Building Augmented Reality Presentations
with Web 2.0 Tools

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Abstract. Augmented reality enables superimposing various kinds of computer generated content, such as interactive 2D and 3D multimedia objects, in real time, directly on a view of real objects. One of the application domains, which can particularly benefit from the use of AR techniques, is education. However, to enable widespread use of AR in education, simple and intuitive methods of preparation of learning content are required. In this paper, we propose an easy-to-use method of augmenting printed books with arbitrary multimedia content. A popular Moodle-based educational platform has been extended with a plugin enabling creation of AR presentations. In addition, an associated mobile application is provided, which helps teachers assign the presentations to book pages and enables students to access the content.

Keywords: Augmented Reality, AR Learning, E-Learning, Web 2.0, Moodle

1   Introduction

Augmented reality (AR) technology enables superimposing various kinds of computer generated content, such as interactive 2D and 3D multimedia objects, in real time, directly on a view of real objects. Widespread use of the AR technology has been enabled in the recent years by the remarkable progress in consumer-level hardware performance, in particular, in the computational and graphical performance of mobile devices and quickly growing bandwidth of mobile networks. Entertainment, e-commerce and tourism are examples of application domains in which AR-based systems become increasingly used.

One of the application domains, which can particularly benefit from the use of AR techniques, is education. AR can provide entirely new, intuitive methods of presentation of learning content. Learning content in the form of interactive, animated, three-dimensional virtual scenes, which – in addition – can be presented directly in the context of a real environment, can significantly improve students' comprehension and involvement [1]. The main problem, however, is that AR presentations are relatively difficult to create in comparison to typical learning content widely used in classrooms. As a consequence, pre-designed, ready-to-use AR presentations dominate in this domain. This significantly limits their utility in the learning process.

In this paper, we propose a solution to this problem by providing an easy-to-use method of augmenting printed books with arbitrary multimedia content. A popular Moodle-based learning platform has been extended with a plugin enabling creation of AR presentations. Also, a custom mobile application is provided, which helps teachers to assign the presentations to book pages and enables students to access them.

The remainder of this paper is organized as follows. Section 2 provides an overview of the state of the art in the domain of AR-augmented books. In Section 3, requirements for effective use of AR techniques in the learning process are discussed and the AR Web 2.0 learning system is introduced. In Sections 4 and 5, the two main components of the system are presented: the AR Web 2.0 Platform and the Mobile AR Learning Application. Section 6 concludes the paper and indicates directions of future works.

2 State of the Art

The augmented reality technology enables presentation of learning content in the form of computer-generated virtual objects appearing directly in the context of real objects [2]. Recent research indicates that AR may significantly increase students' motivation for learning [1][3,4]. Also, a few studies reported on a positive influence of the use of AR techniques on the cognitive attainment of learners in different domains [5,6,7,8,9].

One of the possible applications of AR in education is the creation of augmented reality books – AR books – which are paper books augmented with computer-generated content. AR books provide physical means of operation, which enables users to leverage their prior experience from the real world for natural and intuitive interaction with the electronic content [10].

Until recently, AR books relied on fiducial markers printed on their pages to control the position of virtual objects. Typically, such markers have the form of a black square frame surrounding a special pattern enabling its identification. An AR book is captured with a camera and the captured video is augmented with overlaid virtual objects aligned with the markers. The most recognized software library for tracking fiducial markers is ARToolKit [11].

The approach to book augmentation based on pre-printed fiducial markers causes a number of disadvantages:

- markers must be placed on pages in advance – during the publishing process, which restricts the set of books that can be augmented only to new titles;
- the set of pages with markers cannot be modified, which excludes from augmentation the pages which have not been intended for augmentation during the publishing process;
- markers themselves do not provide significant learning value, so they take up valuable space on book pages;
- artificial markers in a book can be unacceptable for aesthetic reasons.

Nowadays, the problems with explicit markers have been mitigated with the advent of software libraries for tracking real objects based on their natural features. The most common software packages which enable tracking 2D images based on their inherent characteristics are: Vuforia [12], Layar [13], Metaio [14], and D'Fusion [15]. These solutions can be applied to tracking 2D images presented on any plane in a real environment; in particular they can be used for tracking book pages (or fragments of book pages). These software libraries open up new opportunities for the book augmentation. It is no longer necessary to include additional artificial markers in books, since the book pages may act as markers themselves. In this way, it becomes possible to enrich both new and already published books with additional multimedia content.

However, not every page is suitable for tracking to the same extent. For example, it is difficult to recognize and track pages that contain mostly text written in small print. Due to limitations of contemporary cameras, it is difficult to detect differences and distinguish between such pages. On the contrary, richly illustrated pages are more suited for tracking, particularly, if they contain pictures with high-contrast geometric areas. Nowadays, most of the textbooks for primary and secondary schools contain many illustrations, so they are well suited to be enriched with additional content.

