Universitat Oberta de Catalunya

artnodes
E-JOURNAL ON ART, SCIENCE AND TECHNOLOGY

https://artnodes.uoc.edu

ARTICLE

Ciudad Antigua: From remote sensing to virtual interactive experience of a pre-Hispanic settlement in Colombia

Andres Burbano
Universidad de los Andes
Eduardo Mazuera
Universidad de los Andes
Zachary Meyer
Purdue University
Esteban Garcia Bravo
Purdue University

Date of submission: November 2020
Accepted in: May 2021
Published in: July 2021

Recommended citation

Burbano, Andres; Mazuera, Eduardo; Meyer, Zachary; Garcia Bravo, Esteban. 2021. «Ciudad Antigua: From remote sensing to virtual interactive experience of a pre-Hispanic settlement in Colombia». *Artnodes*, núm. 28. UOC. [Consulta: dd/mm/aa]. http://doi.org/10.7238/a.v0i28.375755

Abstract
This study addresses the first photogrammetry reconstruction of *Ciudad Antigua* (CA), a pre-Hispanic archaeological site in Sierra Nevada de Santa Marta (SNSM), which is located in northern Colombia. The construction characteristics and symbolic relevance of places such as *Ciudad Antigua*, constitute a major part of the cultural heritage of Colombia. However, the

remote location and limited public knowledge of the place have proven to be a disadvantage for the protection and conservation of this site. With this virtual representation project, we seek to fulfill three objectives: (1) Establish a strategy to preserve at-risk, remote archaeological sites through digital artifacts; (2) Use computational processes to go beyond representation and further analyze spatial components of the site; and (3) Spark and strengthen community interest in the history, architecture, design, and archaeology of SNSM. This study applies visualization and computation techniques to remote vestiges of cultural value, and demonstrates how these techniques can contribute to the social appropriation and protection of these ancient settlements. We created a functional prototype that could make the results of this research more readily available to the general public.

Keywords
remote sensing, photogrammetry, virtual interactive experience, cyber-archaeology, pre-Hispanic settlement, Sierra Nevada de Santa Marta

Ciudad Antigua: de la teledetección a la experiencia virtual interactiva de un asentamiento prehispánico en Colombia

Resumen
En este estudio se aborda la primera reconstrucción mediante fotogrametría de Ciudad Antigua (CA), un yacimiento arqueológico prehispánico en Sierra Nevada de Santa Marta (SNSM), situado al norte de Colombia. Las características constructivas y la pertinencia simbólica de lugares como Ciudad Antigua constituyen una parte fundamental del patrimonio cultural de Colombia. Sin embargo, por el hecho de estar situado en un lugar remoto y el escaso conocimiento público del yacimiento se ha demostrado que es un inconveniente para la protección y la conservación de este lugar. Con este proyecto de representación virtual queremos cumplir tres objetivos: 1) crear una estrategia para preservar yacimientos arqueológicos remotos en riesgo mediante artefactos digitales; 2) utilizar procesos computacionales para ir más allá de la representación y analizar más a fondo los componentes espaciales del yacimiento; y 3) generar y afianzar el interés de la comunidad en la historia, la arquitectura, el diseño y la arqueología de SNSM. En este estudio se llevan a cabo técnicas de visualización y computación en vestigios remotos de valor cultural y se demuestra cómo estas técnicas contribuyen a la apropiación y a la protección social de estos asentamientos ancestrales. Creamos un prototipo funcional que podría hacer que los resultados de este estudio estén a disposición de la sociedad.

Palabras clave
teledetección, fotogrametría, experiencia virtual interactiva, ciberarqueología, asentamiento prehispánico, Sierra Nevada de Santa Marta

1. Introduction

Remote sensing technology (RST) has become an effective way to perform digital surveys of archaeological sites, visualize their characteristics, and facilitate research. It is also a way of preserving the memory of places at risk of decay, alterations, or destruction. Airborne photogrammetry enables 3D reconstructions to be explored virtually with a fair level of detail, suitable for quantitative and qualitative observations. The two technologies used in conjunction represent valuable input for academic studies that traditional representation methods cannot communicate or be interacted with to the same extent. Also, fieldwork and visits to these places involve costly expeditions with complex logistics. Although it is difficult to fully replace the in-person experience of visiting these remote ancient locations, 3D representations can offer an alternative approach to visiting these sites in person. Airborne photogrammetry uses drones to produce thousands of photos that have GPS metadata embedded. When processing a vast point cloud, each point has precise XYZ information originating from GPS data. A middle-complexity model, such as the one we produced for this paper through a digital lab at Purdue University, has very precise spatial information.

