Chapter VII
Affective Issues in Adaptive Educational Environments

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ABSTRACT

Research in computer science recently began to take emotions into account because their influence in perception, reasoning, decision-making and learning is considered catalytic. In learning the appropriate sentimental background constitutes a significant requirement in order to be effective. However, many designers of adaptive learning systems develop their systems without taking into consideration the emotional factors that are related to the mood and the personality of the student. This omission deprives the learning process from a very important pedagogical dimension. In this chapter, the focus is on affective factors that are involved in the learning process and can be considered in designing adaptive learning environments. We present first the basic theories and models for affective computer. We deal with methods of affective elicitation and representation of affective knowledge. We then present affective educational applications. Finally, we discuss issues and future trends of affective computing in relation to the learning.

INTRODUCTION

From one point of view, human beings are intelligent information systems whose everyday activities are characterized by social, cognitive and affective attributes. Especially the affective attribute is the most critical one in order for some person to interact effectually with other people and communicate with clarity his ideas. Regardless of the fact that emotions are a determined and discriminated factor for the human relations, almost until recently the emotional dimension
was absent from artificial intelligent information systems which are constructed as a mirror image of human beings.

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” (Picard, 1997) 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 (Goleman, 1995), remain today major concerns of the designers of affective machines.

Affective computing is a hopeful and fertile domain that promises to contribute to the integration of emotional and rational aspects of the human’s behavior in machines. Its main purpose is the association of computers with the human beings’ abilities such as the observation, interpretation and generation of emotions and the further improvement on the intelligence of computer systems and the human-computer interaction. While the effort to investigate emotional processes and to implement affective models is not new, the availability of accurate methods and advanced techniques in computer science contributed decisively to the implementation of powerful tools in order to support, refine and evaluate psychological theories of emotion.

Despite the importance of the affective aspect, in most educational systems this crucial parameter seems to have been ignored, since the significant process of learning is supported by methods which are mainly concentrating on the cognitive abilities of the student. Indeed, these systems in their majority develop their educational dimension, based only on cognitive parameters such as learning styles, without taking into consideration the emotional factors that are related to the mood and the personality of the student. Many Web learning designers realize that this omission deprives the learning process from a very important pedagogical dimension. Thus, web designers are at the forefront of shifting attention to affective subjects that influence learning.

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 (Andre, 1999; Conati & Zhou 2002; Lester et al., 1999). Work conducted by Keller (1999), Oren and Ghasem-Aghae (2003) and Martinho (2000), correspond to affective techniques are being incorporated more frequently in educational systems with the aim of recognizing student’s emotions, mood and personality. These educational researchers have begun to examine how traditional student model can be modified in order to be capable of storing affective information.

At this time affective computing is one of the most active research areas in instructional systems and it appears to have increasingly serious attention. Innovative technologies such as speech recognition, text-to-speech, video processing and virtual reality are driving this interest and are providing sufficient tools to construct powerful affective systems. In spite of this ultimate progress, according to Picard there are two major concerns in this field. The first one is how to provide a computer system with a reliable inference engine for the detection of user’s affective state and the second is how to devise an efficient mechanism to generate believable emotions and behaviour in human-like artifacts such as animated agents and robots.

The aim of this chapter is to deal with issues, which involve the field of affective computing. For this reason it concerns theories, methods, techniques, trends and applications in the aforementioned field. The structure of this chapter is articulated in order to comprise the following...
topics: (a) Basic Concepts of Affecting Computing, (b) Theories and Models for Affective Computing, (c) Methods of formal representation of affective knowledge, (d) Methods of emotions elicitation, (e) Applications related to the field of Affective Education, and (f) Discussion and Future Trends.

More analytically, according to the first topic, the reader is going to be provided with the relative definitions on the field of the Affective Computing and is going to be familiar with the most well-known and influential researchers of this field.

In the second topic, affective theories are going to be presented in an extensive way, while being exemplified by appropriately selected examples and cases. For instance, theories such as the Five Factor Model (FFM) which results from the study of Costa and McCrae (1992) are going to be examined. In addition, distinctive models which played a crucial role in the development of the field, such as the cognitive theory of emotions, known as OCC model, which was formulated by Ortony, Clore and Collins (1988) is going to be included.

The third topic concerns the important and demanding subject of the formal representation of personality, mood and emotions. There are many different ways in order for knowledge to be represented formally and flexibly and the most accurate are going to be presented, commented and evaluated. Moreover, in relation to this topic, the cutting-edge methodology of ontology is going to be mentioned particularly, along with the Semantic Web technology.

In the next topic, the methods which are used for emotion recognition, accompanied by an extensive bibliographical support are going to be cited. The variety of these methods points out the ingenuity of interdisciplinary researchers and their significant efforts pay tribute to the ongoing developing field of Affective Computing.

At this point, applications related to the field of Affective Education are going to be presented, in order to epitomize all the above analysis and to demonstrate some of the most innovative attempts of the researchers. Educational environments such as the Prime Climb Educational Game (Conati & Zhou, 2002) and pedagogical agents (Faivre et al., 2002) are scheduled to be presented in this topic.

Finally, this chapter concludes with an extensive discussion with the aim of providing remarks, insights and future trends. According to the topics of the chapter and the following discussion, a wide range of conclusions will be drawn and the reader will be given hints and opportunities for further research.

