Augmented reality mobile information system for the obtaining detailed and non-intrusive information in large environments

Sistema de información móvil de realidad aumentada para el obtención de información detallada y no intrusiva en grandes entornos

Sistema de informação móvel de realidade aumentada para o obtenção de informações detalhadas e não intrusivas em grandes ambientes

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Abstract

Introduction: This article is the result of the augmented reality project "AR position U" for the effective visualization of information of interest dynamically through augmented reality, carried out in the year 2022 in the city of Popayan, capital of the department of Cauca.

Problem: Problems have been identified regarding the location of spaces in very large places by people who have no knowledge of the site causing loss of time and frustration, to the point of being late to the desired location. This leads to the following problem question: What would be the impact of the implementation of an augmented reality application, whose purpose is to provide detailed information to people in a non-intrusive way in large environments?

Objective: To propose a mobile information system that allows users to orient themselves and obtain detailed information in a dynamic and non-intrusive way in large environments through augmented reality.

Methodology: The experimental methodology is used, since a series of tests were determined to reach the validation of the information system, in order to have a product that was articulated with the guide of good practices of project management and meets the needs of the population to which it could be directed.

Results: As a result, the information system based on augmented reality was obtained, allowing for the easy location of spaces due to the usability of the product.

Conclusion: Based on the experimental methodology, it is determined that, although augmented reality improves the detailed descriptions of large environments, it is very limited to the external conditions; however, the tool meets the proposed objectives.

Originality: Augmented reality information system for orientation in large places and obtaining information in a non-intrusive way, under the PMBOK and XP methodology.

Limitations: Due to complexity and time constraints, it is not possible to cover all faculties. On the other hand, 3D interface is only generated by QR tags. On the other hand, the correct functioning of the system can be affected by lighting factors, the distance of the user from the tag, the hardware and software capacity of the smartphone and the internet connection.

Keywords: Augmented Reality, environment, mobile devices, overlay.

Resumen

Introducción: Este artículo es resultado del proyecto de realidad aumentada "AR position U" para la visualización efectiva de información de interés de forma dinámica mediante realidad aumentada, llevado a cabo en el año 2022 en la ciudad de Popayán, capital del departamento del cauca.

Problema: Se ha identificado problemas en cuanto a la localización de espacios en lugares muy grandes por parte de personas que no tienen conocimiento del sitio que necesita ubicar ocasionando pérdida de tiempo, frustración hasta el punto de llegar tarde a la ubicación deseada. Lo anterior, desencadenando la siguiente pregunta problema: ¿Cuál sería el impacto que tendría la implementación de un aplicativo de realidad aumentada, cuyo fin es brindar información detallada a las personas de manera no intrusiva en ambientes grandes?

Objetivo: Proponer un sistema de información móvil que permita a los usuarios orientarse y obtener información detallada, de forma dinámica y no intrusiva en ambientes grandes mediante la realidad aumentada.

Metodología: Se emplea la metodología experimental, dado que se determinaron una serie de pruebas para llegar a la validación del sistema de información con el fin de tener un producto que estuviese articulado con la guía de buenas prácticas de gestión de proyectos y satisfacer las necesidades de la población a la cual podría estar dirigida.

Resultados: Como resultados se obtuvo el sistema de información basado en realidad aumentada permitiendo la fácil ubicación de espacios debido a la usabilidad del producto.

Conclusión: Con base en la metodología experimental se determina que, si bien la realidad aumentada mejora las descripciones detalladas de los ambientes grandes es muy limitado a las condiciones externas; no obstante, la herramienta cumple con los objetivos propuestos.

Originalidad: Sistema informativo de realidad aumentada para la orientación en lugares grandes y obtención de información de forma no intrusiva, bajo la metodología del PMBOK y XP.

