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A Study of Using SmartBox to Embed Emotion Awareness through Stimulation into e-Learning Environments

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Abstract—**Emotions strongly influence human's behavior in individual and social situations and must be seriously considered in any human activity, such as e-Learning. Indeed, the embedding of emotional awareness features into virtual learning environments could offer a more authentic and challenging e-Learning experience, either individual or collaborative. However, the lack of empirical results together with the complexity attributed to the management by computers of human emotions and affective data, seriously limits the advances in e-Learning as it impedes to virtualize many real-world learning situations in which emotions play a significant role. In this paper, we investigate the use of the SmartBox device for emotion measurement of distance learners during their study as well as the development of affective strategies based on the SmartBox's stimulation capabilities. The aim is to collect emotion data from different sources in order to provide the most appropriate affective responses that positively influence distance learners' study and results and ultimately enhance the e-Learning process.**

Keywords- e-Learning; Emotion awareness; affective state; SmartBox; emotcontrol; virtual learning environment

I. INTRODUCTION

Despite the progress achieved the last two decades in education technology, the e-Learning community is still talking about the promise of this technology whereas is questioning its realistic classroom use [1, 2]. One major criticism is that these innovative technologies tend to focus exclusively on cognitive factors and are often unable to adapt to real situations where emotions play a significant role [3].

The embodiment of emotional awareness features into learning environments could offer a more authentic and challenging learning experience, either individual or social [4]. In literature, emotion awareness is defined by the awareness of self (self-awareness) and others' (empathy) emotions [5]. In e-Learning context, emotion awareness can

be identified by (a) the process of receiving emotion input, implicitly (motor-behavioural actions or biophysiological signals) or explicitly (self-reporting of emotions) and (b) the respective affective response that can be provided manually (by human) or automatically (by machine) [6].

However, research still lacks studies to address the presence of emotions within Virtual Learning Environments (VLE). Consequently, we are still far from adequate empirically proven strategies to respond affectively to individual or group detected emotions [7, 8].

Moreover, due to the many opportunities provided by the Internet, more and more people are taking advantage of online distance learning courses supported by VLEs. However, in these systems the e-Learning completion rate is low [9]. One of the reasons is the low study interest when the learner studies the subjects. Therefore, it is very important to stimulate learner's motivation during the study [10].

The current paper explores the convergence of emotions and stimulation and its effects in the e-Learning process, in terms of motivation and engagement [8] during the learner's study as well as the cognitive results. To this end, we explore the use of an end-user smart device named Smartbox [10, 11] for measuring emotions of distance learners from their physical behavior during the study, and then provide an affective response to learners by direct stimulation that has a positive influence in their performance. This response may be combined with other affective feedback to ultimately enhance the e-Learning process [12][13].

We begin our study in Section 2 by presenting previous research on the field of emotions for e-Learning. Section 3 introduces the SmartBox device and shows its main features and results obtained in previous research. Section 4 discusses on the potential uses, benefits and issues of SmartBox for embedding emotion awareness into e-Learning. Section 5 concludes the study by outlining the main ideas of the paper and highlighting ongoing and future work.

II. BACKGROUND

In this section, we review, first, a theoretical background on emotions in e-Learning. Then, based on this review, we present our main developments so far to embed emotion awareness and affective feedback in e-Learning.

A. Emotions in e-Learning

For almost two decades, Pekrun et al. [8] examined the impact of the so-called academic emotions. According to their findings, positive mood fosters holistic, creative ways of thinking. Harmful effects can only be expected in situations, where students are in a good mood and the learning topics are of less importance to them. In this case, the positive emotion might detach them from learning [5]. Negative emotions, on the other hand, direct students' attention to themselves, in most of the cases.

However, negative mood proved to enhance an analytical, detail-focused way of processing information. Curiosity and puzzlement may lead to investigate problems and even frustration may lead to action, despite its negative valence. The state of confusion is considered more positive than frustration because students are motivated to overcome the source of their misunderstanding, whereas in frustration they are more likely to disengage from learning [14]. With regard to emotion transitions, students are more likely to remain in the same affective state if no intervention is provided [15]. This tendency appears to be particularly strong for students in negative affective states.

