Virtual Reality and Affective Computing for Improving Learning

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Abstract. After several years of working independently in development of Virtual Reality (VR) training systems and affective computing, we have decide to undertake an incursion on development of new systems which integrate both fields, so that training can be improved. Here first is presented evidence of importance of emotion in human activity and specifically in training, then we present preliminary insights towards a model for VR inducing emotional states.

Keywords: Virtual reality, student affect, intelligent tutoring systems.

1 Introduction

It has been argued that Virtual Reality is effective for creation of learning contexts within the comprehensive approaches to learning [1]. Here it is claimed that VR is also an effective tool for creation of virtual environments which are able to originate or influence users' emotional states. Although not frequently considered, emotional states of people are present in the whole spectrum of humankind activities. It is only until recent years that computer scientists have started to pay attention to emotions in order to improve human computer interaction [2]. In particular, emotions are also present in any learning process; therefore training systems which understand and deploy emotional states of students might be more effective as training tools. The aim of this paper is to analyze and provide evidence that the emotional factor cannot be omitted in the multidimensional approach to learning, where it is considered that the more influencing dimensions are integrated in each specific learning process; the more efficient is the instruction to reach specified learning goals.

On one hand, VR possesses huge potential for content and learning contexts creation, which integrates different factors favoring knowledge transference. A learning context is conceived as the sum of factors which intervene in a specific learning process. The architecture followed by Virtual Reality Group (VR Group) at IIE, for developing VR training systems, allows observing the benefits of VR in the creation and integration of different influencing factors (dimensions) in the learning process.

On the other hand, in recent years has arisen a new strand of the computer science called affective computing [2, 3], which has shown the importance of considering emotions in human-computer interaction and that might have benefits within different application fields.

Thus, in this paper first we analyze the role played by emotions in learning and provide insights of the features we might be able to integrate to our VR systems so that they provide the emotional support in order to improve learning. Then it is proposed to include the affective dimension (factor) into the comprehensive approach to learning.

The rest of the paper is organized as follows. Section 2 includes a brief description of the comprehensive approach to learning. Section 3 relates VR and Affective Computing. Section 4 shows some insights of the VRG towards a model of VR inducing emotional states. Finally some conclusions are presented followed by a list of references.

2 Multidimensional Approach to Learning

2.1 VR for Training

Virtual Reality is the electronic representation (partial or complete), of a real or fictitious environment. Such representation can include 3D graphics and/or images, has the property of being interactive and might or might not be immersive. [4].

It has been extensively supported in the literature the advantages of VR in a variety of fields [5, 6]. The systems developed for the VRG are mostly devoted to free risk training of highly dangerous maintenance procedures, involving medium tension live lines maintenance and tests to substations.

They operate in three modes namely, learning, practice and evaluation (Fig. 1 a). Before a user enters to any of these modes, the systems allows users to visualize and manipulate catalogs of 3D models of all the tools and equipment needed for maintenance work without being in a company's warehouse (Fig. 1 b).

2.2 Comprehensive Approach to Learning using VR

This approach has been detailed in [1], here is provided a short description. Different approaches and theories have arisen to improve learning, such as behaviorism, constructivism and others might be included. One of the problems here is that instructional design usually does not target groups of students with the same skills; rather they are applied to a heterogeneous audience of learners each one with different skills.

(a) (b)

Fig. 1. (a) Learning mode (b) Tools catalog

From this intuition we can observe that a learning process requires a more comprehensive view so that instruction can impact learning in a broader audience. Following the comprehensive approaches, when dealing with instruction, there is a variety of different dimension or factors which intervene in a learning process (Fig. 2) and that must be considered if we want to accomplish the main goal of any instruction task (knowledge transference). These dimensions can vary on different situations, some are mentioned here:

– *Learner- instructor dimensions:* These dimensions involve, a perhaps just assumed, but decisive demand in order to get a combined effort to get the training goal namely, learners must really want to learn and instructors must really want to teach.
– *Instructional model dimension:* Different instructional model have been proposed (e.g. Behaviorism, Constructivism, etc.) each having strengths and weaknesses. They all provide some truth and some approach for learning improvement (e.g. learning centered on instructors, learning centered in students, learning centered on instructor-student interaction, etc.). Depending on the instruction domain, a model or combination of models must be selected in order to make the instruction efficient.
– *Instructional domain dimension:* It is not the same football training, which is mostly a physical activity than a physics lesson which might be mostly theoretical. It is clear that each domain demands specific abilities from learners, but also determines which instructional method can be better to reach an instructional goal.
– *Learning channels dimension:* Usually three different kinds of learners are identified according to dominant learning channel, namely auditory for those who learn better by hearing, visual for those who learn better through visualization and kinesthetic for those who learn better by manipulating objects. Providing stimuli for these three channels, instruction might reach and be successful in a broader audience.
– *Affective dimension*: Here we are assuming that the affective state of a student and the instructor might also determine whether or not a learning goal is reached successfully. As a simplistic example, a student might have discussed with his girlfriend just before attending a presently classroom lesson. This might originate

an affective state, which derives in distraction and lack of concentration in class. As another example, depending on the exposition method used by the instructor, he might cause an apathy state on students or might motivate them to concentration and reaching effectively the learning goal planed. Emotional states are inherent to students; therefore the affective dimension must be part of the comprehensive approaches to learning.

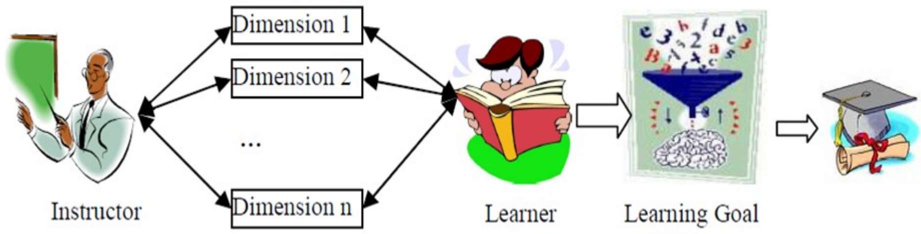

Fig. 2. Different dimension intervene in a knowledge transference task.

Following the comprehensive approaches, intuitively we would expect that identification and integration of influencing factors or dimension (including the affective dimension) into specific learning contexts, would improve the learning process. Since we want to undertake an incursion in affective computing to see how we can integrate the affective dimension in our VR systems, we analyze this technology below.

3 Affective Computing and Virtual Reality

3.1. Affective Computing

The Dictionary of the Spanish Real Academy of Language (RAE, Spanish acronym) [7], defines affective as “Belonging or relative to affect”, in turn one of its meanings defines affect as “each of the passions of the mood, such as, anger, love, hate, etc., and specially love and affection.” These “passions of the mood” seem to correspond to what within the computational (affective) scope is referred as “basic emotions” where authors provide examples such as fear, anger, sadness, pain, joy, annoyance, etc., but it seems that there is no consensus among different authors who consider different lists of emotions. Even more, it is considered that emotions are not expressed purely, that is to say, only one emotion at a time, rather it is expressed a mixture of the so called basic emotions.

In the evolution of computing, specifically within the field of Human-Computer Interaction (HCI), there are attempts to find more efficient HCI by integrating emotional communication, that is, the affective computing [8]. Picard [2], developed computational methods for human emotion recognition and generate synthetic emotions in order to improve HCI (see Fig. 3).

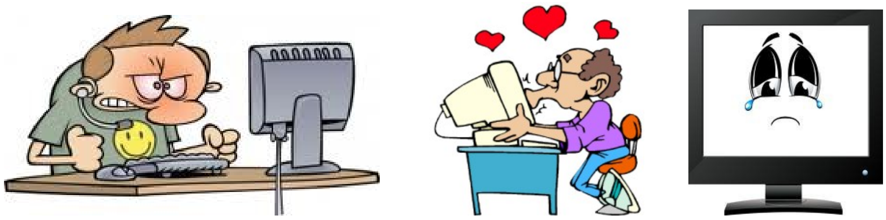

Fig. 3. Affective computing

Usually HCI focuses in the logic aspects of the interaction, in HCI which makes sense. Even in the field of Natural Language Processing, it is pursued a more natural and logic HCI. However, these attempts are simulations which incursion in some functions of only one of the brain hemispheres, the left side. This side of the brain is in charge of the logic reasoning. This effort by the HCI community is necessary but incomplete. Users have other brain hemisphere, the right side, which among other thing, is in charge of the emotional aspect and when a user interacts with a computers he makes it with both hemispheres not only with one of them. This is why integrating the emotional aspect in the HCI, might provide computer systems with more complete and efficient interfaces. On the other hand, affective computing might also widen the application spectrum of computers in general and make it more effective.

