Empathic Technologies and Virtual, Contextual and Mobile Learning in VR/AR/MR Environments

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Abstract

Students' motivation and interest as well interaction between students and teachers in e-Learning and Mobile Learning environments can be improved through the use of affective technologies and empathic systems.This paper introduces Emphatic concepts, an emphatic platform and an Emphatic Forum approach. It contextualizes this initiative within the Emphatic Products, a EU/ITEA2 research project, and proposes future developments in terms of unique features such as moving to, adapting to, even defining a whole new interaction paradigm in Virtual Reality (VR), Augmented Reality (AR) and Mixed Reality (MR) immersive environments.

Keywords: Affective technology; Empathic system; Forum; Virtual reality; Augmented reality; Mixed reality; Immersive environment

1. Introduction

1.1. Emotions, Empathy and Affective Technologies

It is known that emotions remain primarily in the limbic system of the brain as explained by Picard (1997). Emotions are instinctive responses to external stimuli that are not planned ahead or formed according to logical processes. Conventionally, emotions have been considered as the reverse of reasonable and rational action. For that reason, they were perceived as being in conflict with a rational approach. However, the reality is that human reactions and responses are formed by a combination of both emotional and rational processes.

Empathy is the ability to understand the emotions of others in an adequate way, and to experience similar feelings ourselves, as described Nguyen and Masthoff (2009), by allowing us to make increased interactions in social contexts and increasing trust and collaboration as positive behaviors. among others. It is also the skill to assign our own emotions and feelings to an object, such as a work of art (Dictionary.com, 2014). Thus, the human capacity to relate with others, or to create emotional attachments to objects, presents a great opportunity for the improvement of information technology (IT) and information systems (IS). Since emotions determine and structure our perceptions, direct our attention and prepare us for action as stated by Paiva, Leite and Ribeiro (2014), there is an increasing active presence of our affective dimension in our actions and decisions; it is discussed how emotional

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information systems can take us to a different and more powerful level. Many researchers, among them Prendinger, Dohi, Wang, Mayer and Ishizuka (2004), defend that systems interacting emotionally with users, by recognizing emotions for instance, could make those systems easier to use and increase productivity.

The main purpose of affective technology is to contribute to the increase of coherence, consistency, predictability and credibility of a human computer interaction, thus resulting in computers and technologies capable of recognizing human emotions, interacting with them and conveying positive emotions. On the other hand, empathic systems are communication and information platforms, as well as software, whose aim is to provide an empathic, affective component to interactions.

As technology becomes more present and constant in our daily lives, the applications of affective technologies and empathic systems are increasing and being introduced in new contexts and areas of expertise. Affective technologies and empathic systems can have great benefits in Education (both in form of e-Learning and Mobile Learning). Whilst traditional teaching eases the lecturer's role in terms of immediately adjusting himself or herself to student needs, with constant feedback, distance learning, does not make it possible for teachers and students to have physical interactions and know the needs and skills of each other as states Wang, Chignell and Ishizuka (2006). As a result, education technologists and other researchers have focused on the mentioned constraint, focusing on empathic systems and the way how they can improve learner's interest and motivation.

More than ten years ago, mobile learning had to do with using laptop computers. Five years ago, mobile learning referred to the use of smartphones and tablets. One of the current challenges for AR technology is to implement effective technology on mobile platforms as discussed by Rattanarungrot, White and Newbury (2014). We envision that in five years' time VR/AR devices, namely those associated with smartphones, will be widely used in distance and even face to face (AR and MR) learning. In this context, augmented reality can be defined as a concept "for displaying digital contents overlaid on top of real world scenes that can enhance remarkably a user's learning experiences" (Rattanarungrot et al., 2014) by using advanced computer vision and tracking techniques to recognize and make use of markers, images or 3D objects in real environment as suggested by Carmigniani et al. (2011).

Guy (2010) anticipated the use of VR stating that "What is missing currently is a fully mobile VR system". With Samsung Gear VR and Google Cardboard system, among others, affordable mobile VR systems that can be used for learning are no longer missing.

In July 2015, Ambient Insight Mobile Learning Market Report, Atkins (2015) stated that "Smartphone-enabled virtual reality education apps are an entirely new type of Mobile Learning".

1.2. The 'Emphatic Products' project

The Empathic Products project was held under the ITEA2 umbrella and consisted of a consortium of a diversity of companies, big ones and SMB, commercial and academic. These companies came from

several European countries with different empathic technologies that integrated to increase their knowledge through viable prototypes. Those working prototypes were divided into four main domains: Wellness; Immersive Communication; Public Environments; Education and Gaming. Development had to take into account the ability to use empathy, that is, to detect or influence users' emotional states. Empathic information could be acquired through sensors (heart rate, facial expression, motion, brain activity) or extracted from users' inputs (text, voice, interactions). Depending on the product, users could confirm or not the emotional states that were detected or extracted.

