Exploring a Brain Controlled Interface for Emotional Awareness

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***Abstract*— Emotions play an important role in human interaction, communication, coordination, and cooperation. The perception of emotional and affective state in present and past group's activities is a relevant issue since emotional awareness influence the outcome of cooperative work. While there is a growing interest in providing computational support for recognition and representation of emotions, few research efforts explore the potential of Brain Controlled Interfaces (BCI) to collect and present emotional awareness in synchronous collaborative systems. In this paper, we present an initial step in exploring how a low-cost off-the-shelf electroencephalograph (EEG) system can be used to provide emotional awareness information in synchronous collaborative editing systems.**

Keywords-component; Affective Computing; Emotional Awareness; Computer Supported Cooperative Workd; Computer-Mediated Communucation; Brain controlled interface.

I. INTRODUCTION

The CSCW (Computer Supported Cooperative Work) area has many goals including the search for ways in which information technology effectively supports group work. One alternative to achieve this goal is the exploration of awareness resources that provide information on the participants' actions, sense of presence, and emotions during group work.

The resources used to provide awareness information in Collaborative Editing Systems (CES) allow the participants to obtain knowledge of the group activities to know what happened, what is happening and what will happen, and also to provide details about the work and the group. However, most awareness information provided in collaborative sessions relies on the sense of presence and task activities instead of the users' affective state. The reason to investigate emotional awareness in CES is that this type of information is known to affect the design solutions, guide social implications, and influence organizational effects [2].

We choose synchronous CES because this type of application requires immediate response that may impact participant's perception and behavior. We think that synchronous CES has potential for the exploration of emotional awareness. Moreover emotional awareness can be considered a new layer of information employed to understand users' behavior. It also has the potential to enhance the sense of group presence to remote participants.

The motivation for the study of emotional awareness includes the need to identify and better understand how the insertion of such information about personal human affective condition can provide positive or negative impact. These impacts can somehow influence the user experience of an application and also can increase the importance of the computer-mediated affective awareness as a factor in the design and construction of CES.

The goal of this paper is to explore the use of an electroencephalograph system to provide awareness information about the users' affective state in synchronous CES. Our research proposal employs a low-cost off-the-shelf electroencephalograph (EEG) system to collect emotional awareness information in a relevant manner to CSCW research. We also investigate how to effectively represent emotional awareness in CES by designing visual widgets coupled with user interfaces.

The research method is based on the proposition of a set of different visual awareness widgets and the evaluation of them in a controlled experiment that mimics real world collaboration scenarios. Our hypothesis is that some of the visual widgets used to provide emotional awareness contribute to the collaboration more than others and are suitable to provide meaningful emotional awareness in synchronous CES. Our main research effort aims to provide answers to the question: *How emotional awareness can affect collaboration aspects in synchronous CES*?

The rest of the paper is organized as follows. Section 2 describes the definition and applications of emotional awareness in collaborative systems. Section 3 presents the use of Brain Controlled Interfaces to capture emotions directly from the brain. Section 4 discusses how to represent emotional awareness in CES. Finally, Section 5 presents the conclusions, comments and future work.

II. EMOTIONAL AWARENESS

The study of emotions involves many disciplines such as neurology, psychology, and physiology. From the computer science point of view, the Affective Computing area explores how computing relates to, arises from, or deliberately influences emotions [8] arguing that by conferring the computers with abilities to recognize, model, and synthesize emotions, human-human and human-computer interaction will be improved.

The Computer Supported Cooperative Work area studies, among other topics, the necessary factors to create a common context shared by the participants during collaboration. This context prevents that a specific participant feels isolated from the group, thus reducing his contributions and distancing himself from the work being accomplished. The information provided by other

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participants' presences and their roles during collaboration is classified as Collaboration Awareness and is the most common type of awareness available in CES. The Collaboration Awareness is responsible to provide the sense of presence and actions of the group to remote participants. This means that awareness allows each participant of the group to coordinate and organize his/her work, since he/she has information that allows the understanding of what others are doing. The awareness also provides the opportunity to both enhance communication, either informal or formal and support the social protocol used while the work is being produced. The design and construction of groupware that relies on efficient communication technology to support transparent distributed interaction, to the point of achieving the same communication faculty of a face-to-face interaction, are still a challenge.

García et. al [2] state that at the same way collaboration awareness can be used to bring sense of identity and co-location, the use of mechanisms that represent emotions can also provide awareness of their collaborator's emotional state and act accordingly to achieve better results in their joint work. This specific type of collaboration awareness is named Emotional Awareness and follows recent research efforts for Sentiment Analysis and Opinion Mining [7].