3.2 Affective Computing and VR

VR is not only efficient for creation of learning contexts, the vast literature shows that VR is affective also in the creation of environments with different degrees of influence in users' emotive states. Some examples are the following: Riva et al [9] present a study in which is reported the efficacy of VR as an effective mean to induce and influence emotions. They observed that interaction with relaxed and anxiety virtual environments induced relaxation and anxiety states in the users respectively. The sceneries represented a relaxing park (well illuminated and with nice aspect) and the anxiety park (dark and with sullen aspect). The data presented by these authors show a dual feedback between presence and emotion, the feeling of presence increased in the emotional environment and the emotional state in turn was influenced by the level of presence.

VR has also been used in virtual worlds, in which users interact with other users by means of avatars that they can choose as representations of themselves (resembling the use of nicknames in chat channels). Users control their avatars, so they can move freely within the virtual environment, talk, make gestures or represent emotions [10]. All this behavior will be perceived by other users who are represented by their respective avatars and with the same level of control over them, and as in the real world, the behavior of a user might affect the others'. Perhaps one of the most representative examples of environments like these is second live [11].

Another field in which emotions have drawn quite a lot of attention is the game industry [12], in which we can find many of them based on VR. No wonder, in some degree, emotions is what game developers sell.

It can be observed that VR is able to play a role in the creation of emotion influencing contexts, and therefore it can be also a possible creation tool for Affective Computing. We would expect that a VR learning context observed substantial improvement for knowledge transference if it is enriched with Affective Computing technology.

3.3 Affective Computing in Training

Even in the 50's, affect was considered in learning, the so called Bloom's taxonomy, proposed that educational objectives were divided into three "domains": Cognitive, Affective, and Psychomotor [13]. Now, association between Affective Computing and learning is sometimes called affective learning (AL). AL systems try to recognize and deploy emotions during the learning process so that knowledge transfer is more effective. There are intuitions about the relationship between emotional states and learning. For instance Miller [14] points out that affective learning outcome involve attitudes, motivation, and values. Minsky [15] suggests that different emotional states induce different kinds of thinking. Picard et al. [3] mention that a slight positive mood induces a different kind of thinking, characterized by a tendency toward greater creativity and flexibility in problem solving. We can also observe the satisfaction originated by an achieved goal, that is to say, when partial learning objectives are achieved, the students experience a feeling of satisfaction, which in turn motivate them. The opposite is also common, when learning goals cannot be achieved, it produces frustration.

From these few examples we can identify some key terms such as: motivation, positive mood, satisfaction, achieved leaning goal, frustration, and kind of thinking. Others are: encouragement, reflective thinking, active learning, interesting, curiosity, etc. It is clear that there is the need of finding a precise relationship between emotions and learning aspects, but this involves challenges with no answer so far. On one hand, we recognize some emotions but we still do not know how to measure them and usually we do not even know how to control our own emotions. This reminds us that we are dealing with the other side of the brain, the no logical one. Thus, if we want to improve leaning from the affect dimension, we need to influence students' emotions, which demands us some kind of control on others' emotions (Fig. 5).

There are also different works relating the three fields: affect-learning-VR. Some examples are the following: Ho-Shing et al. [17], propose a Smart Ambience for Affective Learning Model, based on VR, which focused on learning of concepts of animal survival. In experiments they conducted, report a high correlation between positive feelings and high learning rate for players. Lee [18] reports a study in which effectiveness of using desktop virtual reality for learning was evaluated; outcome was measured through academic performance whereas affective learning outcomes were measured through perceived learning effectiveness and satisfaction. One of his conclusions was: The results imply that desktop VR technology was effective in boosting the students' affective behavior and the perception of their learning experience. In [19] the relation affect-learning-VR is given through educational games, the OCC model is adapted and affective and cognitive user modeling is achieved by combining evidence from students' errors, this on the basis that achievement and error influence students' affective states.