**BASIC CONCEPTS OF AFFECTIVE COMPUTING**

The term Affective Computing involves the intention of Artificial Intelligence researchers to model and incorporate emotions in intelligent systems. It is a novel and important topic for the field of human computer interaction in order to improve quality of communication and transaction intelligence between human and computer. It is Picard (1997), who coined the term affective computing. She defines affective as the “computing that relates to, arises from or deliberately influences emotions”. Based on this definition, an affective system must be capable of recognizing emotions, respond to them and react “emotionally”. It adopts an interdisciplinary aspect, takes advantage of the knowledge background of different sciences such as cognitive psychology, physiology and computer science. The objective goal of affecting computing is the observation and interpretation of human capabilities in order to integrate affective attributes in computers. It is the key idea and a very challenging task, to develop computer systems which would be genuinely intelligent, provide them with the ability to recognise, understand and express emotions in order to interact naturally with us; that is “behave” in a human-like way in relation to our needs.
In the conceptual map of affective computing, emotions play a predominant role. Although many efforts have been made, there is not an explicit definition for emotion. It is easy to feel, but it is hard to describe it. There are still basic questions in the emotion theory such as what are emotions, why do we have emotions, what exactly causes them, how could we control them effectively, but satisfactory answers are forthcoming. According to Ortony, Clore and Collins, who formulated the so called OCC$^1$ theory (1988), emotions are valenced reactions to events, agents, or objects. Their nature is determined by the way in which a particular situation is perceived. For Scherer (2000) emotion is the synchronized response for all or most organic systems to the evaluation of an external or internal event. Dipert (1998) considers that emotions are intentional and are caused by certain beliefs towards a primarily conceptual and not perceptual target. He maintains the view that “the emotion is an intentional mental state, because it is directed toward an object, its intentional object and produces some physiological, behavioral, or cognitive effects. Parkinson and Coleman have introduced the aspect of a relatively short – term evaluative mental state. Their explanation about the term emotion is focused on a particular intentional object (a person, an event, or a state of affairs).

Love, hate, joy, sadness, fear, hope and anger are some representative emotions. From the literature it appears that there are contradictory views according to whether emotions could be categorized into a set of basic emotions such as joy, sadness, love and hate or should be considered in relation to some intrinsic attributes such as their valence (positive – negative), attention (external – internal) and arousal (excited – calm).

Another important concept in the terminology of affective computing is the term “mood”. While emotion is analogous to a state of mind that is only momentary, mood is a prolonged state of mind, resulting from a cumulative effect of emotions (Fridja, 1994). Mood differs from the emotion because it has lower intensity and longer duration. It can be consequently considered that mood is an emotional situation more stable than emotions and more volatile than personality. Dipert (1998) supports the view that emotion differs from mood primarily because the latter lacks of an intentional object and its causes are mostly evaluative. For instance, a particular situation is evaluated either as desirable or not. According to this rationale, mood can be upbeat, optimistic, cheerful, unhappy, depressed, ill-tempered. Scherer (2000) mentions that mood is an affective state of low intensity but long duration, which is incurred without evident reason and is formulated and varied in relation to person’s subjective sensitivity.

In affective computing the particular occurrence of emotions and the consequent expression of mood are assigned to some extent to the individual characteristics that distinguish one human being from another. These characteristics determine the personality of a person. This is related to the person’s behavior and mental processes and has a permanent character. It would be considered that personality refers to the determinant and predictable attributes and behaviors by which people are identified and categorised. Emotions and moods are connected with the term of personality by the name of traits or factors. Scherer (2000) defines the personality factors as the specific characteristics which consists in one person’s typical inclination of his behaviour and comprise the certain dispositions of his personality. For instance, optimist, imaginative, moderate, nervous, envious, rational, conservative are some personality traits which personify a person.

Motivation is another important term in affective computing. It implies the impetus and the encouragement of a person’s predisposition to perform activities in a certain way. According to Weiner (1992), motivation explains how and why a specific behavior is initiated, retained and terminated in relation to particular decisions and preferences. Motivation is related straightforwardly with emotions as it can be considered that consists
of the appropriate actions which can be taken in order to engage someone in an activity while positive emotions are concurrently preserved and promoted. From this point of view motivation is a crucial factor of thought, belief and action and can trigger a set of definite emotions.

Taking into account the above descriptive frame of the affective computing it is evident that the main research topics of affective computing are focused on three areas, which are examined in more detail in the next session of this chapter. These are: (1) Emotion detection and understanding (2) Emotion synthesis / simulation and (3) Generation of artificial emotions.

**Main Areas of Affective Computing**

As it has been already mentioned in the previous section, the main aim of the research which is being conducted in the field of affective computing is concentrated mainly on the emotion’s recognition /understanding, simulation and generation. In the first one, the objective is the elicitation and detection of the user’s emotions with the aim of adapting the system to his preferences. In effect, the recognition of the user’s emotions aims at improving the interaction between user and system by achieving the system’s appropriate emotional response to the user’s affective state. In the second, the basic concern of most researchers is to develop devices with the ability to express emotions. To achieve this, they work on the implementation of believable entities, like emotionally artificial agents or robots which make use of techniques in order to simulate emotional processes. The final sector of affective research is considered rather the more ambitious and controversial debate in affective computing the autonomous productive synthesis of emotional processes by the machine. Researchers who advocate affective machines believe that machines will be capable in the near future of demonstrating the capacity of possessing emotions as well as developing their own emotions. A typical example is the ability of a machine to empathise a human being. The following summarizes the key issues of the three areas.

**Emotion Detection and Understanding**

Emotion detection and understanding is the most expedient area among the three where the main burden of researchers’ efforts has been focused. It concerns the way to predict, recognise and interpret the emotional states of the user. The main reason for this is the belief that the interaction between the computer and the user could be improved effectively if the machine was capable of recognising the emotions of the person and responding adequately to them. There are four main methods of emotion recognition: (1) emotional speech processing (Delaert et al., 1996), (2), facial expression (Ekman, 1999), (3) physiological signs such as skin conductivity, breathing (Picard et al., 2001) and (4) observable behavior such as eye tracking, mouse movement (Martinho et al., 2000). A wide range of information sources can be used for the evaluation of monitoring changes in emotional states which is captured by speech analysis, face, gesture and posture observation and physiological signal processing, which machines can detect. These sources can prove to be extremely useful to provide researchers with tangible evidence of the intrinsic emotional tasks. The natural data which are collected by the novel interaction devices (such as a touch-sensitive mouse, an eye-tracking camera, a wired seat), in combination with the AI-based processing of them, contribute to building the suitably affective user models that describe user’s emotional states. Picard (1997) bears the view that the most efficient way for the emotion detection is possibly to come up from the harmonic interoperation of low-level signal recognition devices and higher-level reasoning artificial data which help to the construction of reliably multi-modal affective models.