Limitaciones: Debido a la complejidad y limitantes de tiempo, no es posible abarcar todas las facultades. Por otro lado, interfaz 3D solamente se genera mediante etiquetas QR. Por otro lado, el correcto funcionamiento del sistema se puede ver afectado por factores lumínicos, la distancia del usuario respecto a la etiqueta, la capacidad tanto de hardware como software del smartphone y la conexión a internet.

Palabras clave: Realidad Aumentada, Ambiente, Dispositivos móviles, Superponer.

Resumo

Introdução: este artigo é o resultado do projeto de realidade aumentada "AR position U" para a visualização efetiva de informações de interesse de forma dinâmica através da realidade aumentada, realizado no ano de 2022 na cidade de Popayán, capital do departamento de Cáuca.

Problema: Têm sido identificados problemas quanto à localização de espaços em locais muito amplos por pessoas que não possuem conhecimento do local que precisa ser localizado, causando perda de tempo, frustração a ponto de chegar atrasado no local desejado. Diante do exposto, surge a seguinte questão-problema: Qual seria o impacto da implantação de um aplicativo de realidade aumentada, cuja finalidade é fornecer informações detalhadas às pessoas de forma não intrusiva em grandes ambientes?

Objetivo: Propor um sistema de informação móvel que permita aos usuários se orientar e obter informações detalhadas, de forma dinâmica e não intrusiva em grandes ambientes por meio de realidade aumentada.

Metodologia: É utilizada a metodologia experimental, uma vez que foi determinada uma série de testes para chegar à validação do sistema de informação de forma a ter um produto que se articulasse com o guia de boas práticas de gestão de projetos e satisfizesse as necessidades da população a que se destina. poderia ser dirigido.

Resultados: Como resultado obteve-se o sistema de informação baseado em realidade aumentada, permitindo a fácil localização dos espaços devido à usabilidade do produto.

Conclusão: Com base na metodologia experimental, determina-se que, embora a realidade aumentada melhore as descrições detalhadas de grandes ambientes, é muito limitada às condições externas; no entanto, a ferramenta atende aos objetivos propostos.

Originalidade: Sistema de informação de realidade aumentada para orientação em locais amplos e obtenção de informações de forma não intrusiva, sob a metodologia PMBOK e XP.

Limitações: Devido à complexidade e limitações de tempo, não é possível cobrir todas as faculdades. Por outro lado, a interface 3D é gerada apenas por tags QR. Por outro lado, o bom funcionamento do sistema pode ser afetado por fatores de iluminação, distância do usuário da etiqueta, capacidade tanto do hardware quanto do software do smartphone e da conexão com a Internet.

Palavras-chave: Realidade Aumentada, Ambiente, Dispositivos Móveis, Overlay.

1. INTRODUCTION

Many years ago, augmented reality [1] was conceived as science fiction, but today it has scientific bases that support it, in addition to technological advances and the miniaturization of things, which has led to an increase in processing capacity within computer systems and a decrease in costs, which has made access to this technology possible. It is important to highlight the use that can be given to augmented reality, which is very varied: it has great potential in education, business, and the video game sectors, among others. Great benefits have been seen in using augmented reality both for different daily tasks as well as in the professional field. An example of this is the interaction with interfaces in the real world that allows architects or the final client to see the predesigned structures in the same place, giving a more approximate and effective idea of visualizing the final result. In this same sense, the use of this technology has a beneficial potential that, when implemented in large complexes such as: airports, educational campuses, factories, among others, will allow real-time visualizations to be issued, such as showing people where to go or providing virtual advertising of said place without damaging the real environment with visual noise.

Consequently, the need arises for an augmented reality tool that helps people find their way around large places, avoiding interference if necessary. For the development of this idea, an experimental methodology is used, where the effectiveness of the system is tested, which consists of a mobile information system that allows, through the use of a camera, to generate superimposed elements on the real world. Said element consists of a graphical interface that shows the information of an environment in a detailed and dynamic way, having the ability to interact with the user.

