A Novel Authoring Tool for Augmented Books

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Abstract. Augmented Reality (AR) has been studied from different application fields since the early 60s. Different research works in the educational field have been recently conducted, particularly based on a versatile AR application called Augmented Book. This paper focuses on a novel authoring tool for this kind of books. Our approach allows the possibility of adding virtual contents to any existing printed book. The application was implemented following a framework-based approach, making easy to extend with new features. Informal evaluations and observations by academics of different fields were conducted obtaining promising results.

Keywords: Augmented Book, Augmented Reality, Authoring Tool, Computer Graphics

1 Introduction

It has been more than fifty years since researchers addressed Augmented Reality (AR). Sutherland research work [18] is considered as one of the first contributions on this field. He introduced what he called the *"ultimate display"*, however, due to technological limitations these features was mostly not adopted. In fact, both widely accepted definitions of AR were introduced in 1994 and 1997, by Milgram & Kishino [16] and Azuma [5] respectively.

The first definition introduces the *Reality-Virtuality Continuum*. As it is shown in Fig.1, it consists of a combination of real and virtual elements. It has at one end of the spectrum the Real Environment, representing our real world. At the other end of the spectrum is situated the Virtual Reality, representing a pure virtual world. The middle region of this continuum is considered the Mixed Reality, which combines both worlds. The AR is closer to the Real Environment (i.e. real world elements are predominant over the virtual elements) in contrast to the Augmented Virtuality which is closer to the pure virtual world. On the other hand, Azuma's definition has been adopted by the research community as

the basic principle for an AR application. This definition states that AR applications have to meet three basic requirements, namely: (i) a combination of real and virtual worlds; (ii) real-time interaction; and (iii) three-dimensional objects visualization superimposed onto the real environment.

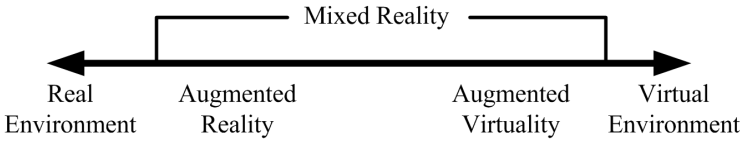


Fig. 1. Reality-Virtuality Continuum.

Based on these definitions, researchers have introduced contributions to different fields, such as medical sciences [7], training [20], games [17] and education [14] among many others. In particular, in the area of education there has been growing interest in AR technology in recent years due to its great potential [12]. AR environments allow students to interact with both the real and the virtual world, exploring objects, learning concepts, developing skills and carrying out collaborative activities. These aspects motivated the incorporation of different types of AR learning environments for regular classroom practices [8].

An AR application with promising capabilities for educational purposes has been expanded lately, named as *MagicBook* by Billinghurst et al [6]. More recently, this type of application is also known as *Augmented Books*. It uses normal printed books with AR fiducials (i.e. special markers that can be recognized by a computer software) as the main interface objects. People can turn pages of the book, look at the pictures and read the text like they used to. However, if they look at the pages through an AR display (e.g. computer screen) they would be able to appreciate virtual contents appearing over the pages. Thereby, augmented books give new alternatives to enhance traditional books with interactive visualizations, animations, 3D models and/or audio, and open up a whole new range of possibilities to merge real and virtual experience.

Many researchers and companies [3, 21] explored AR book experiences, adding new ways of interactions [9, 12] or introducing collaborative tasks [15]. However, in general these approaches consist on books conceived as augmented books from scratch. We propose a new approach for adding AR capabilities to traditional books without having to generate them from scratch. Thus we can enrich pre-existing books embedding different kinds of virtual content. In addition to this approach, we have implemented our authoring tool using a framework-based approach in order to facilitate the incorporation of new features to it (i.e. new interactions and/or new types of augmented contents).

The rest of this paper is structured as follows. Section 2 provides the related work concerning to *augmented books*. In Section 3 details of the approach are presented. In Section 4, the application architecture and details of the implementation are provided. Section 5 presents the discussion of the proposed ap-

proach based on the results from informal evaluation and observations and also we outline research lines for future work. Finally, the conclusion is presented in Section 6.

2 Related Work

Several research works explored various alternatives for augmented books in different areas such as chemistry [4], science [22] or cultural heritage [19] among others. More recently, this simple approach has been proved to be effective, for example for spatial skills development [14] or learning geometric shapes [12].