Despite the inaccuracies of the proposed methods for the emotion recognition some of the researchers managed to achieve reliable results
measuring physiological signs. For example, Picard et al. (2001) analyzed measures of skin conductivity, blood volume pulse, breathing and muscle tension of a person for five weeks recognized with a success rate of about 81% eight emotional states (neutral, anger, hate, grief, platonic love, romantic love, joy and reverence), while Kaiser and Wehrle (2000) analyzing the muscular activity of the face by appropriate apparatus detected emotions related to the facial expression. In a similar way Wilson and Sasse (2000) achieved the adaptation of a multimedia conferencing system according to the level of user’s stress. Measuring and exploiting physiological signs during an interaction between the computer and the user they provided the system with real-time indicators such as the heart rate and the blood pressure, gathering sufficient information in order for the system to respond adequately to the user’s anxiety. Regardless of the medium used to elicit emotions, the affective information could be accumulated from any of these sensory devices channels, or even more ideally, by a combination of all of them together with reasoning about user’s emotional states to detect his current emotions.

As the next logical step to the sequence of emotion recognition, and fully interrelated with it, is the affective understanding that follows in the chain of emotion appraisal. It concerns the process of the perceived emotions in order to classify them according to their particular nature. In this direction, the OCC theory of emotions, which will be described in a following section in more detail, provide a catalytic model for the comprehension of emotions. The affective understanding comprise tasks such as the information gathering, absorption and storage, the building, maintaining and updating of accurate users affect models, the modeling of user’s current mood and the appropriate handling of the affective information (Picard, 2003). Overall, the understanding of emotions plays an important role in exploring their complicated nature, in conceiving their sophisticated operation, in clarifying their structure and finally in categorizing them accordingly.

Emotion Synthesis / Simulation

Research in the area of motion synthesis focuses almost exclusively on the methods, models and architectures that allow machines to synthesize and represent believable emotions. This feature is crucial for an effective interaction between a human and a machine (or between machines), because machines, which are capable of demonstrating an emotional behavior, even though delusive, have better chances to be more acceptable to human beings. The researchers of this area direct their efforts to obtain machines which are able to have and express emotions. This ability acts complementary to emotion detection in order for the computer systems to exhibit sentimental behavior in a convincing manner. There is considerable argument concerning whether machines must have emotions or whether they can demonstrate ultimately emotional behavior (Picard, 1997). Despite questions whether machines can demonstrate emotional behavior (Picard, 1997), researchers (e.g., Clore & Ortony, 1999) continue to develop theories, exploring methodologies and designing architectures with the aim of constructing emotion models for the integration of motivational, cognitive and mental components which enhanced the ability of machines to express emotions.

Emotion simulation can be also helpful in making more interesting and attractive the delivery of information, the acceptance of decision making and the approval of reasoning process in a reliable and more realistic way. For this purpose many researchers concentrated on the development of believable emotional entities such as life-like agents (Reilly & Bates, 1992; Bates, 1994). Consistent to this view is the Elliot’s Affective Reasoner Framework (1992), which is an effort to obtain human-like emotional software agents with rational and credible behavior. Elliot, tak-
ing advantage of the existent emotional theories, focused on developing a multi-agent world populated by several agents who can make inferences on the affective states of other agents. To achieve this, he made use of a formal representation of twenty-four emotion types. The major benefit of this framework is the possibility to reason and make inferences about emotions while in parallel test the beliefs and theories of emotions.

**The Generation of Artificial Emotions**

This controversial and to some extent science-fiction issue concerns the capability of a computational system to produce new emotions. This aspect implies the existence of mechanisms and methods capable of creating believable emotions either from scratch or in relation to existing emotions emitted by others (Picard, 1997, 2003). The objective of the researchers in this area is to construct working affective models or human-like agents based on a psychological theory and to obtain an adequate and flexible mechanism in order to create new emotions from the already developed emotions. In addition to the Picard’s perspective, Bercht (2001) claims that it is possible to develop a mechanism and to be incorporated into an affective system in order to generate new emotions from the emotions that it has already had. For example, an affective agent could be trained to learn or to produce new emotions making use of an affective model that will allow the extension of the existent one. The current operation of the affective systems relies on a specific computational affective model, so the developed emotions are restrictive to this model. In the whole world scientific literature until now, no affective model has ever been presented, that would account for such an agent or any computational system that has the capacity of generating new emotions.

On balance research in the three areas of affective computing fall under four major perspectives: (1) methods for the automatic recognition of the affective state of a person or mechanism in order for a computerised system to express emotional behavior in human-computer interaction; (2) studies of the relationship between cognitive and affective factors which characterize processes such as learning; (3) use of the affective information in order for the system’s adaptation to be achieved; (4) affective computing relates to the designing and simulation of lifelike agents which are software entities capable to exhibit believably emotional behaviour optimizing in this way the effectiveness of human-computer interactions.

**THEORIES AND MODELS OF AFFECTIVE COMPUTING**

In both the Psychology and the Computer Science literatures many valuable theories of emotions have been formulated and used to model emotions and support affective systems. These theories describe emotion either with a multi-dimensional point of view in relation to an individual’s affective current state (Russell, 2003; Scherer, 2005), or considering that a number of basic emotions’ categorization exist (e.g., Ekman, 1999; Izard, 1977). For instance, the circumplex theory of emotion (Russell, 2003), which belongs to the first perspective, proposed that there are two essential dimensions (axes) of emotions, activation versus deactivation and pleasantness versus unpleasantness. The names of various emotions could then be arranged in a circular fashion around these axes. The researchers of the second perspective suggested that an emotional typology is appropriate and there is a consensus on what of these basic emotions might be. In most typology models, emotions such as happiness, sadness, anger, and anxiety are essential. Nevertheless, they hold divergent opinions on some issues such as the number of basic emotions. For example, Ekman’s model (1999) describe six, Plutchic’s (1980) eight and Izard’s (1977) ten. Another important theory is the Lazarus theory (1991), which emphasizes the cognitive aspect. This theory considered that
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an emotion-provoking stimulus triggers a cognitive appraisal, which is followed by the emotion and physiological arousal.

Despite the significant theories that have been proposed for affective computing, the two major theories, where the majority of affective systems are relied on, are the cognitive theory of emotions (OCC) which is related to the origination and the appraisal of emotions and the Five Factor Model which is connected to the explanation and the prediction of a person’s behavior according to his personality.

In order to explain the origins of emotions and to describe the cognitive processes that elicit them, Ortony et al. (1998) formulated the cognitive theory of emotions known also as the OCC model. Regardless of the various attempts that have been made in order to define and explain sufficiently the emotional processes, this theory keeps a distinctive position among them. According to this theory, in connection to a person’s perception of the world, his emotions can be elicited. This process is named appraisal and the OCC model assumes that the emotions can be triggered by the assessment of three perception aspects of the world. These aspects are events, objects and agents. The OCC model provides a classification scheme for 22 in total emotions based on a valence reaction in relation to them. That is, all emotions engage a kind of positive or negative reaction to the way the world is conceived. The intensity of the affective reactions determines whether or not they will be experienced as emotions.

