Emotional intelligence in interactive systems

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ABSTRACT. In this paper, we introduce the Emotional Intelligence Framework, EIF (Salovey *et al.*, 2000) in order to evaluate the state of the art of emotionally adept technology. Our belief is that the EIF can usefully guide further development of affective computing, as it encompasses more than a focus upon superficial sensor-level interaction.

KEYWORDS: human-computer interaction, affective computing.

INTRODUCTION

Since Gardner (1983) challenged the widely held notion that intelligence is a unitary capacity for logical reasoning possessed by every individual to a greater or lesser extent, the concept of multiple intelligences has strongly affected psychology, education theories and neuroscience. Recently, this idea has entered computer science, where it has been used to support the establishment of affective computing, or computing that relates to, arises from, and deliberately influences emotions (Picard, 1997).

Affective computing lies on the border of artificial intelligence and anthropomorphic interface design. It aims to enrich artificial intelligence rule-based systems with 'emotional modules' to recognise user emotions and to give machines 'emotions'. The field is witnessing an extraordinary popularity. Wearable computers equipped with physiological sensors and pattern recognition have been developed to receive and interpret signals which are expected to convey the affective state of the user (Picard, 1997). Affective architectures have been proposed to represent and reason with affective control states such as, preferences, desires and emotions. Animated talking heads have been designed to produce synthetic speech and facial expressions which are expected to convey emotional states (Poggi and Pelachaud 2000).

Product design follows a similar route from functional to affective. Recent trends are towards objects that inspire users, evoke emotions, and even stimulate dreams. Product semantics has been applied to the design of emotionally rich

products: the affective response is embedded in the visual features of the product, such as its shape, colour or texture (Demirbilek and Sener, 2000).

Designing affective products is a complex task. Emotions associated with objects are often a blend of various contradictory feelings, which are difficult to interpret. Emotions are mental events; they are dynamic and depend on our relationship with an object in a particular context. Emotions are subjective, as such they depend on the observer's personality, goal, values and attitudes.

The challenge becomes even more difficult when we attempt to create emotionally intelligent systems, or systems that not only induce affective responses but also understand the emotional status of the user and adapt their behaviour accordingly. There is no established methodology yet, which may help us understand and create emotionally adept technology. Work on emotion, though expanding rapidly, still needs to co-ordinate the effort of many disciplines. Psychology investigates how emotions interface with cognition, personality, and social issues. Physiology links emotions to anatomical structures and processes; sociology investigates how emotions are triggered, interpreted and expressed by group members. Anthropology ties emotions to cultures; philosophy investigates the essential nature and definition. The very same question '*What is an emotion?*' still provokes different and sometimes contradictory answers. Nevertheless, the psychological importance of emotion is widely acknowledged. In contrast to the traditional Western rationalism, a consensus has emerged that emotions augment rather than interfere with cognition. Besides, emotions are considered to be the primary source of motivation: they arouse, sustain and direct human action.

THE EMOTIONAL INTELLIGENCE FRAMEWORK

Emotional intelligence (Salovey *et al.*, 2000) is regarded as the ability to perceive and express emotions, to understand and use them, and to manage emotions so as to foster personal well-being. The concept subsumes Gardner's interpersonal and intrapersonal intelligences in a unique emotional space, so differentiating specific emotional competencies from social ones. According to the EIF, emotional intelligence encompasses several abilities hierarchically ordered in four branches composed of several sub-skills organised according to their complexity.

1. Identifying emotions
2. Using emotions
3. Understanding emotions
4. Managing emotions.

At the basic level there is the ability to perceive, appraise and express emotions accurately. These are basic information-processing skills in which the relevant information consists of feeling and mood states. Emotions are identified in one's own physical and psychological states as well as in other people and objects. Basic skills also include the ability to express emotions and needs related to these feelings; and evaluating accuracy and honesty in the expression of feelings.

The second branch, *using emotion,* refers to the use of emotions as thinking facilitation. Different emotions induce different information-processing styles, hence emotional states can be harnessed by an individual towards a number of ends, such as stimulating creativity and problem solving.

The third element, *understanding emotion,* concerns essential knowledge about the emotional system. The most fundamental competencies at this level concern the ability to label emotions with words, perceive causes and

consequences of emotions, understand how different emotions are related and interpret complex feelings. This knowledge contributes to the fourth branch regarding the *regulation of emotion*, mood maintenance, and mood repair strategies. In order to put knowledge into action, people must develop further competencies. They must be open to feelings, both those that are pleasant and unpleasant. Then, they need to practice and become adept at engaging in behaviours that bring about desired feelings in them selves and in others.

ASSESSING CURRENT AFFECTIVE DESIGN

Our proposal is to employ the EIF as an indicator of technological evolution, to evaluate advances in affective computing, and as an instrument to stimulate further development. Our aim is not to propose a model for Affective Computing, but to raise some neglected questions in a structured way. We are aware that humans are not suitable models for machines, because computing requires formalisation and reductionism, but we need to make sure that such a simplification does not irremediably hamper the target: creating emotionally adept technology.