This paper describes the process of reconstructing a digital model for *Ciudad Antigua* (CA) (Fig. 01), an ancient settlement in the Sierra

Figure 1. 3D model of *Ciudad Antigua*, from drone photogrammetry. Photos by A. Burbano, processed by Z. Meyer, 2020.

Nevada de Santa Marta (SNSM), a mountain range in northern Colombia. We present an interdisciplinary study that combines fieldwork survey, data acquisition, data processing, image creation, architectural analysis and archaeological insights to create a functional virtual reality prototype and full 3D reconstruction, flyover and walkthrough of the ancient historic site.

2. Sierra Nevada de Santa Marta and Ciudad Antigua

The SNSM contains over 200 archaeological sites that date back to the 4th century and constitute a major part of the pre-Hispanic cultural heritage in Colombia (Cadavid and Herrera 1985, Reichel-Dolmatoff 1997). According to the Spaniards' descriptions from the 16th century and recent archaeological finds, the *Tairona* were grouped into chiefdom polities (Giraldo 2018).

SNSM, located by the Caribbean Sea, has settlements which are particularly remote, with most existing from 1000 MAMSL (metres above mean sea level), and fewer up to 2000 MAMSL. Very few have been found beyond this altitude (Reichel-Dolmatoff 1997). Additionally, due to the rugged geography of the SNSM, it took great effort to build roads and settlements on the slopes. Extensive artificial terracing and movement of massive stone elements over a difficult terrain, constituted great feats of *Tairona* engineering. The lithic architecture consisted mainly of retaining walls, terraces, stairs, pathways and water channeling systems, grouped together as compounds of urban infrastructure that once supported villages of up to 8,000 inhabitants (Serje 1984). On top of the terraces and stone foundations were temples, dwellings, storage shacks and public buildings, all of which have since disappeared due to the perishable materials of their construction (mostly wood, palm tree leaves and vines). Archaeological research and historical documents enable us to distinguish different hierarchies and activities for these structures, ranging from prominent ceremonial temples and the homes of political leaders, to smaller utilitarian buildings and humble accommodations (Serje 1984). Usually built on ridges between watersheds or river basins, the settlements were located near freshwater sources and their shape adapted to the topography. Dominant views of the surrounding area characterized the central and greater hierarchy sectors, where the largest terraces and gathering places were built.

Among the ancient *Tairona* settlements, the most renowned is the archaeological park *Ciudad Perdida* (CP), first discovered by looters in the 1960s and later researched by archaeologists in the 1970s. Unlike CA, over time, there has been more literature and research on CP . CP covers an area of about 30 hectares at about 1000 MAMSL on the northern slope of SNSM (Fig. 02). *Teyuna* is believed to have been a major ceremonial and political center with over 200 stone structures (Serje 1984). Much fieldwork has been carried out here, leading to a general understanding of the *Tairona* culture (Giraldo 2018). However, RST has been applied here only recently, with a LiDAR digital survey carried out for the National Geographic Channel (Lin 2019). This research enabled the entire site to be visualized with a 3D model, and it also identified flat, round surfaces on the steep slopes of the surrounding area, hidden under the tree canopy. By means of ground-truthing verification, one of these topographic anomalies was inspected and a new site was revealed (unknown until then), after 40 years of research in the area. For this research, we were able to leverage a similar strategy for CA and surface the same type of information about the lesser known settlements.

Figure 2. *Ciudad Antigua*, Photo by E. Mazuera

The research carried out for this paper takes place in the ancient Tairona settlement known as Ciudad Antigua (CA), on the western slope of the SNSM, at 900 MAMSL (Fig. 03). CA was inhabited from approximately the year 200 to 1600. It occupies roughly 6 hectares and is composed of more than 70 stone structures, including the group

Figure 3. Location of *Ciudad Antigua* (CA). Map from Google Earth.

Figure 4b. Retaining wall and stairs on the east side of main terraces in CA. Photo by E. Mazuera

Figure 4a. East retaining wall, stairs and main terraces in CA. Photo by E. Mazuera

of 5 main terraces where the central political, social and spiritual activities seem to have taken place. This main sector in CA also contains the largest retaining walls and broadest stairs and pathways on the site (Figs. 04).