As a way of validation, this system was implemented under a controlled scenario in the University Institution to which it belongs, allowing students to organize their schedule and optimize their time, obtaining a better coexistence within the facilities.

2. RELATED WORKS

The search for similar jobs where Augmented Reality was implemented helped clarify the different environments in which it can be applied and the benefits they bring; as a reference, we have the following:

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Universidad Cooperativa de Colombia

Medellín has the first Smart Tourism Center in the country, a 4.0 experience for visitors.

Medellín – Colombia [2] looks to be at the forefront of technology and sustainability to offer a unique experience to tourists or nationals. This is done through the Smart Tourism Center, the first in the country, that through the Medellín Travel mobile application provides key information about different tourist places in the city and also has the option of augmented reality that allows you to view typical elements of the Paisa culture, old photographs and thus learn a little about its history.

Augmented reality as a didactic resource for the teaching and learning of historical heritage. The building of the mosaic of the loves of the archaeological complex of Cástulo (linares, jaén).

The archaeological discoveries that have been made in different parts of the world and are on display do not show enough information to convey what is displayed, even more so when the observer has no knowledge of archeology. In this way, by implementing augmented reality, it facilitates the visualization of information for the visitor and provides a 3D image of how it could have been in the past, generating unique experiences and helping the visitor understand the history that it brings with it [3].

Augmented reality mobile application for the location of the classrooms in the Porvenir Campus of the University of the Amazon.

Being able to locate the classrooms within an educational complex in the first days of class at the beginning of the semester is complicated as a new student, which has the negative effect of being late to the classrooms, entering classrooms by mistake or simply causing interruptions in the development of the work. At the University of the Amazon, a mobile application (SARA) that uses augmented reality offers an alternative for being able to discover the different environments that the Future Campus of the entity contains, thus guiding the student in a more effective and timely manner [4].

Campus Guide using Augmented Reality Techniques

The purpose of the application is to allow students and teachers to obtain information on:

- Classrooms: Know if it is available or not, if it has an internet connection.
- Administrative offices: Office hours, contact information to facilitate communication.

In addition to that, it is practical and interactive for the user, since information is obtained through augmented reality using the camera of the mobile device, which is of great help for all staff and even more so when you are new to the university, locating the user within the educational complex and thus improving arrival times to classrooms [5].

Augmented reality using Vuforia for residential marketing

Through the application, the way in which the sale of real estate is understood and promoted is changed, since it is not necessary to travel to its physical location to be able to observe it in detail. This was done through the application of augmented reality to generate the property in 3D, allowing the potential buyer to visualize the place interactively and also making it easier for them to obtain more information, rendering it no longer necessary to make an appointment with the owner [6].

An Augmented Reality App for Smart Campus Development - MSKU Campus Prototype

Smart cities allow locals or tourists to improve interactions and thus guarantee meaningful experiences when visiting the place, with this approach applied to the smart campus. For example, "The University of Exeter disappeared a dynamic AR landscape of flora and fauna. Using Augmented Reality, the campus was transformed into accessible learning materials and resources to support the formal and informal curriculum" [7]. This kind of implementation benefits all staff of an educational institution, whose benefit is obtained through the use of a mobile device that facilitates interaction between students and the entity by having information more efficiently.

Service architecture for the location of people and objects in closed spaces

This was a thesis in marking for a Master's degree in Computer Science carried out by the authors [8]. Due to the difficulty generated when arriving at a shopping center for the first time, where it is difficult to locate and find a point of reference without any guide, the authors propose a service architecture that allows adapting in an easy and less complex way to the different modular components of a localization application in closed spaces, allowing configuration without modifying the services it provides. This is taken as a reference given that the purpose is similar, differentiating it in terms of the use of the technologies used for its construction.

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Universidad Cooperativa de Colombia

ICT applied to cultural heritage: use, dissemination and accessibility. The roman amphitheater of Cartagena

In this project, the authors [9] propose the design and use of a free augmented reality and virtual reality tool to help the archaeologist to fully digitize the Roman amphitheater of Cartagena to provide accessibility to the elderly and people with motor disabilities that prevents them from visiting. This work is very important because it shows the advantages of making use of this type of emerging technology to navigate a place.

