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Towards the Development of a Platform for Children Virtual Books based on Augmented Reality

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Abstract: In the current world, people can both support and improve their skills using new technologies. Particularly, the reading process could be enriching employing virtual reality features, adding educative virtual content in books. A virtual book is composed by 2D/3D content superimposes over a physical printed book, focus into obtain a new perspective of the classical reading process. Then, if this perspective can be added from the early stages of reading process, it could improve that process. Most tools to create these books are associated with a specific domain and development (e.g. editorial-based formats and conditions, according to the kind of book), and they are not free to access. We present a robust and efficient platform to develop interactive books using augmented reality, mainly we focus on children books. The platform is web-based offering a simple and dynamic platform for writers and final users. This is capable to create, distribute, and manage books in a customized way, adding resources such images, sounds and videos. We evaluated our proposal in 20 people measuring the time to complete a virtual book in the created platform, moreover, we achieved a questioner to obtain how difficult the process is. Results allow identifying the advantage and disadvantage for users, validating our approach obtaining satisfactory results. We are focused on continuing the expansion of the virtual book development process, which might be a new expansion research field in our country.

Keywords: Virtual Reality; Augmented Reality; Virtual Books; Reading Process; Web Platform.

I. Introduction

The reading process is an important habit to obtain mental benefits in humans. This helps in the cognitive process, improving our expression capability, increasing our vocabulary, and eases the learning process itself. Reading readiness starts in childhood supported for the Elementary School in different regions around the world. Nevertheless, this process is just the beginning of a consequent habit. The interest in children to read books as a pleasure, above a duty, is considered a real challenge.

There are technological solutions which support the teaching process since early ages. Mainly, these are formed with images, texts, positive feedback and sounds. For instance, the usage of interactive applications to immerse children into books is one to remark, called the augmented reality. Augmented reality (AR) is a technology which adds a new perception and interaction with the real world, allowing users the sensation of a real environment taking additional information from a computer device [1]. This opens a new way to see virtual elements on the real world, letting a new way in human perception. There is evidence that current technologies play a crucial role in modern education models.

According to Azuma [2], the AR is a variation of the Virtual Reality where the user can see the real world around him, supplementing the reality superimposing virtual objects with the real world. Also, Azuma defines three characteristics for each AR system: 1) combines real and virtual, 2) interactive in real time, and 3) registered in 3D. Those characteristics are the basis for different applications in different areas: medical, visualization, maintenance and repair, robot, annotation, education, robot path planning, entertainment, and military aircraft navigation and targeting.

Studies of Furht [3] shown a classification of augmented reality systems based on the mobility of users and systems such as: fixed indoor, fixed outdoor, mobile indoor, mobile outdoor and mobile indoor/outdoor systems. The selection of the type of system is a crucial decision before starting to develop an augmented reality application.

This relation between education and technology is one of the most concerning problems in different research centers which study this field [4]. Focusing in the construction of a reading habit, a few studies have been investigated on that as a systematic way to learn. A complete classification of augmented reality books is presented by Altnpulluk and Kesim

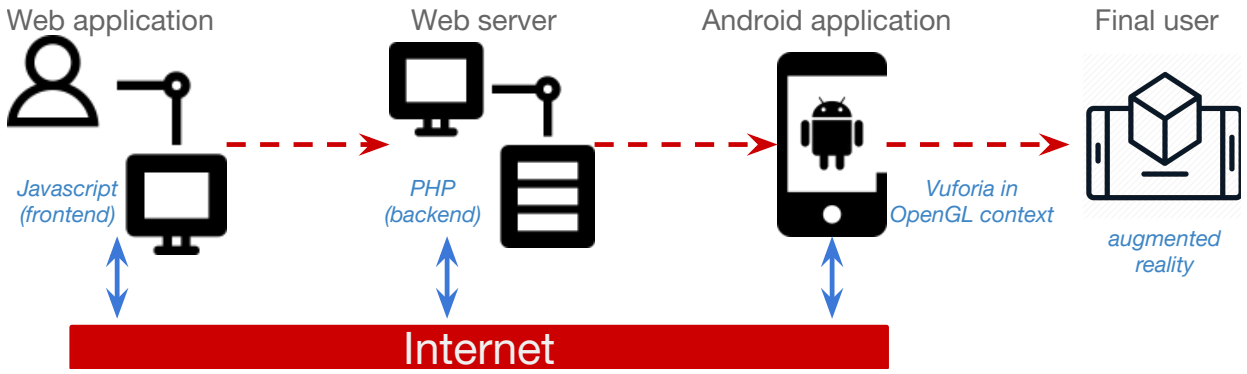


Figure 1: Overview of Proposed Architecture with its Components. Pipeline is Presented from Left to Right

[5], which is an excellent guide to explore more in depth this topic. This paper argues the developing of a platform to develop virtual books for children, defined as interactive books which offer a new experience from the traditional reading process. The virtual book approach is built with augmented reality to make a novelty solution for writers (i.e. authors) and final users (i.e. children). Thus, final users can visualize and manipulate virtual objects over physical book's pages. According to our knowledge, in Venezuela, this is the first research which explores this kind of approach.