Another advantage of solutions based on the natural feature-based tracking is that the pictures on book pages may be semantically related to the overlaid synthetic content. For example, a picture showing a chemical molecule can be used as a marker to display 3D model of the molecule. In this way, learners may receive consistent learning material, which comprises the content of traditional textbooks and related multimedia content. Such content may provide valuable add-on material – 3D model of a molecule is much easier to understand than a drawing, movie may better represent dynamic objects than an image, sound accompanying a book may significantly enrich learning experiences (esp. in the case of learning foreign languages), etc.

A number of studies on AR books have been undertaken in the past. The forerunner of AR books based on fiducial markers was MagicBook [16]. Books designed using the MagicBook concept were normal books with text and pictures on each page. However, some pictures surrounded with thick, black borders were used as fiducial markers for positioning add-on content attached to the book pages. An extended version of the MagicBook metaphor for learning cultural heritage was proposed in [17]. In this solution, users could not only browse virtual objects representing cultural artefacts by turning pages of the book, but could also take actions on the content using dedicated interaction markers attached to the side of the book. The MagicBook concept has been applied in the educational context in the AR-Jam project [10] for early literacy education and in GEN-1 book for learning construction engineering [18].

A novel type of AR books, called mixed reality books, has been introduced in [19]. The motivation of this study was the observation that considering an AR book as a physical container for markers demonstrated lower learning effectiveness of the book. Therefore, the main intention of the mixed reality book was to provide users with a less disruptive reading experience with a book without fiducial markers. The authors presented an AR version of an existing book entitled The House That Jack Built.

Another example of an AR book that does not contain fiducial markers is The Thirsty Crow. This is an interactive AR book for preschool children aimed at learning

numbers using old folklore literature [20]. Users can view virtual objects on a mobile device using a mobile application. The same approach was applied by Carlton Books Ltd. which published a series of books entitled An Augmented Reality Book [21].

The main limitation of the above solutions is that the additional multimedia material accompanying a book is limited to the content designed by the creators of a given book or a specific AR application. Teachers are not able to modify the content based on the learning context, for example, in order to adapt the content to diverse cognitive abilities of different student groups.

3   Web 2.0 AR Learning System

Efficient use of AR techniques to support learning process requires meeting the following requirements:

- It should be possible to augment arbitrary visual markers, e.g., book pages or selected images or drawings, also in books already published;
- Creation of AR presentations should be as easy as possible, so that teachers without advanced technical skills could perform this task. Ideally, creation of AR presentations should be performed in the same way as creation of other types of educational content;
- It should be possible to use different kinds of content as the additional learning material – including 3D models, animations, images, sounds and video sequences;
- The AR content should be easily accessible, in various contexts, without the need of specific hardware;
- The solution should not impose additional costs – neither on the schools, nor on the teachers, nor on the students.

To meet the above-listed requirements, the AR Web 2.0 learning system has been designed. The system consist of two components: AR Web 2.0 Platform, which is a learning content management system with the support for AR content and Mobile AR Learning Application, which enables easy access to the AR content on mobile devices. The two components are described in the following sections.

4   The AR Web 2.0 Platform

In [22], a Moodle-based [23] educational platform has been proposed that provides an easy-to-use and secure environment designed to facilitate employment of various Web 2.0 tools, such as blogs, social bookmarking, e-portfolios, wikis, friend IMs and video embedding, by educationalists. The platform provides distributed communities of teachers with a secure system designed for decentralized creation and sharing of learning content.

To enable efficient use of AR content in the learning process, the abovementioned platform has been extended with an additional, custom-designed plugin *AR Marker&Content*, presented in Figures 1 and 2. The plugin permits adding, removing and

modifying AR markers and multimedia content, which should constitute an AR scene. The AR markers are freely selected 2D images, which can represent parts of real book pages or covers – there is no need for specific markers, such as QR-codes. The Vuforia third-party software library is used to recognize and track the markers within the scene [12]. In turn, multimedia content that can appear within the AR scene can be 2D images, 3D images, video sequences, sound sequences, text or embedded web pages. To enable free composition of AR scenes from arbitrary multimedia content, various scene templates encoded in the CARL (Contextual Augmented Reality Language) language are used [24, 25].

