

Development of a Catalogs System for Augmented Reality Applications

J. Ierache, N. A. Mangiarua, S. A. Bevacqua, N. N. Verdicchio, M. E. Becerra, D. R. Sanz, M. E. Sena, F. M. Ortiz, N. D. Duarte, S. Igarza

II. STATE OF THE ART

Table I shows a variety of AR applications that are currently available, they have been classified based on their field of application.

TABLE I
AUGMENTED REALITY APPLICATIONS

Field	Objective	Application
<i>Entertainment (Films)</i>	Visualize and interact with a movie's content whilst modifying its course of events. Most used device: Augmented Reality Helmet.	CINeSPACE
<i>Education</i>	Enhance materials and contents from traditional education systems.	Magic Book[6], Construct 3D
<i>Marketing</i>	Capture customer's attention through astounding visual experiences. Most used device: PC with a webcam.	Zugara [7]
<i>Entertainment (Television)</i>	Add virtual layers of information to the images that are being displayed on a TV show.	Visual SyncAR [8]
<i>Cultural Tourism</i>	Spread cultural information through the different GPS available systems.	Wikitude [9], Layar [10]
<i>Entertainment (Videogames)</i>	Provide entertainment through visually innovative gaming experiences.	Rocket Racing League[11]
<i>Social</i>	Combine social networks and AR interfaces to enhance the experience of sharing information and meeting people online.	Recognizr [12]

III. PROBLEM POSING

The application development with AR components is in a stage of increasing popularity, especially with the recent appearance of interfaces like Google Glass [13]. However, the development of systems that allow the creation, management, publishing and exploitation of contents for users in a RA context are limited. In this order, Viewar [14] and Zappar [15] stand out. Particularly, the last one allows the self-management of AR content, focused on business cards and advertising, but with limitations on the marker type and with the strict necessity of a viewer application.

On the other hand, there are Augmented Reality applications of the type of AR navigator, in which stand Wikitude and Layar. These applications do not require the use of physical Markers unlike the applications mentioned above, but constantly feed on the Internet and use built-in sensors and available services on mobile devices such as GPS, accelerometer and gyroscope. This leads to a disadvantage. If one of these sensors is not available, the user will not be able to use the application, because it completely depends on them.

Regarding the content management, current applications allow users to create contents but they do not have the ability to create a collaborative environment where users can edit

Abstract—Augmented Reality is a technology that involves the overlay of virtual content, which is context or environment sensitive, on images of the physical world in real time. This paper presents the development of a catalog system that facilitates and allows the creation, publishing, management and exploitation of augmented multimedia contents and Augmented Reality applications, creating an own space for anyone that wants to provide information to real objects in order to edit and share it then online with others. These spaces would be built for different domains without the initial need of expert users. Its operation focuses on the context of Web 2.0 or Social Web, with its various applications, developing contents to enrich the real context in which human beings act permitting the evolution of catalog's contents in an emerging way.

Keywords—Augmented Reality, Catalog System, Computer Graphics, Mobile Application.

I. INTRODUCTION

AUGMENTED REALITY (AR) consists in the creation of an environment in which information and virtual objects are merged with the reality, offering the user an enriched experience without interfering with his natural perception. AR can be used to expand our senses, to define a direct or indirect view of a physical real world environment, whose elements are combined with virtual elements, such as texts, images, audios or videos to create a mixed reality in real time [1]. With the help of technology, information about the reality around the user becomes interactive and digital, allowing it to be stored and retrieved as an information layer over the real vision. AR does not always add elements to the real world; it also can be used to remove information, removing a physical object from the view, replacing it with certain information [2].

Currently, technological advances have allowed AR experiences to be possible not only in personal computers but also on mobiles of high performance, tablets and smartphones. These devices have a great potential due to their mobility and popularity. Internationally, there are various groups in public and private sectors now that have participated in this subject, resulting in the development of toolkits for image recognition, ARToolKit [3], visualization and rendering of 3D models, metaio [4], or geolocation, Layar [5].

