Use of augmented reality technology and GPS to encourage tourism in the Sucre department

D. Salgado¹, D. Benitez¹, A. Morales¹, M. Gonzalez¹ and N. Huertas²

¹Antonio José de Sucre University Corporation (Colombia). ²Technological University of Bolívar (Colombia).

dsalgado012@gmail.com

Abstract. Globalization has boosted the tourism sector, making it one of the most important economic activities in developing countries in the 21st century, creating the need for urban growth through the construction of new physical infrastructures to guarantee accommodation, permanence, the security and mobility of large masses of people, putting the integrity of cultural heritage at risk. For this reason, the objective of this research is to design a system that integrates various emerging technologies, among which Augmented Reality and the Global Positioning System stand out, in order to develop digital content of cultural heritage and preserve its immaterial value, in addition to allowing the tourist to live a different experience when visiting the host place, superimposing digital information in the places they visit. The type of research is descriptive and technological development. Among the results found, the communication between the different technologies of the proposed system is outlined, as well as the flow of data that allow the functionality of the system. It is concluded that the proposed system contributes to the conservation of cultural objects and expressions through the generation of multimedia content and that it allows tourists to live an innovative experience through the proposed technologies.

1. Introduction

Given the confinement situation, in the department of Sucre, there is a high impact in the tourism sector especially in the coastal areas of the department [1]; with a view to the search for options for tourism, the Antonio José de Sucre University Corporation and the Technological University of Bolivar came together to formulate a project, in relation to the Special Plan of Safeguarding, living paintings of Galeras-Sucre (among others). The project called the "technological tool with digital content for the dissemination of cultural objects or expressions of the departments of Sucre", which is in operation in 2020, is based on the line of action of the Research Programme, which becomes a device of memory and understanding of social phenomena, which contributes to the solution of practical problems [2] and according to Goal 11.4 Sustainable Development Goals. To highlight the need to redouble efforts to protect and safeguard the world's cultural and natural heritage [3].

An earlier project, between these two institutions, allowed to identify the possibilities of involving tourism, promoting creative and tourism vocations within the associative sector, in order to improve productivity and that could benefit communities and/or actors in the territory, establishing the need to promote technological tools [4].

The development of computer sciences offers a wide range of solutions to various problems that arise on a day-to-day basis in all sectors in which human beings operate, creating important changes in the
various activities that are developed in these sectors. Among these activities is tourism, an activity that has taken center stage in recent decades for the drive of globalization, tourism is seen as one of the engines for the economic development of countries, because it generates significant jobs and incomes to the inhabitants of the host places; WTO states that tourism's contribution to the economy depends on the quality and innovative strategies tourism offers, WTO insists that developing countries must practice sustainable tourism in particular in order to obtain the different benefits it offers [5]. For this reason and in order to preserve the cultural and natural heritage of different communities the use of emerging technologies can contribute; among these technological trends are the so-called Augmented Reality or AR and Global Positioning System or GPS, which integrated have the ability to improve the experience of the user's perception of reality, by overlaying multimedia digital content supported by an electronic device with digital camera and GPS sensors.

Therefore, the objective of the following research is to design a system that integrates augmented reality with GPS, to allow to visualize objects and cultural expressions of the department of Sucre. The document is initially organized by exposing the tourist inventories of the department of Sucre (Colombia) and the contribution of AR with GPS to the tourism sector, then describes the methodology used in this study, then the architecture of the system is illustrated by block diagrams and flowcharts, and finally, the discussions and conclusions of the research are generated.

2. Tourism sector and emerging technology

2.1. The tourist inventories, valuation and importance of the Sucre department

Based on the methodology for the elaboration of tourist inventories of Colombia, the collection, respective qualification and diligence of the formats established for this purpose, were obtained from the governorate of the department of Sucre the results taking into account the established by the Ministry of Commerce, Industry and Tourism.

It is important to emphasize that attractive inventories along with other information inputs produced in tourism planning processes constitute important elements for decision-making for both the public and private sectors at the regional and national levels.

The updated categorisation sheets of the municipalities of Sucre correspond to the tourist corridor Golfo de Morrosquillo and Sabana: Coveñas, Corozal, Sampués, San Antonio de Palmito, San Marcos, San Onofre, Sincelejo and Tolú; prepared by a team and the Tourist Magister Edgar Villarraga Amaya, coordinator of the tourism area of the Governorate of Sucre, attached to the Secretary of Economic Development and Environment of the department, updated to May 2020. For the towns Sincé, Galeras, San Juan de Betulia, Los Palmitos, correspond to the project FNT-288 "Design of the tourist product Cultura Sabanera for the department of Sucre" in December 2015, by Jorge Gómez.