Despite this relatively large amount of research, many of them were developed for a specific pre-defined domain aiming to a specific target people using augmented books created from scratch. Other researchers proposed authoring tools for the creation of augmented books [10, 11]. Besides these approaches allow people with less technical knowledge to create these kind of books, the created books are conceived as augmented books from the beginning. Other authoring tools have been developed [1, 2, 13], however these approaches are too general and lack of specific features for books (e.g. interactions or contents designed for enhancing reading experience).

As we described, despite the great potential of augmented books, there has been a great limitation with authoring tools that do not consider pre-existent books. Our work tries to overcome this constraint, making the contribution of a novel approach to add the capabilities of augmented books to any traditional book.

3 Authoring Tool for Augmented Books

We present a novel tool for enhance pre-existent books with AR content. The main idea of our work is the traditional books' enrichment by means of the AR, not only showing augmented information on them but also giving the facilities to users (or readers, used indistinctly throughout this manuscript) to incorporate augmented contents to traditional books.

As in common AR systems, this tool is aimed to desktop computers with a camera device. The camera is the input sensor of the real world, and the computer display acts as a window to the augmented world, showing augmentations superimposed on the frames captured by the camera. We considered the use of at least one marker in the surrounding of the book in order to incorporate virtual contents over it. The next subsections describe the design of an augmented book and the usage concept of the proposed approach.

3.1 Book Model

We designed the augmented book as a composition of two concepts: a digital representation of the book itself and its digital contents. The digital representation

of the physical book consists of descriptive attributes, such as the title, authors, cover page, a brief description of the book and its ISBN code. In addition to these attributes, the augmented book can be populated with several augmented contents in a structured fashion.

The augmented book is conformed by containers which are associated to a specific page of the physical book and can be used to separate content thematically. These containers can be attached with different virtual contents. Thus, these elements represent a logical container for the digital contents of the book. Several virtual contents can be added to the augmented book, such as text, web-links, images, 3D-models and sounds. These containers as well as the digital contents are created by the readers. Figure 2 shows an example of the structure of an augmented book.

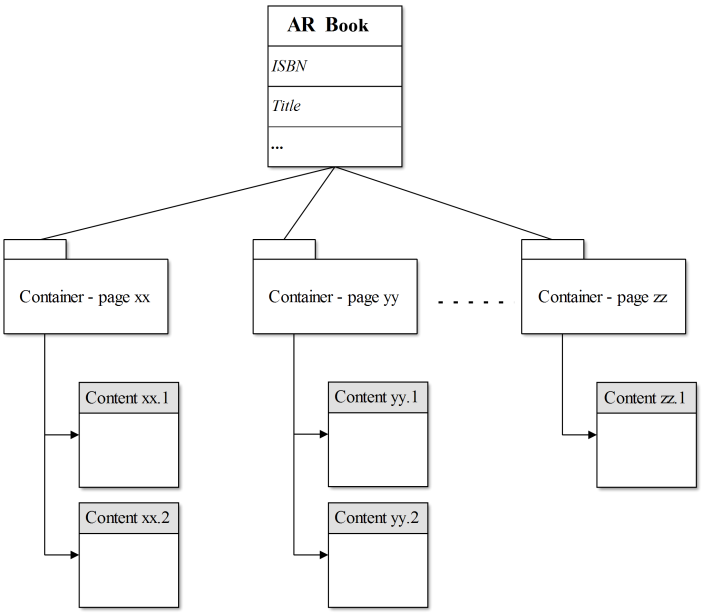
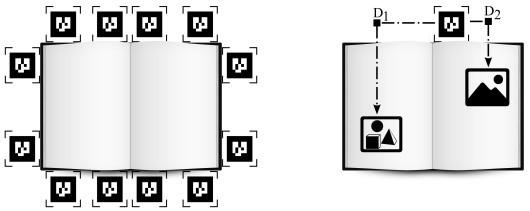


Fig. 2. An example of an augmented book structure.

The main attraction of digital contents is the possibility of being associated with two important features: *renderable objects* and *trackable objects*. The *renderable objects* allow the digital content to be displayed by the Render Engine of the authoring tool viewer, which in turn can be textured images or 3D-models.

The *trackable objects* are the main elements which enable AR. They consist of markers, that are interpreted by the AR Module to obtain its pose (i.e. position and orientation). With this information it is possible to assign a 3D transformation to a *renderable object* obtaining a correct registration in the rendering of

the AR content. We opted for an adaptable way of adding virtual content for the physical books as it is shown in Fig. 3(a). The requirement of extra devices for the application is minimum (i.e. only one marker) as well as easily adaptable to every book. From the chosen marker position, the reader can add the augmented contents displacing the content with 3D transformations as Fig. 3(b) shows. Despite this approach, our authoring tool supports several markers for the AR content input as well as *free markers* (i.e. markers that are not constrained to a fixed position, and the reader can freely move them throughout the book). Users can choose to add more markers for the content creation, tailoring the augmented book design to their particular needs.