The possibilities for applications of emotional awareness in groupware system include: the enhancement of electronic meeting systems with the level of audience interest, better recommendation systems based on opinions and sentiments, availability of information for initialization of casual interactions, aggregation of sentimental information in order to support collaborative decision making, detection of willingness for collaboration on a specific task, and empirical evaluation of user intention preservation when concurrent controls techniques based on the CCI (Convergence, Causality-preservation, and Intention-preservation) [11] model are employed.

The development of emotional-aware groupware is not considered a trivial task since conception, specification and design decisions require the manipulation of sensors and input devices, emotional models, pattern recognition algorithms, and widgets for representing the user's emotional state [3]. Here we focus on the representation of awareness information in collaborative systems that people use to perform group work.

The traditional approach employed to display information about the sense of presence and workspace awareness is visual awareness devices that provide information about the participants and their actions. The interface elements are called awareness widgets and are designed as components of the user interface that offer the opportunity to understand the meaning of the actions and allow the participants to coordinate their activities and enhance the communication. At the current state of development the problem of emotion representation by means of an user interface widget is an open problem since the interpretation of the complexity and richness of such a subject affective state is still at an early stage of development by CSCW research.

The literature of the CSCW area contains many awareness widgets used to represent different types of awareness including informal, group-structural, social, and workspace awareness. Gárcia et. al [2] suggest experimental interfaces to display emotion representation in collaborative systems including: emotional awareness graphs, affective icons and avatars, facial texture mappers, and a mood-drive availability wheel. Although these interfaces present some form of emotional awareness, they do not link the emotional state with artifacts, task or the workspace where the users are collaborating. These links are a relevant issue once they allow the participants to associate their emotional state with a specific action he/she is performing that can be used to understand decisions, organize the tasks and its performers according to mood, and inform how the coordination and communication may guide the flow of the collaboration as a whole.

III. BRAIN CONTROLLED INTERFACES

There are many types of sensors that capture biological signals including: Electromyography (EMG) to measure muscle activity, Temperature (TEMP), Electroencephalography (EEG) used for brain-wave monitoring, Skin Conductance (SC) to measure electrodermal activity, Electrocardiogram (EKG) for heart activity monitoring, Respiration (RESP), Photoplethysmography (BVP/HR) used for blood volume pulse and heart rate monitoring.

In this paper, we focus on the Electroencephalograph (EEG) that is the most commonly used technology in contemporary noninvasive BCI research. EEG uses electrodes placed on the scalp to measure the weak electrical potentials generated by brain activity. The signal provided by an EEG is at best a crude representation of brain activity due to the nature of the detector. Scalp electrodes are only sensitive to macroscopic and coordinated firing of large groups of neurons near the surface of brain, and then only when they are directed along a perpendicular vector relative to the scalp. Additionally, because of the fluid, bone, hair, and skin that separate the electrodes from the actual electrical activity, the already small signals are scattered and attenuated before reaching the electrodes.

Although BCIs are employed mostly in the HCI (Human Computer Interaction) area by exploring its capability to detect brain patterns in order to manipulate elements directly with the brain, we concentrate our attention on EEG work related to the ability to transform raw EEG data streams into emotional and affective states. Considering the available commercial noninvasive EEG, we opted for the low-cost off-the-shelf Emotiv EEG headset [1] due to the resourceful standard SDK that allows three event-based classification suites. The Expressive suite tries to detect the wearer's facial expression; the Affective suite tries to detect mood and emotions; and the Cognitive suite tries to detect occurrences of user-defined cognitive events.

Since we focus on the capture and representation of emotional awareness our research efforts concentrate on the Affective suite, which allows the capture of quantitative data for three affective states: excitement/calm,

engagement/disinterest and meditation. The detections provided by the Affectiv suite search for brainwave characteristics that are universal in nature and do not require an explicit training or signature-building step on the part of the user. Figure 1 shows two users wearing the Emotiv EEG headset viewed by four different positions during our initial exploration of this device.

a) Right b) Front c) Back d) Left

Figure 1. Two users wearing the Emotiv EEG headset viewed by different positions: a) Right, b) Front, c) Back and d) Left

The excitement/calm state is experienced as an awareness or feeling of physiological arousal with a positive value. The excitement/calm detection is tuned to provide output scores that more accurately reflect changes in excitement over time periods as short as several seconds. The emotions related to the excitement/calm affective state includes titillation, nervousness, and agitation.

Engagement/disinterest is experienced as alertness and the conscious direction of attention towards task-relevant stimuli. It is characterized by increased physiological arousal and beta waves (a well-known type of EEG waveform) along with attenuated alpha waves (another type of EEG waveform). The greater the attention, focus and cognitive workload, the greater the output score reported by the engagement/disinterest detection. The emotions related to the engagement/disinterest affective state include alertness, vigilance, concentration, stimulation, and interest.