Therefore, from the inventories as an official source of consultation, the following results are established for the inclusion of a Sucre tourism system: the total resources are 173, of which 156 are the greater than 60 points and up to 70 (the highest score), the other 17 classified obtained a score of 58 and 59 and were considered as potentially susceptible to improvement of which 9 correspond to immovable cultural heritage; 2 movable material heritage; 4 intangible cultural heritage and 2 natural heritage.

The cultural heritage in terms of craft object techniques, classified from previous inventories [6], is diverse in hammocks woven from woven yarn in loom, bags and table runners. Popular traditional craftsmanship: artisanal technique in totumo; craftsmanship of wooden furniture, cabinet making; artisanal technique in tannery. Traditional popular handicraft in tannery: sandals-saddlery. Indigenous craftsmanship with artisanal seed painting technique and handcrafted techniques of making fabrics in arrow cane with headgear: vueltiao hat, the latter is a cultural symbol of Colombia and around it are identified ethnographic and anthropological investigations of the social and cultural manifestations of the Zenú ethnic group [7].

There is also the classification of cultural heritage, in the category of festivities and events, in addition to the sound and dance musical expressions. For this research, the living paintings of the municipality of Galeras stand out since they constitute a manifestation of popular art and festive and recreational
events. In addition, they meet the requirements of belonging, representativeness, relevance, nature and collective identity, validity, equity and responsibility [2]. It is also a "community artistic expression" that encompasses events, allegory, religious, moral, historical, satirical and everyday events. For this research project within its classification will take into account the first and second place of the traditional and contemporary paintings, from 2014 to 2020.

2.2. Emerging technologies
In the 21st century, emerging technologies are considered to be any technology little known but that creates high expectations in the fields in which they are applied, in terms of the tourism sector can be highlighted among these technologies augmented reality or AR and the Global Positioning System or GPS, which have taken center stage thanks to the arrival of mobile cellular devices that integrate multiple sensors, allowing to detect actions and/or external stimuli to the device that integrates them. The AR and GPS features provide answers to the needs of the tourist in being informed about both historical and cultural data and to be located in unknown places without fear of being lost.

AR is defined as the integration of digital information within physical environments, by overlaying text, 2D and/or 3D animations, videos, graphics among other computer-generated multimedia content displayed through the screen of a technological device [8], such a device must have minimal digital cameras, software that has the properties of reflecting the information on the screen when activating the device camera and a trigger or information activator, which can be 2D images, 2D codes (bar code and QR code), real objects (chairs, doors, among others) and/or geolocation points [9] (see figure 1).

![Figure 1. Structure of an AR system. Source authors of the article](image)

With regard to GPS technology, it provides the possibility to determine the geographical location of an electronic device by identifying the network devices to which the mobile electronic device (Smartphone and Tablet) is connected or directly by the internal GPS receiver, communicating directly with the satellites orbiting the Earth, which are able to locate the devices located somewhere on the planet with a minimum margin of error [10].

It should be noted that the positioning is given by the integration of software technologies associated with the GPS device, which can also be supported by IP location or by geometry of wireless networks. Electronic devices, in addition to geographical coordinate location, can orient cardinal points towards the situation and synchronize other georeferenced information using orientation sensors, magnetometers, inclinometers and inertial sensors, which allows to increase the accuracy of the location of the device [11].

Now, in what concerns AR and GPS studies in the tourism sector, the latest findings reflect that this technology allows the user or tourist to take full advantage of the exploration of the scenarios and attractions of the host place, promoting historical, cultural, social data, entertainment and commercial and economic information in real time and in different multimedia formats, making it an attractive technology especially for new generations that are more likely to use electronic devices [12]. Likewise, AR supports integration with other technologies both at the software level such as the use of databases, applications for photography, artificial intelligence for process automation, software for generating GPS points, among others, and at the hardware level with the use of sensors and actuators such as the accelerometer to measure the movement of the device, gyroscope for reading the orientation of the
device, capacitive sensors for the detection of events on the touch screen, GPS sensors for the geographical location of the device, among others, increasing the autonomy of the tourist, allowing him to explore the destination in an enriched and entertaining way; this integration with other technologies enhances the use of AR and complements functions that especially benefit tourism companies. Another advantage of AR is given in the educational field, because it allows to visualize information from different perspectives, intuitively, interactive, personalized and attractive in real time [13], capturing the attention of the tourists, allowing them to appropriate knowledge of the places, structures and / or tourist spaces, creating awareness of the cultural and heritage wealth of place, managing to convince the tourist that frequent the places visited and protect those riches; It should be noted that through the elaboration of multimedia contents such as photographic, videos and 3D modeling it is contributed to the conservation of cultural heritage, in addition to adding the function of giving life to static elements, allowing the visitor to live a different experience, bringing this group of people closer to cultural spaces and themes, which are regularly ignored by them.

