Automatic Guidance Tools for Enhancing the Educative Experience in Non-Immersive Virtual Worlds

Preliminary results from project V-LeaF

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Abstract— **The interest of the Education community for Virtual Reality (VR) technologies has increased in the last few years due to their attractive 3D immersive worlds and facilities to provide a good environment to develop educational and collaborative tasks. However, these technologies present three main drawbacks: (1) a high cost in terms of hardware and infrastructure, (2) a high level of technology knowledge, and usually programming skills, is required to build up an educational and functional platform, and (3) once the educational platform is available for use, the educators are limited to the functionalities provided by the platform used. Our previous experience, designing and deploying a VR educational platform, named V-LeaF, showed that non immersive platforms (close to the gaming 3D platforms) provide High School educators and students with an attractive environment in which many features of the teaching/learning experience can be explored. However, this technological strength appears as a potential weakness feature of our platform when is used by high school students. Serious problems to maintain the student attention in this kind of domains have been detected, so the educators must employ time and dedication to ensure that students are really attending and acquiring the educational concepts scheduled. In this paper we describe an initial set of software tools developed (for both teachers and students) to solve the previous problem. An eye-gaze monitorization device allows teachers to focus the students' attention. A forms-based recommender system allows students to guide teacher's activity.**

Keywords: Virtual worlds; Virtual reality; Education; Recommender systems; Opensim

I. Introduction

The application of Virtual Reality to education requires a specific infrastructure, such as hardware in the classroom, or wearable devices, and its economic cost can be high as it is the case for immersive technologies. In this paper we show a software infrastructure capable of emulating hardware devices and communication between these devices. Specifically, we have created virtual versions of immersive virtual reality teaching-oriented devices, most of them based on monitoring the activity of students and teachers.

For example, students' eye-gaze monitoring allows us to provide teachers with a virtual device capable of displaying the "attention-level" of students. Eye-gaze is a key factor to check the comprehension level of students in immersive virtual environments [1] [2], but the effects of this factor in non-immersive environments (such as V-LeaF) has not been checked yet.

From our previous experience using Virtual Worlds environments with High School students, under the project V-LeaF[1] , we detected problems to maintain reasonable attention levels in the students. To monitor students by using immersive devices does not look to be an operative and scalable solution. For this reason a new system has been designed in a particular VR educational platform that allows in a non-intrusive way to monitor the attention of the student. The non-intrusive characteristic is essential if the educators need to provide a free environment for the student, improving their cooperation and collaborative skills. On the other hand, automatic recommendations and information about the attention level of the students must be provided dynamically to educators.

The paper is structured as follows: section II provides a brief description about our VR educational platform and other related work. Section III describes the automatic monitoring system. Section IV gives details about the scheduled experiments to be carried out by using the proposed system and, finally, Section V shows conclusions and future work.

II. VIRTUAL REALITY EDUCATIONAL TECHNOLOGIES

A. Underlying technology

The proposed monitoring and recommender system has been created by using the V-LeaF platform [3] [4], an infrastructure initially oriented to high school teachers and students, aimed at enhancing the teaching and learning experience respectively.

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[1] See http://this.ii.uam.es/vleaf

V-LeaF uses the infrastructure provided by OpenSimulator [2], an open source project which allows **developers** to extend the base functionality by means of pluggable software artifacts named *modules*, such as RealXtend[3]. An in-world programming language oriented to **users** is provided, aimed at providing functionality to in-world objects. In such a way, V-LeaF extends functionality by allowing teachers to use (and, eventually create) in-world objects with a given functionality. By using this approach the adoption barrier is lowered, by allowing teachers to create teaching devices for the V-LeaF community. Objects created under this contributory philosophy can be modified and extended by other teachers, evolving according to the users (teachers) needs.

The V-LeaF project site provides teachers with manuals and tutorials in two levels: basic and advanced. The basic level provides information about how to use the teaching devices, not requiring technical skills at all. The advanced level provides material about the in-world programming language (Linden Script Language, or simply LSL), the development of teaching-devices such as the ones described in the basic level, and the V-LeaF installation guides to allow teachers to create their own V-LeaF virtual worlds. The skills required for the advanced level have been minimized. Most of this material was requested and supervised by high school teachers participating in the first V-LeaF experiments carried out during the 2008-09 course.