Most of the research on affective computing has concentrated on the first stage of the EIF taxonomy, and particularly on perceiving user emotion or displaying computer emotion. With regard to perception, two types of sensors have been proposed so far: those that require user intent and those that passively collect data from the user. Typically, devices for communicating affective feedback are intended to help people express their frustration. They can be interface widgets operated by the user or pressure sensitive devices that recognise intentional or even unintentional muscle tension or speech variations. Passive sensors record the user behaviour (e.g., typing) or physiological variations (e.g., blood volume pulse, electromyogram, skin conductivity and respiration rate).

The basic assumption behind the psychophysiological approach is that emotions are biologically grounded and universal. This is true if we address the basic physiological process of emotion. Highest stages of the emotional system are socially grounded. The appraisal of the events which have generated an emotion, and the relevant norm for behaviour vary as a function of personal variables, such as culture, gender, age or social factors, such as relative power and relationships.

Physiological measurements may tell us that the body is undergoing some physical changes, but the meaning of that change still varies among different people. A possible solution may be training a computer, as has been done in the speech recognition field. However, passive sensing still opens many issues, related to the acceptability of the solution, loss of control and privacy. The basic question is: Do I really want a projector to sense and react to my apprehension before giving a talk, when I am doing my best to hide my emotions from the audience?

People express their feelings through communication and action, but these feelings are always grounded in a social context. Sometimes they need to be ignored. Sensing without intelligence is useless if not dangerous. Information collected in the first stage of a process will hardly be transformed into useful behaviour without further skills. The request for feedback may be a partial solution to the ambiguity of the perception level, and a very anthropomorphic one. If the machine senses a change in the user status, it should first verify that that change is due to an emotional reaction, and that the user wants the issue to be addressed.

Another relatively well-explored area concerns the expression of emotions in the computer. The current approach is very anthropomorphic in nature: talking

heads are designed to display even subtle feelings with voice and facial expressions, such as eyebrow and lip movements. This viewpoint is justified by the highly influential media equation paradigm stating that individuals' interactions with computers are fundamentally social and natural, exactly like people-people interactions in real life (Reeves and Nass, 1996). Nevertheless, the design of animated faces based simply on the representation of surface signals (physical movement) does not catch the full complexity of the phenomenon. Cultures vary in the display and interpretation of facial expression of emotion. Individuals vary in the emotional intensity that they attribute to facial expressions, as well as on the inferences they draw from those expressions. Facial emotion appears to be connected to the language a person is speaking with evidence of Hindi-English bilingual people producing different expression according to the language spoken. Again, believable talking heads need further branches of intelligence, to meaningfully co-ordinate their gesture and language.

Verbal language is a powerful channel to express emotion. Our research with chatterbots (De Angeli *et al*., 2001a) has proved that emotional and social intelligence are instrumental to the believability of artificial creatures. Their absence dissolves the illusion of life, as demonstrated in the following interaction between Alice and an occasional user.

User*:* *do you have feelings Alice?*

Robot*:* *as a robot I do not have any human emotion. My apparent emotional responses are simply algorithms designed to make me easier to interact with.*

Client*:* *I suspect that you do not exist and that you are simply an interface made by some ambitious programmer*

DISCUSSION & DEVELOPMENT

Affective computing is in its infancy, with most of the proposed solutions covering only the basic skills of emotional intelligence while aiming at the highest emotional competency: emotion management. The inevitable computational reductionism has generated a misunderstanding, assuming that emotions are physical and cognitive, whilst they are actually deeply grounded in social contexts. Also current approaches tend to separate emotional intelligence, from other types of competencies which contribute to 'intelligent behaviour'.

The time is right to develop the field, addressing functional demands and innovative metaphors. We must understand what we are trying to achieve with developing emotionally adept technology. Applying the theory to real user needs may help us to understand how to design these technologies. We need to understand which computer-supported activities may be enhanced by emotional intelligence in the machine and which user emotional needs can be satisfied. If we can sense emotions, we need to know how this knowledge may be used to improve the user experience. We need to differentiate functional context, where we need tools for functional purposes, from social and emotional ones, where we want to exploit the full range of human ability.

Electronic commerce appears a promising domain to experiment with affective computing (De Angeli *et al.*, 2001b). Virtual shops need to evoke positive affect, if they want the customers to return and buy. In this context, we may set a clear goal for affective systems: to *please the user*, enhancing or repairing the user's mood. Research under laboratory conditions indicates that it is possible to elicit target

emotions. Of the diverse techniques available, films are the most effective in eliciting common emotions among different people. This has been attributed to the fact that films have a relatively high degree of ecological validity. Emotions are also generated by dynamic auditory and visual stimuli. Computer interfaces can be regarded as a collection of snap-shots, composed of diverse visual and auditory stimuli designed to directly engage the user into the interaction

Affective computing is still following a hard-computational approach. The possibility of success may be increased by a softer view based also on knowledge of psychology. A psychological perspective, as the one presented here may help us to understand the nature of emotional intelligence in interactive systems and evaluating what emotions are expected and accepted in a machine.

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