Basically, our solution is composed of two main components: a web platform and a phone-based application. The solution provides to authors a robust and friendly tool to develop interactive books, and it provides to children some activities such as watch, select, download and play books with AR using an android-running device (i.e. tablet, smartphone). The available content for books is easily inserted using the web platform. The reader should bear in mind, that this study is based on children with the capability to manage smartphone devices and with the reading readiness initiated.

First, in Section II, the paper outlines a brief overview of existing solutions in literature for virtual books using augmented reality. Next, in Sections III and IV, we introduce our approach to assess our contribution to creating virtual books, explaining in detail each developed component. Following, Section VI shows the evaluation of our solution both qualitatively and quantitatively to test its impact. Finally, conclusions and future work are presented in Section VII.

II. Related Work

The study of Dünser and Hornecker [6] examined how the young children interact with augmented reality storybooks. The study shows different behaviors according to the integration of interactive sequences using AR technologies. Also, their observations demonstrated that most children were able to interact with the system without much prompting.

Magic Book, developed by Billinghurst et al. [7], might be considered as the first successful attempt to create books using augmented reality. With Magic Book, users are able to read the text in a traditional way mixed with AR elements. The pages are enhanced, showing a 3D content using a traditional PC. Nowadays, this approach is replacing by the usage of massive mobile devices such as tablets or smartphones.

Some authors have considered the study and development of children virtual books using mobile devices whether to show 2D/3D content [8][9][10], being part of classroom activities [11][12], or other interesting topics [13][14]. Likewise, some studies are focus on the semantics of mixed reality books, and in the graphical design space user experiences [15]. Most researches use a mobile device to give the flexibility and availability in multiple environments. Indeed, there are approaches which use additional specialized hardware such as head mounted display [16] or a kind of specialized paper [17].

Recently, some noteworthy solutions were presented: Children's Literature [18] and Coloring Book [19]. The first explains, in a simple way, the Bible story adding music, animations, voice, and storytelling. The second one is an application to draw 3D designs with hands-free interaction, getting a high-level of the artistic expressions from users. Also, in 2016 Laine et al. [20] presented a game-based book and storytelling as methods to generate intrinsic motivation in learning.

On the other hand, exploring the commercial companies, they exploit this new tends on technologies using mobile devices to create virtual books. An instance, the company Carlton Publishing Group[1] which sales a collection of books that include augmented reality sequences on each book. Its approach is based on the usage of a mobile application available to download. An outstanding application of this kind is called ZooBurst[2], which is distinct as a digital storytelling tool to create 3D pop-up books using iOS devices. Another alternative of this kind is Augment[3], an application which works on both Android and iOS operating systems getting a set of tools to construct different applications, using augmented reality.

Overall, there seems to be some evidence to indicate the rich experience stimulates the human senses. It allows a comfortable interaction user-content in reading, hearing and displaying static images or 3D models through AR, thus

[1]https://carltonbooks.co.uk
[2]https://zooburst.com
[3]https://augment.com

enhancing the learning process. Despite of existing options, they require a medium-to-complex setup, or to buy a usage license, or is only available for joined authors in a particular publishing company.

Using all these previous works, we are motivated to create an open and free platform for the creation of virtual books without a dependency or restrictions of commercial companies. Also, we try to integrate usability aspects to enhance the user experience, even for writers and final users.

III. Approach

A visual overview of the proposed approach is presented in Figure 1. We decided to use in our investigation the mobile indoor and outdoor approach [3]. Our solution offers the development of a virtual book using a web platform and an Android application to interact with the augmented reality elements. The virtual book is represented as a printed book with markers, displaying the AR when the device's camera is pointing to markers into the physical book. Figure 2 shows an example of how it looks in a real scenario.

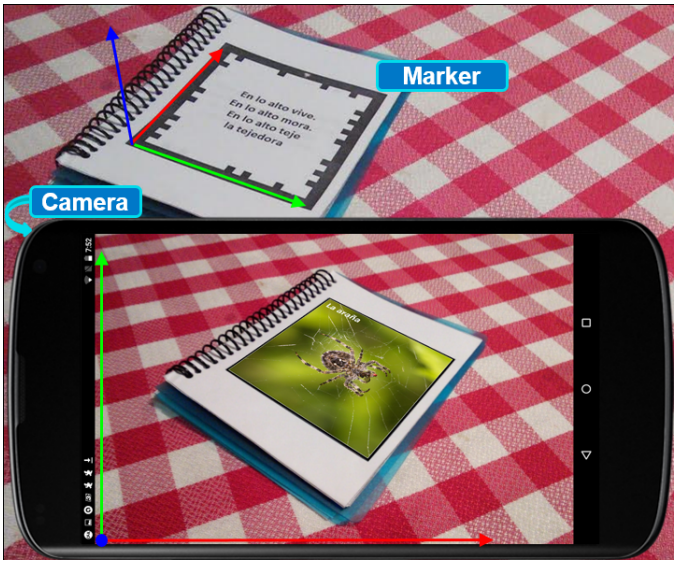


Figure 2: Example of our Approach Displaying an AR Element over a Physical Book

The pipeline process (see Figure 1) starts with a web application running into a web server, that can be access from a web page or from an Android application. The application allows an entire mechanism to build, store and publish virtual books. Similarly, a web server and database are provided to manage the permanent storage and the web services. Both modules (web application + web server) are grouped in a web platform, explained in detail in Section IV. Then, this platform allows the creation, composition and posterior download of virtual books.