As was seen in the Empathic Products project, empathy comes in many ways and different contexts. Being its aim to make human interaction more effective while using technology to access information or communicate with others, it is therefore no surprise that many of the implemented use cases evoke VR/AR systems. When words like "immersive" are applied to systems consisting of flat panels, some with touch input, when 3D environments are used to manage information and recognize who is also interested in a certain topic, VR/AR/MR comes naturally as the next frontier to explore. That is what this paper intends to do based on, for the time being, laboratory settings with two VR systems, Oculus Rift SDK2 and Google Cardboard viewer. The software development is based in Unity3D technologies which is the main development platform for these systems and allows, with technology from Microsoft, also to simulate AR/MR experiences for Hololens.

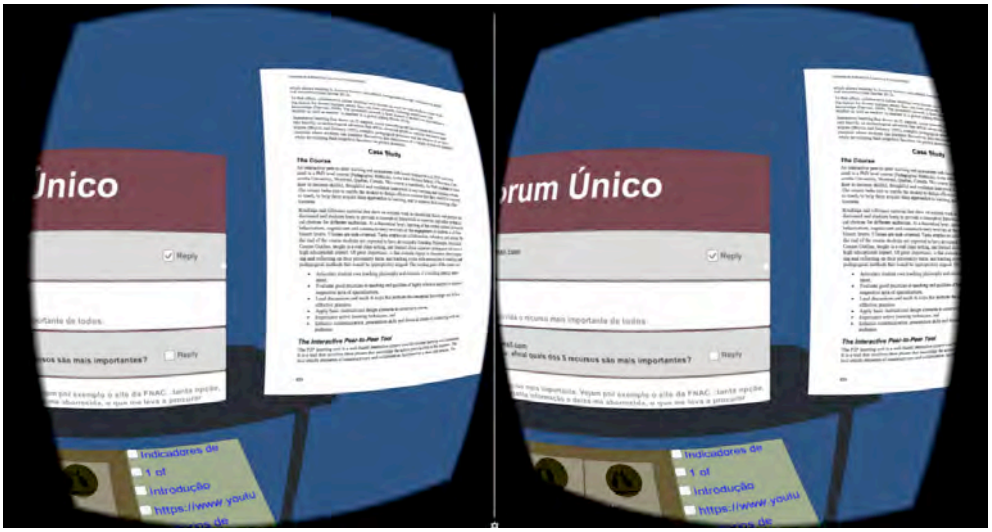

Figure 1. Using Unity3D tools to target devices like Oculus Rift and Google Cardboard

The initial conceptual environment will still be the one present in Umniverse. Nevertheless, being the Umniverse client written in Javascript, it will be rewritten from scratch in Unity C#. For the backend, it has been decided to invest in a new 100% cloud solution using Google's Appengine Java PaaS (Platform as a Service). Still less rich than the previous Umniverse technologies, this move prepares us for the foreseeable future and leads us to rethink the whole concept, thus facilitating new approaches allowed by new interaction frameworks. Being Unity a tool with a wide support to develop to the most

recent VR, AR and MR platforms as shown in Fig. 1 (Oculus Rift and Google Cardboard), it still enables to target a wide variety of other systems from desktop (i.e. Windows, Linux, MacOS), to mobile operating systems (i.e. iOS, Android, Tizen, Windows) not leaving out gaming consoles (i.e. PlayStation, Xbox) nor TV (i.e. Apple TV, Android TV, WebOS, Tizen). The web browser, the only client platform of Umniverse, won't be neglected with two HTML5 clients, one of them using a WebGL based version exported from Unity.
As the previous R&D frontend-backend 3D environment was called Umniverse, the present one is, for the time being, called TAT as meaning the intersection of our Tapalife, Apluk and Tappnet R&D projects.

1.3. Adding a 3D Immersive environment

One of the main research hurdles of the previous tested, Umniverse, was to be able to distinguish how easy and natural the use of an Empathic Forum was while at the same moment the user was subjected to a learning curve through the Umniverse environment itself. Using a 3D environment in a 2D monitor and using as an input a mouse, cleary 2D, and keyboard was nothing but natural. VR/AR/MR has thus the potential to allow users to navigate and experience a 3D world the way human beings have evolved in doing so, with their senses and hand movements interacting in a 3D space.
The Empathic Forum Umniverse experience and its undealt potential is still so strong that in TAT every communication is based around “virtual apps” as if each one was a forum. Thus, any “virtual app” allows communication among the app users taking advantage of the same Empathic Forum features that were previously implemented and tested. This implementation is even technically improved for, being cloud based, one has to prepare for situations where there are MOOC (Massive Online Open Course) with thousands of students and communities with up to millions of members/friends/followers.

