STEDUS, a new educational platform for Augmented Reality applications

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Abstract
Augmented Reality (AR) is a technology that has drawn the attention of educators in the recent years. The technology combines virtual worlds with the real environment, creating an immersive and interactive experience for the students and trainees. Several experimental works have shown that the use of AR for learning and training purposes provides good results. However, there is no common method or practice for using AR for learning purposes. Some years ago, the creation of AR applications was possible only by means of programming. Due to this fact, it was difficult to implement the technology in the learning environment, as programming skills were needed and creating the applications was time consuming. In the recent years, researches have realised about this problem and they have been trying to cope with it. Nowadays, as a result of research work, there are some already available authoring tools that enable educators to create their own applications. However, this process is still time consuming (and sometimes also still difficult) for the educator as the applications need to be created individually and they usually stay on the creator’s computer only. They can be reused by the educator and even by the educator’s institution, but other institutions cannot take advantage of the work. In this paper we present STEDUS, a new platform that enables schools and universities to have a common access to a growing number of AR applications for learning purposes. The applications are created on demand and offered to all subscribed customers. In this platform, the creation process is carried out by technical workers, while the educational work relies on the educators. The platform contains a common engine for Augmented Reality and enables the educators to download the available applications that they may need. Therefore, institutions from the whole World can benefit of the work that has been carried out in other places, thus creating a collaborative environment.

Key Words: STEDUS, Augmented Reality, Educational platform, Training platform, Augmented Reality on Demand (ARoD), Collaborative environment.

1. Introduction
Augmented Reality (AR) is a technology that combines Virtual Worlds with real images. Usually, a live video of a real scene is captured by a camera and is augmented using the power of Virtual Reality and other multimedia contents. This technology provides, thus, an interactive augmented environment. This approach
makes possible the visualization of any kind of educational and training content with high levels of interactivity. It is especially useful in those cases where 3D visualizations of complex structures (e.g. chemical molecules) are needed or when “invisible” behaviours (e.g. gravity forces, magnetics fields, etc.) need to be explained. Moreover, AR offers the possibility of interaction with objects that cannot be handled in real life (e.g. showing the behaviour of the whole solar system in a desktop size environment) or using virtually machines and devices that are highly expensive or unique without any risk of damage (e.g. industrial robots).

Several studies have already shown that the use of AR in educational and training environments enhance the learning process (e.g. Kaufmann and Dünser 2007, Balog et al. 2007, Billinghurst and Dünser 2012). Therefore, there is a growing interest in the use of AR for education and training purposes. However, there are still some drawbacks that prevent the general use of this technology in the field.

The creation of AR applications has been traditionally tied to programming experts who made use of several programming libraries, such as ARToolKit (Kato and Billinghurst 1999). This means that, generally, programming skills were needed for the implementation of the desired applications. Therefore, there was a gap between the educational and training experts and the AR developers, as educators were not usually familiar with programming environments and developers lacked of enough educational and pedagogical knowledge.

Researchers have realised about this problem and several authoring tools have appeared in the recent years (e.g. Haringer and Regenbrecht 2002, MacIntyre 2004, Ledermann and Schmalstieg 2005, BuildAR 2008, Martínez et al. 2011, Dünser et al. 2012). The aim of these authoring tools is to enable non-programmers to create AR applications. Although the majority of these tools are not specifically focused on educational and training purposes (some exceptions are the work presented in Martínez et al. 2011 where users are able to create their own educational applications with an intelligent virtual tutor or the work proposed in Dünser et al. 2012 that provides capabilities for the creation of augmented books), they can be used by educators to create their own educational applications.

The mentioned authoring tools have finally filled the gap, allowing educators to create personalised AR applications for the educational and training content they target. However, there are two issues that still limit the progress of AR in educational and training fields. The first issue is that although educators are able to create their own AR applications, it still requires time to get familiar to the authoring tool environment and to properly create the applications (precise positioning of virtual elements, defining interaction methods, etc.). This is not always suitable for educators, as the process may be still time consuming. The second issue is that, even if educators spend the required time for developing the AR applications, these applications stay on the educator’s computer (or in the whole workgroup network), but they cannot be used by any other institution. Due
to this fact, different institutions with same educational or training problems need
to create their own applications, which means that a double effort (or even more)
needs to be done.

This paper presents STEDUS, a new educational platform which tries to cope
with the aforementioned issues. The platform allows subscribed institutions to
access to AR applications. The applications are developed by programmers based
upon the requirements provided by educators. This means that educators can
concentrate in the pedagogical content without spending time in the development
of the applications. The great advantage is that the applications developed are
shared by institutions from the whole World, making it worth the time spent as
educators can benefit not only from the applications they have designed and
requested, but also from the applications designed and requested by other
educators.