The plugin can be used in two modes: the activity mode and the block mode. The activity mode allows *AR marker–AR content* pairs to be created and placed in the context of a given course section. In Figure 1, it is illustrated, how the AR Marker&Content plugin can be used to add an AR activity within a course available on the AR Web 2.0 Platform. The process of creating an *AR marker–AR content* pair requires uploading an image file representing the AR marker, i.e., a digital image of the paper book page or cover, and some multimedia content to be presented on the marker, e.g., a 3D model representing a chemical molecule to be shown on the book page.
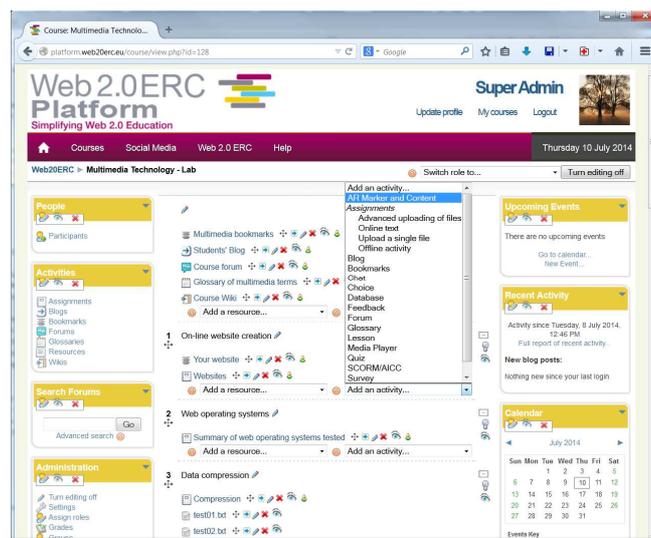

Fig. 1. Adding a new AR Marker&Content plugin instance in the activity mode
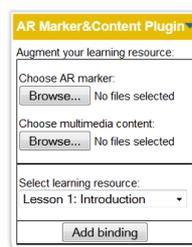

Fig. 2. AR Marker&Content plugin in the block mode

In the block mode presented in Figure 2, the proposed plugin allows *AR marker–AR content* pairs to be bound with the Web 2.0 learning resources already created within the course. For instance, an AR marker can be associated with video content in the context of a wiki-related augmented learning scene, while – at the same time – the marker can be associated with sound sequences in the context of a blog-related augmented learning scene. Also, with this approach, large multimedia objects can be uploaded once and effectively reused with different markers or different Web 2.0 resources.

The initialization of an augmented learning scene on a mobile device can be performed in two ways: either by browsing the learning content and clicking on the link representing an AR resource or by selecting an AR resource from the list of available AR resources provided by the server through Web Services. Based on the available set of AR scene templates designed for presentation of different types of multimedia content, the plugin creates XML-based specification of a particular AR scene in the CARL language. The CARL specification of an AR scene contains descriptions of the markers to be tracked, the content to be shown, and the interface used for manipulation and control of the AR scene.

The CARL specification is then used by the Mobile AR Learning Application as the input. An example of a trackable marker specification in CARL is presented in List. 1. The *Trackables* object is used to specify the binary representations of AR markers that can be detected and tracked within the 3D space by the mobile application. Moreover, it indicates which object will be used as augmentation content (initialized in the Begin section).

List. 1. CARL – specification of a trackable marker and an associated content object

```
<Trackables uri="http://platform.web20erc.eu/t/covChem.dat">
  <Trackable id="chemistry">
    <Begin>
      <ObjectBegin id="moleculeID"/>
    </Begin>
  </Trackable>…
```

In turn, List. 2 shows an example of multimedia content description generated by the plugin. It provides a location of the multimedia content (in this case a 3D model representing a chemical molecule) indicated by a URI address and actions that can be executed on this object by the mobile application. There is only one default action declared, named *init*, which is responsible for setting the position, scale and orientation of the object in a 3D space. The action also activates the multimedia content and sets its state.

List. 2. CARL specification of a content object to be presented on a marker

```
<ContentObjects>
  <ContentObject id="moleculeID" initState="hidden">
    <Resources>
```

```
    <Component id="molecule">
      <Location detail="med" uri="http://web20erc.eu/mol"/>
    </Component>
  </Resources>
  <Actions>
    <Action name="init" state="hidden">
      <SetPosition comp="molecule" x="0" y="0" z="0"/>
      <SetScale comp="molecule" scale="5"/>
      <SetOrientation comp="molecule" axis="x" angle="0"/>
      <Activate comp="molecule" active="true"/>
      <ObjectState value="shown"/>
    </Action>
  </Actions>
  <ContentObject>
<ContentObjects>
```

5   Mobile AR Learning Application

The Mobile AR Learning Application has been designed to enable convenient access of students to the AR learning material and to support teachers in the process of creating AR resources. To run the application, a mobile device equipped with a camera and the Android operating system is required. The application can be configured to work with a particular AR Web 2.0 Platform server – eliminating the need of manual insertion of connection details.

Students may access the AR content within the Mobile AR Learning Application in two ways:

- by retrieving all the AR content for a course, or
- by accessing a single AR activity during a course.