When a virtual book is downloaded, it contains the references for each placed element such as text, images, sounds and videos encoded as markers. Each marker can be read using the mobile device application, to reproduce the AR element. Once the virtual book is printed into a regular paper (i.e. physical white paper), the Android application is used to connect it directly to the web server, and to obtain the AR elements and correspondingly reproduce them. Notice that all mentioned modules require connection to Internet.

Lastly, a final user can visualize the AR elements over the physical book, and the user can interact with that elements. For instance, the user can show/hide elements, or reproduce several times a video.

IV. Web Platform

A web platform is designed using tools to create new virtual reality complements. These complements were incorporated in the virtual book platform. Basically, this platform is composed for a front-end and a back-end module (i.e. a classic web platform). Specifically, we used the following technologies:

- Front-end: JQuery[4], JavaScript programming language and Bootstrap[5]
- Back-end: PHP programming language, ZipStream-PHP[6], MySQL[7], Apache and Google Chart Tools: infographics[8]

Likewise, the internal architecture of the web server is composed of different layers: Request Manager, Logic, Data, and View layer. The Request Manager layer analyses the HTTP requests and invokes the core-algorithms (i.e. the functional workflow) to be applied; this layer is connected with the font-end. The logic layer contains all transactional algorithms to interact both Data and View layers. The View layer generates the HTML content to be shown to the users (i.e. front-end). Finally, the Data layer manages the persistent data and multimedia resources. The Data layer has direct access to the database; however, it could change according to certain data protection policies.

Given the nature of the functionality-based structure of our solution, where several layers are involved in a single fully-functionality process, we produced tasks that have to be accomplish by the web platform instead of associated tasks on each layer. This division allows us not to enter in depth technical details of our development (in the domain of this article). For instance, the following tasks are implemented:

- Selection and visualization of multimedia content: It allows to the users to select the multimedia content to be stored in the platform. This content should be available to incorporate them into virtual books according the user permissions, as limited or full access to all available resources in the server.
- Incorporation of new multimedia content: It allows to users the capacity to add their own multimedia contents, and specify their visibility for public or private content. In this context, public means available to all users in platform, and private that is only available for its owner.

[4]https://jquery.com (Javascript library)
[5]https://getbootstrap.com (HTML/JS/CSS library)
[6]https://github.com/maennchen/ZipStream-PHP (Streaming library)
[7]https://mysql.com (Database manager)
[8]https://developers.google.com/chart (Web-based visualization library)

Figure 3 shows an example in how the available content is presented to the writers in the platform.

Figure 3: Example of Available Content for Writers in the Web Platform

- Edition of pages: It offers to the users a set of options to add into a page of a virtual book.
- Storing data: It efficiently stores the data to access by a user in any request. The web platform uses thumbnails to present the content.
- Adding description: The users are able to add a short text description of a book, also to add a cover image to identify it on future requests (e.g. a thumbnail image).
- Generation of fiducial markers: It offers to the users the option to mark an image as a fiducial marker. Generally, the fiducial marker should be a special symbol: QR code, geometrical filled polygon, or others. The solution provides the option to use images, being markers recognized by the Android application.

In our context, a fiducial marker is defined as an object or image placed on top of another image or region of interest. It is used as a reference point to identify a spatial location, a measure or a feature in a page of a virtual book (i.e. spatial layout location). A fiducial might be a simple coin with well-known dimensions, or a metric rule used to calibrate some dimensions on captured images.

The web platform besides offers basics functionalities presented majority of the web-based systems: the CRUD operations (Create, Read, Update and Delete) of data stored in relational databases. Therefore, validations of data input and user control are components of the proposed web platform. Once all elements of the web platform are setup, we focus on the creation process of a book by the writers.

A. Book Management

The first step for the writer user in the web platform consists in the creation of the book. This process requires adding required information to get a proper books profile in the platform. As part of these information, is noticeable the following:

- Title: specifies the title of the book.
- Author(s): indicates the main author(s) of the book.
- Synopsis: conveys a full narrative of the book.
- Cover: identifies the book cover image.

The introduced information is received for the front-end module, and the back-end module processed the data to validate the inputs in some cases such bad image formatting, existing book's title, and any kind of validations. Each book maintains one of two possible conditions: "in construction" or "finished". The default condition for books is "in construction', until the writer decides to finish the creation of the book, changing of status.