3. Methodology

Research is technological development type, according to MinCiencias, this type of study is given in the application of the results of research or any other type of scientific knowledge, for the design or development of new processes, systems or provision services, as well as substantial technological improvement of materials, products, processes or pre-existing systems, this activity will include the materialization of research results in a plan, scheme or design, as well as the creation of non-marketable prototypes [14]. The purpose of this research is to generate the design of a computer system that integrates augmented reality and GPS technology for the preservation and dissemination of expressions and cultural objects of the department of Sucre located in Colombia.

3.1 Instruments

Based on the methodology for the elaboration of tourist inventories in Colombia, the collection, respective qualification and completion of the forms established for this purpose, were obtained from the government of the department of Sucre; which are based on what is established by the Ministry of Commerce, Industry and Tourism [15]. Los inventarios de atractivos junto con otros insumos de información son de trascendencia para la toma de decisiones para el sector público y privado en los niveles regional y nacional [16].

On the other hand, the bibliographic matrix and content analytical matrix instruments were used to organize the information of the consulted theoretical references and analyze the requirements of a software with augmented reality technology using GPS and physical Target, in addition to the application of this technology, in the tourism sector. Finally, unstructured interviews were conducted with experts in cultural heritages of the Sucre - Colombia region, which serve as a communicative process for the collection of information, which takes place through meetings between subjects, previously agreed and planned [17].

To conduct the research, two phases were developed using the waterfall software development methodology (see Figure 2):

![Figure 2. Waterfall Methodology. Source authors of the article](image_url)
In the requirements phase, the documentary analysis of the information provided by the Sucre Governorate and academic documents research results on tourism-related topics in Sucre and the use of AR and GPS technologies in the tourism sector was carried out, in order to identify the functional and non-functional requirements of the system proposed in this research.

For the design phase, the requirements identified in the previous phase were taken into account and from there, through the use of block diagrams and flowcharts proceeded to the design of the system architecture relating the communication between the different technologies that integrated the operation of the system.

4. Results

4.1. Descripción de Resultados

Initially, a bibliographic review of documents, research results, referring to issues of AR and GPS integrated with the tourism sector was made, which were organized with the help of the bibliographic matrix and later they were analyzed with the help of the analytical matrix of content.

Subsequently, semi-structured interviews were made and developed with teachers M. González and M. Huertas, experts in the area of tourism, which provided information for functional and non-functional requirements. (see table 1).

| Functional requirements                                                                 | Non-functional requirements                                      |
|----------------------------------------------------------------------------------------|-----------------------------------------------------------------|
| The System must provide a means that allows adding Points of Interest (POI).            | The Graphic Interface must be simple and intuitive so that the user does not get lost in the use of the application. |
| The System must superimpose digital content with the use of the web camera, cultural objects and expressions in multimedia format. |                                                                 |
| The System must be able to communicate with the web server.                             |                                                                 |
| The system must recognize points of interest (POI)                                      |                                                                 |

For the development of an application of this type, there are 2 methods to do it, which are Online and Offline, below, the operation of the application is exposed using both methods (see figure 3).

4.1.2. Offline operation via TAG. The following diagram describes the operation of the application and how it reacts to the different actions of the user, it starts by requesting the POI parameters, this process is supported in a web API, if these are not accessible the application will activate the camera and start a recognition cycle of TAG offline, when a TAG is found, the content of this is rendered and then viewed by the user through the device screen, if the user decides to exit it will start to dismount the previously requested resources, otherwise the POI parameters will be requested again.