J. Ierache, N. A. Mangiarua, S. A. Bevacqua, N. N. Verdicchio, M. E. Becerra, D. R. Sanz, M. E. Sena, F. M. Ortiz, N. D. Duarte, and S. Igarza are with the Augmented Reality Research Group of the Engineering Department (DIIT) in the National University of La Matanza (UNLaM), San Justo, Buenos Aires, Argentina (e-mails: jierache@ing.unlam.edu.ar, nmangiarua@ing.unlam.edu.ar, sbevacqua@unlam.edu.ar, realidadaumentada.unlam@gmail.com).

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them. The content creator is the only one with the ability to manage and share contents with other users, who can only visualize them.

In this paper we present the development of a Catalogs System for Augmented Reality Applications (CSARA), which acts as a tool to create, publish, exploit and manage contents and AR applications built for different domains, such as education, tourism, commercial and industrial applications, without the initial need of expert users. It provides intuitive interfaces for these functions in a collaborative context, without depending entirely on services and/or sensors of mobile devices for the proper operation of the application.

IV. THE PROPOSED SOLUTION

In order to provide a solution to the abovementioned problem, an AR Catalog system has been designed by the Augmented Reality Research Group of the Engineering Department of the National University of La Matanza. The concept behind the CSARA relies on multiple groups of Markers defined by the user, which link physical objects with a determined amount of virtual contents that are also designed by the user in regard to their criteria. This also provides the user with the possibility to share their Catalogs with a specific group of people or publish them publicly. This means that an augmented social environment that emerges from reality is achieved.

The CSARA pretends to demonstrate that the creation of AR contents can be performed by any individual without any specific knowledge in Computer Science with the objective of being shared and exploited in a completely elementary manner, leaving aside the technical and programming difficulties that often appear when trying to use this kind of technology. The proposed solution provides a web application and mobile application, two platforms that are very popular at the present time.

This will allow the user to create a Catalog for a specific topic of their desire (which might be for educative, commercial, industrial, entertainment or even cultural purposes), and later on to be published with the purpose of contributing to their community with the augmented product. In the proof of concept section, a detailed explanation on some implementations of the Augmented Virtual Catalog system in different fields of application can be found.

Regarding the system's behavior, it acts as a framework that allows the user to declare Markers over a preselected surface inside the operating domain, then the user starts the AR application in a mobile device or computer.

Using the mobile device's camera, the user can observe on the screen the enrichment of the real environment that surrounds them, by virtue of the addition of virtual elements, which may range from audio, 3D objects, text, images to videos. All of them have attributes such as scale, rotation and position relative to its Marker. The user interacts with the elements of the proposed solution without leaving aside their presence on the real environment. Fig. 1 shows the abovementioned elements.

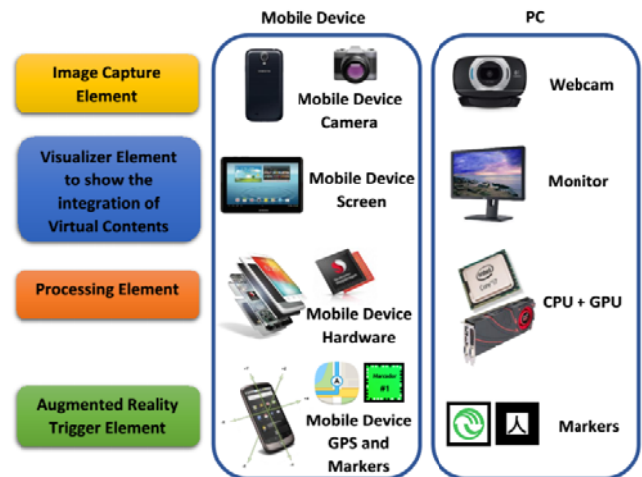


Fig. 1 Basic elements of Augmented Reality devices

V. CSARA IMPLEMENTATION

Catalogs System for Augmented Reality Applications (CSARA), provides a distributed design, which consists in three applications with exclusive responsibilities, it accomplishes a great scalability and modularization, allowing a simple integration of new components in the future. These main functionalities are described at the next paragraphs:

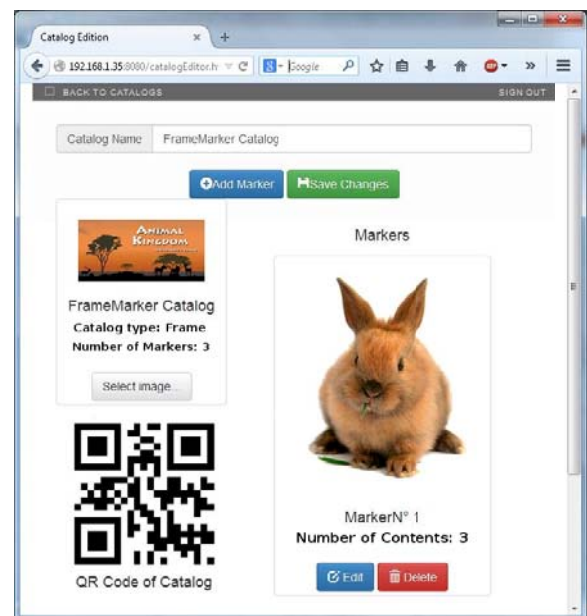


Fig. 2 Catalog Editor Screen

A. Catalogs System for Augmented Reality Applications, Web Editor

This application has the purpose of acting like a Catalog's web editor, this allows the users to create, edit and share contents of AR from their mobile devices or PC with online access through the Catalog's system.

If you want to build a Catalog, first of all the user has to be logged into the web application. Then, they will be able to create an empty Catalog's instance, which will be shortly described below. The next steps consist in adding Markers and

contents to the Catalog previously created.

Fig. 2 shows a Catalog's menu, which was created by a user through the web application. Each Marker can be enriched with different kinds of augmented contents like texts, images, sounds, videos and 3D models. Moreover, Fig. 3 shows the section of marker's editor of the web application.

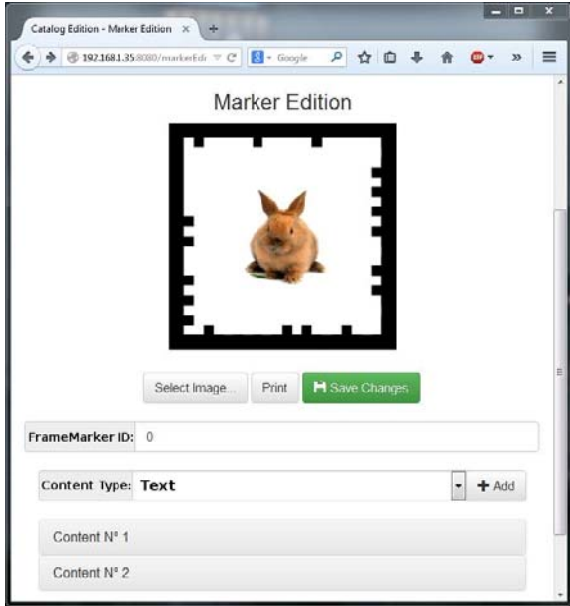


Fig. 3 Types of contents for a Marker

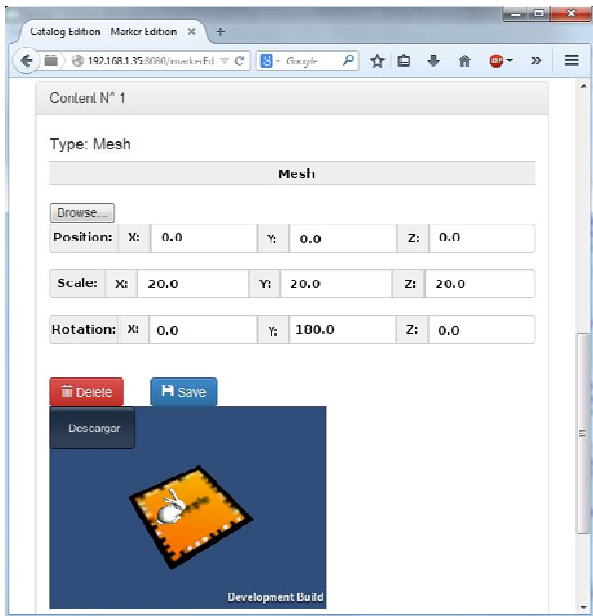


Fig. 4 3D Content Web Editor

Likewise, each content has a position, a rotation and a scale, which are relatives to the Marker that includes them. These parameters are taken by the 3D web's editor, which locates the content in relation to these values. Fig. 4 shows the 3D web's editor screen.