Using the web interface, the users can visualize the existing books created by themselves, screening relevant information such as date of creation, status, and size in megabytes. Next, it is likely to add multimedia content to the already created books. This process is explained in detail in Section IV-B.

The last step after completing a book creation process is the publishing stage. To publish a book, all the content must have a maximum of 100 to 150 MB, mainly for the limitations in the network (i.e. low and mid-range internet speeds). It is clear that the multimedia content is stored in the server, and the Androids application have to download that content join with the definition of fiducial markers. For example, if a book contains seven fiducial markers corresponding to seven multimedia contents of 100 MB each one, then the application must download 700 MB, only for the first usage. The proper balance of the multimedia data is relevant to the constructions of virtual books. However, that limitation on size in bytes, could be change according to our storage device capacity and the networking capabilities.

The publishing process output consists of a single file. This file contains all items mentioned in Table I. The file might be download using the mobile application and stores in the device memory.

Table I: File Content to be Installed in the Mobile Device

Content	Description
Fiducial Marker	Multimedia content interpreted to be executed as AR
QR code	Identification of each book in the system
Readme file	User instructions to incorporate AR into physical book

When a book is marked as "finished", the publishing process, which runs in the server, sends a notification to all users which have that virtual book installed in their mobile devices. For instance, this notification appears for users as shown in Figure 4.

Each book created in the platform must have been a unique identification instead of using classical id correlative numbers. We used QR codes (Quick Response Code) which can be read using the camera of the mobile. In this way, it is possible to determine which is the book to download from the web server. A simple QR is a trademark based on a 2D barcode, which is encoded to store data efficiently.

B. Multimedia Content

The main goal in the book creation process is the addition of multimedia content to virtual books. When a multimedia

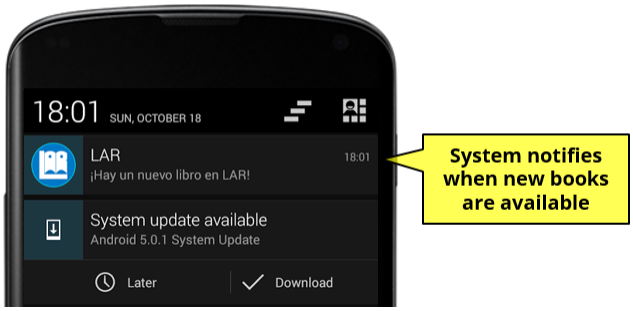


Figure 4: Notification Message when a New Content is Available to Download

content is added into a book, a fiducial marker is linked with an image, sound or video. This content is chosen from a predefined list of resources, or can be inserted as new content. To add a new content, it is necessary the following information:

- Description: It adds a short description of the content. This field works as a reference in the available list of resources presented to users.
- Permission: It identifies the kind of usage permission of content. (e.g. rights managed, royalty free, public or private)
- Error message: In case of any error when the content is downloaded, it allows shows a personalized message written by the author.

In order to standardize the content, we decided to use PNG and JPG formats for the images; MP3 format for the sounds; and MP4 for the videos. Indeed, we strongly recommended that each file cannot be larger than 75 MB. For other side, to maintain a good quality on the server side, the server executes auto-maintenance functions. When certain content does not belong to any finished book, and it has more than 4 weeks on the server, then that content is removed. This policy is applied for storage limitations in low-end servers.

V. Android Application

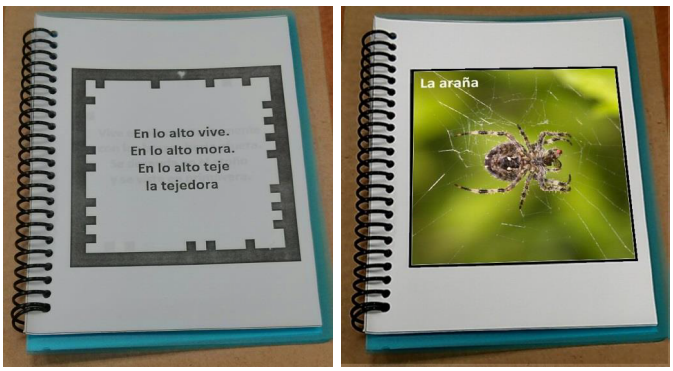
Currently, several libraries and SDKs have been developed to include augmented reality into software applications. Noteworthy examples are Zappar[9], ARToolkit[10], DroidAR[11], Blippar[12], Layar[13], Metaio[14], NyARToolkit[15], and Vuforia[16]. It is might being clear that there are a few more, but those are a subset focus only in mobile applications development. After tested the advantages and disadvantages of each one, we chose Vuforia. This selection was followed after the evaluation of aspects such markers detection, QR decoding, licensing, ability to play music, video, and audio.

