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ReW: Reality Windows for Virtual Worlds

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Abstract: In this paper, we present the ReW system, a two-way bridge connecting Virtual and Real worlds, aiming at improving the virtual world extension of classical classroom didactic, facilitating the diffusion of blackboard content in virtual environments. The system adopts low cost hardware and is not intrusive in common lecture practices since its classroom front-end is controlled by a virtual button on the blackboard that results really usable for the teacher and does not require to alter his/her didactic habits. In this way, the system aims also at affording one of the obstacles against the adoption and diffusion of virtual worlds, the effort required to control the didactic and collaborative actions. The system has to be intended as a support to already available presentation systems and was specifically created for quickly distributing hand-written content produced during lectures. The prototypes have been developed for two diffuse 3D virtual worlds, with some slight differences due to different technological support offered by the underlying technologies.

Keywords: virtual worlds, e-learning, virtual-real worlds bridge, virtual blackboard, image analysis

Introduction

This paper presents the ReW (Reality Windows) system, a hybrid solution distributed between the real classroom setting and its Virtual Worlds replicas. The proposed system (available from http://delta4.dmi.unisa.it/software.html) provides a source of information for the distance learning actions by recording the classroom blackboards or whiteboards (henceforth, the word blackboard will stand for both, black and white ones) and complements the content provided in-world by available virtual world presentation systems with on-line hand-written data.

The main drawback of Virtual Worlds is also the main obstacle for their adoption and diffusion in distance learning and collaboration: novel users need to cope with an initial complexity when controlling their actions. Indeed, the representation of a 3D environment on a 2D medium (i.e., the screen), requires the implementation of some tricky form of control that may result unfriendly to not expert users. In particular, in e-learning scenarios, while for student it is possible to expect a technological background or skill improvement, one of the actors is the teacher. It appears difficult to force traditionalist teachers to change their didactic habits for adopting a different way of providing content but, more in general, for a different way of conducting their didactic actions.

ReW tries also to be a low-cost solution to previously exposed problem, since it implements an easy way to support the classical lecture based on blackboard writing and classroom interaction. In particular, the interaction required to the teacher during the lecture is restricted to an area on the blackboard, which is reserved to control the ReW real front-end. When he/she needs to save and transmit to the virtual world ReW window an image of the board, the teacher needs only to pass his/her hand (or the rubber, before deleting the text) on this area. Alternatively, the saving can be requested directly in-world (i.e., when in the Virtual World). An additional benefit provided by ReW system to Virtual

World didactic and collaborative action is an improved sense of immersion and realism. The remote users are immersed in replicas of the real classroom and ReW increases their sense of immersion by providing them real blackboard images contemporarily improving the perceived realism and involvement.

1. Related Work

Several authors, such as [7] and [13] affirm that 3D web Virtual Worlds may really represent a likely hypothesis on the future of the web and it can be easily foreseen how the evolution of web exploration scenarios and interaction metaphors will go towards more natural real world practices and attitudes.

The metaphor of 3D collaborative virtual meeting rooms hosted in Virtual Worlds is really diffused and accepted. It is proposed by several tools available in different Virtual Worlds, such as [2], [11], [14], [19], [20] and [5]. In all these environments human participants are represented by avatars. In [5] a Second Life (SL) virtual environment supporting the control and setup of collaborative learning activities has been proposed. In [20], a remote physical experiment, concerning magnetism, is reproduced in Wonderland [23] and effectively exposed to the interaction with students. Wonderland was an interesting framework for the development of pure JAVA 3D virtual setting, but, after the acquisition of SUN by ORACLE, the Wonderland project has been dismissed. As a proof of interest towards these technologies, a non-profit corporation, the Open Wonderland Foundation [15] is continuing the development of a community fork of Project Wonderland.

As a confirmation of interest for the chances offered by virtual worlds to collaboration, Lindeman et al. in [12], experiment the use of SL for the yearly cycle of a program committee meetings (IEEE Virtual Reality 2009). They conclude that SL is a good and cheap alternative to face-to-face settings and avoids the time and money wasting associated with face-to-face meetings.

Virtual Worlds such as Active Worlds [1], Croquet [4], Open Wonderland [16] and SL [21], propose didactic and collaborative environments which are quite diverse, ranging from realistic replicas of real universities to simulations of other planets, or completely fantastic settings. Considering that future users are today's 'digital natives' (i.e., they are growing up in a technological environment, such as multi-player online games and instant messaging), it will be natural and pleasant for them to use a virtual world for distance learning and collaboration.