Events are situations which are interpreted by people in a certain way. Consequently, events result to emotional reactions which are provoked by pleasant or unpleasant situations. The emotions of the OCC model that are attributed to events are grouped into three sets. The first set includes the happy-for, resentment, gloating, and pity emotions and is characterized as fortunes-of-others set. The second set includes the hope, fear, satisfaction, disappointment, fear-confirmed, and relief emotions and is characterized as prospect-based set. The third set includes the joy and distress emotions and is characterized as well-being set. Objects are material or abstract constructions. This aspect of the world includes emotional reactions with objects which are related to the emotions of attraction such as liking and disliking. Agents can be human beings, animals, artificial entities which represent humans or animals and software components which act in a specific way. This aspect of the world includes emotional reactions which are related to the emotions of attribution such as pride, shame, reproach, and admiration. There are also compound emotions due to agents’ interactions. These include gratification, remorse, gratitude, and anger emotions.

The origin of emotions relate to the subject’s perspective against Goals, Standards, and Attitudes. The events are evaluated in terms of their desirability, according to the goals of the subject. For example, one may be pleased if the event is desirable and displeased in the opposite case. The particular emotion emitted depends on whether the consequences of the event are for oneself or for another person. Standards are used to evaluate actions of a subject arising emotional reactions of approval or disapproval kind. Objects are evaluated as appealing depending on the compatibility of their attributes with subject’s attitudes.

Nonetheless, the authors of the OCC model admit that their model is oversimplified, since in a real situation a person experiences usually a mixture of emotions, however they consider that it could be computationally implemented and help explain the emotions that human beings feel, and under which conditions emotions are exhibited. Furthermore, they believe that relying on this model, human reactions to the events and objects are predictable and explained. According to this point of view, the OCC model has been integrated in many affective computational systems with the aim of recognizing the user’s affective state and implementing emotions in machines.

The second significant theory that is used for the integration of affective systems is the Five
Factor Model (FFM; McCrae & John, 1992). This is the most known model of personality and results from the study of Costa and McCrae (1992). It is a descriptive model with five dimensions (Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism) and views the personality as the set of all those characteristics that distinguish one human being from another. Due to these dimensions the model is also called OCEAN model. This model describes an Openness person as accessible to new experiences, creative, imaginative, intellectual, interested in culture, social, emotionally aware, with a significant sense of freedom and exploration. According to the intensity of these characteristics a person who belongs to the Openness category is characterized either as Explorer, or as Moderate or as Preserver. Conscientiousness refers to a person who is well-organized, dutiful, responsible, persistent in achieving goals, thoughtful and in detail before acting, controlling his impulses, with consolidated points of view. According to the intensity of these characteristics, a person who belongs to the Conscientiousness category is characterized either as Focused, Balanced or as Flexible. Extroversion refers to a social, energetic, talkative person who is liable to make new acquaintances easily and to demonstrate positive emotional behavior. According to the intensity of these characteristics a person who belongs to the Extroversion category is characterized either as Extrovert, or as Ambivalent or as Introvert. Agreeableness refers to a person who is cooperative, modest, friendly, accommodating, trusting, positive motivated in his interactions with other people and lacks antagonistic intentions. According to the intensity of these characteristics a person who belongs to the Agreeableness category is characterized either as Adapter, or as Negotiator or as Challenger. Finally, a negative emotionality is predominant in a Neuroticism person, thus this person usually feels nervous, anxious, in pressure, insecure, emotionally unstable and prone to pessimist thoughts. According to the intensity of these characteristics a person who belongs to the Neuroticism category is characterized either as Reactive, or as Responsive or as Resilient.

The FFM provides a reliable way to connect a user’s personality with his mood and emotions that he possibly develops during his interaction with an affective system. The descriptive character of FFM and the particular characteristics that accompany each type of personality (traits) allow us to model effectively the user’s personality (Oren & Ghasem-Aghae, 2003) and use this information in a wide range of applications (commercial, educational, etc.) (Conati & Zhou, 2002).

METHODS OF FORMAL REPRESENTATION OF AFFECTIVE KNOWLEDGE

The recognition of the user’s emotions or the detection of his emotional state would be invaluable without the subsequent storing, processing and reasoning of this information. In order to take advantage of these features the integration of the emotional information is demanding. In affective computing the various affective-captured data are integrated in user affective models. In this way the adaptation of a computer system to the human feelings is achieved via a well-structured model with the capability of maintaining the sensitively acquired data. After the emotions detection and representation the system is required to infer the origins of these emotions. This necessity indicates imperatively the use of a dynamically updated rational user model enhanced with the emotional dimension which is named affective model. The affective models have to deal with emotional and subconscious factors which affect our behavior and to handle user personalized information in dynamic situations in order to promote and support sustainable information of the real world. In general, dynamic situations are characterised by increasing complexity and for that reason their representation is difficult to be restricted to
explicit declarations. Our senses perceive selectively the knowledge of the real world, our mental models are however simplified and our reasoning mechanisms are also imperfect. As a result, the anticipated knowledge is incomplete and with nuggets of uncertainty. This intrinsic deficiency is underlined in case of the computer systems, the “intelligent potential” of which is limited further due to the low degree of the emotions’ recognition accuracy and by the interrelation of affective and rational factors.

For the above reasons the representation of emotions is an extremely complicated and challenging process. Despite these difficulties computational models of emotions have been proposed since the early sixties. For example, Abelson’s model of hot cognition (1963), Colby’s model of neurotic defence (1963) and Gullahorns’ model of a homunculus (1963) are some of the theories which have been applied. Psychologists suggest three kinds of emotions’ modelling. Dimensional models with three dimensions (valence, arousal, and stance) (Russell, 1997), discrete models which regard emotions as basic universal adaptive mechanisms, that evolved during the evolution in order to ensure survival (Ekman, 1992), and cognitive models which consider that emotions are triggered by inner cognitive process (Ortony, et al., 1988).