4.1.3. Online operation via GPS or TAG. When starting, the application makes an AJAX request to the web server, to obtain the JSON control list where it specifies the components that make up each of the POI entities that are uploaded to the web server (the reload function to make the request again, is available as a button on the interface). The application pre-loads the model meshes and the geographical references obtained from the server, and for each geographical reference a single POI entity is created. An algorithm proceeds to generate a geographic matrix with the previously defined POI entities. Then, a cycle begins where the system performs two essential functions in the application and in a process that repeats itself indefinitely:
It captures the GPS data of the device and compares it with the geographical matrix of the POIs by means of an algorithm of approximation and correlation of points, which allows to show a POI as "close as possible". In case of finding a geographical match between the GPS position and one of the POIs in the matrix, the pertinent information of the POI, the textures of the 3D model and associated multimedia content are downloaded from the server to be displayed in the Augmented Reality Viewer.

The feed data of the camera is validated in search of a valid QR TAG within the system. In case of finding a match, the pertinent information of the POI, the textures of the 3D model and associated multimedia content are downloaded from the server to display it in the Augmented Reality Viewer.

Figure 3. Sequence diagram - customer. Source authors of the article.
Next, the operation of the application is exposed starting from the point where the Mobile App makes a request to the API. (see figure 4):

![Sequence diagram - Server](source)

**Figure 4.** Sequence diagram - Server. Source authors of the article.
Pre-requisite:
(Constant connection to the Internet and the App must have made a Request to the API). The process described below is a general view of a request to the API, because given the nature and type of request, a more specific process must be carried out to deliver a response according to the request.

The process carried out by the application is as follows:

When starting, the application receives an AJAX request from the mobile application, this request must be validated, seeing that it comes from a valid source, that it does not contain wormStrings and that it is correctly composed within the valid patterns of the API. After validating the request in case of not passing the test, an "ERROR" response is returned that will be processed by the corresponding Mobile App and the request to the API is completed. Otherwise, if the request is correctly validated, we proceed to process the request and verify the type of request, and then process the specific data of the request, generate a JSON Response as a result of the algorithm and return "SUCCESS" so that The Mobile App processes the Chord response.

Next, the general operation of the system is exposed noting the way in which the various technologies that compose it are related, such as the vuforia SDK, the AR application and the web API. (see figure 5):

![Figure 5. Block diagram - Application interaction.](image-url)
Vuforia: It is a Framework for the development of Augmented Reality applications, which runs on Unity, so that it integrates with the development of the application with Unity and Vuforia provides tools for the detection of markers, or POIs, based on geographic data. Likewise, it performs image processing to display a composite video feed in the application.

Augmented Reality (AR) Application: This application developed using the Unity + Vuforia Framework, and the application is responsible for processing the geographic data obtained from the GPS of the mobile device, and making inquiries to the API to display relevant information to the end user during the AR process.

API (Web Server / WebDav / Database): The API is an interface that allows the mobile application to connect with the web server, so that the application can request the processing of certain data from the server side, as well as request multimedia content or specific assets.

The following describes the process of how the aforementioned applications interact.

The mobile device has a constant interaction with the AR application, which performs different operations, one of which is the query of sensor data, this process makes a request to the Vuforia SDK, which through the camera performs different processes for the correct operation of the application, during this process the recognition algorithms are found, which work in 2 types, one with TAG and the other with POI points, both use the cache memory of the operating system to carry out this task.

In addition, it has Cloud Recognition of vufororia which is used as an administrative platform for the management of "tigger" triggers. When some of the 2 aforementioned methods recognize a point of interest, the content is obtained and rendered, this is done through the web server, which contains all the multimedia content hosted in a database. Then this content already rendered is shown on the device screen, this process is carried out by the AR application, the requests to the server are also made by said application which maintains constant communication with the web server.

5. Conclusions

Tourism, like other economic sectors, has been affected by the decrees issued by the leaders in recent months, where for reasons of the Sarv-Cov. 2 governments have had to implement contingency measures through resolutions to prevent its spread, and based on this, the economy of many countries has been drastically affected, seeing how these measures gradually affect tourism, it has been necessary to implement mechanisms that help to face this situation, with technological advances being one of the options that offer us the most tools when it comes to promoting mechanisms to impart culture in a didactic and creative way, in order to represent the heritage and cultural expressions of certain places.

On the other hand, it is concluded that thanks to the contribution and ideas that are given in the research sector, the problems imposed in the document can be mitigated, where through technological development projects, the AR technology with GPS contributes in what today it is known as sustainable tourism, and providing advance tools for the sector where they are established, in this case and specifically the tourism sector.

The applications proposed for the development of the project provide innumerable tools to be able to carry out completely integral systems, in addition to having a free license, which facilitates the use in certain processes.

By using augmented reality and integrating it with GPS and having a web server where all multimedia content is stored, it is possible to achieve an optimal system, since the content load being hosted on a server, the AR application will consume less resources on the device where it is running.

