

Collaborative e-Learning framework for creating AR mobile educational activities

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Abstract. This paper introduces an Augmented Reality based framework for e-learning platforms that allows the creation of collaborative courses and activities for mobile devices. The easy-to-use authoring tool is Web3D based and can be integrated with e-learning platforms as another activity. The Augmented Reality content is added to the scenes and a state-machine is built by setting events that trigger a change of scene. The students can download any activity with a mobile device and play it in a multiplayer collaborative mode. The presented framework solves the problem of standard integration of Augmented Reality applications in education offering an authoring tool as a module of e-learning platforms.

Keywords: Multimodal Platform, User Interaction, Augmented Reality, Collaborative Learning

1 Introduction

The use of new technologies is rising and its alignment with knowledge is setting a new reality in which the connectivity, interactions and the visualization of all the activities are not centralized, but distributed, collaborative and interactive. From the educational point of view, it is very important to improve the educational process taking advantage of science, new technologies and resources that can enhance learning. In that way, nowadays, the use of IT tools to support education is a reality which is optimizing the teaching and learning process.

On the one hand, the use of e-Learning in higher educational environments is a good example of the use of IT tools to improve educational processes. In addition, according to [3] e-learning has to move beyond platforms such as Learning Management Systems (LMS) to get students to do collaborative activities using actively the IT resources.

On the other hand, IT tools such as Augmented Reality (AR) could bring benefits to teaching-learning processes, by means of an intuitive way for interaction and collaboration between real and virtual objects. Such an approach is not possible for instance, adopting Virtual Reality techniques, where a complete simulated world is deployed and interaction between real and virtual objects does not exist [6].

In this context, the main goal of the system presented in this paper is to integrate both AR and LMS technologies to create a powerful collaborative educational system, i.e the main goal is to develop a set of computer tools focused on collaborative and interactive learning through AR contents. With this purpose, an authoring tool integrated in a collaborative LMS platform has been developed, which allows non-expert users to create AR applications according to their needs or desires. The application generated by the authoring tool and located in the LMS can be run by students in an interactive way on mobile devices, with learning purposes.

As an example, consider that the natural science teacher generates an AR application using the authoring-tool located in the LMS and relating in this manner it with the subject. The generated application can be a serious-game in which a 3D model of the Earth is shown along with other labels and models and where the AR scenario is going to change depending on the interaction between student-user and the current AR state.

In order to achieve this, the main contributions of this paper are:

1. The **authoring tool** which allows non-expert user to generate a whole AR application easily.
2. The **integration** of the authoring tool **in LMS**.
3. A **distributed AR engine** that allows to create applications whose architecture is based on The Cloud.
4. **Collaborative applications** with a learning purpose.

2 Related Work

AR technologies have been quickly developed in recent years and many robust real-time applications are currently available for mobile devices. As a consequence, the use of AR has received a lot of attention in education. Nowadays most students have access to smart phones making it possible to learn through 3D interactive content, which complements the standard learning material. There is no doubt on the potential of AR content for improving motivation and learning as showed in studies like [11], but the lack of standards drags out the integration in educational environments.

Currently, AR based educational systems still don't offer a standard solution that gathers all the functionalities previously mentioned in the Introduction. One of the first approaches to an educational platform with AR was presented by Liarakapis et al. [8]. They took advantage of the first versions of Web3D technologies to introduce a web-based editor for creating 3D content and a viewer for educational purposes. Although the idea was innovative the installation of specific plug-ins was required and it was intended for a tabletop environment.

Some works use AR for a particular educational application. For example Ming-Jen Wang et al. [12] propose a simple interface for examination applications that allows user interaction with the finger. This approach limits the user to say yes or no, and still no standards are applied for integration with LMS. Also

the system in [5] uses an authoring tool to develop AR applications for industrial sequential procedures. Despite the sequential application is a considerable improvement it is required to use specific hardware and software.

Kose et al. [7] present an AR based mobile software that provides 3D and multimedia E-learning material for complementing books or other educational support. Markers embedded on books or other supports can be used to launch the AR tracking for enriching the education content. Although this work proposes an integration with LMS tools it is quite limited as there is no general authoring tool for creating the content.