This web's application is developed under the HTML

standard with a JavaScript implementation and public domain libraries like jQuery [16] and Bootstrap [17].

Regarding 3D web content's editor, the same viewer is implemented as in the mobile application, ensuring the correct content positioning.

The online editor was developed in Unity3D [18] the same as the Catalogs System for Augmented Reality Applications Base Viewer's Application, allowing users to locate, rotate and scale marker's contents.

The web editor is supported by a Java [19] back end through an Apache Tomcat [20] server and Spring IO Platform [21]. From these components, we acquire flexibility and reutilization of mainstream tools, which dramatically decreases implementation's resources.

B. System's Main Application

The main application of the Catalogs System for Augmented Reality Applications (CSARA) plays the role of the back end of the web application, providing services to create, edit and storage Augmented Reality application through a Web Service. The Web Service implements a RESTful (Representational State Transfer) API [22] using the HTTP protocol and URL mapping, increasing the system's reusability and offering the possibility to use it by any application that is compatible with the RESTful API's methods. Besides that, the API provides the four basics functions of CRUD (Create, Read, Update and Delete) to any element contained in the CSARA., implementing a Protocol Buffers' serialization [23] and the LZMA library [24] for data compression. Both of them are public domain's libraries and have implementations in the most common programming languages.

The API Rest is also served by a Java environment using the Spring Framework and Apache Tomcat. The data storage can be handled by any DBMS (Database Management System) with JDBC support. Therefore, H2 [25] was used in the development environment and MySQL [26] in the testing environment for the first prototype of the CSARA. Fig. 5 shows components, tools and frameworks that were used in the main application of the CSARA.

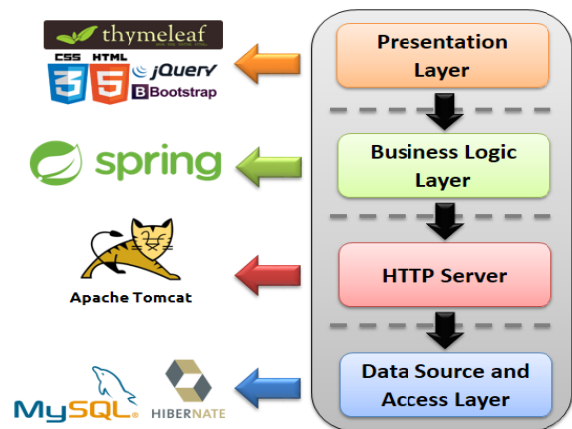


Fig. 5 Conceptual Component Diagram of the Main System Application

C. Catalogs System for Augmented Reality Applications, Base Viewer Mobile's Application

This application acquires Catalogs through the RESTful API and works like a viewer platform for the Augmented Reality contents. This application uses the integrated camera, built-in sensors and processing capabilities of any Android mobile device. In the first place, the user has to login into the CSARA. Then they would be able to download and visualize Augmented Reality application that was created in CSARA with the aid of the web application. This mobile application was developed for Android mobile devices in Unity3D, a multi-platform graphics engine, with the Vuforia [27] library, which is a recognition library of Markers. Fig. 6 shows in a conceptual diagram, components, tools and frameworks that were used in the mobile application.

