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Affective Computing: Is a Computer Able to Feel Emotions?

People always think about how technology is going to be in the future, and sometime, based in new ideas or theories, they relate this thinking to create fictions stories with a whole futuristic universe, where some of the current developing technologies are showed. In this scenario, we can think about many examples that show some kind of emotional intelligence in computer systems. These systems usually act like humans, and think like humans, being able to answer stimulus with fear and excitement, or even other type of emotions. The idea of developing emotions in computer systems was described, for the first time, in the book *Affective Computing* that also named this new branch of Artificial Intelligence. My goal in this paper is to explain how emotions are developed, and how we can build these systems giving examples of existing technologies and existing models showing a variety of applications that can be developed using the concept of Affective Computing.

Affective Computing is a multidisciplinary field, and the first step to understand this concept is going deeper into the cognitive and the physical approaches of emotions, learning the basic roles of the brain and body in their development. There are some questions we should ask ourselves to better understand the development of emotions, such as: What exactly is an emotion? How do we know if someone likes something? What is the difference of mood and emotion? How they influence your decisions? Are they cognitive like thoughts or physical like a smile? (Picard 1997). These questions are important because their answer will give us some

ideas about how to build a computer system able to analyze emotions, and also able to reproduce them. The definition of emotion is very complex, but mostly it can be described as a group of cognitive and physical expressions that we present when our brain reacts to some internal or external inputs, generating what we can categorize as being a mental state. Emotions can be described as 6 basic elements: happiness, sadness, anger, fear, disgust, and surprise. The basic emotions can also be separated into 2 different categories: pleasant (happiness, surprise), and unpleasant (sadness, anger, fear, disgust) (Gokcay, 2011).

When we talk about development of emotions, we need to be concerned that the regions of the brain involved in these functions are multi-tasks, or more specifically, they can execute different tasks in the same region of the brain with different purposes. This is extremely important when we describe physical and cognitive aspects of emotion, as most part of emotional reactions, both physical and cognitive, are developed in the same region of the brain. The cognitive and physical behaviors of emotions work in a very similar way, but the distinction of these two categories is very important when we analyze the brain and its functions aiming to build a computer model. Emotional physical sensations are mostly developed in the limbic system, and the regions of the brain responsible for these sensations and reactions can be described as: Hypothalamus, Brain Stem, and Medulla Spinalis. In the main structure, the hypothalamus act like a relay station. It receives signals as inputs from different parts of the brain, and its main function is to maintain the internal stability and controls many emotional behaviors of the body. The hypothalamus also has an important role in the activation of the Autonomic Nervous System that is responsible for the internal environment homeostasis. The Autonomic Nervous System is divided in two categories: Sympathetic and Parasympathetic. While one of the systems increases body reactions the other one decreases. The Parasympathetic

System is activated when it is necessary to maintain energies for a determinate reason. The Sympathetic system has a great responsibility in the physical development of emotions, and its main role is to increase physical signals to indicate changes in the environment, for example when the individual demonstrate signs of fear, making the heart beats to increase along with the blood pressure, indicating an alert state. When the individual are in an alert state, the Parasympathetic System start to work as soon as the individual realizes that there is no danger anymore. The Parasympathetic System will release neurotransmitters that are going to counteract with the Sympathetic System. Another important region of the limbic system is the amygdala, which is a complex structure that participates in the most part of the behavioral functions, including attention, perception, and explicitly memory. It also helps regulating learned emotional responses. One of the most famous experiments, to prove the role of the amygdala in the regulation of these functions, was made by Joseph LeDoux. The experiment was based in relating sounds with electric shocks, where rats received electric shocks while listening to these sounds. After some tests, LeDoux was able to prove that only the sound was able to activate fear in the rats due to the previous experiences, what was called further of emotional experience.