[9]https://www.zappar.com (AR solution)
[10]http://www.artoolkitx.org (AR library)
[11]https://bitstars.github.io/droidar (AR framework)
[12]https://www.blippar.com (AR solution)
[13]https://www.layar.com (AR solution)
[14]https://metavision.com (AR solution)
[15]https://github.com/nyatla/NyARToolkit-for-Processing (AR library)
[16]https://developer.vuforia.com (AR framework)

Vuforia does not force the usage of a watermark in the screen (as other solutions do). Also, it can be used with a free license excepting the image recognize cloud feature (which is not included in this work). Additionally, a very important matter to consider using Vuforia in our project is the documentation for developers, which is free to access and contains several examples. For the technical point of view, we integrated other libraries in our proposal. For example, the Zbar library, available in http://zbar.sourceforge.net, is used to recognize effectively the QR codes, and the SQLite database manager to store the data locally.

The Android application is the component of the system which interacts directly with the destination user (i.e. children). This application contains a set of basic functionalities in a lightweight application stored in the mobile device. These functionalities are summarized as follow:

- Marker recognition: It finds into the captured image a known pattern to reproduce its associated multimedia content.
- Content reproduction: It reproduces through the output device (e.g. mobile screen or mobile speakers) the content using the augmented reality technology. For example, the Figure 5 shows a printed riddle surrounded by a marker using the mobile device camera, where the answer is presented an image and text (i.e. spider).



(a) A simple riddle (b) Image showing the answer

Figure 5: Reproduction Example of the Content using the Android Application

- Extraction and data management: It consumes web services available to users, which is available as augmented reality add-ons. This allows selects which feature will be used to store in the internal memory of mobile device. Then, once is stored in local memory, there is no necessary the Internet connection to transfer the content.
- QR decode: It decodes the QR code and does the communication with the web platform to download the data for a specific book.
- Add-ons administration: It allows managing the augmented reality add-ons which are store locally. Also, users can manage the add-ons available on the server to be download to their devices. Notice that this process is performed under request of users.

The Android application was designed using the Model-View-Controller pattern, to construct the user interface. A part of the graphical user interface is shown in the Figure 6. The proposal design considers the web server where is hosted the web application and the centralized database.

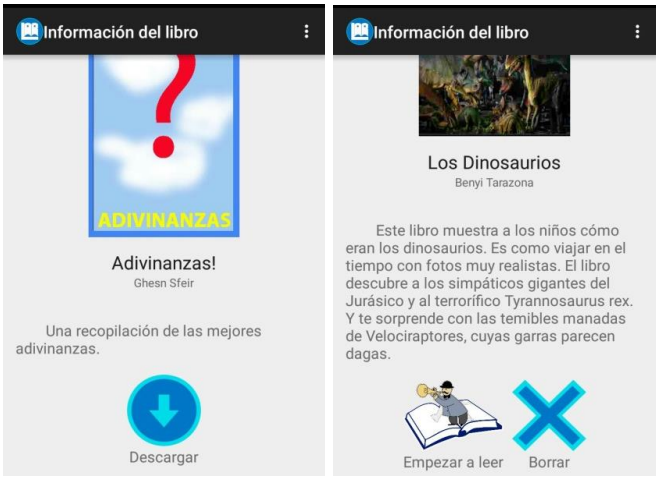


Figure 6: Examples of the Graphical User Interface in Mobile Devices

From the technical perspective, this approach allows an easy switch for the native code developed to reproduce images, videos and sounds indistinctly in a captured image. The multimedia content in virtual books complements the existing information, without discarding the importance of the written content in the physical paper.

A. Augmented Reality

When the content is rendered in the screen of a mobile device, the application should setup a scenario. This is not always applied owing to augmented reality setup consumes resources in processing. First, the initial environment is created once the camera turns on. This environment consists of the creation of an OpenGL context, after, a list of available contents in the server is loaded. This loading process is completed asynchronously showing a logo during this process (e.g. a visual way to wait for the loading).

Next, the recognition process of marker location is done using image processing algorithms. For instance, an image mask is created where a low-pass filter, thresholding, and the Harris corner detector are executed (in the mentioned order) to obtain the location of the marker. These algorithms work assuming a good lighting conditions at the moment of capture.

Finally, the location of the multimedia content is calculated, projecting a 3D plane over the found markers, and re-project onto the screen 2D to obtain the output location in device's coordinates. The center of these coordinates is found projecting the content, which might be a reliable solution for our proposal. Figure 7 shows an example of the video location in the mobile device screen.

Figure 7: Reproduction of a Video once a Marker is Detected

VI. Experimentation

1) Virtual Books: A case-study was chosen to evaluate the effectiveness of our proposal. We built a total of 22 virtual books changing the number of pages, number of images, number of videos, number of audio and size on each one. The behavior of our application is analogous in all cases, getting similar results. For instance, if all resources have the same size, the construction of a virtual book with five multimedia resources consumes X MB, and a virtual book with ten resources consumes $2 \times X$ MB approximately. There is no a considerable payload of data excepting by the multimedia data. If the same resource is selected twice, then that resource is only store once.

A sample case of a virtual book created can be appreciated in Figure 8, where 4 pages are displayed. From left to right, markers represent an image, a video (both enclose into a square) and two sounds (eighth note encloses into a square). For instance, that virtual book was printed in bookbinding to be used by children.