Finally, it is concluded that the AR integrated with GPS represents great benefits for the tourism sector, representing the cultural part and keeping it intact with the passage of time, giving an enrichment of the entire history to the tourist, involving him in a striking and creative way, diversifying his model representative for all audiences.
References

[1] E. Villarraga, Interviewee, Coordinador de turismo, adscrito a la Secretaría de Desarrollo y Medioambiente de la Gobernación de Sucre. [Interview]. 23 junio 2020.

[2] Ministerio de Cultura, "Plan Especial de Salvaguardia. Cuadros Vivos de Galeras, Sucre," diciembre 2013. [Online]. Available: https://www.mincultura.gov.co/prensa/noticias/Documents/Patrimonio/14-Cuadros%20vivos%20de%20Galeras%20Sucre%20-%20PES.pdf.

[3] CGLU, "LA CULTURA EN LOS OBJETIVOS DE DESARROLLO SOSTENIBLE: GUÍA PRÁCTICA PARA LA ACCIÓN LOCAL," Barcelona, 2018.

[4] M. González, N. Huertas and E. Lugo, "Diagnóstico de las organizaciones solidarias del sector artístico-cultural en Córdoba y Sucre," Revista Venezolana de Gerencia, vol. 25, no. 89, pp. 174-188, 2020.

[5] OMT, "Desarrollo Sostenible," [Online]. Available: https://www.unwto.org/es/desarrollo-sostenible. [Accessed 11 Agosto 2020].

[6] M. González Vergara and A. Baquero Tobías, "PRODUCTO TURÍSTICO CULTURAL ARTESANAL EN MORROA Y SAMPUÉS SUCRE-COLOMBIA," International Journal of Scientific Management and Tourism (2018) 4-1: 7-28, pp. 7-28. Volumen 4-1, 2018.

[7] P. Trocha, "Sombrero Vueltaio: Transformaciones de un objeto artesanal," Cuadernos del Centro de Estudios en Diseño y Comunicación [Ensaios], no. 87, pp. 165-220, 2020.

[8] J. Malca, B. Carrasco, V. Guamán, B. Guevara, F. Ruiz, J. Delgado and P. Vinuela, "REALIDAD AUMENTADA APLICADA AL TURISMO - CASO DE ESTUDIO EN RIOBAMBA, ECUADOR.,” International Conference on Information Systems and Computer Science (INCISCOS), pp. 116-123, 2019.

[9] D. R. Dela Cruz, J. S. Sevilla, J. W. San Gabriel, A. J. Dela Cruz and E. J. Caselis, "Design and Development of Augmented Reality (AR) Mobile Application for Malolos Kameztizuhan (Malolos Heritage Town, Philippines).” IEEE Games, Entertainment, Media Conference (GEM), pp. 15-19, 2018.

[10] C. Rodríguez, "ETOURISM APLICANDO TECNOLOGÍA DE GEOLOCALIZACIÓN, RECORRIDOS VIRTUALES Y MÓVILES DE REALIDAD AUMENTADA,” IEEE Trigésima Quinta Convención Centroamericana y de Panamá (CONCAPAN XXXV), pp. 1-6, 2015.

[11] J. Fombona, M. Del Valle and E. Vázquez, "Análisis de la geolocalización y realidad aumentada en dispositivos móviles, propuestas socio-educativas relacionadas con el entorno y las salidas de campo,” Revista de currículum y formación del profesorado, vol. 22, no. 4, pp. 197-222, 2018.

[12] N. López, E. Loredo and J. Sevilla, "REALIDAD AUMENTADA EN DESTINOS TURÍSTICOS RURALES: OPORTUNIDADES Y BARRERAS,” International Journal of Information Systems and Tourism (IJIST), pp. 25-33, 2019.

[13] J. Azevedo and B. Alturas, "The Augmented Reality in Lisbon Tourism," Ieeexplore, pp. 1-4, 2019.

[14] MinCiencias, "Tipología de proyectos calificados como de carácter científico, tecnológico e innovación.,” MinCiencias, Bogotá, 2016.

[15] MinCIT, Metodología para la elaboración del inventario de atractivos turísticos, Bogotá, 2020, p. 26.

[16] MinCIT, Metodología para la elaboración del inventario de atractivos turísticos, Bogotá, 2010, p. 3.

[17] Septiembre 2007. [Online]. Available: http://sedici.unlp.edu.ar/handle/10915/64407.