2. Literature Review

In general, affective computing studies how computers can recognize, model and respond to human emotions and how these emotions can be expressed in a such remote environment as an interface / computer interaction as explained by Picard (1997).
We can differentiate two crucial dimensions of affective computing. One has to do with using technologies capable of capturing the intricate variety of human emotional responses. The other is an affective response to the collected data that has been captured through the mentioned technologies. Humans use body language and facial expression as a mean of expressing emotions and as a result, computers need to decide on the right emotional responses in order not to have negative reactions from users (Picard, 2003). Picard (2002, 2009) referred the use of affective technologies in medicine. This technology can undoubtedly play a role while a treatment is conducted, thus improving the well-being of the patient. Besides the use of these technologies in medicine. Other authors (Prendinger et

al., 2004) have identified five possible uses for empathic technologies: i) tracking and measurement; ii) reflection and interaction; iii) selection of specific approaches; iv) building of social relationships; and v) building of predictive models. All the above referring to the affective states of agents or avatars.

Bickmore (2003) introduced a theory to describe long-term social relationships between computers and computer artifacts and users. This would allow users to build relationships and also provide them with support during a negative emotional state, for example, in the context of a health treatment (Bickmore, 2003).

Empathic systems have increased importance within e-Learning and Virtual Learning Environments (VLE). Kort, Reilly and Picard (2001) developed a four-quadrant model describing interrelations between learning and emotion and suggested a computerized "learning companion" to answer according to the affective states of the user. In this model students would start in a quadrant and evolve to other quadrants, consequently helping the students regain interest and enthusiasm.

Akbiyik (2010) used this model to study the effect of introducing Information and Communication Technology (ICT) in the classroom. They concluded that in order to be more efficient, systems should consider a myriad of variables (Akbiyik, 2010).

Shen, Wang and Shen (2009) not only concluded that it is possible to improve the results of students by providing an emotionally aware learning environment, but also provided a list of key aspects that will need to be researched and addressed in the future (Shen et al., 2009): i) more varied technologies to capture emotions; ii) affective learning systems will need to cope with entire courses and not with singled out materials; iii) the mentioned systems will need to cope with teaching and group learning; and iv) e-learning models will adjust teaching strategies to affective states.

Rubens, Kaplan and Okamoto (2014) introduce and develop the concept of Web 3.0 and e-learning environments. This includes a component of 3D environments. In what immersive 3D environments is concerned, Tang, Biocca, and Lim (2004) explain and debate the differences of Virtual Reality versus Augmented Reality and respective advantages/inconvenients. Being focused in social interaction, it becomes particularly interesting for our education/communication project. Focused explicitly on education, Ly, Saadé, and Morin (2015) show that there are many advantages on using immersive environments, whatever learning theories one supports (constructivism, cognitivism), namely to visualize and contact with what a human can hardly see in real life.

Mujber, Szecsi, and Hashmi (2004) present Virtual reality (VR) as a "rapidly developing computer interface that strives to immerse the user completely within an experimental simulation, thereby greatly enhancing the overall impact and providing a much more intuitive link between the computer and the human participants". In fact, the primary concept behind VR is that of illusion. Therefore, this type of technology allows illusion to gain form, by letting its users enter through the computer screen into a three-dimensional (3D) world. The user can move around and interact with the presented worlds as if they were real (Mujber et al., 2004). In an educational context, VR can offer learners an audio-

visual dimension that presents more contextual and linguistic information than a standard textbook can provide (Yang, & Liao, 2014).

One can say that virtual reality and augmented reality complement each other, since virtual reality creates the environment that will be used in the augmented reality.

Blascovich et al. (2002) defines a virtual reality environment (VRE) as "synthetic sensory information that leads to perceptions of environments and their contents as if they were not synthetic".

Augmented Reality, especially in its Mixed Reality version, includes the fusion of any digital information within real world sceneries (we can say that the information co-exists with real objects), that means that this technology is able to enhance one's immediate surroundings with electronic data or information, in a multiplicity of media formats that include not only visual/graphic media but also text, audio, video and haptic overlays (FitzGerald et al., 2012).

Klopfer (2008) indicated that the concept AR should not be defined in a restricted way. This concept could be applied to any technology that combines real and virtual information in a significant manner.