In general, there are no adequate empirically proven strategies to address the presence of emotions in learning, especially the negative ones [5]. Theoretical background has been built upon theoretical foundations of pedagogy/affect or recommendations made by pedagogical experts [15]. However, despite the evidence of the positive effects of positive mood and emotions, there are no clear rules such as: positive emotions foster learning, and negative emotions are detrimental [5].

B. Collection of Emotions

In face-to-face situations, students communicate and exchange information, enriched with emotion cues like facial expressions, voice intonations, gestures, body positions, etc., in an attempt to transmit what the respondents really want (need, desire, love, etc.) or do not want (afraid, dislike, hate, detest etc.). On the contrary, the exchange of emotion data in online learning environments is quite limited. Developers and designers are striving to empower learning environments with usable interfaces that trace student emotions in an unobtrusive and noninvasive way, without extra cost, equipment or expertise, and without language barriers [16].

In the majority of these research studies, three main input channels are used to collect emotional information [12]:

- Psichological tools, such as Self-reporting (verbal or pictorial scales, questionnaires, etc).
- Motor-behavioural activity (facial expressions, voice intonation, body posture and movement, etc).
- Physiological signals (electromyogram, electrodermal, electrocardiogram, blood volume pulse-BVP, etc).

A separate category refers to emotion recognition from the user's text input through sentiment analysis or opinion mining by Natural Language Processing algorithms.

There have been various updated endeavours in modelling the management of emotions and affectivity in learning systems, showing promising results [1, 12, 13, 15, 17]. Nevertheless, emotion recognition is susceptible to the same vulnerabilities of speech recognition; despite the advancements that have been attained in experimental settings, their utilization to cope with everyday needs is restricted by the lack of resources (cost of equipment, complexity of systems, etc.). Sensors are more precise but costly and time consuming [17]. Self-reporting on the other hand is less costly but often considered subjective and out of context. In the majority of the studies, multimodal integration is preferred (combination of the input channels).

A fundamental criterion to select an appropriate detection method is dictated by the availability of resources. Most computers on a lab or portable devices are equipped with a camera that can be used for facial expression recognition. Students' emotions can be inferred by analyzing mouse and keyboard movements that are stored in log files. Text is also an important modality for sensing emotion since the majority of computer user interfaces today are textually-based [12].

C. Affective feedback

Once the learner's affective state is recognized, the obvious next question is what to do with this valuable information. The user needs to see some reaction from the system; an adaptation to his/her feelings. Affective feedback can be either parallel-empathetic (exhibit an emotion similar to that of the target), reactive-empathetic (focus on the target's affective state) or task-based (change task sequence - supplementary to empathetic strategies). Common tools include dialogue moves (hints, prompts, assertions, and summaries), immersive simulations or serious games, facial expressions and speech modulations, images, imagery, cartoon avatars, caricatures or short video-audio clips [15].

Unfortunately, there are few studies that exploit computer mediated affective feedback strategies and their impact on users' task performance or affective state. Furthermore, the number of tools and strategies to design expressive avatars in response to learner's emotion detection is quite limited.

D. A Tool for Emotion Collection and Affective Feedback

In our previous research [12, 13], we developed a web tool, named *emotcontrol*, consisting of three main components: (a) the basic system that is a self-reporting interface for students to report their affective states, (b) the affective virtual agent component that provides affective and task-based feedback to learners, and (c) the visualisation monitors that depict the individual and group affective states together with the respective feedback from the virtual agent. This computational system implements our conceptual model to manage emotions in e-Learning reported in [12] (see Fig. 1 for a graphical representation of the model).
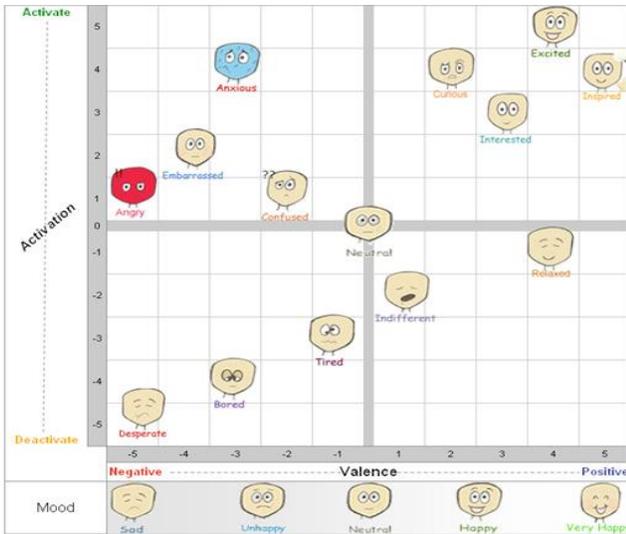
Figure 1.   A two dimensional diagram of our conceptual model of emotion