The understanding of emotions is extremely important in the development of human-like emotional intelligent systems. One of the main reasons for the development of these systems is to bring a new experience of interaction, where the system can evaluate the users' mental and physical states to decide the best way to interact with them. Given the reasons to understand cognitive and physical aspects of emotion, the next step for computer science in Affective Computing is the translation of the human emotional systems to computational models. These models have the objective to represent functions and processes of emotion happening in the human brain, for example, in analyze and expression of emotions. A computer system that can

recognize emotions needs some specifics aspects according to Picard in the book Affective Computing. The aspects are defined as: Inputs, Pattern recognition, Reasoning, Learning, and Outputs. In the other hand, computer that can express emotions are expected to have other different aspects: Inputs, Intentional vs. Spontaneous, Pathways, Feedback, Bias-exclusion, Social Display Rules, and Outputs. It is important to emphasize that these components have an important role in the development of emotional intelligence systems that are able not only to understand external emotions, but also to analyze its own emotions and regulate affect, adapting its own behaviors according to the current environment. Also, some studies suggest the inclusion of consciousness in emotional intelligent systems, although it is not necessary for all emotions, this aspect would be responsible to help the system to reflect about existing emotions, and also learn from this reflection. Another important point in an emotional intelligent system is the applications of emotional experience, which helps us to better understand our own emotions and also regulate the respective reactions, even though a system without emotional experience is also possible to be developed, where these characteristics would not be taken in consideration. To summarize we can say that emotional Experience is consisted of: Cognitive Awareness, Physiological Awareness, and Subjective feelings.

In the development of emotional intelligent systems, it is valid to affirm that all applications implementing Affective Computing concepts need to answer the following three questions: “What is the relevant set of emotions for this application? How can these best be recognized/expressed/developed? How should the computer respond to the user given this information?” as explained by Picard in the book Affective Computing. Based in these concepts there are some different kinds of emotional computer models we can analyze that are divided in different categories, as we can see in the Figure 1.