Augmented Reality (AR) is a variation of Virtual Reality (VR). VR technologies completely immerse a user inside an artificial context. While immersed in this context, the user cannot see the real world (Azuma, 1997). In contrast, AR allows the user to see the real world and allows the user to interact with the virtual environment using real objects. Azuma (1997) provides a frequently accepted definition of AR as a technology which merges real and virtual descriptions, it is interactive in real time, and records the virtual imagery with the real world. Hence, AR enhances reality, rather than completely replacing it (Azuma, 1997).

Dunleavy and Dede (2014) identify two forms of AR presently accessible to educators: location-aware and vision-based. The first presents digital media (text, graphics, audio, video, 3D models) to learners as they move through a physical area with a GPS-enabled smartphone or similar mobile device, this allows to enhance the physical environment with narrative, navigation, and/or academic information relevant to the location (Dunleavy & Dede, 2014). The second introduces digital media to learners after they point the camera in their mobile device at an object (for example with QR code technology, 2D target) (Dunleavy & Dede, 2014).

AR, as well as the more sophisticated MR, has persuasive qualities and characteristics for educational purposes; its potential and affordance can be further developed when an AR system is designed by connecting multiple types of technologies (Wu, Lee, Chang, & Liang, 2013). Wu, Lee, Chang and Liang (2013) state that AR could facilitate learning content in 3D perspectives, ubiquitous, collaborative and situated learning, learners' senses of presence, immediacy, and immersion, visualizing the invisible, and bridging formal and informal learning.

One of the advantages of AR/MR is that it is useful for supporting ubiquitous learning in real environments. Frequently ubiquitous learning engages the use of mobile devices, such as smartphones. By using the location or other context data of the user, the system can supply some learning content

and present the information onto the real context thereby creating a stronger relation between the digital content and the real environment (Santos et al., 2016).

3. Empathic Forums New VR/AR/MR Prototype

Any forum can be considered empathic. Every post generates a reaction from other forum readers, eventually leading to a reply. A forum tool was selected for the first steps in entering the new visualization and interaction paradigm present in 3D immersive environments.

For that purpose, the Umniverse platform (2011a, 2011b) has been selected. This is a research and development environment with applications in learning (distance and mobile learning) among others, with a forum available. In TAT, or Umniverse 2.0, original Umniverse's forum's advanced features were not removed but, as was previously stated but important to underline, were made available for each and every app that is available on the platform. This way, every app becomes a forum where users can use the same empathic signaling to their posts as they did in Umniverse. The presentation of the posts and its management can now free themselves from a 2D screen, although with a 3D representation, and take advantage of the much wider “space” available in an almost real 3D immersive environment. Those features included being able to reply to multiple posts with a single post and to indicate that a post covered more than one topic at once, being these not only textual topics but, as described in previous work [31], full objects such as documents and videos. Mostly important, the empathic tagging will be kept, in its automatic and manual modes, as well as all the search and learning analytics capabilities over empathic information.

Finally, let us underline that Umniverse, even if still on R&D grounds, was way more mature than it is now the TAT environment. TAT is a platform just now experimenting with the new VR/AR/MR potential. Sharing this early prototype with our empathic forum technologies, now in an 3D immersive environment, signals a future commitment to having a realistic set for teachers and students to collaborate where sensory information must go hand in hand with emotions and affections.

Fig. 2 and Fig. 3 illustrate the radical user interface changes that immersive environments imply.

Figure 2. A view of managing forum posts on the Umniverse platform

Figure 3. A simulated MR view of managing forum posts on the prototype of the 3D immersive platform

4. Conclusions

Having eliminated the particular learning curve from the Umniverse environment, it is still to be seen what will be the learning curve of users to the new VR/AR/MR platform. If 3D immersive environments are here to stay, in a few years that will no longer be a cause for concern for its main aim will certainly be attained as to let the user interact in a most natural way.

Having not yet collected any data from the user experience to put it through a framework such as UTAUT, the first VR/AR/MR prototypes with the equivalent to the Empathic Forum setup provided the following early indications:

- VR/AR/MR is indeed the natural next step to the classic 3D virtual screen based environments;

- Tagging messages with emotions continues to be powerful and, having now more realistic avatar that the ones in Umniverse, and transposing the written emotions to avatar expressions and body language becomes natural and almost urgent;

- TAT apps appear to be a more powerful concept than objects in Umniverse for they have an intrinsic representation, in this case both in 2D and 3D, associated with them. Instead of being an afterthought, apps design is at the forefront of their creation, together with attributes and behaviour which were the basis for the object classes; the AR/MR simulator seems to have even more practical use cases than VR has, namely for mixing distance learning moments with eventual face to face classes or work group sessions.

- The concept of having nine avatars at once was easier to grasp in Umniverse coarse environment than in the more realistic TAT one. Users are only now becoming at ease with these new worlds and cumbersome technology still gets in the way.

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