1)   Emotion collection

Emotcontrol (Fig. 2) is a cross-platform, open-source web tool designed to be embedded into the VLE and learning objects and resources [13] during the learning process by utilizing rich multimedia (fancy colours, playful images and text labels). It has adopted the shape of a spiked circle, in accordance to the Geneva Emotion Wheel (Fig. 2), involving a range of emotions that usually appear in a learning experience. Additional text boxes have been provided for respondents to report other emotions than the default ones.

Figure 2.   *Emotcontrol* (right panel) embedded into a storyboard learning object. Upper part of the panel shows the Geneva Emotion Wheel to collect emotions and bottom part shows an avatar to provide affective scaffold

2)   Affective Agent

The affective feedback mechanism consists of animated, virtual agents (avatars) (Fig. 2) that provide a variety of scaffolds (hints, prompts, jokes, games, etc.) of various types (empathetic, task-based, entertaining, relaxing, etc.), with respect to the user's both cognitive and affective states. These avatars are displayed embedded in the learning environment and employs facial expressions and voice intonations to provide empathetic dialogue moves (see Fig. 2). The affective agents are activated automatically, based on fuzzy rules, or manually, in order to experiment on affective feedback strategies and possible affective sequences [12, 13].

In the experiments that were conducted with university students, we found that students were willing to participate and express their affective state, once a tool provided an easy and usable way for them to do it, empowering in that way their engagement [12]. However, students needed to see a reaction from the system in response to their emotions' sharing, immediately or after a very short period of time. Affective feedback. enriched with task-oriented scaffolds could improve student cognitive performance and emotion regulation, at least when it was conducted by human decision. Group emotion awareness also appeared to improve social interaction. Our findings uncovered an initial limitation of emotions labels to adequately express the respondent's exact feelings [12].

In the current research we include alternative paths in the learning sequence based on emotion reporting, in an attempt to provide more personalized and adaptive learning. To this end, we introduce next a new device named SmartBox to collect emotions from the user's behaviour and then `provide a new type of affective response based on stimulation.

III.   SMARTBOX: AN END-USER DEVICE FOR e-LEARNING

SmartBox [9, 10, 11] (Fig. 3) is an end-user smart device of small size and very cheap, which was originally intended to both control distance learners during their study and check the patients health situation, in a Wide Area Network (WAN) using JXTA-Overlay platform [18].
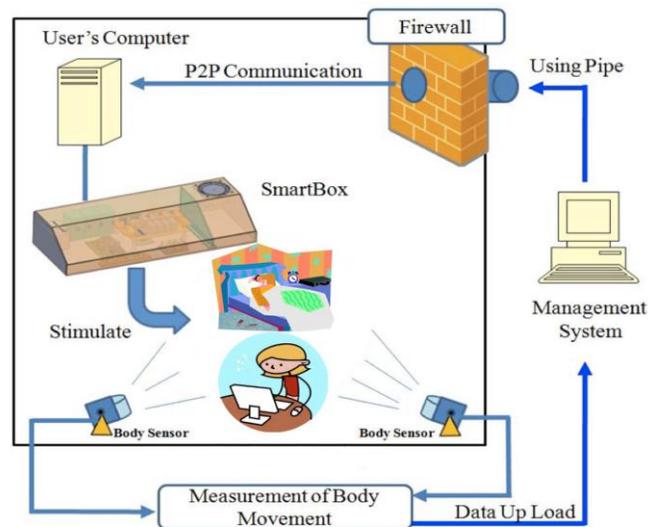
Figure 3.   Implemented SmartBox system