An improvement was made in the work in [2] by presenting a Web3D based authoring tool for designing an AR scene using a textured marker and a reference image of the real world. Once the scene is created the application is available to download in a mobile device that will render the scene as designed in the authoring tool. The strong point is that standard web technologies are used but still this is limited to a single scene and no integration with educational platforms is presented.

We propose a framework integrated with LMS that provides an embedded Web3D authoring tool for creating sequential AR applications for mobile devices. The applications are presented as activities in LMS courses so they can be remotely downloaded by the student at any time. An XML file encodes the sequence of scenes that the mobile application uses to launch the selected activity.

3 System Architecture

The AR framework consists of four principal modules that make it possible to create, distribute and execute a mobile application and finally, to integrate it with LMS. The architecture of the main modules is shown in Fig. 1a and can be described as follows:

- Creation module: It is a Web3D authoring tool that allows the creation of an AR activity. A non-expert user can create an AR application by setting sequences of scenes and events.
- Distribution module: A server on The Cloud stores the multimedia content, the applications, an AR engine and the different user's data. This way the created content and applications are available to download remotely.
- Execution module: The mobile application is able to select and download any activity created with the authoring tool. Once the content is downloaded the mobile application starts tracking texture markers and renders the corresponding scenes.
- Integration module: To facilitate the use of the platform in the educational environment we implemented a gateway for integrating the Authoring Tool with LMS. The applications created are shown as activities in LMS courses.

In the next paragraphs the different modules of the framework are explained in detail.

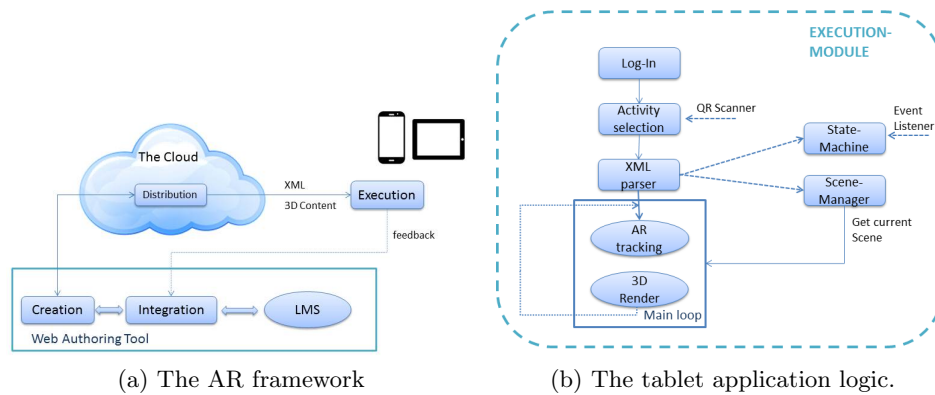


Fig. 1: The Creation Module schema and the Execution Module schema.

Creation Module

The module for creating AR educational applications is a Web3D based Authoring Tool. The web interface consists of a state-machine editor, a scene editor and an action and event editor. See Fig. 2.

Going back to the previously mentioned example, the AR application should do the following: when a specific textured image is captured by the camera in the mobile device a 3D model of The Earth must appear augmented in the scene. Some questions about The Earth's layers will be asked to the student, who must answer by clicking with the finger in the right area of the model rendered. If the answer is correct the application will change to the next AR scenario. The state-machine editor represents this whole AR scenario using a flowchart. The teacher can build the flowchart by placing boxes and arrows in the graphic interface. Each box is a state and the arrows represent the conditions for passing from one state to another. The teacher may select a box to configure the scene associated, which is done in the scene editor.

The scene editor allows to configure an augmented scene. The user must select a textured marker image and a picture of the real world in which that textured marker appears. The pair of images is sent to the remote AR engine, which returns the 3D camera position. This position is used to overlay the augmented content on the picture. The user can rotate, translate and scale any object.

The multimedia objects available can be images, videos or 3D models. After an object is placed in the scene the action editor will show a list of actions for that object, like "show", "launch animation" or "hide".