Although the meditation state recognition is provided by the Emotiv EEG headset, it is not associated directly with any emotion that indicates a noticeable user mental status usually presented in the normal use of computational systems. Moreover, this detection is provided to guide users to a relaxed state of mind that avoids the expression of emotions instead of the explicit detection of them.

The Emotiv EEG headset contains many differences regarding complexity, cost and operational use compared to invasive and noninvasive medical EEGs employed to exam and study the brain. However, the information it provides is adequate to the study of emotional aspects for computer interaction and emotional state by employing the many EEG concepts, techniques, models, and other resources originated for the several years of advancements that come for the medical study of the brain.

IV. REPRESENTING EMOTIONAL AWARENESS IN CES

In this work we propose the exploration and study of emotional awareness in order to conceive, design, create and evaluate new widgets that represent emotional awareness collected directly from an EEG. To guide the design of our awareness widget we follow basic awareness principles proposed by previous work [5, 9] which include: no explicit actions required, least effort, no additional space, and focus of attention. We also investigate how existing awareness frameworks [6] can provide useful foundations for the design and evaluation of the widgets that display emotional awareness.

We chose to use the Emotiv EEG headset as a device to collect emotional state in order to achieve two main goals: (1) understand how this emotional information can influence general collaboration aspects (communication, coordination and cooperation); and (2) use this information to provide additional awareness for the users in remote collaboration scenarios aiming to provide a further sense of presence.

Considering the second goal, the criterion, results, insights, and findings from previous work [5, 6, 9] are related to emotional studying from the awareness perspective as a guide to how model, present, convey, and evaluate emotional information in the context of remote CES. We did not expect to influence, suppress or manipulate human emotions in any way during our study.

We believe that new technologies for collecting emotional data can provide further explanations for the main research question of this work compared to traditional emotional gathering techniques employed for emotional monitoring found on the Affective Computing research efforts [8], such as the analysis of body language, voice, and face emoticons. The base for this argument is the fact that traditional emotional detection techniques require complex sensors and apparatus, demand high level of manual and ad hoc data gathering, do not provide non subjective reliable emotions information, and lack real time quantitative data suitable for awareness widgets found on CES.

Although it is possible to research emotional data from theoretical models that focus on simulation of emotions or predicted data [4], the complexity and unexpected interactions usually found on remote CES sessions suggest that emotional data provided by simulated collaboration sessions do not represent well how the users behave in such situations where communication, cooperation and collaboration aspects assume different forms.

Besides the existing widgets that represent affective state associated with artifacts manipulated by participants on a synchronous collaborative session, we are exploring alternative representations of emotions in the user interface. The visual cues and widgets we are exploring include the use of color-coded and size-coded words to represent emotional in multi-user text editors, heat-map superimposition on a new layer of the virtual workspace, and Telepointer/Telecaret augmentation with icons for real-time mood representation. We are also looking at the possibility to augment the video/audio stream [10] used as external

channel in collaborative sessions to better convey the affective state of the participants, thus improving the communication aspect of the collaboration.

The design of a future experiment for evaluating the proposed widgets that display emotional information in CES include the monitoring of user emotional state while using traditional interaction devices (e.g. mouse and keyboard) to perform common actions such as moving objects, changing shapes, editing text, and selecting objects required to execute simple collaborative tasks supported by a CES .

V. CONCLUSION AND FUTURE WORK

In this paper, we propose the exploration of Brain Controlled Interfaces (BCI) aiming to study the possibilities to collect and represent emotional awareness in synchronous collaborative editing systems. We reviewed some of the existing literature in the CSCW area that discusses the importance of emotions in rational thinking and human interaction and the need to support emotional awareness in the design and implementation of groupware.

The main contribution of this paper concentrates in the novel use of the EEG technology combined with awareness widgets to provide emotion feedback from the biological signals generated by the participants of a synchronous collaborative session. The central question we want to answer is *How emotional awareness can affect collaboration aspects in synchronous CES*? The possible answers to this question can increase our understanding of the groupware domain, lead to more focused research, and influence commercial products.

We believe this work represents an initial step in exploring how brain sensing technologies can be applied in a relevant manner to contemporary groupware emotional research area. With the new awareness information provided, it is possible to enhance the coordination and communication of actions between the participants of collaborative sessions, giving them awareness information somehow beyond what is found in face to face meetings.

Future work includes the evaluation of how the introduction of users' emotional awareness in a collaborative application affects the group work in order to assess the effectiveness of new visual awareness widgets. Future work also includes a comparison of the existing widgets traditionally employed to display awareness in CES providing valuable information on how the participants communicate and coordinate their activities when they possess emotional awareness of each participant of the group.

Finally, this work represents a starting point of research work that explores how computers can collect emotional state within our minds to help us coordinate, communicate and cooperate better while producing group work. We hope this work will inspire and encourage other researchers in the CSCW community.

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