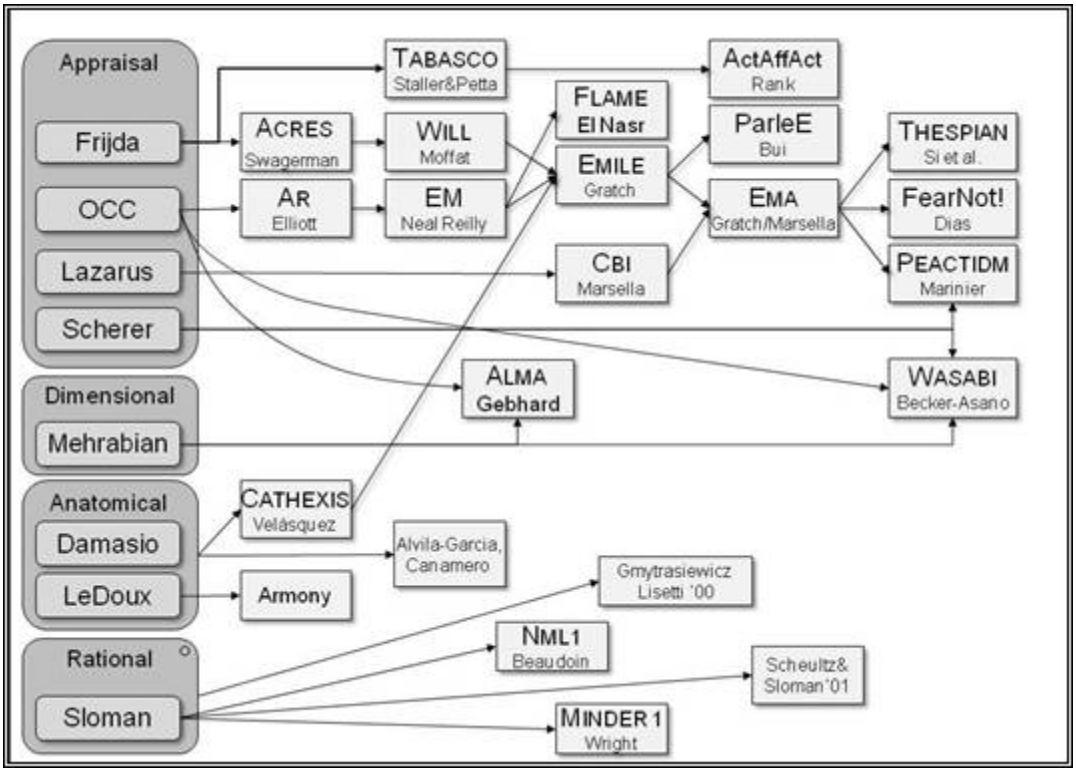

Figure 1 - Computational models of emotion

The first step to understand and implement computational models is to have a defined and clear structure of the process presented in the theory. The first category and one of the most important in the current scenario of emotional computer models is the appraisal theories. In appraisal theories, emotions are generated from the relationship between events and the beliefs of an agent. It also explains the connections between cognition and emotions, where appraisal models are designed as the cause of emotions and described by labels that define an emotional state. As the second category, dimensional theories have a complete different point of view of emotion, compared with appraisal theories. It states that an emotion cannot be described as a group of entities, but it is described as points in a continuous dimensional space. Dimensional theories also emphasize the use of terms like mood, affect, and core affect, in contrast with emotion's definition stated in the appraisal theories. The third category, Anatomic theories,

emphasizes the reconstruction of neural links in emotional reactions. Anatomic theories describe emotions as neural circuits emphasizing the processes related to these circuits. The last category covered in this paper, but also extremely important, Rational theories describe emotion as a set of processes and constraints with adaptive value.

Although we can still say that Affective computing is a very young branch of artificial intelligence, we can list some interesting application that can be developed based on its concept. One of the applications proposed is a system able to mirror human behaviors, helping the user to improve some determined tasks, measuring its cognitive and physical signs, and suggesting changes in the user's behaviors. An example of this application is when the user is practicing for a job interview. Another suggestion is a system that is able to transmit emotions throughout text messages. This would be helpful, as sometimes it is hard to recognize emotions while reading a text, for example in an email message. The proposed application would measure your signals and send them to the recipient, helping them to understand your emotions, avoiding an emotional ambiguity that usually happens in these scenarios. Another example of intelligent system is a technology that is already presented in the world, voice synthesizers. This technology could be drastically improved if emotions were applied. One of the problems of this technology is the difficulty to identify different emotion in the voice, as it is spoken in the same tone, not considering all the emotions presented by the agent. In this application, the system would be responsible to measure the user's emotional signals, and express these emotions through the voice synthesizer, modulating the voice in different tones. Another example is the development of computer systems that are able to learn your preferences according to your emotions, distinguishing if you like or dislike something, and also analyzing your current preference to decide what is the best decision to be taken. For example, the user could describe emotional

preference about when the system can interrupt an important meeting to send an urgent message, by demonstrating frustration when the system interrupts the meeting. As the last example, a feedback system could also use the concepts of Affective Computing to determine if the user needs help to execute a specific task, measuring the frustration of the user. An example of this application can be seen when the user is trying to learn how to use a new software program, while the system analyzes the problems, and suggest different options and solutions. Although these examples represent some applications of Affective Computing, it is necessary to emphasize that there are still many other different approaches and solutions, in the current scenario, that were not covered in this paper.

In conclusion, it is important to emphasize that Affective Computing is still a new idea, and as Artificial Intelligence, it is not mature enough yet. As it was said in the beginning, Affective Computing is an interdisciplinary field that covers not only artificial intelligence, and for this reason, it is extremely important to put all the involved areas and stakeholders to work together in the development of Affective Computing, such as in the study and improvement of existing theorems and also in more efficient computer models, for a faster and more centered growing of the field. Although we have many expectations about Affective Computing in the future, we still have a lot to learn, not only in the development of emotional intelligent system, but also about a deeper understanding of other emotional functions, physically and cognitively. Also, I truly believe that emotional systems have an important role in the future, where the computer-user interaction will reach a complete new level, creating new solutions and different approaches in the way we interact with computer systems.

Related Work

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