The event editor is enabled when the user selects an arrow on the state-machine editor. The event editor shows the list of objects in the source scene and the available events for each object: "click", "end animation", "timer". At least one event must be selected for any of the objects. If more than one event is selected both will trigger a change of scene. For example, a change of scene may be triggered by either clicking on a 3D model or when an animation finishes.

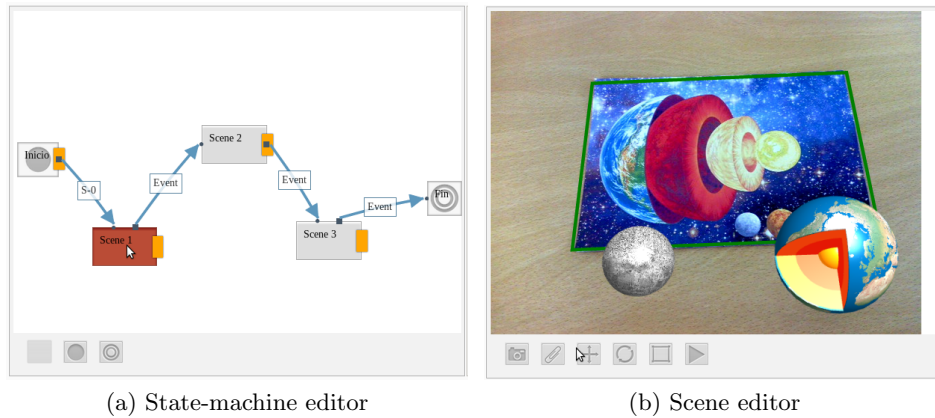


Fig. 2: The AR Web3D authoring tool

Once the activity is finished it may be saved and exported as an XML file. The document encodes the state-machine, the URL for the multimedia content and the position matrix for every element at each scene. The XML file is stored in The Cloud so any student can download it remotely.

Distribution Module

The functionalities of this module are to separate the AR processing from the authoring tool, to store the multimedia content and applications and to manage students' interactions and feedback. A server on The Cloud controls all these tasks.

In order to augment extra information in the environment the position and orientation of the mobile device must be calculated in real-time. Mobile devices already offer position and orientation information, using some internal sensors such as GPS, compass and accelerometers. But the position obtained using those sensors is not accurate enough to insert 3D virtual elements in the real scene. However, using vision-based algorithms and the camera of the mobile device is sufficient to calculate the localization of the device accurately.

The AR engine developed in this paper implements vision-based algorithms that use a previously known marker to locate the device. The marker is a specific image chosen by the user through the authoring-tool, and must be trained previously. When the AR application is running, using the camera of the device, the marker can be recognized in the environment and consequently the localization of the device can be calculated easily and faster.

For this reason the AR engine is distributed between The Cloud, where the training process is done, and the mobile device, where the tracking process is done real-time using the camera.

The AR engine trainer is listening for the Creation Module's petitions. When a pair of images marker-scene is sent to the AR engine, the detection and training

process is launched. The characteristic points of the marker, named *KeyPoints* must be detected. In this case, the features are detected using a corner detector algorithm named FAST [10]. When the *KeyPoints* are detected, are saved with the position in the image, and their descriptors. Descriptors are vectors that encode the description of each point. In this case the descriptors used are FREAK [1] owing to the agility to process them.

When the AR application is launched in a mobile device, a tracking process is launched locally. The main goal of this process is to recognize the marker in the environment and calculate the position of the device.

The Cloud module also stores the applications created, which are encoded as an XML file. The document encodes data from each scene, actions, events, and the 3D position of multimedia content, the URLs of downloadable content and the course associated in the LMS.

The server also has functionality for collaborative activities. Several students can run an activity in their own devices remotely, in a similar way a multiplayer game is played. The server controls a unique state-machine and event handler for all the students and shares it via TCP connection. When a device reports an event, the server checks it is valid for a change of state and propagates the new state to the rest of devices. All the students will see synchronized scenes at their respective devices.

Execution Module

It is necessary to install a mobile application to play the created activities. The goal of the application is to be as general as possible so it can cope with any kind of activity. To achieve this, the application implements a XML parser, a state-machine interpreter and a scene manager. (Fig. 1b).