The formulation of the OCC theory as a cognitive model of emotions changed the scientific view and led the appraisal theory of emotions to renegotiation. The OCC model provided us with a useful framework for the modelling and representation of emotions. The vast majority of the contemporary affective systems are based on the OCC cognitive model of emotions. This model has a great contribution to the appropriate representation of emotions in the affective models. For instance, after a user is identified either as surprised or happy, the application ought to represent his emotional state. This representation is conducted ideally via the OCC model leading to the suitable adaptation of the computer system to the user’s affective state. Based on the OCC model more sophisticated models of emotions have been proposed by Conati and McLaren (2005) and Marsella and Gratch (2006). Despite the indisputable usefulness of these advanced models, most of them are highly dependent on the context, user’s prior knowledge and individual traits such as user’s personality.

Recently, some researchers focused on alternative ways of emotions’ representation. Meyer (2004) developed KARO a logical formalization framework which comprises of actions, beliefs and choices under a specific logical perspective. He used this framework to describe happy, sadness, fear and anger and to associate these emotions with complex production rules. On the other hand, Ochs et al. (2005) concentrated on the emotional facial expression for embodied agents. Based on the OCC model and a rational interaction theory Sadek et al. (1997) developed a logical formalization for the representation of joy, sadness, hope and fear. They assigned to these four emotions attributes such as intensity degree and tried to handle uncertainty factors. Moreover, they applied logics of belief, intention and uncertainty for the spatial mixing of emotional facial expressions.

Another modern approach in relation to emotions’ representation is the use of ontologies. Ontological knowledge representation contributes to the building of consistent user models and obtains the basis for interoperability support to authors and system developers especially in the complex knowledge domains of the Web-based educational systems (Dicheva & Aroyo, 2002).

The use of ontologies to the representation of emotions in Web-based educational systems has the benefit that allows the student model to handle explicitly information related to the student’s goals, his prior knowledge, his individual cognitive abilities, his emotional states and his interaction with the system (Mizoguchi et al., 1996). In the usage of ontologies in Web-based educational systems significant attention must be paid to the design, maintenance, integration,
sharing, re-using, and evaluation of the ontology (Mizoguchi et al., 2000). Leontidis et al. (2008) make use of the ontological methodology in order to achieve the formal representation of emotions in MENTOR a Web-Based Affective Educational Module for the student’s affective and learning support in distance learning. Using an XML ontological structure managed to represent an overlay student’s affective model open for inspection by him in case that he wishes to make comparisons with his own model.

Furthermore, many researchers in order for building intelligent educational systems and integrating flexible, reliable, consistent and robust affective student models into them, engaged a wide range of knowledge representation methods such as neural networks, fuzzy logic, symbolic rules, Bayesian networks, case-based reasoning (Alani et al., 2004; Conati & Zhou 2002; Oren & Ghasem-Aghae, 2003; Kinshuk et al., 2001; Horvitz et al., 1998). Any of these methods aims to ground a strong theoretical basis in combination with intelligent techniques to model student’s affectivity while concurrently adding a human-like sense to the represented knowledge.

Of late, some other researchers (e.g., Picard, 2003) took an interest in the area of affective databases and employed a novel methodology to achieve efficient interrelation between the knowledge that is represented and the interactions of the students. The benefits from this method are focused on the tacit background knowledge, change of emotional states, personality traits, and situations with increasing complexity. Besides, well-designed affective databases operate as part of an overall model for web-based affective educational systems where the domain and the student model, the learner interactions and goals and the teaching methods are being integrated effectively. Despite the innovative character of this methodology the lack of significant amount of affective databases is a major cause of the stall of affective computing. Motion captured data, speech recognition and expression, and facial expression recognition demand an important database storing and handling of multi-model affective data. Because of the shortage of related affective theories and experiments this method is not enough mature to be used credibly in the area of affective computing.

METHODS OF EMOTIONS ELICITATION

The process of capturing the affective information comprises of a certain range of methods such as the emotional speech recognition and processing, the facial recognition and expression, physiological signals such as skin conductivity, heart rate and observable behaviour such as eye tracking. In this section the main methods of emotion elicitation is analysed furthermore.

Emotional Speech Recognition and Processing

The field of emotional speech recognition involves methods which can deal with the bulk of enormous real-time speech data, extracting the speech characteristics that convey emotion and attitude in a systematic manner (Mozziconacci & Hermes, 2000). The task of recognising emotions in speech is difficult even for humans, who can in generally recognize one of about six different emotional states from speech with about 60% accuracy (Scherer, 1981). This task in a computer is performed by a speech recognition component that receives speech signals via an input device (e.g. microphone), recognizes the speech as a path through its grammar, and outputs a semantic token representing the speech. Research results on human vocal (prosody), led to the implementation of emotional speech models which have been integrated into computers with the aim of recognising emotions. For instance a person who is talking loud and fast in a specific moment might be recognised with high accuracy as angry
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(Murray & Arnott, 1993). In emotion recognition the methods are focused on extraction of voice features (Mansoorizadeh & Charkari, 2008). The most important features are the pitch signal, the shape of the vocal tract and the short-term energy. The pitch signal, also known as the glottal waveform is produced from the vibration of the vocal folds and has information about emotion (Pierre-Yves, 2003). The emotional states modified the shape of the vocal tract and this feature is a significant factor in the speech processing (Zhou et al., 2001). Related to the arousal level of emotions is the short-term speech energy from which useful information can be extracted for emotion recognition (Ververidis & Kotropoulos, 2006). For instance, fear is an emotion with with a high pitch level and a raised energy level, though anger is the emotion of the highest energy and pitch level (Iida et al., 2000).

Usually, the systems of speech emotion recognition make use of pattern recognition methods and algorithms to perform emotion classification and prediction. The output of an emotion classification method is a prediction value about the emotional state of an utterance, which is a segment of speech that corresponds to a phrase or a word. The most significant emotion classification methods are the (ANNs) (Womack & Hansen, 1996), which is based on artificial neural networks, the multi-channel hidden Markov Model (Womack & Hansen, 1999) and the mixture of hidden Markov models (Fernandez & Picard, 2003). There are also, other valuable prediction algorithms in emotion recognition for sadness, anger, happiness and fear such as the maximum likelihood Bayes classification, kernel regression, and k-nearest neighbor in emotion recognition for sadness, anger, happiness and fear (Dellaert, 1996). Although these algorithms perform its prediction using restrictive assumptions, such as when the sentence content is known, the systems manage to achieve automated speech recognition with 60% accuracy (Hansen, 1999).