The concept presented in this paper is similar to the concept of Video on
Demand (VoD), i.e. subscribed users are able to watch unlimited videos on
demand. Therefore, we present STEDUS as an Augmented Reality on Demand
(ARoD) platform where subscribed users can access to the AR content (i.e. AR
educational applications) on demand. The proposed platform provides an
additional advantage compared to VoD concept, which is that users are not passive
to the content creation as the content they are going to use can be directly affected
by their needs.

The rest of the paper is structured as follows: section 2 describes the STEDUS
platform and its components, providing an overview of the whole platform and the
user interaction. In section 3, the novelty of the platform and a pilot experience are
discussed. Finally, in section 4 the future steps for the platform are commented.

2. STEDUS platform

This section overviews the proposed educational platform in its current state.
STEDUS is a platform that allows the use of AR applications for education and
training and the collaboration between institutions for enhancing the applications
and thus, the learning process.

STEDUS application is the main core of the platform as it is the application
that comprises the common engine for the AR applications and handles all the
educational and training content. It is an application where users can easily
download and run the AR applications. From STEDUS, users connect seamlessly
to STEDUS server and browse for the desired content (i.e. the AR applications).
Once the right AR application has been found, the user is able to download it and
run it from the same application. The installation of the AR applications is totally
transparent to the user as there is no intervention required.

STEDUS platform contains also a website where users (e.g. institutions,
universities, training companies, etc.) can log in and request new applications.
Users can also interact between them by means of a forum where they can discuss not only about STEDUS itself but also about the learning and training content.

Fig. 1 details the use case model of the platform. The model describes visually the behaviour that has been introduced in the paragraphs above. There are four actors and four use cases. The main actor (i.e. the user) is able to install/update the AR applications (first use case) by interacting in a transparent way with the user called “STEDUS server” and also to use the AR applications (second use case). Both use cases involve the utilizing of the STEDUS application.

The other two use cases are related to STEDUS website. The main actor can interact with other users (which can be considered as a new actor in the model) and also request new AR applications. This request is handled by the actor called “STEDUS developers” who is in charge of developing the applications upon the requested requirements and updating the actor called “STEDUS server”.

The interface of STEDUS application has been designed to be simple and intuitive. The interface is made up of a panel with the list of categories and applications to allow the user to navigate through them and to select the desired AR application to be run. The same navigation behaviour has been implemented for browsing through the available AR applications on the STEDUS server.

Fig. 2 shows the activity diagram of the user interface navigation in STEDUS application following the notation of UML (OMG, 2005). As it can be seen, the navigation has been designed to be simple to use as it has been mentioned before.
Fig. 2 Activity diagram of the user interface navigation in STEDUS.

When the application is launched, the currently available categories and applications installed in the computer are displayed by means of category navigation. Once the application is selected, the application dialog appears showing the information related to the application. From this dialog, the user is able to run the application and also to open detailed instructions (these instructions are handled by the default pdf reader installed in the computer). Finally, if the user selects the “Run” button, the running of the AR application begins.

The navigation through the available AR applications contained in the STEDUS server follows the same approach. When the desired application has been selected, a similar application dialog appears showing the same information. In this case, instead of running the application, the user is able to download and install the application.

Finally, there is a third option in the activity diagram that allows users to update the applications that have been already installed in the computer.

Fig. 3 shows a screenshot of STEDUS application. In the figure, the available subcategories in the computer for the current category (i.e. mathematics) are displayed in the main panel. These categories and subcategories are generated.
when an AR application has been downloaded and installed from the STEDUS server.

![Screenshot from STEDUS application.](image)

**Fig. 3 Screenshot from STEDUS application.**

Once the user starts an AR application, a dialog showing information about the application (e.g. description and instructions) is displayed (Fig. 4). In this dialog, the user is also able to select the desired camera and the resolution. Finally, when the camera and resolution have been selected, the application starts.

![Example of AR application dialog.](image)

**Fig. 4 Example of AR application dialog.**
As it has been mentioned before, STEDUS platform comprises also a website where users can request new AR applications and also interact between them by means of forums. Fig. 5 shows a snapshot of the forums already available for members in the STEDUS website.

![STEDUS forums](image)

**Fig. 5** Snapshot of STEDUS forums.

3. Discussion

In this paper, we have presented a new platform for education and training by means of AR applications. The platform combines the pedagogical knowledge from educators and the technical skills from the developers to create AR applications with high value in terms of usability and learning content.