At the beginning a log-in screen verifies the user credentials against the LMS. Next there is a screen for selecting the desired activity. This is done by scanning a QR from the course web page, which encodes the URL of the XML file. Also the user can invite other logged users to play the activity in a collaborative way.

Once the activity is launched the mobile downloads the XML file from The Cloud, as well as the multimedia content. The application creates the state-machine and the scene manager and starts detecting markers in the scene.

The scene manager renders scenes associated to the current state. When a texture marker is detected in the real world, the current scene is rendered until a trigger event occurs. The multimedia content is displayed according to the actions set by the teacher for the scene.

In the tracking process the features of the image must be detected using FAST [10] and FREAK [1]. Then the *KeyPoints* of the training image and the camera image are compared, calculating the Hamming distance between descriptors. It is considered that a pair of *KeyPoints* are the same point in the both images (training and current) if the distance between them is the smallest. Once the match between all the *KeyPoints* is done, and the position of the points in both images are known, it is possible to extract the 3D pose of the camera using a homography calculation [4].

Integration Module

The potential of this platform for educational purposes is in part thanks to the integration of the authoring tool in LMS. The AR activities are a resource of the LMS, just like the Quiz in moodle or like embedding a video from youtube. This allows editing them and receiving feedback from the students when they play an activity.

The teacher can add a resource to a course, which in this case will be an AR activity. The editing page will show an embedded authoring tool. The activity created will encode the name of the course and activity as well as the name of the teacher and an unique ID. In order to facilitate the student's experience, activities are represented by a QR code embedded in the course. The student can access to the course view at any moment and download the activity just by facing the QR with the tablet.

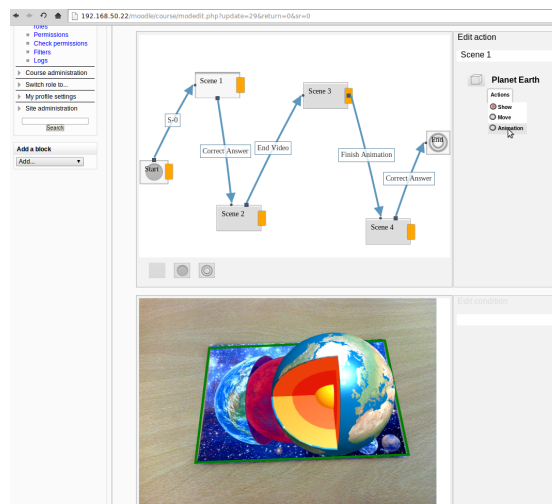


Fig. 3: Authoring tool integrated with moodle.

Also feedback from the activity is sent back to the LMS so the teacher may want to evaluate the results.

4 Integration with Moodle

In this section the particular case of integration with Moodle is explained, as it is a LMS that is currently used in many universities and schools.

Integration with Moodle just requires the installation of the AR module. Moodle is designed to detect new modules automatically so the installation process is trivial. This module provides a new resource that can be added to courses by the teacher.

If a teacher selects the AR module and goes to the editing window an embedded Web3D authoring tool will appear. Once the activity is created and saved a QR code is attached to the course, just visible for the students. As any other Moodle's resource, the AR module has information of user's privileges and credentials and is able to retrieve qualifications.

5 Conclusions and Future Work

We have presented a framework for creating, distributing and executing AR collaborative activities that completely integrates with LMS. The activities can be easily designed by a non-expert teacher just by browsing the LMS course web page. Multimedia content can be added and used again and activities can be stored and re-edited later.

Students can play the activities remotely since they have got a smart phone with internet connection. All the technologies are standard and multiplatform so the integration with the educational environment is as simple as possible.

Currently the AR framework is able to design augmented scenes based on the desired texture marker. A less intrusive approach would be the tracking of any 3D textured object instead of the restriction to a 2D texture marker.

Also a 3D reconstruction module would allow the handling of occlusions between virtual and real objects, which will become a substantial improvement in practical tutorials with machinery, for example.

Although our approach covers the main aspects required for a teaching AR framework (as exposed in [9]), it still lacks of geolocation awareness. While for an activity based on a texture marker this is not relevant it would be interesting for outdoor tutorials or courses where the student position is required for triggering a state.

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