Since 1989, CA has been owned and administered by NGO Fundación Pro Sierra Nevada de Santa Marta (FPSNSM), which protects and preserves the natural and cultural heritage of the SNSM. With the implementation of RST in 2020 came a new understanding of this site, and others in SNSM (Fig. 05). Recent research focuses on the intervisibility of sectors within each ancient settlement in CP and CA, with collaboration between FPSNSM and the Department of Anthropology in the University of Minnesota which provided the LiDAR equipment and data processing.[1]

Figure 4c. Retaining wall on the west side of main terraces in CA. Photo by E. Mazuera

1. «Co-authors of that paper, submitted and currently under revision, are PhD Santiago Giraldo, Director of FPSNSM; PhD candidate Daniel Rodríguez from University of Minnesota; PhD Andrés Burbano, MA Eduardo Mazuera, B. Arch. Estefanía Figueredo from Universidad de los Andes.»

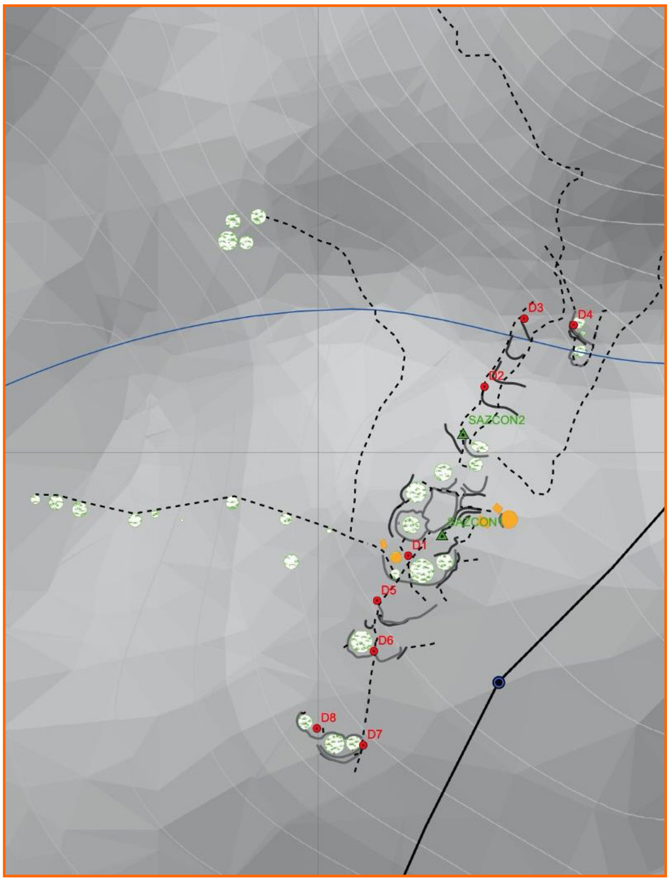

Figure 5. Map of CA produced with total station survey, 2018.

3. Field Work and Data Survey

Although our research included LiDAR for data collection on-site, this research mainly discusses the use of photogrammetry to create a functional digital reconstruction of CA. This procedure consisted mainly of two methods: fieldwork on-site survey using massive sets of photos with a large drone project generating point clouds, DSM (Digital Surface Models) and DTM (Digital Terrain Models); and lab work, analyzing, interpreting, processing the data and finally transforming it into a fully immersive, virtual, interactive experience. With this virtual representation project, we seek to fulfill three objectives: first, to establish a strategy to preserve as digital artifacts remote archaeological sites that may be at risk; second, to use computational processes to analyze and understand the sites indepth; and third, to spark and strengthen community interest in the history, architecture, design, and archaeology of SNSM.

Since 1994, 3D surface measuring techniques have been used to create meshes automatically (Shih et al. 2007). Our project is among others that, similarly, utilize UAV (Unmanned Aerial Vehicles) to reconstruct high-resolution digital maps of heritage sites. As technology evolves and graphics capabilities increase, it is essential to continue documenting heritage sites in the highest possible resolution (Baaske & Warden 2020) (Fig. 06).