B. Related Work

Second Life (SL) raised the educators' interest towards virtual worlds due to its high power/easy-of-use ratio. For the first time, the application of virtual worlds to education is in teachers' hands, and many studies involving high school teachers have been carried out [5-8]. Some of the authors participated in the creation in SL of a virtual version of our academic institution (EPS-UAM) [4] in 2008. Although we realized the possibilities of this environment, we noticed that this virtual world could be improved in several aspects:

- To create objects in SL requires renting a parcel. This is an administrative task with an economic cost.
- The parcel is not isolated of the rest of the SL world. While students attend a course, other users can get in this parcel and interact with the students, which may interfere in the lessons course.
- The lack of parental control (as a "black" list of locations not recommended) discourages this world for under-18 students.

Although the SL parcel's access-control policy can be customized, the skills required to achieve this task are high for average users (teachers). V-LeaF provides teachers with a web application to organize students in groups, thus simplifying this management task (see Fig. 1). V-LeaF students belonging to a given group are bounded to a specific "island", and the access policy prevents students from leaving the island and prevents students in other groups from getting into the island.

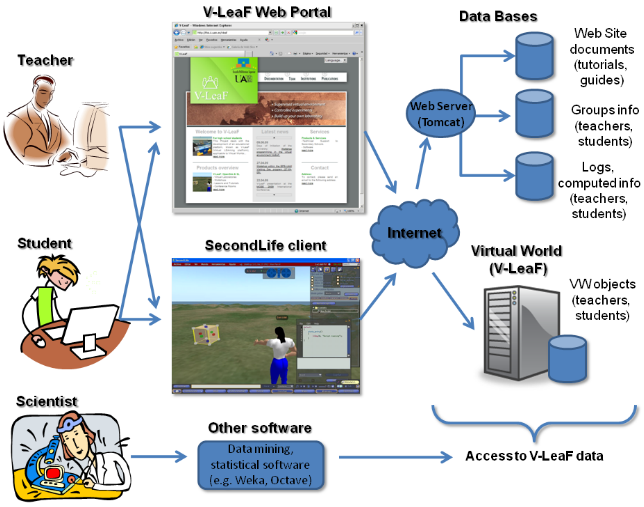

Figure 1. The V-LeaF infrastructure.

OpenSim can be regarded as a non-commercial version of SL. OpenSim is free source, and can be downloaded and installed for free. The compatibility with SL is almost complete: the in-world programming language (LSL) is portable, objects are interchangeable between these worlds and even the communication protocol between clients and servers are compatible. An enthusiastic community of developers provides new software modules to extend the basic functionality (e.g. to allow new in-world programming languages). Our aim is to create a similar community but oriented to teachers, not to professional software developers, focused on teaching devices and teaching techniques.

An additional benefit of using open software is that the functionality of the platforms can be modified. This task requires advanced skills (e.g. management and development of C# software projects), and is not intended for teachers, but it is the added value of V-LeaF. For example, V-LeaF can monitor students and teachers silently. However, SL or the "non-hacked" OpenSim (on which V-LeaF is based), warn users when they are going to be monitored.

III. V-LEAF VIRTUAL DEVICES IN ACTION

There is a need for evaluative systems to measure the success of virtual environments by monitoring students, teachers, contents an technologies [9]. Having this objective in mind, the following is a list of relevant virtual devices developed by our team. The selection of these devices was the result of a requirement analysis made by high school teachers that attended the first V-LeaF experiments carried out during the academic course 2008-09.

A. Monitoring the students eye-gaze

As we pointed out previously, the importance of eye-gaze in learning is well known. For example, there is a relation between teacher's eye gaze and student's attention and contents comprehension [1]. Another interesting experiment from this

[2] See http://opensimulator.org

[3] See http://www.realxtend.org

[4] See http://www.ii.uam.es/esp/sl/index.html

study states that the location of the student in the virtual classroom has a direct effect in the student results. These experiments were carried out in immersive environments in which each location changed the student view of the teacher, privileging locations close to the teacher and with a direct vision (face to face).