Mobile augmented reality prototype for a mass transportation system in the city of Barranquilla

The authors [10], through augmented reality, seek that public transport users can visualize nearby routes and parking lots with the aim of facilitating movement by providing effective and truthful information using the Android platform and the OpenGL library. This article contributed the study of the platforms which was important for the implementation of the app that is proposed as AR position U.

Means of tourist interpretation through the use of augmented reality in the Cuicocha lagoon

The author [11] posited that the use of augmented reality technology has become an important factor in different fields of action. To comply with this work, research methods, techniques and instruments were specified, as well as the tourist context where the implementation of augmented reality was carried out in order to manage the provision of information for the Lagoon of Cuicocha in an interactive and dynamic way. This project shows the importance of using augmented reality as a means of tourist support for those who visit this place.

Augmented reality and geographic content in educational itineraries. Didactic proposal for its enhancement in the training of Primary Education teachers

In this article [12], the authors present a proposal where they intend to show the geographical contents in a significant way through the didactic methodology based on constructivism in order to create a significant teaching-learning process through augmented reality as a complementary instrument.

Traveling to other worlds. Virtual reality and augmented reality in cultural spaces

Here, the author [13] presents the realities regarding the use augmented and virtual reality with respect to the inclusion of cultural dissemination and its commercial exploitation. This article was very important since it could support the justification of the proposed tool.

Use of augmented reality in teaching - learning of Natural Sciences

In this article [14], the authors propose augmented reality as an instrument for the teaching and learning of Natural Sciences, where animations were recreated in a dynamic way that helped reinforce the learning of the contents in an interactive way. This work was referenced for its methodological process model.

It is important to mention the different theoretical bases that support the work and, in turn, highlight the use of augmented reality in different scenarios:

Augmented reality

There are two technologies that can be confused; therefore, it is important to highlight the differences between "virtual reality" vs "augmented reality". Despite having similarities, virtual reality detaches the user from reality and augmented reality allows reinforcing reality with digital projections through equipment such as smartphones or tablets [15].

History

In 1901, the writer Frank Baum imagined glasses that allowed information about people to be visualized. In 1957, Morton Heiling, a cinematographer, implemented augmented reality through his Sensorama, improving the user experience. However, time passed, and in the 1990s, the Boeing researcher Thomas Caudell coined the term augmented reality [16].

Definit[i]on

Augmented reality is a technology that allows generating new experiences by combining the digital world and the physical world from an easily accessible device such as the mobile phone [1].

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Universidad Cooperativa de Colombia

How does it work

Augmented reality is based on superimposing virtual objects that can be in 2D or 3D on the real world. For its execution or operation, it requires the following elements:

- Camera: which is responsible for capturing images of the real world.
- Device that allows for the visualizing of the result of the combination of the virtual and the real.
- The application in charge of carrying out the combination.
- A Marker: a physical image that acts as the trigger for augmented reality, and to which the virtual elements are anchored. It is identified by the device's camera and the software processes the image to carry out the required actions.

Augmented reality applications

The use of augmented reality when applied facilitates the interaction and understanding of the real world. This is applicable in different areas where human beings interact:

Games

Games are a clear example that allow us to demonstrate the evolution of this technology. Augmented reality transforms the game environment and allows greater realism, thus generating new experiences. The Pokémon video game was launched in 1996 for the Nintendo Game Boy console, and after 20 years through the course and evolution of the different game consoles, it has now reached the screens of mobile devices with "Pokemon Go" that implements augmented reality which, according to the dynamics of the game, through the camera and GPS of the mobile device, you must search and catch the creatures called Pokémon that are in the player's environment [17].