In the context of software requirements negotiation, Erra et al. compare in [8], face to face meetings, a three-dimensional virtual environment and a text-based structured chat. Underlining the importance of communication media richness, they report that the teams using the three-dimensional environment perform most like those in face-to-face groups.

However, as stated by Witmer et al. [22], several factors contribute to increase the success of an immersive experience aggregated in the perception of presence: Control, Realism, Distraction and Sensory input. Also Chittaro et al. assert in [3] that disappointment can negatively influence users' predisposition to learning: when the expectation of learners contrast with the perception of the system, users are less involved in the learning process. In particular, they underline the amplified participation of learners in presence of increased realism.

In that direction, our system enhances the perception of realism by opening a "window on the reality" and increases the sensation of efficacy by letting users control the Reality directly from the Virtual World. In particular, we expose the classroom blackboard to virtual world users without altering the teacher habits and in usual classroom settings.

Before dismissing the Wonderland project, SUN was proposing the Porta-Person hardware component, a system with functionalities analogous to the proposed ones. Porta-Person is a tele-presence device aiming at improving, like the ReW system, the connection between the Virtual World and the real setting of a meeting. It is based on a rotating display that shows a remote participant's video image or their animated representation [24].

Several commercial systems propose expensive hardware to implement electronic and, in the best cases, interactive boards, that can be considered affine to the ReW one. Proposed solutions range from simple screen for saving board content to complex interactive instruments capable also to run didactic simulations.

Multimedia Interactive Boards are hardware devices that use a computer, a projector and some touch detection mechanism on the screen to gain the position of the mouse pointer and the pressure of its left and right buttons. The interactive solutions available on the market require an economical effort ranging from few hundred of Euros to several thousand for multi-touch active models that do not require the projector. As an example of extreme sophistication, Hitachi proposes an interactive 50 inches touch screen overlay system for boardrooms [18], customer meeting rooms, training, distance learning and video conferences. The overlay hardware adds an infrared image sensor system to plasma displays obtaining a resolution of 500 lines/inch.

The proposed system, in particular the EleBBo front-end, adopts a quick technique for board command detection, that are collected on the blackboard as shown in the following. In our case the resolution obtainable with adopted webcams (and the related light frequencies) is adequate for our goal but not comparable with the commercial solutions.

2. The Proposed System

The proposed system spans from the classroom to the virtual world and requires only a low cost webcam as main input source.

It is important to point out that Open Wonderland is still equipped with a specific module for viewing live streaming video from webcams [17], but our solution is slightly different:

- The teacher controls when the blackboard is to be published by simply acting on it
- The produced output of the system is a set of recorded images and not a video stream.

Figure 1 depicts the architecture of the proposed system whose component can be classified respect to their location:

- Classroom front-end (EleBBo)
- Virtual World front-ends (ReW and ReW4SL)
- Data Server.

EleBBo (i.e., Electronic BlackBoard) is the classroom front-end of the system and is depicted in the central part of Figure 1. As previously specified, it is hosted on a normal desktop pc set on the classroom desk and equipped with a webcam pointing at the teacher blackboard. EleBBo is the source of blackboard images and is usually controlled by the teacher, even if it exposes a socket interface to the saving requests coming from the other subsystem. In this way, it is possible to control the classroom actions also from the Virtual World front-ends.

ReW and ReW4SL (Reality Window and R.W. for SL), the two prototype front-ends to the virtual part of system we developed, are depicted in the leftmost side of Figure 1. ReW has been developed for Open Wonderland technology while ReW4SL is its porting to SL. Both are hosted in realistic replicas of the real didactic settings.

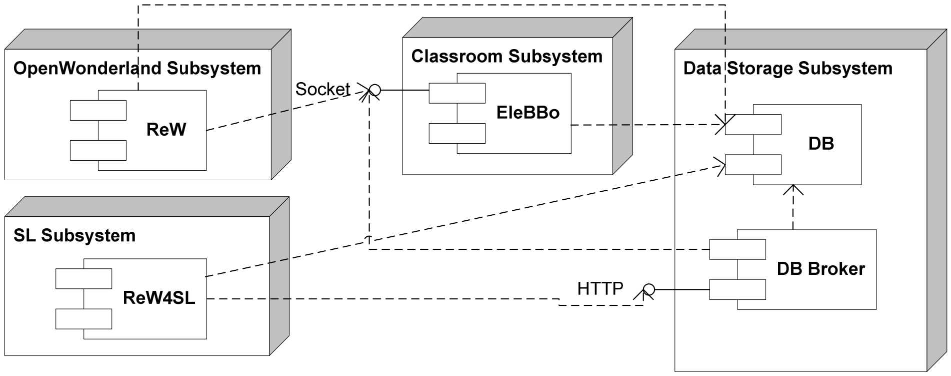

Figure 1. The ReW system architecture: dashed lines represent connections between nodes.