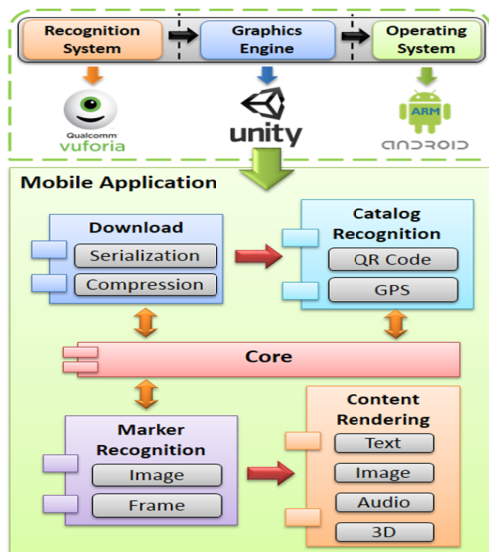


Fig. 6 Conceptual Components Diagram of Mobile Catalog's Viewer

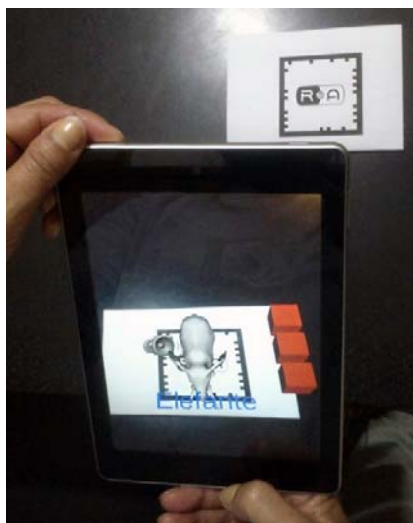


Fig. 7 Android Mobile's Application showing contents from CSARA

Fig. 7 shows the mobile application running, where some contents of a previously created catalog are shown. These

contents can be activated or deactivated from the same application through a few state change blocks, which act like buttons.

VI. SPECIFIC PROOFS OF CONCEPT

Despite the fact that the CSARA was designed and currently developed to carry out its basic functionality, in order to identify some of the most relevant application areas, it has been implemented independent proofs of concept. These developments set the focus on users in a specific context, to identify key elements that are necessary to ensure the suitability of an Augmented Reality Applications. Therefore, the CSARA is now concentrated in potential test applications, which are listed below.

A. Augmentation of Traditional Teaching Aid

In educational context, the need to transmit contents dynamically between teachers and students was detected. To this end, we offer the possibility to create virtual catalogs with a sequence of contents, using elements in an educational institution as AR markers, such as a simple map of a country or continent. The purpose of the augmentation of traditional teaching aid application is that teachers and students share information in a dynamic collaborative environment, using a simple editor that promotes the tasks. In [28] a proof of concept was developed as a potential implementation, to know the interest in the educational community and the versatility of the products of the tool. At the Congress of Technology in Education and Education in Technology 2014 (TE&ET), teachers expressed their interest in the tool and its acceptance with the presented development. Fig. 8 shows how the application Mapa Aumentado [29] recognizes a map of Argentina and superimposes additional information on it, in this case, coloring the different geographical regions of the country. Clicking on any of them, detailed information of the particular region appears in text and audio format.



Fig. 8 Mapa Aumentado RA's Application

B. Augmented Reality Applied to Art

Every two years on the National University of La Matanza campus, the event Bienal de Arte Integral takes place, which is focused on social inclusion through art. This event has as its main attraction a sample of art works from various artists from around the country.

In November 2014, we present a mobile application, called Bienal de Arte Integral 2014 [30] which contributed to the Catalogs System for Augmented Reality Applications as a proof of concept, enriching the art works. To achieve this task, it was designed more than 30 custom AR markers with the artists and a printed catalog of their works under the event. These custom markers were placed next to the appropriate work and with each artist in the printed catalog. Fig. 9 shows how the application recognized these markers and allowed users to view and learn more information about the artist and his work, with the possibility of sharing the information on social networking sites such as Facebook and Twitter.



Fig. 9 Bienal de Arte Integral 2014's Application

VII. FUTURE WORK

Each subsection describes the future work with Catalogs System for Augmented Reality Applications (CSARA):

A. Real-Time Dynamic Contents

We want to allow users to add dynamic contents on Markers, which change their state in real time with data obtained via Web.

For example, a user could be able to link certain Markers with a Twitter Hashtag in order to visualize in AR a list of tweets that include said hashtag in real time. In a similar way, it is possible to link and update in real time the information included in SQL databases.

Another example, in the industrial field, is to show data of interest that is managed by a SCADA (Supervisory Control And Data Acquisition) control panel. The CSARA would get the virtual information from an external source to link it to a marker. In this way, the machine supervision is enriched, augmenting the industrial environment with relevant information. As an example, a concept proof is shown in Fig. 10, where the information would be supplied by the manufacture system included in the frame of the Data

Acquisition and Supervision System that are updated dynamically in the catalog. In this application domain, the catalog would be considered as the company owner.