Currently, researchers are concentrated on finding adequate combinations of classifiers to improve the classification efficiency in real-life applications. The research findings are used in dialogue systems to enhance the expressivity of computer systems. For example, in a ticket reservation system or a call-centre application that use speech recognition algorithms to recognize the annoyance or frustration of a user and to change its response accordingly (Schiel et al., 2002, Lee & Narayanan, 2005), or in the case of giving commands to a robot (Batliner et al., 2004). Despite the great progress that it has been done in the speech recognition area, the lack on the capture and the process of more reliable physiological data restricts the expected advance in this field. It is expected in the near future, that the enhancement of the theoretical models in relation to the vocal communication of emotion and the ability to acquire and process large-scale speech data, to make a great contribution to the emotional speech research. More detailed information for readers who interested in emotional speech recognition and processing can be found in the overview of Ververidis and Kotropoulos (2006).

Facial Expression Recognition

Researchers in the facial expression recognition field examine approaches with the aim of recognising specific muscle movements, such as eye lids, eye brows, nose, lips and skin texture, often revealed by wrinkles and bulges that can be used to recognise emotions or to construct any facial emotional expression (Tian et al., 2001). To deal with this use appropriate apparatus such as cameras, sensors to observe one person’s behaviour and to match it into patterns (Lisetti & Rumelhart, 1998; Yacoob & Davis, 1996). In the facial expression recognition the main purpose of the computer system is to assess a set of measures according to such patterns and relate them to the user’s emotional state. Sophisticated pattern recognition software in combination with
the corresponding equipment are used with the intention to detect facial muscle movements such as wrinkled brows, wide opened eyes, smiled face and assign them with emotions like anger, surprise, happiness (Chibelushi & Bourel, 2003). Also important is the intensity of facial actions which may be measured by determining either the geometric deformation of facial features or the density of wrinkles appearing in certain face regions (Fasel & Luettin, 2003). Visually trained information data processed under certain restricted conditions produce automated models capable of recognizing a wide range of facial expressions (Chen et al., 1998). Although a specific expression doesn’t always mean the existence of the corresponding emotion, facial expression recognition has demonstrated high rates of accuracy (approximate 95%). For example, Essa and Pentland (1997) relied on the Facial Action Coding system (FACS) theory of Ekman and Rosenberg (1997) who developed a system that can recognize from video six deliberately made facial expressions for a group of eight people with an accuracy of 98%. FACS uses 44 action units (AUs) for the description of facial actions with regard to their location and their intensity. Another, similar method which proposed by Pantic and Rothkrantz (2000) described facial expressions as combinations of Facial Action Units (FAUs). Based on this method, Kotsia and Pitas (2005) developed two novel real-time techniques for facial expression recognition in image sequences, which achieved a facial expression recognition accuracy of 95% for six basic facial expressions (anger, disgust, fear, happiness, sadness and surprise).

Other methods for facial expression recognition are Hidden Markov Models (HMM), neural network, Point Distribute Model (PDM), optical flow, geometrical tracking method, electromyograms (EMG) method, Gabor wavelets (Yamamoto et al., 1992; Lyons et al., 1998; Kobayashi & Hara, 1992). Due to its good performance and low restriction in relation to the sensitivity of face posture and the lighting background, the Gabor wavelets method is the primary choice by many researchers. Finally, the MPEG-4-SNHC (Koenen, 2000) is another sophisticated standard that encompasses analysis, coding and animation of faces (Tsapatsoulis et al., 2000). For readers who require more detailed information Fasel and Luettin (2003) have conducted a seminal survey.

**Physiological Pattern Recognition**

Physiological Pattern Recognition relies on the point of view that emotion recognition is more accurate when engages multiple types of low-level signals which are provided by monitoring physiological variables such as blood volume pulse, muscle tension, galvanic skin conductivity, respiration and heart rate. Physiologists have invented appropriate laboratory apparatus and tests in order for the user’s emotional state to be reliably measured. The main idea is to relate a person with particular patterns of his behavior using sensors and to input these patterns into a computer system in order to associate them with affective information that had been stored in user’s affective model. In this way the computer assesses measurable external changes and makes inferences about the user’s emotions.

The methods that the psychologists make of use are electromyograms (EMG) to detect electrical activity in muscles (Wiederhold et al., 2003), eye tracking devices to measure pupil responses to emotional stimulations (Partala & Surakka 2003), electroencephalograms (EEG) to monitor users’ brain activity for the detection of task engagement and user attention (Pope et al., 1995), Galvanic Skin Response (GSR) to sense user affective states, such as stress (Healey, 2000), or cognitive load (Verwey & Veltman 1996) and heart rate measurements to determine user’s affect (Prendinger et al., 2005). Although a significant number of experimental methods are available, existing empirical results suggest that the most reliably assessed affective measures are arousal and valence. The most accurate practical signal
for arousal detection is heart rate (Cacioppo et al., 1993). Other measures of arousal, such as galvanic skin response, or blood volume pressure do not supply readily assessed data (Orr & Abowd, 1998).

Picard et al. (2001) made use of some of the above methods to recognise eight different emotional states (happiness, sadness, anger, fear, disgust, surprise, neutrality, platonic love, and romantic love), when a user intentionally expresses these, by showing emotion specific pictures to elicit them. The measured signals were further analysed by specific algorithms and pattern recognition tools. As a result an important classification accuracy of 81% had been achieved.

**Observable Behaviour**

There is a significant amount of research based on methods which aim at recognising user’s affect from the observation of his interactions with the system (Paiva, 2005; Vicente & Pain, 2002). Such interactions might be the engagement with the system’s user interface, the execution time, how frequently a specific tool is used etc. The system is provided with such actions and in the next step these actions are further analysed by suitable algorithms. In this way it makes inferences about user’s emotions. According to Picard (1997) the recognition of emotions can be achieved by a multi-modal approach which combines a low-level signal recognition and a sophisticated software inference mechanism. Paiva (2000) adopts the view of a multi-modal affective sensory system and considers the different means of emotions recognition complementary. Related to this approach, the user’s affective model is a major factor and assists the affective system to respond properly after the user’s emotional state has been detected. It is a debatable issue on how to analyze the dynamic characteristics of the user’s affect and how to make the computer react properly according to the identification result of affective information. Some work on this field has been conducted by using different techniques. Among them are Conati and Zhou (2002), who made use of Dynamic Decision Networks (DNNs) to model affective characteristics of a student during his interaction with an educational game, Vicente and Pain (2002), who model the student’s motivational states based on factors which are obtained by the student’s observable behavior in order to motivate him appropriately, and Martinho et al. (2000), who defined a dynamic affective model for the collaborative game Teatrix. The affective information that is produced by the observable behavior is related to personal, cognitive, social and cultural factors to extract inferences about the current emotions and mood.