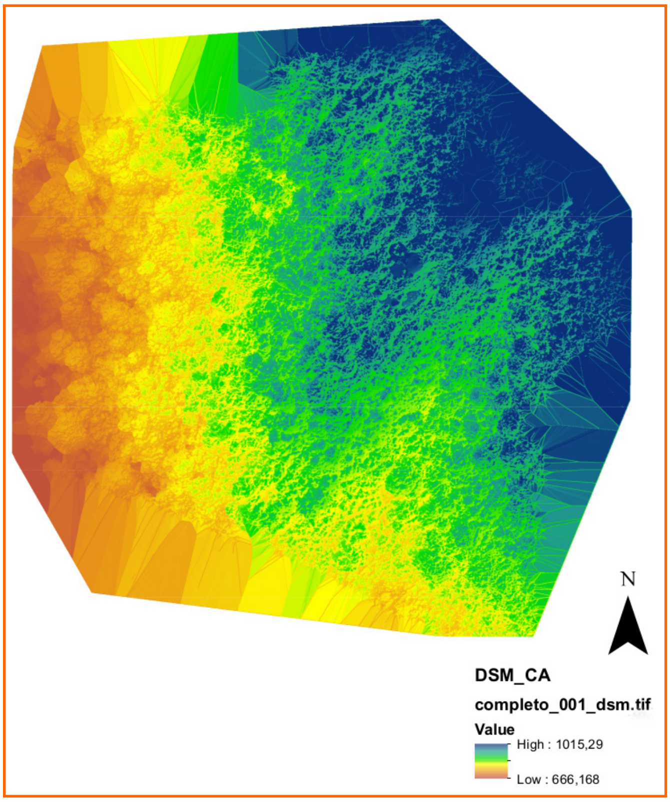

Figure 6. CA DSM, made with photogrammetry process with Pix4D, Photos A. Burbano. Processed by E. Figueredo.

This project relates to both the archaeological and architectural space, documented through photogrammetry. The dataset acquired was processed twice, first with Pix4DMapper and again with Agisoft Metashape through the Computer Graphics Technology Department at Purdue University. These processes are characterized by their non-invasive and varied methodological components such as data acquisition, data processing, point cloud visualisation, point cloud editing, DSM, and DTM generation (VanValkenburgh & Dufton 2020). The computational maps obtained were processed with spatial analysis tools based on 3D point clouds, resulting in elevation data contextualized in GIS, which expanded our understanding of the territory (Lee & Yang 2019).

For this study, we used several sequences of aerial photographs as the starting point of the photogrammetry process. These were taken with two UAVs: the DJI Mavic Pro and the DJI Phantom 4 (Pavelka et al. 2019). The flight patterns of the UAVs were a mixture of scheduled routes and Pix4DCapture. In each case, we aimed for a visual information redundancy between 70% and 80%. In total, 16 flights were planned from the cleared terraces in the central area of CA. From there, the flights were deployed in all directions, covering the entirety of the archaeological site and its immediate surroundings. The information was pre-processed in the field with fieldwork laptops. With the Pix4DMapper software, it was possible to evaluate the type of photographic material and the redundancy, or overlap, for the move from 2D to 2.5D. This facilitated the process of transforming two-dimensional images into the generation of low-resolution point clouds and DTMs, which together is known as 'Transplane' (Schröter 2014). The conclusion of the material analysis from the survey determined that the 2,400 photographs captured fulfilled the technical requirements necessary to start the computational lab-work.

From an archaeological perspective, the settlements in SNSM encourage us to question the meaning of the terraces, their location, and the potential implications of the gaze relationship with different social practices or the visual coverage of specific areas (Hillier, 1989). In the computational field, it is necessary to generate two types of files derived from photogrammetry. As a result of the first process with Pix4DMapper, a DTM file was produced, as well as a DSM, from which a high-precision three-dimensional map of the CA territory was obtained. Additionally, ArcMap was used to differentiate between stone constructions and vegetation-covered areas.

The main terraces in central CA lie on a ridge and include massive structures on both sides - east and west - that form large foundations for esplanades. Evidence of man-made constructions are valuable in finding new archaeological sites (Serje 1984). For example, the retaining wall to the west consists of three distinct levels of staggered vertical and horizontal surfaces, which are rather easily recognizable as *Tairona* architecture. Similarly, the east side of the ridge is contained by a combined structure of intertwined stairs, pathways, and a piled series of horizontal layers that adapt to the topography with an irregular gradient (Fig. 07).