(a) (b)

Fig. 3. Considered marker fixed positions (a) and example of the concept of displacements (D_1 and D_2) from a single marker to situate two augmented elements over the book (b).

3.2 Usage Concept

The usage idea of the proposed approach is basically divided in two phases: a stage among books and another stage within a book.

Among books. On one hand the user can create a new augmented book for his/her desired physical book. On the other hand, the reader can open previously created books. In this way, several books can be managed concurrently.

Within a book. Once the augmented book is open, the reader can navigate through its containers and contents. The reader can select each content type and perform the corresponding interactions (e.g. view images, play sounds, etc.). The selected augmented contents will be displayed over the book on the viewport of the application.

In order to add a new content to the issued augmented book, the user must select a container. When there is no container associated to the desired page or the user may want to separate contents thematically, the reader ought to create a new container. Then, he/she can select the content type to be created and choose specific characteristics about this content.

Finally, the reader can add augmented features for the issued content. In such case, the reader must select a marker (trackable object) and its position in the surrounding of the physical book. Also, besides the predefined positions for markers, a floating marker is considered. This feature allows to use this marker freely (i.e. user can move it without restrictions).

The basic 3D transformations (rotation, translation and scaling) can be performed to set the desired spatial position of the content over the book, that is translating the content from the marker location. All this process is totally interactive and is shown in real-time in a seamlessly manner.

4 Authoring Tool Implementation

4.1 Architecture

The proposed authoring tool was designed with several modules, maintaining them independent, in a loosely coupled manner. In this way, future modifications will not affect the overall application. Moreover, several object oriented patterns were followed and a framework-based approach was employed, allowing to easily extend the system with new features. The overall architecture of the system is shown in Fig. 4.1.

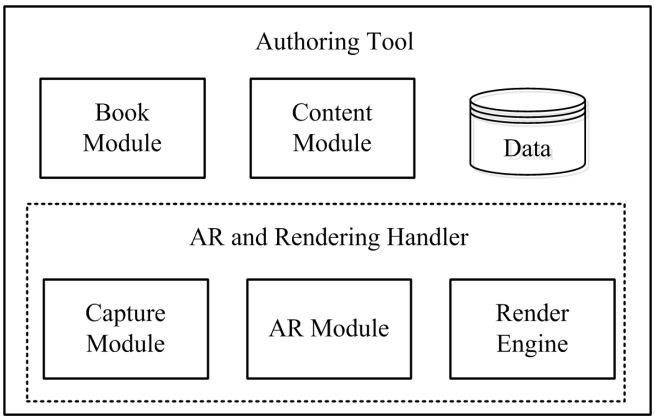


Fig. 4. System Architecture overview.

Each module aims to the different operations of the application. Hence, the *Book Module* handles all the actions related to search and creation of the augmented books. The creation of contents is achieved by the *Content Module*.

In addition to the described modules, the application consists of a group of modules to handle the rendering and the AR detection. The camera is accessed via the *Capture Module*. Frames captured are displayed by the *Render Engine*

which in turn will display virtual objects over the book images. These AR features are handled by the *AR Module*, detecting the markers on the captured screen and obtaining the pose information of them. The functionalities from these modules are managed by a special handler, which performs the communication among them.

4.2 Implementation Details

The proposed authoring tool has been implemented in C++ using the Qt Framework [3]. The *Render Engine* was developed using OpenGL and the *AR Module* was designed using the ALVAR[4] library.

The application was developed for the Windows platform and deployed on a machine with AMD Phenom II X4 840 CPU, 4GB DDR3 memory and an ATI Radeon HD 5750 video card running Microsoft Windows 7 64-bit operating system. The application showing AR contents using the mentioned hardware was able to run smoothly with frame rates of about 30fps.

5 Discussion and Future Work

5.1 Informal User Observations

The application was tested by academics from different areas in order to obtain informal feedback and observations about the proposed approach. We suggested a simple task that involved the creation of an augmented book for their desired book, adding contents with AR features. Like in every first contact with an AR application, users needed a brief introduction to this technology (e.g. what is AR, the need of a marker, etc.). The feedback obtained was very positive and users were pleasantly surprised by the natural way of adding contents to the book. In general, they did not experienced problems with the interface and the proposed marker approach around the book. Figure 5 shows examples of different augmented contents created by academic readers.