For the sake of e-Learning, SmartBox is used to stimulate distance learners' motivation and increase the learning efficiency [11]. The motivation behind is the low completion rate found in open universities and e-Learning courses in general [9, 13]. One of the reasons of this issue is the low study desire when the learner studies learning materials. Furthermore, due to the opportunities provided by the Internet, more and more people are taking advantage of distance learning courses. For instance, the recently established Massive Open Online Courses (MOOCs), a new

generation of online education, easily and widely accessible on the Internet and involving a large or very large number of students [19], are claimed to face high drop-out rates over 90%. Therefore, it is essential to stimulate distance learners during their study in order to enhance learning motivation.

In order to deal with these problems, we implemented in the SmartBox [10] many functions and sensors such as body sensor, infrared sensor, chair vibration control, light control, smell control and sound control (Fig. 4). The SmartBox was then integrated in a P2P JXTA-Overlay platform, which is able to overcome security devices without changing network security policy (Figs. 3 & 7). The goal is not only to monitor and control the students' activity in a WAN, but also to stimulate and increase their motivation. Next, we detail the functionalities of this smart device for e-Learning along with the most relevant evaluation results obtained so far.

A. SmartBox Functionalities

In this section we briefly explain the main I/O SmartBox functions and results for e-Learning purposes based on data collected in the experiments [11] (Fig. 4).

1) Body Sensor for detecting body movement (input)

We considered where was the point of effective stimulation for learners from the sensing rate values. We observed that the interval of the body sensor response was very active at the point around 20-30 seconds, but it was less active after 30 seconds meaning that the learners made certain actions once every 30 seconds while they were studying. After 50 seconds, there was almost no reaction from the body sensor.
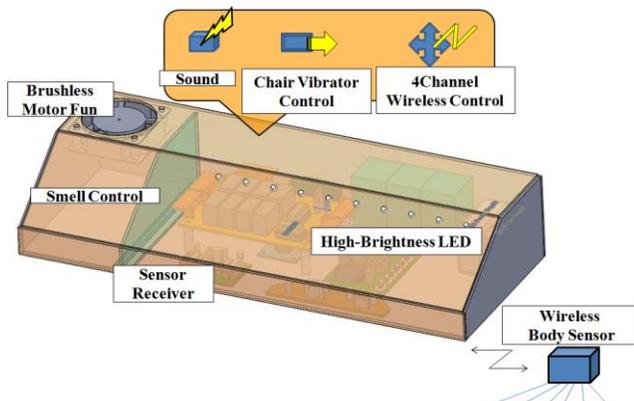

Figure 4.   SmartBox functions

2) Keyboard/mouse for controlling computer use (input)

We observed that if after 20 minutes a learner did not use the computer keyboard or the mouse, s/he had lost concentration. Still, if the learner did not use the keyboard or mouse after 30 minutes, we assumed s/he was sleeping or dropped out the learning activity.

3) Light Function for adjusting the room light (output)

We implemented the room light control function by which we can change the room brightness and stimulate learners to increase the learning efficiency (see Fig. 5). Moreover, we implemented a Remote Control Socket for controlling AC 100V socket (on-off control of room socket).

Figure 5.   Room light control

4) Sound Function to emit relaxing sounds (output)

In the case when the learner does not change his behavior by the Light function, the system emits a relaxing sound to change the mood of learner. Another function is implemented using the cellular phone. We used the sound function of mobile phone to send some music to the learner.

5) Chair Vibrator Function for chair vibration (output)

In the case when the learner still does not react we considered the vibration function. We realized this function by using the vibration function of the mobile phone. Another implementation was carried out using a motor in the chair and controlling the chair vibration (Fig. 6). By changing the angle of the motor, the system can change the learner mood.