Teaching [18]

The strategies that teachers use to teach imply a lot in the speed of learning of the given subject, even more so when there are technological tools that support the development of this activity, allowing to visualize objects in 3D from what facilitates having a better perception and comprehension. One example is for architecture students; they can generate elements of a building and in this way speed up the generation of ideas and architectural proposals. Another example would be the Google SkyMap application, which superimposes information regarding stars as the user observes the sky through the mobile device's camera.

Marketing and sales [19]

Marketing represents a fundamental part of many companies, because the demand for a product depends on the marketing strategies used to capture the attention of the consumer; even more so when they involve innovative sales methods or seek the comfort of the client. By implementing augmented reality in sales, customers will be able to test the product without having to have it physically. Benefits can be had when there is a requirement to measure clothing or accessories, or when trying to fit furniture for a house.

Travel and tour guides

Tourism is an area that has evolved in the way it is promoted in order to attract tourists. In many places, they have implemented technological means that allow tourists to relive the history of the environment through the mobile device. "Latest generation holograms, augmented reality and immersive videos are part of the experiences offered by the center, located in Parques del Río" [20]. It is the first smart park located in the city of Medellín, which focuses on being friendly to the environment using renewable energy and through the Medellín Travel mobile application, the tourist will be able to access images, videos and audio logs regarding the culture of the region.

Maintenance processes

Complex machinery, such as vehicles or aircraft, require strict maintenance processes. Augmented reality allows for the optimization of the repair or maintenance work times by overlaying information about the parts that are being manipulated. This technology may be used by large companies such as Boeing in the aircraft wiring process, or simply by non-experts looking to carry out simple repairs of equipment or installations at home.

Search processes

At present, navigation and search processes have been automated from a device, otherwise it is done through a physical map or by asking people. With technological advances, applications have emerged that optimize this process to find places more easily, such as: parking lots, parks, drug stores, hotels, restaurants, etc. In this way, by implementing augmented reality, the user will be able to view, through the camera and the screen of the device, information on places of interest, or with improved coverage, the streets of a city or the corridors of a building.

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Universidad Cooperativa de Colombia

Medicine

Medicine is a field with a variety of high-risk procedures, so professionals in this area require a lot of context information. Having the 3-dimensional layout of organs or bones involved in a surgical procedure is very helpful by providing information digitally and easily accessible to the interested party. It should be clarified that in this situation markers will no longer be used for their actions, but wave-based systems to obtain said information. Augmented reality in the field of medicine is not specifically defined by the complexity, costs, technological equipment and other implications that it entails; However, there are prototypes. An example is at the Virgen de Rocío Hospital in Seville, which has software with the ability to give a three-dimensional view of a heart and thus provide greater precision, thus facilitating timely diagnoses and avoiding invasive procedures in the patient [1].

Visual search engines

By a different path, but related to augmented reality, are the visual search engines that allow the user, through the camera of his mobile device, to take a picture of the object, plant, animal or text on which they want to obtain more information. Therefore, the environment would become a kind of catalogue, with infinite possibilities. An example is the Google Lens application which has multiple actions such as searching from an image loaded from the device. Activating the camera, it is possible to translate text, identify and copy text, etc., thus speeding up writing text or voice dictation to the search engine [21].

3. METODOLOGY

For the development of this project, it was divided into phases, which in turn were subdivided into tasks allowing control and order in its elaboration. For this reason, for the elaboration of the ARPositionU proposal that is described in this article, *The Guide To The Fundamentals Of Project Management Or Guide* PMBOK [22] was referenced in order to establish the phases in which the project was divided. In this way and through the task breakdown diagram Figure 1, it was decided that this would be under an agile development framework, for which three phases will take place:

- Phase 1. Initiation and planning.
- Phase 2. Execution.
- Phase 3. Training and closure.

3.1. Startup and planning phase: This phase is for the identification and planning of the necessary tasks to achieve the objective of the project and also obtain viability; this from the elaboration of the following activities:

3.1.1. The feasibility study was clarified from the elaboration of: Technical Offer to determine if qualified personnel were available to develop the project, taking into account the scope, perspective and functionality of the product, together with the restrictions.