2) Construction Time: We performed a test to measure the construction time of a book. Then, we set up a population of 20 users to create two different books. The ages of the users are between 20 and 35 years. On average, the time to develop the first book was 31.5 minutes; and for the second book were 27.75 minutes. Despite the time, two users could build a ten-pages book in a time less than 15 minutes.

To be more precise, the number of pages constructed by test users were between eight and ten pages. This requirement was settled by authors, to obtain a more precise measurement and avoiding a difference for the number of pages. Also, only the 50 % of resources were available on the server. Users must download part of the content from the Internet, simulating the real book construction process.

3) Construction Process: After a little survey at the same population (i.e. 20 people), we carry out the following question:
How do you consider the complexity in the construction of the book using the Web platform?

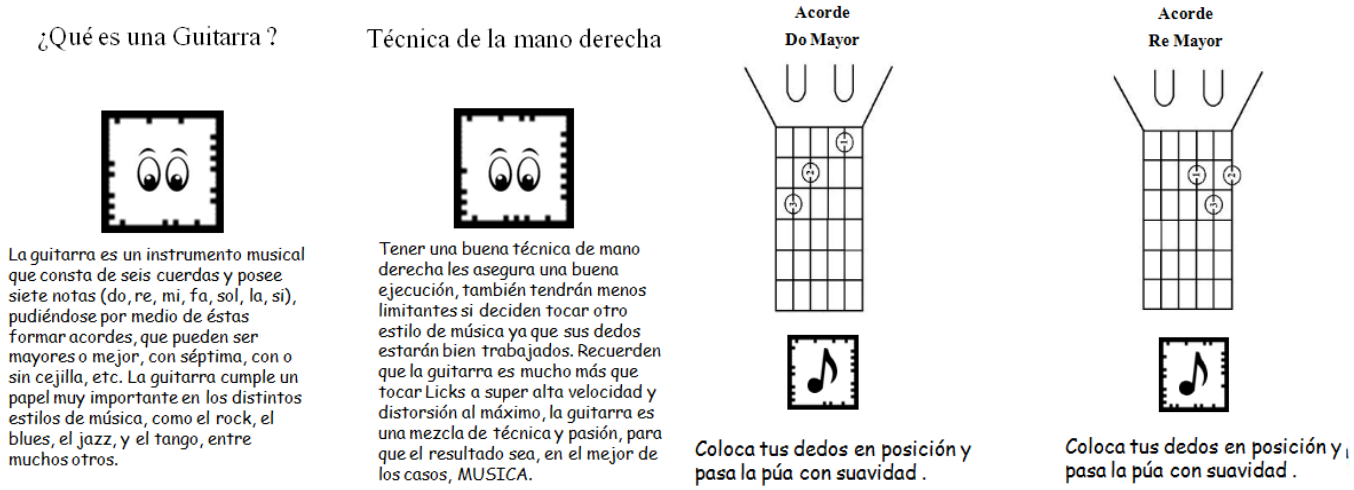


Figure 8: Example of four Pages of the Virtual Book titled "Mi Guitarra y Yo"

The results are shown in Table II, where answers were classified from very easy to very complex (five options).

Table II: Answers Concerning Complexity of a Book

Options	% of answers
Very complex	0
Complex	10
Regular	20
Easy	25
Very easy	45

Results show that users do not consider a **very complex** process the web platform (10%). The 45% answered that process was **very easy**, and other 45% consider the process as **easy-regular**. Importantly, most of the users have a knowledge about filling forms online, with the capacity to write and continue a guided process in web pages. Separately of the age range or abilities to handle online forms, could be very useful have some kind of measurement tools in order to balance the results according the capacities of users before start the process.

In order to continue exploring the users' capacity, we fulfilled another question in the same group:
How difficult is to incorporate markers into books?.

Using the same scale previously defined (very complex to very easy), results show that 15% answered Complex, 40% Regular, 15 % Easy and 30% Very easy. Thus, the multimedia content would be placed in a specific location, with a precise size and resolution (for images), to get a good visual result in the final printed book. For this, the users take more time adding this content. We believe that knowledge in visual design or aesthetic to diagram content is a plus for this process, reducing the construction time.

4) Survey: For this test, we performed three questions to evaluate the final result. These questions were made thinking in final users, the children, considering their ability to read and handle mobile devices. Table III shows the pair question/answer presented to 10 children with 6 to 11 years old. The possible answers are Yes/Not, being short and easy to answer.

Table III: Results of Questions Asked to Children

Question	Yes	Not
Do you like it?	9	1
Is it new to you?	10	0
Do you want see more?	9	1

The most remarkable aspect is concerning the novelty of the application. In spite of aforementioned aspect in Section II, there are applications of this kind. However, those are widespread applications such as games, camera-related or social-media networks. In any case, the positive impact surveyed is noticeable. Again, we have to remark that these results are into our test domain and clearly do not represent a widespread population where other aspects should be considered (exposition time to electronic devices, social environment, among others).