While the ReW component, implemented using the Java program language, is capable to directly connect to the EleBBo socket interface and control its actions, as well as to connect to the DB and fetch the images, the ReW4SL one needs to connect via HTTP request to the DB Broker to overcome proprietary language restrictions. The DB Broker is depicted in the rightmost side of Figure 1 and is a component of the Data Storage Subsystem which is responsible of controlling data storage and retrieval.

When not explicitly specified, in Figure 1, components connect with the adopted MySQL DBMS using JDBC API [10].

3. EleBBo: the Classroom front-end

The EleBBo front-end is the teacher interface to the system and is hosted on a desktop PC in the classroom. The front-end exposes two interfaces as depicted in Figures 2 (a) and (b). The former controls the image acquisition while the latter regulates the access to stored images. Combined with a classroom projector, the EleBBo subsystem can also be useful for retrieving previously stored content. To start the acquisition modality, the EleBBo subsystem requires the teacher to physically set a visual marker on the board. The marker should be adequately in contrast with the board surface: a white one is good for blackboards, a darker for whiteboards. Since our board is white, in Figure 1, a black marker has been used and is visible in all the five pictures. The marker will represent the virtual button to press when the teacher wants to save a ‘screenshot’ of his/her classroom board.

The detection of the marker is started by the teacher who clicks on the part of image exposed by the acquisition interface and depicting the marker. After this input, the system is capable to detect the button area on the image by searching all pixels similar, in term of intensity, connected to the clicked area.

It is important to point out that our images are memorized in terms of their three color bands: red, green and blue. Without loss of generality, the rest of the discourse will consider all bands as a single grayscale image or, equivalently, the tree bands average. Figures 2 (c), (d) and (e) depict the image elaboration pipeline adopted to enhance the virtual button detection. The original video frame is depicted in Figure 2 (c). The pixel values of the images are then stretched in the full range [0 255] obtaining the frame depicted in Figure 2 (d), without any loss of information. Indeed, if m is the minimum intensity value among all pixels of the image and M the maximum, for all pixels of the image represented by the matrix $PIX\,[\,i\,,j\,]$, the stretched values will be:

$$PIX\_STRETCHED\,[\,i\,,j\,] = 255\,(\,PIX\,[\,i\,,j\,] - m\,)\,/\,(\,M - m\,)\,.$$

The quantization noise is then removed by applying an average local spatial operator [9] and obtaining the image depicted in Figure 2 (e). As shown in the enlarged box of Figure

2 (a), the detected button is circled with a colored box with the word “SAVE”. The image elaboration pipeline adopted ensures good detection performances, but it is important to point out that the button setup procedure is supervised by the teacher who may repeat it in the case of errors.