The Management Offer made it possible to establish the organizational infrastructure based on the task breakdown diagram in Figure 1 and translate it into a Gantt chart where dates were indicated for the execution of the different tasks.

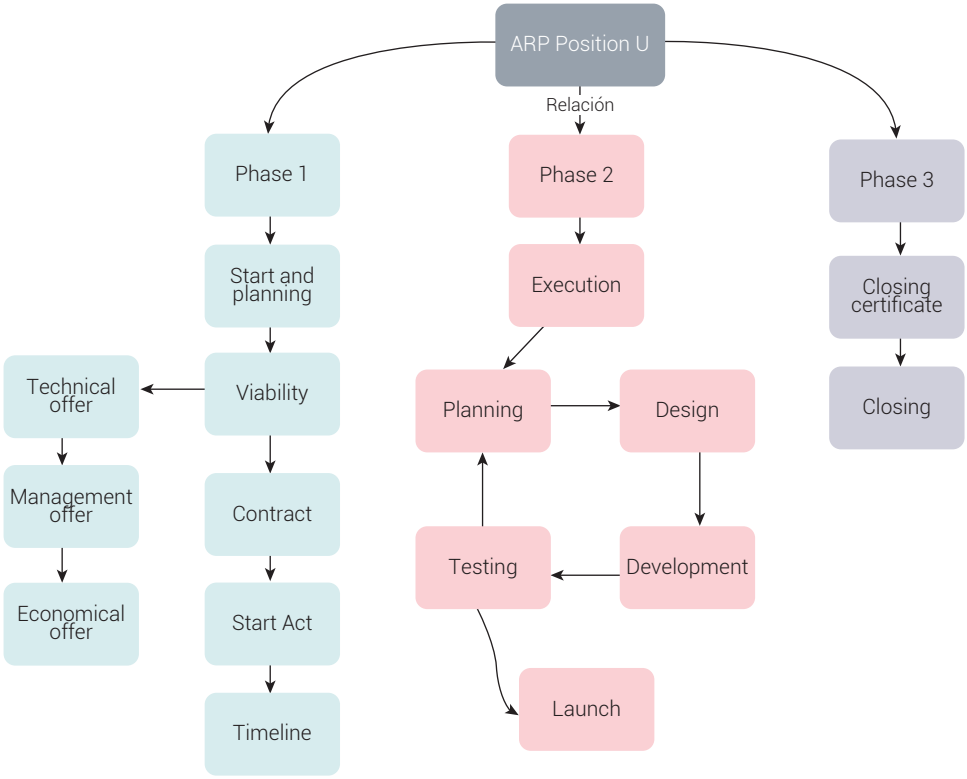

Figure 1. Task Breakdown Structure
Source: Own work

Finally, there is the economic offer, where all the asset flow required for the product was reflected.

In the same way, within the management, a contract and a start-up act were structured to open the proposal that was proposed and start with the development of each of the planned activities.

3.2 Phase 2. Execution: The execution was carried out under an agile development framework, for which the different existing methodologies for this type of development were taken into account and it was decided to implement the XP methodology (Extreme Programming) [23]. Composed of 5 phases, it stands out for having a functional product in a very short time. Iterations are also continuously carried out to obtain a better quality product and it works well for small work teams thanks to its simplicity. It is important to note that this methodology is also extinct thanks to a systematic review of the literature [10], which provided the necessary arguments to reach their selection.

3.2.1. Planning: In this phase of the methodology, the different guidelines that must be met, and the application and the plans to be implemented in the development were defined. It began with the construction of user stories [24], where the functionalities that the system must have were specified. The iteration plan was also established; in this case there were two. In the first iteration, 8 user stories were assigned, which comprised moderate difficulty, and in the second iteration, the remaining 3 user stories.