Fig. 4. Controlling mood? (Taken from [16])

There is in fact a vast and recent literature in which VR is being used as a tool for affective learning.

4 Towards the Model for VR Inducing Emotional States

4.1 Towards the Model of VR

One of the features of VR which might support effectively the induction of emotions, is that it can induce feelings of presence, "the feeling of been there." This has a huge potential, since depending on the kind of emotive states wished to induce, it can be decided what kind of elements to include in specific VR environments. Thus, possibilities are unlimited since creation of VR environments is only limited by imagination of creators. This provides evidence that VR is effective to influence and induce emotions. Fig. 5 shows a simplistic view of what might be a VR model for AC.

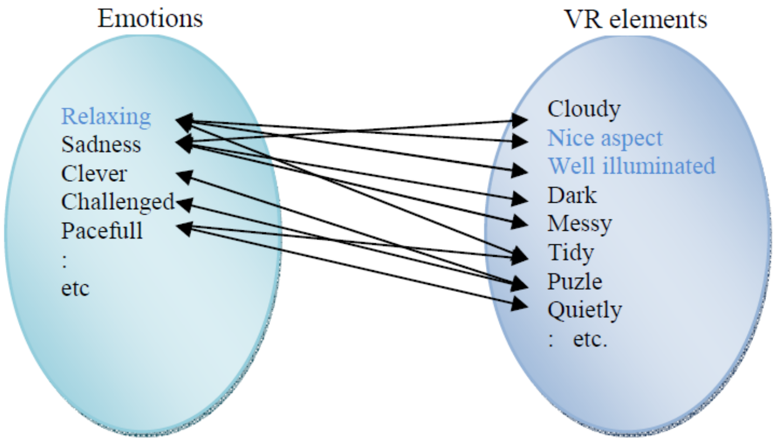

Fig. 5. Toward a model for the integration VR and Affective Computing

The overall idea seems to be quite simple; each emotion must be related with a set of VR elements which induce such emotion. Nevertheless, deeper research is needed to make a mapping between a set of emotions and a set of elements which induce those emotions. Then in order to implement this mapping by using VR, we might map these elements into VR elements, which can be presents within VR learning environments trying to influence students' mood.

An instance of the model is shown in Fig. 6. Based on the work of [9] described above, where the authors relate relaxing park environment with the feeling of relaxation. In turn the relaxing park is associated with a well illuminated place and with nice aspect. Then Fig. 7 relates for instance, a 'relaxed' state with 'nice aspect' and 'well illuminated'. This does not mean that those are the only VR elements needed to trigger a relaxing state; it is only exampling the mapping between feelings and VR elements. This mapping would provide some guidelines for the features that should integrate the virtual reality environment so that it originates this specific emotive state on users.

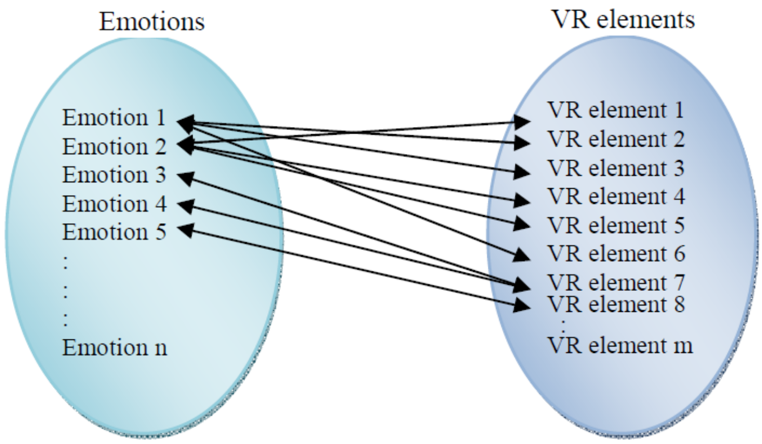

Fig. 6. Example of mapping between emotions induced by possible elements within virtual environments on the basis of presence

VR can be really powerful at inducing emotional states because it possesses different tools which enables it to integrate different VR elements within any virtual environment, examples are: recreation of environments with different levels of realism, different intensities and colors of lights, integration of different kind of audios and sound effects and even music, visual representation of environments and visual effects, avatars able to show different emotional states, integration of voice, and it is even possible to represent unreal environments, among others. All these elements provide VR with a vast arsenal for the creation of a wide variety of environments each addressing some emotive state(s).