The platform follows the concept of Video on Demand services to provide what we have defined as Augmented Reality on Demand service. This means that subscribed users can make unlimited use of the available applications. The list of applications grows with the time with an added value: the users are responsible to define the requirements for the new applications as well as suggesting improvements to those already existing. This approach has a double advantage as users can define applications based on their needs but also take advantage of the applications that have been designed by other users as all applications are shared by all users in the platform. Moreover, the platform contains a website where users can interact directly and discuss about the learning and training content, the requirements for existing or new applications and the output they receive from the use of the applications in their own institutions.

The STEDUS application has been designed following a minimalistic approach with a clear and easy to use interface where the required user input is minimal. The goal is that the user interacts with the AR applications instead of dealing with the download and installation processes.
Currently, the platform contains only demo applications as it has been recently launched. Although they are completely functional without limits, we consider these applications as demos due to the fact that they have been developed without the help of pedagogical experts, which is the goal of this platform. These applications have been developed to show the potential of AR for education and to provide an overview of the platform functioning.

However, these demo applications currently available in the platform have been already tested with real users in a pilot experience in the Mathematics Night held in Heureka, the Finnish Science Centre (Heureka, 2012). The applications were placed in one setup prepared for the event and the experience was open to the general public. Although no formal feedback was obtained by means of traditional questionnaires due to the age of users (mainly kids), the response in terms of usability and interest from users was satisfactory. The curiosity was a key factor to draw the attention of the audience. Once they were in front of the setup, they quickly understood the functioning of the application thanks to the inherent fast learning curve of the technology that has been perceived in several studies (e.g. Damala et al. 2008, Sumadio and Rambli 2010). Although the applications were not developed by educators, a knowledge acquisition from the kids was observed as they were performing better in the successive turns of the game (e.g. kids from ages around 10 years old were able to learn and memorise prime numbers).

It was also observed that, during the whole event, a large number of participants returned to repeat the experience, showing that there is not only an interest in the learning part but also an entertainment component that engages the users. There was an additional interesting outcome from the experience: as many users were kids of very small age, the use of the application involved their parents too in order to help them to achieve the goals, creating a collaborative experience between them.

In Fig. 6, an image from the pilot experience at Heureka is displayed. In the image, two AR applications can be seen. The first one is a big screen application where users have to hide the right numbers to get the answer for a mathematics question. Each marker in the floor correlates to one number from 0 to 9. The second application is presented over a table with the use of a monitor (left part of the image). In this case, the application was a game where users had to guess or remember the distance from the Earth to the Sun. Users had two markers with the Earth and the Sun on top of them and the goal was to fix the right distance while they were seeing the behaviour of the rotational movement of the Earth around the Sun according to the distance. As it can be seen, the applications used were highly interactive which was translated in a great interest from the users from all ages.
In words of Siina Vasama, Event Producer at Heureka, the feedback from the event was also very positive, showing thus, the interest from all parts involved in the education process (i.e. educators, parents and science institutions):

At the Night of Mathematics in December 2012 at Heureka, the Finnish Science Centre, Mr. Seppo Laukkanen and Mr. Héctor Martínez from SenseTrix organized a workshop using their pilot applications. This pilot was designed especially for the Night of Mathematics and it gave children of all ages the possibility, for example, to do sums and practice with prime numbers. We had some 2000 visitors at the event, and the feedback on SenseTrix’s workshop was very positive. Children had fun and said they learned a lot. Many came back several times. In science centre terms, the workshop had both drawing in-power and holding-power. Parents clearly appreciated this new way of learning and were themselves interested in using the technology. We also had many teachers among our visitors, and we heard many of them wishing they had this kind of tools at school. People appreciated the physical aspect of the workshop, as well as the social one: they jumped around and talked a lot while counting.

Siina Vasama, Event Producer, Heureka, the Finnish Science Centre

4. Future work

The proposed platform has been already developed and deployed online (STEDUS 2013). As STEDUS is in its early stage days, the number of available
AR applications is still limited due to the fact that, up to date, the major effort has been made to develop the overall platform. The next step to follow is to develop new AR applications targeting different educational fields (e.g. physics, chemistry, natural sciences, etc.). Some demo applications (understanding “demo” as fully functional applications developed without the advice of pedagogical experts) will be developed in short term and fully pedagogical-based AR applications will be developed upon the requirements of the first subscribed institutions.

Besides the development of new AR applications, the goal is to introduce the use of physical objects that will be augmented to enhance the learning process. Some examples may be the use of different boxes and blocks to explain the forces involved in objects moving through different slopes, where virtual arrows would be augmenting the physical blocks, or the use of test tubes showing the 3D molecules of their content and/or the reactions when mixing them by means of augmenting the molecules over the tubes. The goal of this approach is to improve the interactivity of the process showing behaviours and concepts that cannot be seen in real life (e.g. the forces between objects or the molecules of substances) combined with the physical elements related to these behaviours and concepts.

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