Fig. 10 Example of an AR Industrial Mobile Application

B. Geolocated Augmented Reality Contents

The user will be able to opt for the creation of Geolocated Virtual Catalogs. By using the device GPS and its network connection, it will be possible to know the accurate location of the user with the purpose of visualize Geolocated Virtual Catalogs that are located near their position. As a possible implementation, there could be a Geolocated Virtual Catalog that works as a touristic guide which is activated in the user's device when it is near from a previously defined touristic zone.

C. Didactic Games with Feedback

Along the lines of didactic and interactive games with feedback, we want to develop a Virtual Evaluation Tool. This tool allows students to incorporate new knowledge about subjects which are chosen by the teachers. An Augmented Reality Applications have Markers, which define categories and knowledge fields, with virtual questions associated. The Virtual Questions' contents have a question shown after a video is displayed. When a student focuses on a marker, a random video will be played in an AR environment. Then, the student will be required to answer a question about the video by selecting one of the options. All the answers are stored and evaluated for further feedback. Based on the results obtained in each category, the application will suggest the student to improve their knowledge in the fields that they might have not achieved a passing mark.

In addition, we developed Juega PulsAR Play [31], a Question and Answer Augmented Reality Video Game, where two players share a Smartphone and a physical game board. The objective is to be first player to reach the end of the path by answering a series of randomized questions. In order to be able to play, the user needs a physical game board which was designed with Markers specifically for this application. All the spaces on the path are Markers. Each one represents different categories, which can range from history, music, to movies. A 3D model of a pawn piece represents the player position on the path. Each turn a player rolls a virtual dice, the pawn moves to the determined location. Then a video is played over

the Marker in said location. After the video a question is prompted with 3 possible answers, a picture of a player selecting an answer is shown in Fig. 11. If the player answers correctly, they will have a chance to throw the dice again. If the answer is incorrect, the other player ends their turn.



Fig. 11 Juega PulsAR Play's Application

Based on our experience and feedback from users of this application, we considered to apply the same mechanism for pedagogical purposes. This tool tends to motivate the participation and consequently the acquisition of knowledge. The teacher creates an instance of an Augmented Reality Applications in to CSARA for games with the features mentioned, specifying a set of questions and answers for each category.

Along the lines of dynamic videogames published in the CSARA, we develop an AR video game; called El Imperio Re Contraataca RA [32] Fig. 12 shows the in-game perspective of this application. The objective is to destroy all the enemy's spaceships. This application received positive feedback during the series of local technology events such as ExpoProyecto 2014 and PlazaCiencia2014 in which we took part. These events helped us to improve our practices with certain tools and frameworks to develop mobile applications for Android, Unity3D and Vuforia.



Fig. 12 El Imperio Re Contraataca RA's Application

VIII. CONCLUSIONS

Initial demonstrations of the system were made in [33] allowing users to attach contents such as images, audios, texts

and videos to a Marker through the CSARA Web Editor. And then, they were able to download and visualize their creations thank to the Mobile Catalogs Viewer Application installed in their Android mobile devices.

Our goal is to give the possibility of using AR technologies to any user through the CSARA, where everyone can contribute by sharing their creations and AR contents to other users in a simple way.

We provide an integration service between virtual object and the reality, using new technologies that society can use to be more participative in the Web 2.0 environment.

In 2015 we expect to launch CSARA for high school institutes in La Matanza District, Buenos Aires, Argentina. This will allow both teachers and students to create, edit and share AR catalogs among them, improving the teaching process in the classrooms.