Thus, VR reality is able to create different realities and engage users within them through the feeling of being there (presence), inside these realities and unchaining different emotive states.

Nevertheless, this simplistic model must be completed with other features already proposed by other authors.

VR and AC have been integrated within the learning field, for instance Elliot et al [20] believe that animated 3D pedagogical agents would make a good tutor if they understand and deploy emotions. Based on STEVE (Soar Training Expert for Virtual Environments), they also provide intuitions about the features that a PA should deploy in order to improve learning. The PA must appear to care about student and his progress, so that he feels that he and the PA are “in things together”. The PA must be sensitive to student´s emotion in order to encourage in case of frustration, should convey enthusiasm for the subject matter, in order to foster enthusiasm in the student, but at the same time the PA should make learning more fun.

Table 1: Set of possible behaviors for a Virtual Pedagogical Agent

Behaviors	Description
Negation	Shaking head as sign of negation
No understanding	Slight leaning trying to hear
Suggesting	Extend hand in signal of explanation
Sadness	Showing a sad face
Thinking	Looks aside and puts a hand on the chin
Saluting	Nodding head and rising a hand
Congratulating	Applauding
Waiting	Observing the actions of the students
Recognition	Nodding head
Happy	Happy expression
Explaining	Extend both hands and point to elements in the environment

Considering the fast changing nature of context, in [21] is proposed a dynamic model based on the OCC cognitive model for emotions [22]. The model of the student is composed by three elements namely: the profile of the operator, the pedagogical model and the affective model. The emotions of the student are thought of as a function of achieved goals. Here the student emotional state is inferred from indirect sources such as personality and knowledge of the topic.

Once the affective state of the student is inferred, the tutor should decide which the learning activities are most suitable for him. Then it establishes a relation between the affective and pedagogical state of the student with the training actions oriented to improve training. It is also proposed an animated PA with the behaviors listed in Table 1.

To start with, the VR Group might integrate this set of behaviors listed in Table 1, to an animated agent within a virtual environment of the systems developed.

All these intuitions might be another kind of elements in addition to VR elements which can be included in the emotions model based on VR.

In the virtual reality model for emotion, there might be even the possibility of regulating the intensity of the emotion originated by adding of removing VR elements in the virtual environment. For instance, a sullen aspect environment might be added with audio effects or shady animations to increase the filling of anxiety.

4.2 Emotions as a Dimension in the Comprehensive Approaches to Learning

On the basis of the shallow analysis presented above we have evidence of the role played by emotions in the human activity including the learning process. In section 2.2 we have included the affective dimension within the comprehensive approach to learning. In the previous section we have even identified some behaviors that might constitute a departure point to consider the affective dimension in the VR Group developments. Nevertheless, the VR Group still needs to do more research in order to complete a VR model for emotions, to find a precise mapping between emotions and VR elements, inclusion of affective PA, etc.

5 Conclusions

Discussion presented before seems to allow us inferring the wide potential of VR for influencing emotions. We have presented the first insights towards an emotions model based on VR. Deeper research is needed to make a better mapping [VR elements] ↔ [emotions]. VR Group has developed different training systems whose development methodology can be enriched with infrastructure to integrate emotive aspects which surely will improve the learning process.

Affective Computing might be located into an upper level within the evolution of artificial intelligence. Beyond pursuing the simulation of human cognitive and inferential processes, it comes into the emotional aspect which is under control of the other brain hemisphere (right) and somehow considered as a human factor separated from reason (left hemisphere), although they are rather complementary. IIE has been working separately on Affective Computing and VR, but now in order to improve training and offer better systems to our customers, in a very near future we want to integrate both fields within a new generation of training systems based on VR.