3-D multiuser virtual environments (3-D MUVEs) [10] such as V-LeaF, are found familiar to students due to its similarity to modern 3D games. Although these environments do not provide students with the realism of immersive technologies, both approaches share the importance of social aspects of digital learning environments [11]. For example, the theory of Transformed Social Interaction (TSI) [12] divides the potential of real-time transformations during interaction in three groups:

- *Social-Sensory abilities*. These transformations complement human perceptual capacities. For example, virtual devices can monitor student's activity to be reported to the teacher in real time. This is the most relevant aspect exploited in V-LeaF.
- *Self-representation*. A given avatar can be rendered (transformed) in different ways. For example, it could be the case that some students learn better with smiling teachers, while others improve their learning with serious teacher faces. Although the virtual world provided by V-LeaF is the same for all participants, there is an exception: student's view point. Unlike immersive environments, in MUVEs it is important to distinguish between the avatar's view point and the user's view point. For example, although the student's avatar is quiet facing to a given object, the student can observe this scene from any direction by moving his/her own "camera". This fact can be exploited to suggest users to move their cameras to a privileged position, without having to move their avatars.
- *Social environment*. The perception of the rest of participants can be modulated to filter, for example, distracting gestures of participants. This aspect cannot be modified in V-LeaF.

The virtual device named "Students Monitor" (SM) comprises the teacher monitor and a bracelet that each student must wear on his/her wrist. Each wrist monitors the student eye-gaze (indeed the position and direction of his/her camera) sending the information to the teacher monitor. This monitor shows a graphical representation of the location of each camera (see Fig. 2), in which color and blink are visual indicators of the student visual focus. The monitor has a default configuration, but this can be configured by the teacher, with parameters for (only the most significant are shown):

- *List of relevant objects*. By default it comprises only the teacher, but this list can include other objects relevant for the students learning process, such as blackboards or workbenches.
- *Maximum gaze inattention time*. Number of seconds that the student can lose visual attention. When this limit is exceeded, the student blinks in the teacher's monitor.
- *Refresh frequency*. Number of times per second that the teacher's monitor request data to each student's bracelet.

All the information managed by the Students Monitor is available for researchers and teachers through a web application in which raw data are provided as CSV files. Some basic analysis is shown in the web application pages.

The teacher's monitor can be attached to the user's view to avoid indiscreet students' views. This mechanism, provided by OpenSim is also used by the virtual device shown in the next subsection.

Figure 2. Teacher's monitor of the "Students Monitor" virtual device. This monitor is a virtual object that can be attached to the user's view (usually the teacher's view). In this example it is attached to the upper left corner.

B. Evaluating the teacher activity

One of the student demands is a mechanism to anonymously evaluate the teacher activity. To this end, a virtual device named "Teacher Evaluator" was developed by our team. This device comprises a Questioning Object attached to each student's view (see Fig. 3) and an Evaluator Object attached to the teacher's view (see Fig. 4). As all the objects are attached to the participants' views, the anonymity is guaranteed for students and teachers.

The Questioning Object prompts students with questions one at a time and it is configured externally through a web application. These are the most relevant parameters:

- *Evaluation frequency*. Number of minutes between questions. There is a random delay to avoid the synchronization of the students' responses.
- *Questions*. This is the list of questions that will be presented to the students during the teacher's activity. Although there is a default set of generic questions, these questions can be adapted to the subject domain to provide a more precise result. The current implementation only considers mono-answer questions in order to simplify and minimize the student's response time.
- *Answer tolerances*. Each answer has a tolerance associated. This tolerance is the percentage of students that can answer this question. When this tolerance is

exceeded, the Evaluator Object warns the teacher, who will reformulate or retell the conflictive topic.

The Evaluator Object can be configured to relax the warning conditions for different situations. The conditions in a 10 min. talk may be different to the conditions for a 50 min. talk.

As for the Students Monitor, the information recorded by this virtual device is exported as a CSV file for additional analysis and a basic summary is displayed in the web application pages.

Figure 3. Questioning Object (upper left corner) in action. A question with 5 possible answers is prompted to the student. The student can provide an answer or cancel the request.

Figure 4. Teachers' Recommender system in action. The Evaluator Object displays the recommendation in the teacher's view centre. Information collected from the students' questioning objects is used by the recommender to guide teacher's activity in real-time.

IV. Scheduled Experiments

This section shows a set of scheduled experiments to be carried out by high school students during the course 2009-2010. These experiments exploit the virtual devices described in the previous section.

A. Related to monitoring students' eye-gaze

By using the Students Monitor, we have designed the following experiments:

1) Test the Bailenson results. Bailenson reported the existence of privileged positions (close and facing to the teacher). These results were obtained in immersive environments, and we should check that this effect is observable in 3D-MUVEs such as V-LeaF. If this effect was observed the utility of an automatic recommendation system for students could be evaluated. This system could suggest the better user's view (camera position) to attend a teacher's lecture.