**AFFECTIVE ADAPTIVE EDUCATIONAL SYSTEMS**

During the last years, in the list of the affective computing bibliography, an ongoing number of affective educational systems have been recorded. Among them the work of Martinho et al. (2000), Conati and Zhou (2002), Faivre et al. (2002), Leontidis et al. (2008) seems to exploit efficiently features of affective computing in order to implement educational systems.

Martinho et al. (2000) integrated an affective student model in an educational game named Teatrix. Based on foundations of collaborative learning Teatrix motivates collaborative students for creating a story. Using a list of available actions, Teatrix encourages students to pick up the most suitable of them in order to manipulate an animation character. Evaluating these actions Teatrix appraises student’s emotions making use of predefined rules which map emotions to student’s actions. In addition to the description of inferring rules the system relies on student’s preferences and goals, which were detected in a previous session, in combination with the OCC model to elicit student’s emotions. According to this approach that is best known as Cognitive-Based Affective User
Modeling the student’s observable behavior is a way to forecast, detect and interpret his emotional state. The dynamic student model that contains the affective information is constituted of two parts. In the first one the detected student’s emotions are stored. In the second is stored the student’s affective profile which holds information about the likelihood of a user to experience a particular emotion and the usual duration of this emotion. The Teatrix’s affective student model is based also on the BDI (Belief-Desire-Intention) model, which perceives an affective system as a rational agent (Rao & Georgeff, 1991; Woldridge, 1999) which has certain mental attitudes of belief, desire and intention. This theory describes the exact way for the representation of the motivational and deliberative states of an agent.

The Prime Climb is an educational game designed by the EGEMS (Electronic Games for Education in Math and Science) at the University of British Columbia and is designed with the aim of supporting students to learn number factorization. The operation of this game is relied on a probabilistic model which proposed by Conati and Zhou (2002) in order to infer student’s emotions. The model was based on the OCC model and was built using Dynamic Decision Networks (DNNs), represents the goals of the student, the satisfying status of these goals, the educational events and their desirability and the action’s of an agent. The use of Dynamic Decision Networks allows the explicit definition of the student’s emotions especially in cases that he experiences mixed emotions. Furthermore, Prime Climb enables the explicit representation of the probabilistic dependencies between student’s emotions and the causes which trigger them. Prime Climb takes into account six emotions of the student (joy, distress, pride, shame, admiration and reproach) and divides them into two categories, the positive and the negative according to the desirability of the educational events and the agent’s actions. That is, events which are evaluated as desirable in relation to the student’s goals are considered to provoke positive emotions (joy, pride, admiration) while undesirable events provoke negative emotions (distress, shame, reproach). Correspondingly, the emotions which are triggered by the actions of the agent are categorized in the same way. The students’ goals are defined in two phases. In the first, before playing with Prime Climb, they are given a pretest and a questionnaire in order to evaluate their prior knowledge on the number factorization and to measure their exact goals according to the game. In the second, log files with the interactions of the students are collected with the aim of analyzing how the students play the game. The FFM theory is used in this phase in order for the students’ goals to be identified. For instance, a person who is conscientious is more likely to have the goal Avoid-Falling, that is to perform careful movements during the play of the game, while a disagreeable person is more likely to have the goal of Succeed-by-Myself, without external help.

Having considered the relations among cognition, emotion and action in contextual learning, Faivre et al. (2002) proposed a multi-agent architecture in which two emotional agents were integrated in an Intelligent Tutoring System, ITS. The first is designed with the aim of recognising and analyzing student’s emotions by his interactions with the user, while the second displays the tutor’s emotional expressions and gestures. The system uses an affective model which is divided into two units. The first is the Short Term Mood Memory and is in charge of storing the emotions which has been recognised. The second is the Long Term Mood Memory and contains information about the student’s mood profile. This information is the result of the average of measures which are taken during various learning sessions. The Tutor is implemented as a 3D embodied agent and makes use of non-verbal facial expressions and body gestures to interact with the student. It controls the learning process by selecting the educational content and resources, and tutorial strategies in order for the system adaptation to
be achieved suitably according to student needs. The selection of the appropriate tutorial strategies is determined by the affective state of the student and is performed by the use of “if – then” rules. The Tutor uses also “if – then” rules in relation to the OCC model for the emotion modelling.

MENTOR (Leontidis et al., 2008) is another Web-based affective adaptive educational module for distance learning that has been designed with the aim of providing the student with a more personalized and friendly environment for learning according to his personality, moods and emotions. The basic concern of MENTOR is to promote and maintain a positive emotional state in the student during the learning process. To achieve this, MENTOR recognizes the emotions of the learners and takes them under consideration to provide the students with the suitable learning strategy. This kind of strategy is based both on the cognitive abilities and the affective preferences of the student and is stored in the student’s model. The operation of MENTOR is based on the FFM and the OCC model. The module is attached to an Educational System providing the system with the essential “emotional” information in order to determine the strategy of learning in collaboration with the cognitive information. 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 Adaptive Educational System with the affective dimension optimizing the effectiveness of the learning process and enhancing the personalized teaching. The affective model of MENTOR uses an ontology of emotions for their formal representation. It is a proper way to represent the specific knowledge of a domain, providing an explicit and extensive framework to describe it. This ontology has been built to represent 10 emotions which are: joy, satisfaction, pride, hope, gratification, distress, disappointment, shame, fear, reproach. The former five emotions compose the classification of positive emotions and are related to the positive student’s emotional state. The latter five emotions compose the classification of negative emotions and are related to the negative student’s emotional state. The construction of the ontology was based on the OCC cognitive theory of emotions. The affective module uses the DL-OWL (Description Logic – Ontology Web Language), a reasoning and inference mechanism to acquire the essential production rules, as well as to analyse the domain knowledge and interaction data. An AI technique (decision tree approach) is adopted to extract information from the proposed “emotional” ontology and to make inferences about the emotions of the student. This approach, which is used for carrying of the representation and the inference of emotions, is based on the OCC model which combines the appraisal of an Event with the Intentions and Desires of a subject. Thus, taking advantage of this model, MENTOR infers about the student’s emotions after the occurrence of an educational event which is related to his learning goal. After the recognition of student’s emotion, MENTOR has sufficient information to provide the student with the appropriate affective tactic. Its structural characteristics enable MENTOR to be independent from the specific domain model of educational systems, so that it has the capability to be used by a wide range of users.

