Affective Human-Computer Interaction

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INTRODUCTION

Affective computing facilitates more intuitive, natural computer interfaces by enabling the communication of the user's emotional state. Despite rapid growth in recent years, affective computing is still an under-explored field, which holds promise to be a valuable direction for future software development. Human-computer interaction has traditionally been dominated by the information processing metaphor and as a result, interaction between the computer and the user is generally unidirectional and asymmetric. The next generation of computer interfaces aim to address this gap in communication and create interaction environments that support the motivational and affective goals of the user.

This article will introduce and elaborate on the field of affective computing. First the background and origins of the field will be discussed. Next the elements of affective computing and affective human-computer interaction will be discussed along with associated concerns and issues. Next, examples of the diverse range of affective computing applications in current and recent development will be provided. Finally, the article will present a discussion of future directions for this promising technology, followed by some concluding remarks.

BACKGROUND

Computer usage has traditionally been regarded as a rational activity in which emotions are not involved. This view, however, has been changing as the importance of emotions in all aspects of human thinking, activity and interaction is becoming more apparent. Human interactions do not just include those with other people, but also with their surroundings, including inanimate objects. One such object that has a big role in the day to day life of many people is the computer.

It is not uncommon for a person to spend more hours in a day interacting with a computer than face to face with other people. For this reason it is important to design computers that are user-friendly and easy to use (Preece et al., 1994). One important aspect of this drive towards user-friendliness is that the user should be able to use his or her natural way of interacting rather than having to learn new ways of working (Norman, 1988). The goal of improving the interaction between users and computers requires that emotions be taken into account in this interaction.

The field of HCI has greatly matured over the last several decades since the first conference on human factors in computing systems was held in the early 1980's. Since this time the emphasis within HCI has shifted from a focus on trained systems operators, to analyzing how technology influences the general user. To this end, there has been a substantial amount of attention devoted to the concept of usability, as well as the role of the user in the development of successful interfaces. Usability is simply defined as "the extent to which a product can be used by specified users to achieve specific goals with effectiveness, efficiency, and satisfaction in a specified context of use" (International Organization for Standardization, 2010). This broad definition sets the stage for the fact that usability is a complex construct that can be influenced by a large number of external factors including context or environment.

In the early 80s, the role of a HCI specialist would be to evaluate interface components such as menus or terminology. As the field progressed, and the specialists came to realize the broader applicability of their work, new directions and specializations were created. The term "user-centered" is extensively used in the field of HCI (Karat & Karat, 2003) when describing approaches

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to building usable systems. For user-centered design, the main focus is that the needs of the user are used as a way to inform design (Vredenburg, Isensee, & Righi, 2001). This perspective is also sometimes referred to as human-centered design, or human centered computing (HCC). HCC broadly describes the methodology that would be applied to any field that uses computers in any form where users directly interact with them (Jaimes, Sebe, & Gatica-Perez, 2006). Thus HCC aims to integrate human sciences (such as cognitive and affective) into the existing body of computer science and HCI knowledge with a human focus throughout the lifecycle. HCC is said to incorporate social and cognitive sciences more closely than traditional HCI (Foley, 2006).

The recognition that interaction is not limited to simple interface modalities gives support to the development of new technologies. The ISO 9241 standard encapsulates this view in the following high level goal for user-centered design: "the design addresses the whole user experience" (International Organization for Standardization, 2010). This acknowledges that the HCC principles of cognitive and affective design are important when developing usable software and systems. To this end, a successful user interface would have an understanding of what emotions are, how they can be identified and what the implications of various emotional patterns are for a given interaction situation.

The term "affective computing" was coined as long ago as 1997 by Rosalind Picard, who defined it as "computing that relates to, arises from, or deliberately influences emotions" (Picard, 1997a, p. x). This is the most comprehensive and widely used definition and is often cited. Picard, a pioneer in this field, reports that the initial response to the very concept of emotion-sensitive machines was somewhat lackluster (Picard, 2010), and it is interesting to observe the dramatic rise in interest from both developers and the research community over the last decade.

Affective computer interfaces improve human-computer interaction by enabling the communication of the user's emotional state. The growing interest in affective computing arises from findings in psychology and physiology which demonstrate the importance of emotional state in human behaviour (Partala & Surakka, 2004).

It is widely understood that there is an interaction between emotional and cognitive events (Cytowic, 1989). The interaction between affect and cognition is bi-directional, thus the underlying affective state of the individual will also influence the outcome of various cognitive processes. This, predictably, has far ranging implications. There is evidence that emotion has an impact on the speed at which information is processed (Öhman, 2001) and whether it is attended to (Anderson, 2001; Vuilleumier, 2001). Emotion also has a relation to motivation in that evaluations or feelings regarding the current situation will largely determine the action that is taken in response. Therefore, emotions are often precursors of motivations (Oatley, 1992). Memory is also impacted by emotional state, and again there are many mechanisms by which this can occur (Reisberg & Hertel, 2003). Thus there are substantial potential benefits to be had from the development of user interfaces that support users' emotional, as well as cognitive processes, in their day to day work or life.

Currently, affective computing research is conducted in a large number of areas including education, autonomous agents, games and healthcare. There is also a rapidly growing body of published literature on the subject with 2010 marking the launch of the *IEEE Transactions on Affective Computing*. This is the first cross-disciplinary, international journal dedicated toward disseminating the results of research in areas such as theories of affective human-computer interaction systems, algorithms to detect and respond to emotions, and applications of affective computing.

AFFECTIVE HUMAN-COMPUTER INTERACTION

Although a computer will not actually experience emotions in the same way that a human would, the quality of interaction has been shown to improve even if the system *appears* to do so. Klein, Moon and Picard (2002) conducted a study in which users interacted with a computer system that was designed to deliberately elicit negative feelings of frustration. It did this by inserting random delays or periods of unresponsiveness to hinder the users from carrying out the goals of the study. The results demonstrated that if the computer system provided users with the ability to vent their frustrations (as a form of affect-support), users continued to interact with the frustrating system significantly longer than if no affect-support was provided. Empathic agents have also been successfully used in software to improve us-