2) Evaluate the utility of the Students' Monitor. Two groups of students are required. Both are evaluated after a teacher's lecture by means of a contents questionnaire. One of the groups will have a teacher assisted by the Students' Monitor. Significant deviations should be identified to show the effectiveness of this virtual device.

a) The effect of being monitored. The behavior of students can change when they know that they are monitored. This should be researched. V-LeaF allows both policies: silent and classical monitoring.

3) Evaluate the efectiveness of the Teacher Evaluator. In a similar way to the evaluation of the Student's Monitor, the efectiveness of the Teacher Evaluator module should be tested with two sets of users.

B. Evaluations wars

Let us image a classroom in which students evaluate the teaching quality (perceived quality) and teachers pay attention to students' gaze inattention. It could be the case that students with low gaze attention became stressed by the teacher, resulting in a negative feedback for both students and teachers. This kind of destructive effect between virtual devices could be an interesting matter for research.

V. Conclusions and Future Work

For many years, immersive environments have shown that teaching can be improved in different ways. For the last years, the fast development of personal computing has resulted in powerful computers with graphical features capable of providing users with rich 3D virtual worlds. Many of the lessons learned in immersive environments can be applied to these new low-cost environments.

Our team has built, on top of the OpenSim platform, a software infrastructure, named V-LeaF, initially oriented to high school students and teachers but with a wider application scope. Any social task involving avatars can benefit from this platform.

One of the results of the application of V-LeaF to real high schools was a list of "useful" teaching virtual devices, identified by both teachers and students. The most relevant virtual devices created are shown in this paper, as well as the experiments that can be carried out. As we have described in section IV, next steps will include several experiments with educators and students from high schools to obtain analytical measures of the results by using our new monitoring device.

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REFERENCES

[1] J. N. Bailenson, N. Yee, J. Blascovich *et al.*, “The Use of Immersive Virtual Reality in the Learning Sciences: Digital Transformations of Teachers, Students, and Social Context,” *Journal of the Learning Sciences,* vol. 17, no. 1, pp. 102--141, January, 2008.

[2] W. Steptoe, O. Oyekoya, A. Murgia *et al.*, "Eye Tracking for Avatar Eye Gaze Control During Object-Focused Multiparty Interaction in Immersive Collaborative Virtual Environments," in IEEE Virtual Reality, 2009, pp. 83 -- 90.

[3] M. Rico, G. Martínez, X. Alamán *et al.*, “Improving the Programming Experience of High School Students by Means of Virtual Worlds,” submitted to *International Journal of Engineering Education*, 2009.

[4] M. Rico, D. Camacho, X. Alaman *et al.*, “A High School Educational Platform based on Virtual Worlds,” in 2nd Workshop on Methods and Cases in Computing Education (MCCE 2009), 2009, pp. 46--51.

[5] L. Jarmon, T. Traphagan, M. Mayrath *et al.*, “Virtual world teaching, experiential learning, and assessment: An interdisciplinary communication course in Second Life,” *Computers & Education,* vol. 53, no. 1, pp. 169--182, August, 2009.

[6] A. Lamb, and L. Johnson, “the potential, the pitfalls, and the promise of multi-user virtual environments: getting a second life,” *Teacher Librarian,* vol. 36, no. 4, pp. 68--72, April, 2009.

[7] A. Trotter, “Educators Get a 'Second Life',” *Education Week,* vol. 27, no. 42, pp. 1--17, June, 2008.

[8] J. K. Waters, “A 'second life' for educators,” *T H E Journal,* vol. 36, no. 1, pp. 29--34, January, 2009.

[9] E. W. Black, R. E. Ferdig, and M. DiPietro, “An Overview of Evaluative Instrumentation for Virtual High Schools,” *American Journal of Distance Education,* vol. 22, no. 1, pp. 24--45, January, 2008.

[10] N. Omale, W.-C. Hung, L. Luetkehans *et al.*, “Learning in 3-D multiuser virtual environments: Exploring the use of unique 3-D attributes for online problem-based learning,” *British Journal of Educational Technology,* vol. 40, no. 3, pp. 480--495, May, 2009.

[11] K. Bielaczyc, “Designing social infrastructure: Critical issues in creating learning environments with technology,” *Journal of the Learning Sciences,* vol. 15, no. {3}, pp. 301--329, 2006.

[12] J. N. Bailenson, and N. Yee, “A longitudinal study of task performance, head movements, subjective report, simulator sickness, and transformed social interaction in collaborative virtual environments,” *Presence: Teleoperators and Virtual Environments,* vol. 15, no. 6, pp. 699--716, 2006.