Figure 6.   Chair motor control

Considering the above functions and input values, in the SmartBox experiment we set the following stimulation rules:

- If movement of learner's body is not detected for 30 seconds, then the Light function is activated.
- If the learner did not move for about 40 seconds, then a Sound Function is activated.
- If the learner did not move for about 50 seconds, then a Chair Vibration Function is activated.
- If the learner do not use the keyboard or mouse for 20 minutes the system sends a first alert by changing the display color into yellow. A second alert is sent after 30 minutes by changing the display color into red.

The cognitive results of the experiments [11] showed that when using the SmartBox the amount of study by learners is higher comparing with the case of not using

SmartBox. This is because the reaction time when using SmartBox is better than not using SmartBox and thus the concentration of the learners is increased. We also found that the sound stimulation had better effects in the learning process than the light stimulation. Eventually, the experiments showed that the use of SmartBox is an effective way to improve the learner motivation during the study.

B. SmartBox Network Communication

Virtual universities and campuses are one of the most widely used form of virtual organization in today's teaching and learning environment. However, most of the current virtual organizations use C/S approaches, where the shared resources are centralized on servers and members of the virtual community (clients) access them through requesting protocols Thus, everything is done at server side while the client side is just an interface. In general, C/S approaches show several drawbacks, such as lack of scalability and efficiency in virtual campuses of thousands of students.

The most powerful alternative to C/S approaches is the use of decentralized approaches, such as Peer-to-Peer (P2P) systems [18]. In such systems, the computational burden of the system can be distributed to peer nodes of the system. In addition, the emerging of technologies, such as ad-hoc networks, sensor networks, body networks, and home networking, makes them a very interesting option to build ubiquitous e-Learning systems that can offer an equal educational environment regardless region, age, time or place. However, in large-scale networks such as Internet, it is very difficult to control the network devices, because of security problems. For instance, the firewalls are used for checking the information between private and public networks. The information is transmitted according to some decided rules and it is very difficult to change the network security policy, resulting in many networks and Intranets that do not allow the information coming from other networks.

JXTA-Overlay on P2P systems is able to overcome firewalls, routers, NATs, etc in private networks without changing the network policy [18]. It is based on a uniform and location-independent logical addressing model. A JXTA peer is identified by a unique ID, which allows the peer to be addressed independently of its current physical IP address.
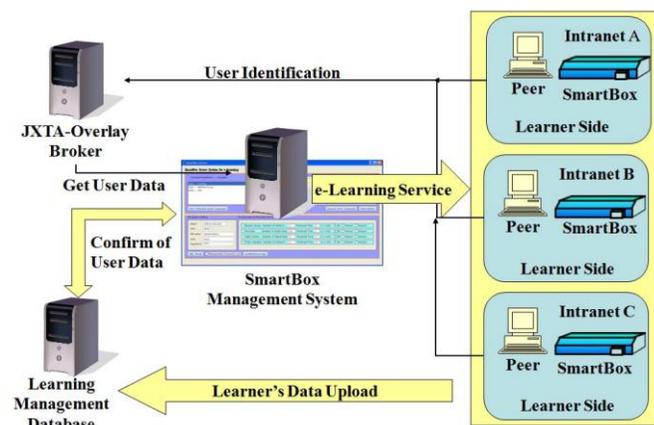

Figure 7.   SmartBox P2P network for e-learning based on JXTA-Overlay

We implemented our SmartBox stimulation device in a P2P e-Learning system based on JXTA-Overlay (Fig. 7) in order to control peers in a private network from a peer in the Internet as shown in [11]. By implementing this kind of network in our SmartBox, we are able to collect data and control the peers in a Wide Area Network (WAN). Therefore, we are able to control all devices that are connected to the peers, such as body sensors, room light and chair motor control.

IV.   DISCUSSION

In this section we briefly discuss on the use of SmartBox for emotion awareness in e-Learning environments as well as potential strategies to influence the learners' affective state by the incorporation of SmartBox in our computational model on emotions (*emotcontrol*) presented in Section 2-D.