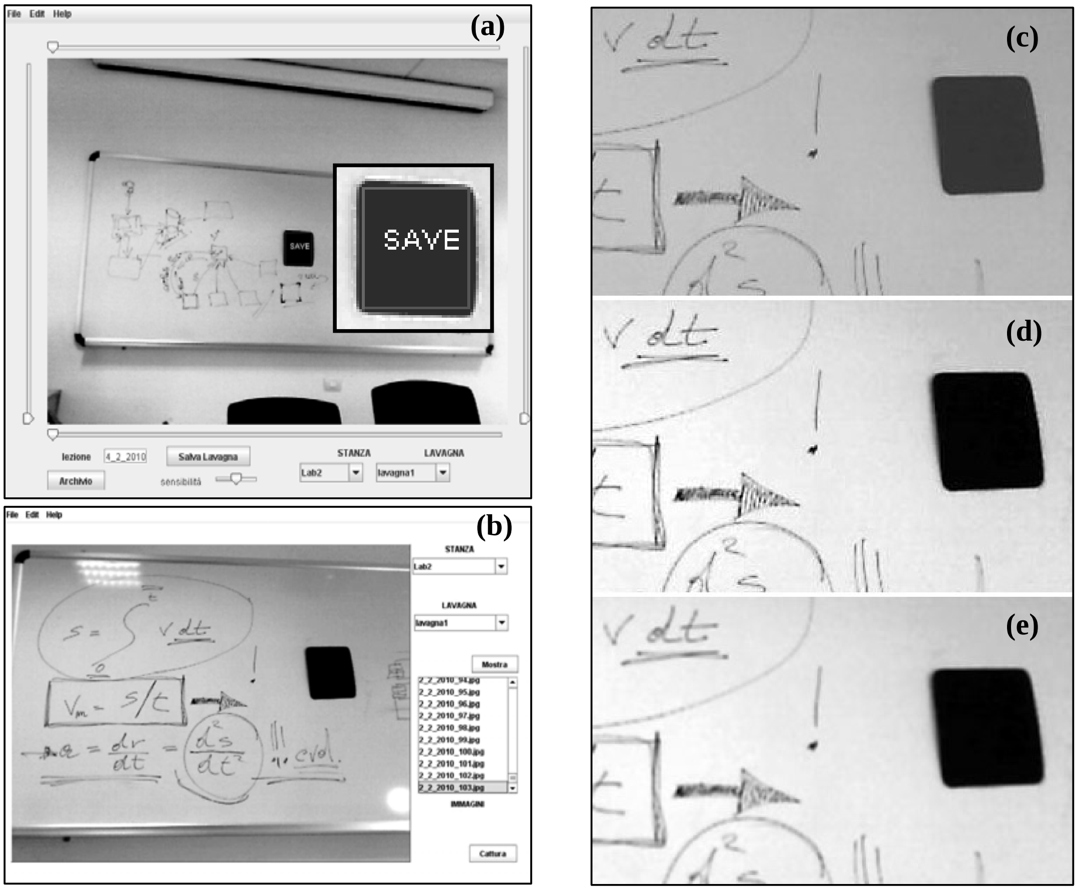

Figure 2. The Classroom EleBBo front-end (a and b) and the image elaboration pipeline applied during the button detection (c, d and e).

After the setting of the virtual ‘SAVE’ button, when the teacher needs to save the board content updating what is shown to remote users, he/she passes a hand on the button. The EleBBo subsystem detects the luminosity change in the controlled button area and stores an image of the starting RGB picture on the Data Storage subsystem, signaling with an audio feedback the successful recording.

The system is useful also to save blackboard hand written content: the interface proposed in Figure 2 (b) is used for lately retrieving stored pictures.

4. ReW and ReW4SL: the Virtual World front-ends

ReW and ReW4SL are the Virtual World front-ends to the system; they are virtually represented by virtual boards, they are hosted in the replicas of the classrooms, as depicted in Figures 3 (a) and 4.

The ReW prototypes have been developed, with some differences, for two diffused Virtual Worlds: respectively ReW is the Open Wonderland version (see Figure 3 (a) and (b)) and ReW4SL the SL one (depicted in Figure 4).

During the remote lecture, the teacher avatar stands near the ReW clients, both representing a reference point for distance learners and streaming to the Virtual Worlds the audio of the lecture. When in on-line modality (always in the case of ReW4SL), the virtual boards poll a periodic request to the Data Storage subsystem querying the last saved image. In this way remote users, both in Open Wonderland and in SL, can see the last saved image of the classroom blackboard. ReW exposes to users the configuration interface depicted in Figure 3 (b) that is used also to access stored data. The teacher may customize the update delay acting on the slider and can select and retrieve previously stored images.