REFERENCES

- [1] C. Manresa Yee, M. J. Abásolo, R. Más Sansó, M. Vénere, "Realidad virtual y realidad aumentada. Interfaces avanzadas", 1st ed., National University of La Plata, La Plata, 2011.
- [2] R. T. Azuma, "A survey of augmented reality", in *Presence: Teleoperators and Virtual Environments*, vol. 6, no. 4, pp. 355-385, August 1997.
- [3] ARToolkit, <http://www.hitl.washington.edu/artoolkit/>, last accessed, November 2014.
- [4] Metaio, <http://www.es.metaio.com/>, last accessed, November 2014.
- [5] Layar, <https://www.layar.com/>, last accessed, November 2014.
- [6] M. Billinghurst, H. Kato, I. Poupyrev, "The MagicBook: a transitional AR interface" in *Elsevier: Computers and Graphics*, vol. 25, no. 5, pp. 745-753, October 2001.
- [7] Zugar, <http://zugar.com/>, last accessed, November 2014.
- [8] Visual SyncAR, <http://www.diginfo.tv/v/13-0014-r-en.php>, last accessed, November 2014.
- [9] Wikitude, <http://www.wikitude.com/>, last accessed, November 2014.
- [10] Layar, <https://www.layar.com/>, last accessed, November 2014.
- [11] Rocket Racing League, <http://www.rllgames.com/>, last accessed, November 2014.
- [12] Recognizr, http://readwrite.com/2010/02/24/recognizr_facial_recognition_coming_to_android_phones, last accessed, November 2014.
- [13] J. Subhalaxmi, "Project Glass: Google glasses". Koustuv Institute of Technology Chandrasekhar, Patia, 2014.
- [14] Viewar, <http://www.viewar.com/>, last accessed, November 2014.
- [15] Zappar, <http://www.zappar.com/>, last accessed, November 2014.
- [16] jQuery, <http://jquery.com/>, last accessed, November 2014.
- [17] Bootstrap, <http://getbootstrap.com/>, last accessed, November 2014.
- [18] Unity3D, <http://unity3d.com/es>, last accessed, November 2014
- [19] Java, <http://www.oracle.com/us/technologies/java/standard-edition/overview/index.html>, last accessed, November 2014.
- [20] Apache Tomcat, <http://tomcat.apache.org/>, last accessed, November 2014.
- [21] Spring IO, <http://spring.io/>, last accessed, November 2014.
- [22] R. T. Fielding, "Architectural styles and the design of network-based software architectures". Doctoral dissertation, University of California, Irvine, 2000.
- [23] Protocol Buffers, <https://developers.google.com/protocol-buffers/docs/overview>, last accessed, November 2014.
- [24] LZMA, <http://www.7-zip.org/sdk.html>, last accessed, November 2014.
- [25] H2, <http://www.h2database.com/html/main.html>, last accessed, November 2014.
- [26] MySQL, <http://www.mysql.com/>, last accessed, November 2014.
- [27] Vuforia, <https://developer.vuforia.com/>, last accessed, November 2014.
- [28] J. Ierache, N. Mangiarua, S. A. Bevacqua, M. Becerra, N. Verdicchio, E. de la Llave, N. Duarte, D. Sanz, F. Ortiz, S. Igarza, "Herramienta de Realidad Aumentada para la explotación de material didáctico tradicional" in *TE&ET 2014: IX Congreso de Tecnología en Educación y Educación en Tecnología*, 1st ed., pp. 250-254, June 2014.

- [29] Mapa Aumentado RA, <https://play.google.com/store/apps/details?id=com.unlam.realidadaumentada.mapaaumentadoargentina>, last accessed, November 2014.
- [30] Bienal de Arte Integral 2014, <https://play.google.com/store/apps/details?id=com.unlam.realidadaumentada.bienaldearteintegral2014>, last accessed, November 2014.
- [31] Juega PulsAR Play, <https://play.google.com/store/apps/details?id=com.unlam.realidadaumentada.juegapulsarplay>, last accessed, November 2014.
- [32] El Imperio Re Contraataca RA, <https://play.google.com/store/apps/details?id=com.unlam.realidadaumentada.elimperiorecontraataca>, last accessed, November 2014.
- [33] J. Ierache, N. Mangiarua, S. A. Bevacqua, M. Becerra, N. Verdicchio, M. Sena, N. Duarte, D. Sanz, F. Ortiz, S. Igarza, "Sistema de catálogo para la asistencia a la creación, publicación, gestión y explotación de contenidos multimedia y aplicaciones de realidad aumentada" in *XX Congreso Argentino de Ciencias de la Computación*, 1st ed., pp. 918-927, October 2014.