Considering that SmartBox measures learner's behavior, such as body movement, we can classify this tool in the motor-behavioral area (see Section 2-B and [20]). Indeed, this device can collect emotions by measuring behavioural expressions and changes in physical body that communicate one's emotion experience, both positive and negative, such as boredom, tiredness, excitation, and so on. Its major asset is the ability to evaluate subject's affective state by using traditional devices, such as mouse and keyboard, though special software is needed [16]. Moreover, tools in the motor-behavior area use sensors that are less obtrusive and invasive, and more objective than physiological tools [17, 20]. Also, measurement is applied in parallel with user's task (real-time) without interrupting the learning process. Finally, SmartBox is a very cheap device, which may be affordable for any educational organization to deliver it to students as part of the learning resources [12], and there is no need of expertise to use the equipment [20], though technical support to install it is required. A final distinctive feature of SmartBox is its network implementation by using P2P and JXTA-Overlay, which can overcome firewalls, routers and other security barriers in a WAN when controlling the learner's study, even if at home, in a private network.

However, a main pitfall of SmartBox is the lack of privacy as both the learner and his o her personal study room (e.g. home electrical power, light, chair, etc) are monitored and manipulated by the system. Also, installing the tool at home may bring technical problems. In order to overcome these issues, first, a legal contract between learners' and the educational organization should be signed, where the learners agree on his o her personal study room to be controlled and changed by SmartBox. Moreover, technical staff of the organization should support the student to install the tool. Finally, for those learners reluctant to use the system at home, they could move to a support center or library belonging to the organization, which would be already prepared with SmartBox.

The possibilities of using SmarBox to influence positively the learner's affective state by the stimulation functions become very interesting. Specific rules can be set up to match the learner's physical behavior during the study with specific emotions (see Table 1).

TABLE I.   EXCERPT OF EMOTIONS COLLECTED AND AFFECTIVE STIMULATION BY USING SMARTBOX FOR e-LEARNING

Learner's behavior (SmartBox input)	Learner's emotions	Stimulation function (Affective state)
Body movement (sensor = 10 seconds)	Inspired / Angry	Light down (Excitement/Calmness)
Body movement (sensor = 20 seconds)	Confused	Light brightness (Compassion)
Body movement (sensor = 30 seconds)	Bored	Sound control (Thoughtful)
Body movement / keyboard & mouse (sensor = 40 seconds / computer use = 20 min)	Indifferent Tired	Chair vibration Display color = red (Humorous-annoyed)

Most interestingly, different and appropriate affective strategies can be designed based on SmartBox output's stimulation capabilities. Table 1 proposes intended affective states of learners after the SmartBox's stimulation received.

Finally, SmartBox can be easily integrated in our *emotcontrol* tool [12, 20] in order to combine our psychological mechanisms for collecting learner's emotions (i.e. self-reporting) with the behavior-detection mechanisms provided by SmartBox. Specific affective responses can be designed that consider both types of inputs in order to provide a more precise and objective affective response. Also, SmartBox input of user behavior alone could activate an affective response on *emotcontrol*, and vice versa, *emotcontrol*'s inputs of self-reporting alone could activate SmartBox' functions as affective response.

As a result, Smartbox is able to enhance distance learning in terms of amount of study and effectiveness [11]. By the incorporation of the emotional dimension in SmartBox, we expect to improve further these results.

V.   CONCLUSIONS AND FURTHER WORK

This paper explores the use of an end-user smart device called SmartBox to deal with distance learners' emotions during their study time as well as the enhancement of the overall e-Learning process. To this end, we started with providing theoretical background on emotions in e-Learning and setting up our conceptual and computational models already implemented in previous research. We then review the SmartBox device and show its capabilities in terms of input functions to collect the learner's behavior (body movement and keyboard/mouse use) as well as output's stimulation functions, such as room light, sound and chair vibration. We finally discuss on the opportunities and issues to manage emotions for e-Learning by using SmartBox' functions. We conclude by believing that SmartBox can become a step forward to manage emotions in e-Learning and influence positively learners' affective state.

Further work includes the implementation of affective rules in SmartBox and its integration into our *emotcontrol* framework [20] as a new component to collect motor-behavior-based emotions and provide more appropriate affective responses from combining different sources.

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