In the first case, when a student logs-in to the platform, he/she selects a desired course from the list of available courses. The application then retrieves CARL specifications of all the available AR activities. The CARL specifications contain both the descriptions of visual markers to track and the AR content to present on the markers. When a student points his/her mobile device towards a concrete book page or illustration, the AR activity assigned to the currently visible visual pattern appears on the screen of the mobile device.

In the latter case, while following a particular topic and browsing the related course on-line with all its resources and activities, a student can select the *AR Marker&Content* activity on a particular topic and then can point the camera of a mobile device towards a designated page in the book. The Mobile AR Learning Application retrieves CARL specification of the AR activity to be used by the student and starts presentation of the AR content. This approach may be connected with game-like scenarios, where a student has to find appropriate content in a book, e.g., performing a kind of a quiz.
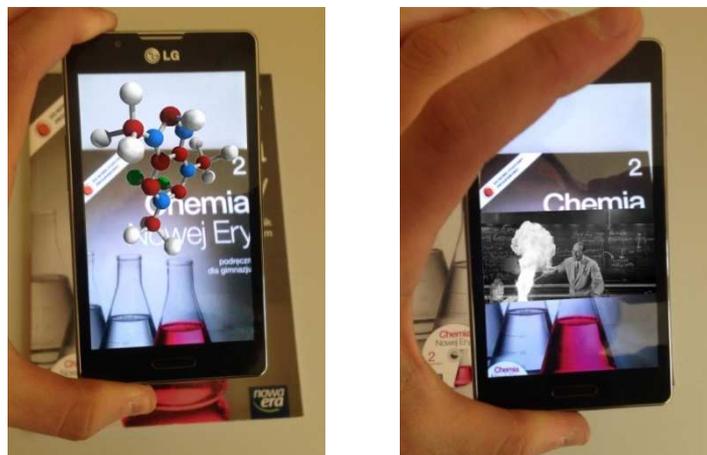
Fig. 3. Augmenting a chemistry book with a 3D model (left) and a video (right)

After activation of an AR activity, a student can interact with the presented multimedia content using gestures such as pinch or pan to scale or rotate a 3D object or tap to start playing a video sequence. Figure 3 (left) shows augmentation of a chemistry book with an interactive 3D model of a molecule. Another example is shown in Figure 3 (right), where instructional video is presented on the book cover.

AR presentations may be configured directly within the Mobile AR Learning Application, in the teacher mode. A teacher makes a photo that will be used as an AR marker – an image of the book cover or a book page, part of the page, etc. Then, using the application, the teacher connects to the AR Web 2.0 Platform, selects a course and a topic and creates a new *AR Content&Marker* resource. The platform uses an AR marker service (e.g., Vuforia) to convert the image into an AR marker binary file, which can be later directly used during the tracking process. Then, the teacher may attach the AR content to the marker. The content may be selected from the list of multimedia files available on the mobile device used by the teacher. If the teacher does not have access to the content (e.g., the content is stored on a computer), the application attaches the original image that may be later replaced using the edit mode on the AR Web 2.0 Platform.

6 Conclusions and Future Works

Nowadays, mobile devices, such as smartphones and tablets, are powerful and widely available to both adults and children. It is important to exploit the potential of these devices beyond typical web browsing, social networking and gaming – which constitute vast majority of their usage. AR learning applications provide a good opportunity to benefit from the advanced technical capabilities offered by available mobile devices, to make the process of learning more effective and appealing.

The system presented in this paper, which extends the popular learning platform Moodle and couples it with a mobile AR application, makes the creation of AR con-

tent almost as simple as the creation of other types of learning content. Therefore, teachers without advanced technical skills are able to perform this task, so their students may benefit from the AR technology. Using the AR Web 2.0 learning system, teachers sharing a common course on a server may jointly prepare AR content for their students. Moreover, as the plugin follows security policy of the platform, a teacher may precisely specify which users can access the AR plugin functionality in which mode (e.g., editing or non-editing students or teachers).

Students can access the AR activities using available mobile devices – either in the classroom or at home. AR provides an intuitive and convenient interface to access various types of interactive multimedia content. Moreover, since the content is associated with printed books that the students are familiar with, the content is well organized and easy to access – being always at hand.

For the proof-of-concept implementation, the Android OS has been selected, as it is currently the most popular mobile operating system. However, other mobile platforms, such as iOS and Windows Mobile, could also be supported.

There are several directions for future works. First, support for other types of mobile devices should be provided to enable the use of the system by a vast majority of teachers and students. Second, a classroom evaluation of the system should be performed to verify students' and teachers' acceptance of the system and educational value of this kind of additional learning content. Third, possibilities of gamification of the AR activities should be explored to further increase students' motivation – through the use of engaging scenarios – performed by students both separately and in groups.

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