An important not-measurable aspect, at least for this research, was the notorious surprise and emotion of children. In all cases, they show positive feedback in all books presented to them. Figure 9 shows one of the surveyed, Jade a 7-years old girl, playing with one developed virtual book.

5) Considerations: When the mobile application is running, there are some external factors to consider: lighting conditions, camera quality and distance from camera to marker. A strong incident light over the marker on the physical paper will not allow the proper detection by the algorithms. This aspect, joining with the quality of the camera, allows an appropriate image to be processed. In this research, we captured an image on each frame, after the image is pre-processed to determine if the captured image is valid to be consider as a marker. Our tests show that when the resolution of the camera is less than

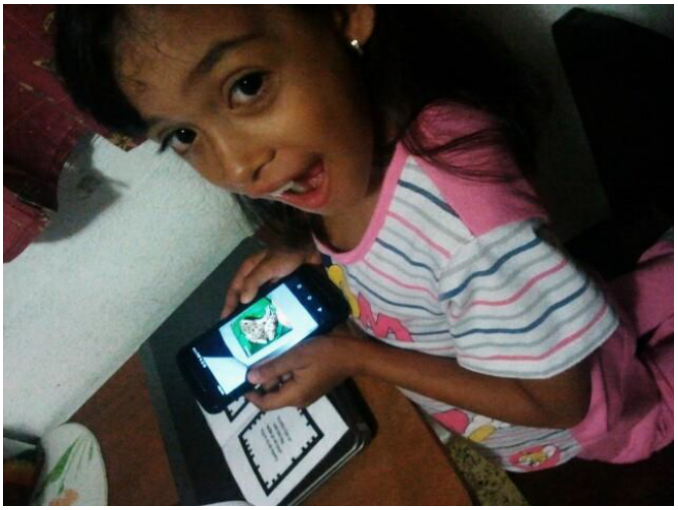


Figure 9: Usage Example of the Application. Photography Conceded with the Authorization of *Mr. Bocanegra*, Jade's Father

3 MP, there are false positive in corner's detection around of 40% cases, tested 50 times with 4 different devices. In this study, we are only considering the megapixel count, however there are other aspects that strongly impact into a good quality of images such as sensor size, pixel size or focal length.

Finally, the distance of the device to the printed physical paper is relevant. Also, the quality of the camera affects directly this feature. Bigger distances (between 30 cm and 80 cm) are captured very well using good pixel resolutions of cameras (i.e. 5 MP and above). However, this distance is not acceptable in lower pixel camera resolutions. To reach the expected results, we strongly recommend a distance between the focus of the camera (around 5-15 cm) until 25 cm for all cases.

VII. Conclusion and Future Work

This research was undertaken the design and development of a solution to create virtual books for children using augmented reality which pop-up image, video, and audio over the physical printed books using a mobile device. The solution includes an available web platform for writers and, an Android application for final users. Final users are children, which in our test, always demonstrate to be surprised by presenting visual results in devices.

Our solution presents high flexibility to writers designing books. Thus, virtual books are benefiting from the creativity that writers added to them. This offers a huge variety of styles to reproduce the augmented reality elements. Similarly, the fact to add their own content to increase the mentioned flexibility. There is no limitation to the final goal of the books: educational, entertainment, recreational, and other book genders.

There is no doubt about the impact of the augmented reality in bringing to the real-world multimedia content, enriching the read experience. Particularly, modern children find new ways to learn using the new technologies. The virtual books are an outstanding demonstration in how the new technologies can improve our habits. Moreover, we think that might be endless ideas and possibilities using AR.

It is important to remark that we assume a permanent connection to Internet. All multimedia content must be downloaded at least the first time, from the web server. This might be inconvenient due to the size of the content and the response time to show them, which depends on the networking platform. Also, it can be affected when limited mobile devices are used. In a near future, it would be a good approach the designing of a full desktop application for more advanced users, or offer a more complex options for advanced users too.

Therefore, a definite need for visualizing 3D content on the virtual books is a challenge. This can be reached allowing the loading and displaying of this content on the web platform and the mobile application. Also, now the application is limited to Android-based devices, being iOS devices a big market alternative. Further, in the near future, we plan to create books to support our previous researches focus on educating children [21][22] in particular goals. At the same time, it is possible to compare our solution with other platforms/libraries and determine the differences, focus into take advantage of the final product.

Emphasis on the impact of our solution, we only measured the technological and perception aspects from children. It is very important count with a study in the correlation between the usage of the solution with the time to measure a learning progress. This should be done to determine an expected positive result, increasing the learning curve. However, this topic is out of our knowledge and could be running by psychologists and children educators.

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References

[1] G. Kipper and J. Rampolla, *Augmented Reality: An Emerging Technologies Guide to AR*, Syngress, 1st edition, December 2012.

[2] R. Azuma, *A Survey of Augmented Reality*, Presence: Teleoperators and Virtual Environments, vol. 6, no. 4, pp. 355-385, August 1997.