The results of these informal observations are promising. Several suggestions were provided for special uses in different fields of endeavour, such as in a classroom environment as well as for exhibitions or demonstrations purposes. In general the users were not distracted with the marker location, however they had to be careful to not occlude the marker. All the users agreed that this technology would be very useful in their respective areas to motivate students with this enhanced reading experience.

5.2 Drawbacks and Future Work

Although promising feedback was obtained, this application still should be tested using a formal evaluation in order to obtain detailed results. The authoring tool

[3] http://qt-project.org/
[4] http://virtual.vtt.fi/virtual/proj2/multimedia/index.html

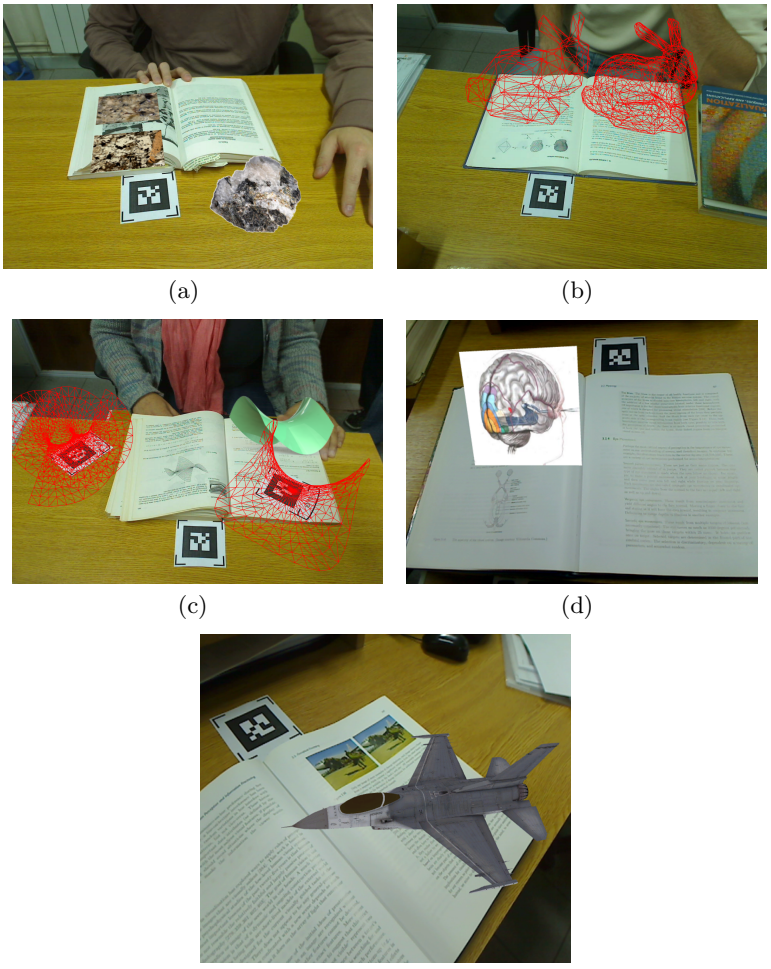


Fig. 5. Examples of four augmented books created using the authoring tool: a book of Geology (a), Computer Graphics (b), Mathematics (c) and Visualization (d,e).

provides several digital contents and interactions for these contents. However, there are still other contents to be considered (e.g. videos) as well as other kind of interactions (e.g. multimodal interactions). From the informal conducted user observation, suggestions to incorporate additional contents like digital notes or some kind of handwrite notes were provided.

Though the single marker or several markers approaches are effective, we plan to improve the existent AR features adding *Markerless Registration and Tracking* in order to obtain a more natural interface with the book. This kind of registration methods were considered in the design of the application but these are not implemented yet.

Finally we also plan to port our authoring tool to mobile devices. A mobile version could be used in different environments where it would be difficult to have a desktop computer to every reader (e.g. a library).

6 Conclusion

In this paper we presented a novel authoring tool for augmented books. The application allows readers to incorporate augmented contents to pre-existing printed books. The application has been used to create Augmented Books by academics of different areas. Informal user observation and interviews were conducted and the feedback obtained suggests that this technology is easy to use and opens up great possibilities to enrich the traditional reading. Users were able to create new digital contents for their desired books and experienced the facilities offered by the proposed authoring tool to complement the reading experience. We summarized future directions for this approach and we expect to use this technology in different environments such as libraries or classrooms.

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