(a) **(b)**

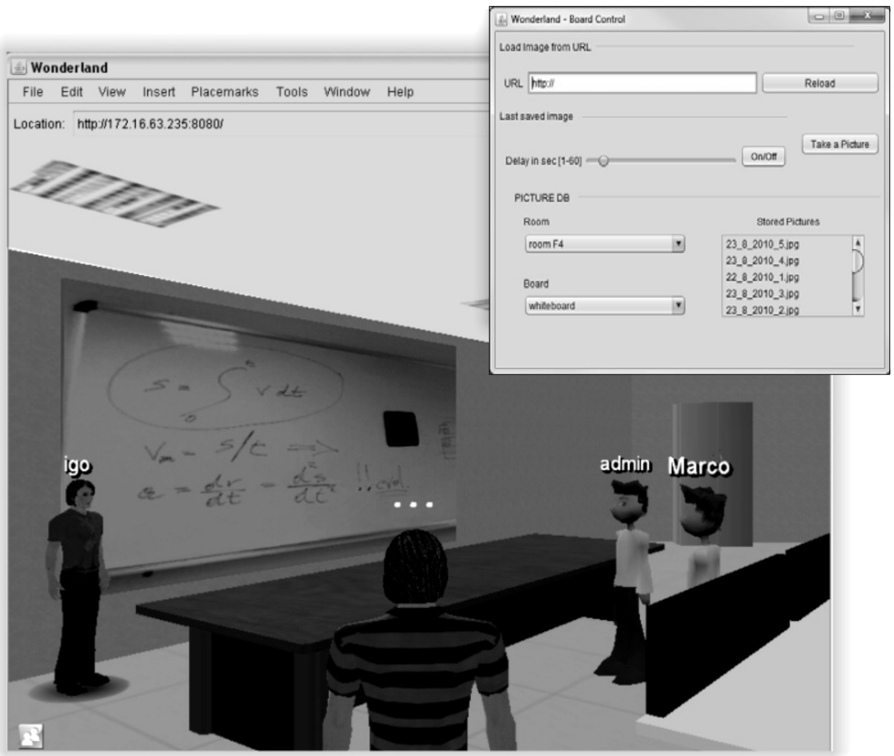

Figure 3. The Open Wonderland ReW front-end (a) and its control interface (b).

A different usage scenario enables remote users to request the 'SAVE' operation in the real lecture setting (i.e., the EleBBo front-end) and update the image shown in the virtual setting.

At this aim, the ReW front-ends expose a 'Take a Picture' button that cause EleBBo to save a picture of the classroom blackboard. This scenario strongly increases the immersion perception of remote users since they feel, as it really happens, to directly act on the real setting.

The Rew4SL front-end overcomes the limitation imposed by SL technology on connections outside SL world by connecting to an intermediate broker for sending 'SAVE' commands and retrieving the images. Exploiting the capability of SL objects to address HTTP requests outside the Virtual Worlds, it connects to the DB Broker of Data Storage Subsystem that returns the image in the form of web images displayed in-world. For the difficulty of listing big amount of data in SL, the ReW4SL front-end does not offer the image archive access and permanently exposes the control area. It enables the teacher to choose among three pre defined update frequencies and to control the saving and updating of the blackboard image.

Figure 4 shows, in the rightmost side, the ReW4SL system near a pre-existing presentation system [5]. In this case the ReW system fully reveals its utility in a concrete scenario: for normal lecture exposition the teacher uses the 'traditional' presentation system, while he/she distributes the notes written on the blackboard via the ReW(4SL) system.

Figure 4. The Second Life ReW4SL front-end.

The right part of the ReW4SL front-end exposes the control area where the teacher can set the update frequency and push a SAVE command to the EleBBo subsystem.

5. Conclusion and Future Work

In this paper we presented the ReW (Reality Windows) system. It is a hybrid solution distributed between the real classroom setting and its Virtual Worlds replicas and provides a remote camera on the classroom blackboard complementing the content provided by available virtual world presentation systems, with on-line hand-written data.
First users' opinions about the system have been really good. In particular, even if a video stream is not an innovation for Virtual Worlds, users were favorably impressed by the ability to control directly in-world the webcam in the real classroom. The ReW system seems to create a high contextualization of remote actions and to ideally enforce a strong connection between the Virtual World and the Reality.

Exploiting this characteristic, a further new extension of the proposed Virtual-Real worlds connection will be in the context of remote collaboration. The system proposed in [6], enables users to collaborate, via mobile devices, in augmented reality collaborative forums, spatially contextualized in typical classrooms or laboratories. Virtual Words will be used to provide remote access to the collaborative forums in such a way to respect the contextualization of collaborative spaces: the remote access will be still contextualized adopting the virtual replicas of the places. The benefits will be both for the collaborative augmented spaces user, who will be free to remotely work on forums and for the Virtual Spaces, populated by (virtual) spatially localized user bots.

As a future work, we are also planning to empirically evaluate the efficacy of the proposed system in a controlled experiment and to enhance the system capabilities by exploiting and combining the classroom projector with the blackboard.

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