References

1. Miguel Pérez-Ramírez, Norma J. Ontiveros-Hernández: Virtual Reality as a Comprehensive Training Tool. WILE-MICAI. Guanajuato, Mexico (2009)
2. Picard, Rosalind W.: Affective Computing. MIT Press, USA (2000)
3. R.W. Picard, S. Papert, W. Bender, B. Blumberg, C. Breazeal, D. Cavallo, T. Machover, M. Resnick, D. Roy and C. Strohecker: Affective learning — a manifesto. BT Technology Journal 22(4) (2004)
4. Pérez Ramírez Miguel, Zabre Borgaro Eric y Islas Pérez Eduardo: Prospectiva y ruta tecnológica para el uso de la tecnología de realidad virtual en los procesos de la CFE. Instituto de Investigaciones Eléctricas. Reporte Interno IIE/GSI/022/2003 (2003)
5. Grigore C. Buerdea and Philippe Coiffet: Virtual Reality Technology. Second Edition, Wiley- Interscience (2003)
6. K.M. Stanney (Ed.) Handbook of Virtual Environments, design implementation and applications. Mahwah, NJ: Lawrence Erlbaum Associates Publishers, 1232 p. (2002)
7. Diccionario de la Real Academia Española de la Lengua. http://rae.es/
8.

9. Emiliano Causa, Andrea Sosa: La Computación Afectiva y el Arte Interactivo. Noviembre de 2007. http://www.biopus.com.ar/txt/textos/Computacion_Afectiva_Y_Arte_Interactivo-Emiliano_Causa-Andrea_Sosa.pdf
10. Giuseppe Riva, Fabriziamantovani, Claret Samantha Capideville, Alessandra Preziosa, Francesca Morganti, Daniela Villani, Andrea Gaggioli, Cristina Botella, and Mariano Alcañiz: Affective Interactions Using Virtual Reality: The Link between Presence and Emotions. CYBERPSYCHOLOGY & BEHAVIOR 10(1) Mary Ann Liebert, Inc. DOI: 10.1089/cpb.2006.9993 (2007)
11. Digital Space Technologies Inc. Digital Space 3D Authoring Kit, 2.0, P/N 2003-00-0, EE. UU (1997)
12. Second Life. http://secondlife.com
13. Eva Hudlicka: Affective Computing for Game Design. In: Proceedings of the 4th Intl. North American Conference on Intelligent Games and Simulation (GAMEON-NA), McGill University, Montreal, Canada, pp. 5−12 (2008)
14. Terri Langan: Bloom's Taxonomy for Affective Learning and Teaching. on line (2012)
15. Mary Miller: Teaching and Learning in Affective Domain. The University of Georgia. http://epltt.coe.uga.edu/index.php?title=Teaching_and_Learning_in_Affective_Domain
16. Minsky M: The Emotional Machine, http://web.media.mit.edu/~minsky/ (2003)
17. Wikicurios. La ptenorofobia, el miedo a las cosquillas. Wikicurios ~ Información y curiosidades en un click. 16 septiembre, 2011 de Wikicurios en Curiosidades, Salud. http://wikicurios.com/2011/09/16/la-ptenorofobia-el-miedo-a-las-cosquillas/ (2011)
18. Horace Ho-Shing Ip, Julia Byrne, Shuk Han Cheng, and Ron Chi-Wai Kwok: The SAMAL Model for Affective Learning: A multidimensional model incorporating the body, mind and emotion in learning. DMS, pp. 216-221. Knowledge Systems Institute (2011)
19. Elinda Ai Lim Lee: An investigation into the effectiveness of virtual reality-based learning. PhD thesis, Murdoch University. http://researchrepository.murdoch.edu.au/4070/ (2011)
20. George Katsionis and Maria Virvou: Personalised e-learning through an Educational Virtual Reality Game using Web Services. Multimedia Tools and Applications. 39(1) 47−71, (2008)
21. Clark Elliott, Jeff Rickel, and James Lester: Integrating affective computing into animated tutoring agents**.** In: Proceedings of the IJCAI-97 Workshop on Animated Interface Agents: Making them Intelligent, pp. 113−121 (1997)
22. Yasmín Hernández, Gustavo Arroyo-Figueroa, L. Enrique Sucar, Miguel Pérez-Ramírez: Comportamiento afectivo en sistemas de capacitación inteligente para operadores de sistemas eléctricos. Komputer Sapiens (2013)
23. A. Ortony, G.L. Clore and A. Collins: The Cognitive Structure of Emotions. Cambridge University Press (1998)