the exactitude of MENTOR’s prediction, an experiment was conducted with fifty-four participants. The participants were all students in the field of computer science and their age was between eighteen and twenty-five years old. With the aim of recognizing the student’s personality, they were given with the NEO-PI-R personality test [3], which was presented via MENTOR. According to this test MENTOR classified twenty-one students who belonged to the Extraversion category, fourteen to the Agreeableness category, nine to the Conscientiousness category, six to the Openness category and four to the Neuroticism category. In this way students formed five groups and they were given an assessment pre-test. In the next step every student had the opportunity to interact with a pre-selected course of MENTOR (e-learning content about artificial intelligence – beginner’s level) for thirty minutes. During this interaction every student obtained the educational material which consisted of lecture notes, examples, exercises, problem-solving projects and an assessment post-test. As a result, the students had the opportunity to deal with the educational events of MENTOR’s environment and had been provided with various affective tactics. Every student’s action was recorded by the system’s log files. Consequently, in every moment MENTOR was aware of the emotional state of the student in order to offer him the appropriate AT.

The objective of the experiment was to measure the suitability of the suggested AT’s. In order to achieve this, the students asked to declare their affective state before and after they obtained the AT’s. Also, they asked to state if the suggested AT’s helped them to preserve a positive mood and to achieve their educational goal. Finally, the students were given an evaluation questionnaire to fill in where they wrote down their impressions from the interaction with MENTOR. The questionnaire examined three factors, which were the students’ opinion in relation to the
suitability of the AT’s, the impact of the system in their learning process and the satisfaction from their interaction with the system. Then taking their responses into consideration and after the examination of the system’s log files we were provided with the results that are shown in the Table 2 and Figure 4, where the categories of the students’ personalities and the corresponding suitability of the suggested Affective Tactics are demonstrated in a graphical way. From this diagram we can easily draw the conclusion that for the categories of Openness, Conscientiousness and Extraversion MENTOR had better accuracy in the suggestion of their affective tactics.

The implementation of MENTOR has been done using the PHP5 language supported by Apache HTTP server 2.2. At this time we have implemented twenty different affective tactics. The designation of these tactics has taken into account the professional opinion of experts in the field of Education and Psychology. We hope in future versions that the accuracy of the suggested AT’s will be improved and the number of affective tactics will be further evolved in order to include more cases.

7. References


6. Conclusions and Further Research

In this paper we presented a framework to support the student’s actions during the learning process in an affective way. The basic structure of MENTOR is presented and the proposed method for the selection of the appropriate AT is analyzed. In our framework the affective knowledge is captured using an ontological approach. We propose the specific Ontology as the knowledge representation mechanism of MENTOR’s affective information. Also, we presented how the necessary inferences can be extracted from this Ontology using the reasoning capabilities of the BN’s. An experiment has been conducted as well, with the aim of evaluating MENTOR’s performance and has been presented in detail in the previous section. The preliminary experimental results are encouraging for the further development of the proposed model.

Table 2. Student’s results from the interaction with MENTOR

<table>
<thead>
<tr>
<th>Level</th>
<th>Satisfaction from MENTOR’s interaction</th>
<th>Success in learning process</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>88%</td>
<td>82%</td>
</tr>
<tr>
<td>Medium</td>
<td>9%</td>
<td>13%</td>
</tr>
<tr>
<td>Low</td>
<td>3%</td>
<td>5%</td>
</tr>
</tbody>
</table>

Figure 4: The accuracy of MENTOR’s Affective Tactic suggestions according to the student’s personality.