Table 1. User stories template

STORY NAME	SN - #
How:	
I want:	
For:	
Then:	
Conditions ….	

Source: Own work

3.2.2. Design: Once the iteration plan was established, the simple design phase began with mockups of the different interfaces that are part of the navigation in the application. It was also designed for augmented reality, as can be seen in Figure 2. Additionally, the sequence diagram was generated, in which the functionality of the application is evidenced in an organized way.

Figure 2. Augmented reality interface
Source: Own work

3.2.3. **Development**: The previously established iteration plan and the coding of the functionalities according to the assigned user stories were executed. For this, tools such as: IDE Unity, Visual Studio Code, SDK Vuforia, Firebase were used.

Table 2. Iteration plan template

ITERATION	USER STORY	TASK
1	User account	Authentication and registration interface design
1	Element generation	Interface design AR
		Generating an element for an environment
…	…	…
2	Manage administrators	Add admin
		Edit Admin
		Find administrator
		Remove admin

Source: Own work

3.2.4. **Testing**: The purpose of this stage was to evaluate the fulfillment of the functionalities that were established from the user stories and to verify the fulfillment of the established objectives. For this, the acceptance test plan was

designed by implementing the template (see Table 3). 8 test cases were needed, of which the success was 8 out of 8; in this way, it was possible to verify the correct operation of the application.

Table 3. Acceptance test template

ACCEPTANCE TESTS	
Code: A000	**N° User story**: HU-00
User story:	
Execution conditions:	
Input/execution step:	
Expected result:	
Test evaluation:	

Source: Own work

3.2.5. Launch: Once the 4 previous stages were finished, the ARPositionU mobile application was obtained. for use by students and teachers to facilitate obtaining information from the environments of the engineering faculty, in which the reference labels for the generation of interfaces were installed in augmented reality.

3.3. Phase 3. Training and closure: In the last phase, a focus group was interacted with, to which the main functions of the application were explained, according to their role; they also have the support of the user manual. In this way, it was possible to verify and analyze the user parameters. Finally, the documentation and source code was delivered to close the project.

4. ANALYSIS AND RESULTS

The study of related works was crucial in the consolidation of this proposal, as it allowed us to explore the most suitable platform for developing the tool, and to determine the methodological approach towards its construction. Through the adoption of agile methodologies, we were able to systematically structure each stage of the Extreme Programming (XP) development process. In this regard, the theoretical foundation identified helped us justify the use of Augmented Reality as an interactive means of conveying information. As a result, this theoretical basis enabled us to consolidate our proposal and validate the use of Augmented Reality.

The platform used (Unity) facilitated the accelerated development of the application thanks to its graphic tools and integration with technologies such as Vuforia for the implementation of augmented reality, but with the limitations of working with a version equal to or greater than Android 8.0 and permanent Internet use.

In the tests carried out, it was shown that the download and registration processes in the system required more time than expected, due to the limited speed of the Internet and the additional verification steps outside the application. After this, the user who logged into the application was able to organize some of the subjects corresponding to the schedule of his semester. Finally, these materials can be represented as augmented reality elements in the place where the users were found, facilitating being able to locate themselves within the facilities. For this, the label located near the room must be approached to be able to visualize and obtain detailed information of the event in real-time. These users could publicize the benefits of the presented utility, where arrival times at a destination will be reduced without the need to interfere with the activities that are in progress in said environment.

5. CONCLUSIONS

It was possible to verify the correct functioning of the system, satisfying the needs of users when orienting themselves in a place, avoiding intrusion and improving times, resulting in a useful and accepted tool by the student and teaching community.

Augmented reality by superimposing virtual objects on the real world makes it easy for users to obtain information about a university environment, which is available through an application on a smart mobile device that most people have today. In the same way, it is applicable in different fields, such as: tourism, education, medicine and factories, thus promoting the creation of new projects of this type by recognizing the usefulness it can provide.

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