DISCUSSION AND FUTURE TRENDS

Affective computing is a relatively new area of interdisciplinary research interest. The coordinated efforts of psychologists, computer scientists and physiologists promise a breakthrough in this field. However, at this moment affective computing is
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still in its infancy. The shortage of a sufficient amount of adequate affective theories, namely, psychological studies which can be exploited effectively by AI scientists in order to reason unambiguously about the emotions, limit progress in affective computing. As a result, computer systems capable of adapting appropriately to the emotional state and the sentimental needs of a human being have a long way to go before coming to fruition.

Furthermore, another weak point is the current inadequacy to integrate affective information into affective models. In most cases the nature of this information is dynamic and for this reason demands suitably real-time processing algorithms to deal properly with them. On the other hand, the impotence of existing representation methods to define and describe satisfactory this dynamic information and the partial relations between the different formats of the affective data remains a restricting factor to the development of completely affective models. Accordingly, the adaptation of the affective system to the user’s affective states and personalized requirements cannot be considered persuasive especially in real scenarios.

Moreover, the methodological problems of affective computing occur in Web-based educational systems and believable pedagogical agents. Here, the objective of research is focused on how emotions and affective states can be recognized in the educational environment during the learning process. Which are the mental and emotional processes and the interrelations between them? Which are the basic emotions that must be selected for modeling? Which are the teaching and pedagogical methods that are more appropriate in relation to the student’s affectivity? The emotional and cognitive processes which take place during learning are not neither fully understood, nor easily observable. The use of today’s specialized affective apparatus does not enhance the accuracy of the observable measurements. We are still far from the point of appraising the subtle fluctuation in a person’s affective state.

Despite the promising evidence that is brought by the emergence of affective computing, some ethical and sociological questions have been also raised. The modern societies “face” with skepticism the new era that comes into view and the potential prevalence of intelligent machines which will be not only be intellectual but also sentimental and more “human” than ever. Some authors (e.g., Whitby, 1996; Warwick, 1998) have alarmed the public about the social effects and dangers that possibly would be brought about by the progress of this AI’s branch.

Apart from these debatable points, there are practical dimension of affective computing which have been already stated implicitly in the previous sections. For instance, the detection of a person’s affective state from the perceived data is an extremely complex process; the existing developed methods and techniques need significant improvement. Even for a human being the recognition of another’s emotions is a difficult and questionable task and its success depends on individual factors and abilities such as the personality and the instinct. Whereas some researchers according to their experiments claim that a computer system is able to detect user’s emotion with about 80% accuracy (Picard et al., 2001), major assumptions and simplifications had been made such as the specific selection among eight kinds of emotions. Matters are worse in case of emotional states where we have of mixture emotions. In this case instead of recognizing discrete emotions, a much more complicated identification of mixing emotions is required. Despite some progress, significant work remains to be conducted to advance research in the elicitation of emotions.

Besides, when the recognition of emotions has been accomplished, a forthcoming step will be the appropriate classification and regulation of them in order to reinforce positive emotions and avoid possibly negative impact during the system’s response to the user’s affective state. The main purpose for an affective application is to support effectively the user to his goals.
achievement such as demonstrating motivation and interest in educational environments, empathy in persuasive dialogues and compassion or enthusiasm in computer games.

However, the emotional expressiveness by computer system is restricted by the lack of physical body. Facial movements, gestures, postures, eye movements cannot be performed in a natural and persuasive way by computers. Due to the absence of anthropomorphic appearance the existing computer systems are not able to express realistic or at least convincing behavior. The designers of embodied agents and mechanical robots have a long distance to cover before building believable, human-like artifacts that respond humanly to human beings.

Having considered all the above issues the question is how close enough are we for building a realistic affective system? An emotional machine which could be recognize in great accuracy user’s emotions and to respond appropriately to his affective states by adapting itself suitably? Our sense is that we have a long way to go before such a system comes a reality.

Suggestions for Future Research

Future research must concentrate on the discovery of new methods or improvement the existing ones in order an affective system to be able to recognize accurately the user’s motivational states. New methods of emotion detection should be adequately assessed and validated as well. A significant drawback of most affective systems is the shortage of evaluative reports which test the reliability and the validity of their affective adaptive mechanisms. Although, in the field of affective educational systems some proposed models (Vicente & Pain, 2002; Martinho et al., 2000; Leontidis et al., 2008) point to the possible direction, there is still a need for further refinement of their quality and applicability in various educational situations.

In addition there is also a need for the emotional information to be formally represented and stored in a consistent affective model. There are three critical questions to be answered. Firstly, which are the basic emotions and the affective states that it would be better to represent? Especially, in educational environments, where there are specific interactions between the student and the system during the learning process, the affective and cognitive information should be formalized and validated in an appropriate way. Secondly, how the perceived dynamic affective information can be adequately represented and handled? That is, h, how this information can be exploited efficiently and how the adaptation algorithms can be improved in order to achieve better response to the user’s affective states in real scenarios? Finally, because of the dynamic nature of affective information how often and under which circumstances should an affective system be adapted to the user’s affective state? Change of the mood over the time is different from the corresponding emotions. Also additional factors related to a person’s individual traits and personality must be taken into account. Currently the existing affective models make use of clichéd emotional cues and personality traits. As a consequence their flexibility and efficiency in natural interactions with a user is today questionable. The answer to these questions in a satisfactory way would be unquestionably a catalytic factor in order to produce better affective educational systems in the near future.

Despite of the above remarks the progress that has been made in the field of affective computing is remarkable, and many past problems have been overcome. The number of affective systems is increasing and this makes promising the future advancement of emotional machines and their application.

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ENDNOTE

1 OCC comes after the initials of the three authors Ortony, Clore and Collins