[3] B. Furht, *Handbook of Augmented Reality*, 1st edition, Springer, August 2011.

[4] E. Olmos, J. Ferreira Cavalcanti, J.-L. Soler, M. Contero, and M. Alcañiz, *Mobile Virtual Reality: A Promising Technology to Change the Way We Learn and Teach*, Mobile and Ubiquitous Learning. Perspectives on Rethinking and Reforming Education, pp 95-106, Springer, Singapore, 2017.

[5] H. Altnpulluk and M. Kesim, *The Classification of Augmented Reality Books: A Literature Review*, in Proceedings of the 13th Annual International Technology, Education and Development Conference (INTED2016), vol. 1, pp. 4110-4118, Valencia, Spain, 2016.

[6] A. Dünser and E. Hornecker, *An Observational Study of Children Interacting with an Augmented Story Book*, ser. Technologies for e-Learning and Digital Entertainment, vol. 4469, pp. 305-315, 2007.

[7] M. Billinghurst, H. Kato, and I. Poupyrev, *The MagicBook - Moving Seamlessly Between Reality and Virtuality*, IEEE Computer Graphics and Applications, vol. 21, no. 3, pp. 6-8, May/June 2001.

[8] S. Singh, A.D. Cheok, G.L. Ng, and F. Farbiz, *3D Augmented Reality Comic Book and Notes for Children Using Mobile Phones*, in Proceedings of the Conference on Interaction Design and Children: Building a Community, pp. 149-150, 2004.

[9] A. Dünser and E. Hornecker, *Lessons from an AR Book Study*, in Proceedings of the 1st International Conference on Tangible and Embedded Interaction, pp. 179-182, 2007.

[10] N. Taketa, K. Hayashi, H. Kato, and S. Noshida, *Virtual Pop-Up Book Based on Augmented Reality*, in Proceedings of the Symposium on Human Interface 2007, pp. 475-484, July 2007.

[11] L. Kerawalla, R. Luckin, S. Seljeflot, and A. Woolard, *"Making it Real": Exploring the Potential of Augmented Reality for Teaching Primary School Science*, Virtual Reality, vol. 10, no. 3, pp. 163-174, December 2006.

[12] M. Billinghurst and A. Dünser, *Augmented Reality in the Classroom*, Computer, vol. 45, no. 07, July 2012.

[13] G. Ucelli, G. Conti, R. De Amicis, and R. Servidio, *Learning Using Augmented Reality Technology: Multiple Means of Interaction for Teaching Children the Theory of Colours*, ser. Intelligent Technologies for Interactive Entertainment, vol. 3814, pp. 193-202, 2005.

[14] R. Grasset, A. Dünser, and M. Billinghurst, *Edutainment with a Mixed Reality Book: A Visually Augmented Illustrative Childrens' Book*, in Proceedings of the International Conference on Advances in Computer Entertainment Technology (ACE'08), pp. 292-295, 2008.

[15] R. Grasset, A. Dünser, and M. Billinghurst, *The Design of a Mixed-Reality Book: Is it Still a Real Book?*, in Proceedings of the 7th IEEE/ACM International Symposium on Mixed and Augmented Reality, pp. 99-102, September 2008.

[16] C. Juan, F. Beatrice, and J. Cano, *An Augmented Reality System for Learning the Interior of the Human Body*, in Proceedings of the 8th IEEE International Conference on Advanced Learning Technologies, pp. 186-188, July 2008.

[17] M. Back, J. Cohen, R. Gold, S. Harrison, and S. Minneman, *Listen Reader: An Electronically Augmented Paper-based Book*, in Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, pp. 23-29, 2001.

[18] M.A. Galvão and E.R. Zorzal, *Aplicações Móveis com Realidade Aumentada para Potencializar Livros*, Revista de Novas Tecnologias na Educação, vol. 10, no. 1, pp. 110, 2012.

[19] A. Clark and A. Dunser, *An Interactive Augmented Reality Coloring Book*, in Proceedings of the IEEE Symposium 3D User Interfaces (3DUI), pp. 7-10, March 2012.

[20] T. Laine, E. Nygren, A. Dirin, and H.-J. Suk, *Science Spots AR: a Platform for Science Learning Games with Augmented Reality*, Educational Technology Research and Development, pp. 1-25, January 2016.

[21] L. Lima, D. Torres, and E. Ramírez, *Un Juego Serio para la Preservación de la Fauna Silvestre en Peligro de Extinción en Venezuela*, in Proceedings of the 3ra. Conferencia Nacional de Computación, Informática y Sistemas (CoNCISa), pp. 50-60, Octubre 2015.

[22] F. Moreno, J. Ojeda, E. Ramírez, C. Mena, O. Rodríguez, J. Rangel, and S. Álvarez, *Un Framework para la Rehabilitación Física en Miembros Superiores con Realidad Virtual*, Revista Venezolana de Computación (ReVeCom), vol. 1, no. 1, pp. 8-16, 2014.