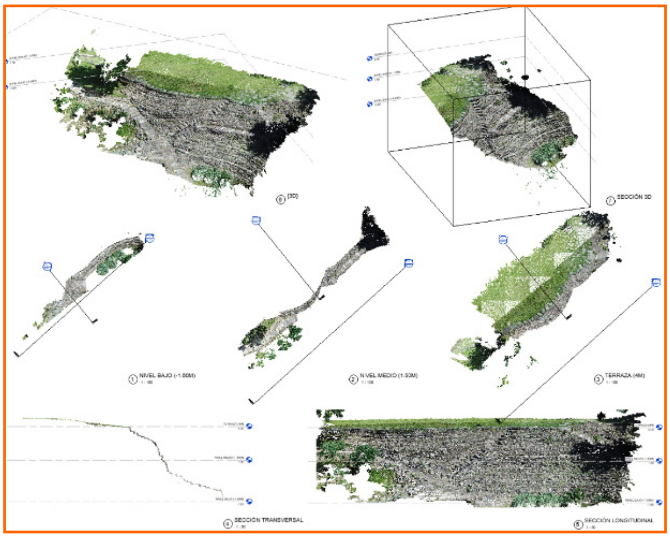

Figure 7. 3D models, plan, section and elevation of east retaining wall in central CA, produced from photogrammetry. Photos by A. Burbano, processed by E. Figueredo, 2019.

Amidst a rugged terrain, covered by vegetation and centuries of organic stratigraphies, a retaining wall like the east side of central CA may most likely be discarded or ignored when looking for potential human-made structures in DTM. Structures like this are usually overlooked since they differ in appearance from the more distinguishable ones. In the case of the east side, the inclination is similar to the gradient of many slopes on SNSM, which is useful for future DTM analysis and searches for new settlements that may have similar structures. Although these structures are rare and less common, the architectural typology of the aforementioned retaining system must be incorporated into the repertoire of *Tairona* structures and kept in mind when prospective archaeological exploration takes place.

Virtual interactive experiences can compensate for the lack of documentation and facilitate knowledge of these ancient settlements. The convenience of virtual visits can contribute to social appreciation, and cultural identity construction. The vast system of the pre-Hispanic road network and hundreds of interconnected *Tairona* settlements in SNSM is practically unknown to most people within the region and country, not to mention outside it as well. Additionally, archaeological research can benefit from the information produced here, with a detailed description of the structures, like the atypical retaining walls and stairs in CA.

It is important to note that most of CA is covered by a dense forest that did not exist during the *Tairona* period. The UAV photogrammetry mostly registers surfaces closest to it and very little or none of what is beneath the forest canopy. From a surveyed area of 216,973 m2, the binary classification between stone and vegetation areas yielded only 2,081 m2 of stone surface: less than 1% of the total site. This percentage corresponds to the cleared central terraces, retaining walls, stairs, and pathways that interconnect them. As a result, this cleared-out area constitutes the surveyed sector for the 3D model created after the second photogrammetry process in our research. The digital reconstruction of a larger area where more stone structures are present would require the removal of many large trees or the implementation of another remote sensing technology: terrestrial LiDAR. In this research, we focus instead on the processing of UAV photogrammetry data and consequent image production (Pavelka et al. 2019).

4. Data Processing and Results

The photogrammetric recreation of CA was produced using (1) Agisoft Metashape, a specially designed 3D photogrammetry software using inputs of either pictures or laser scanned data, and composed in (2) Unreal Engine 4, a 3D real time rendering game engine, for the final viewable model. Four different sets of photos were used to create the 3D models. The photo sets consisted of three separate areas of CA and the surrounding area. From these sets, four models were created separately due to the limits of computational power of the machine being used to process and complete the meshes.

The production started with importing the photographs for an individual set into Metashape. Each picture had to be processed by the software to determine the location of the camera and the time when the picture was taken. Metashape compares pictures to create tie points that connect to one another to calculate the location. The tie points default to a value of 4000, which must be changed to 10,000 when prompted during the alignment of the camera in the scene. The processing computer used an Intel i-7 8700k, Nvidia GeForce GTX 1080, and 16GB of DDR4 RAM.

Following the camera alignment, Metashape creates a point cloud and depth map of the model. The depth maps were made using the camera tie points, while the point cloud of the model was generated from the previous depth maps. The point clouds varied in size from four million to twenty million points for each model.

Once Metashape had finished generating a point cloud, the mesh had to be created. This program can use the point cloud or depth maps for this phase to create a model. For the highest fidelity, Agisoft recommends using the point cloud, as well as calculating the vertex colors in this process. The output from this step is a final mesh with a simple texture, but not a texture file.

The final step in the mesh creation in Metashape is to project the pictures onto the mesh and calculate a high-quality texture file. Each texture file is a 4096 x 4096 pixels square to ensure the highest quality, while also reducing the need for higher computational power due to the higher resolutions available to the software. Once the mesh and texture have been generated, Metashape offers an export feature for both the model and texture file (Figs. 08, 09, and 10).

Once each of the four models had been created, they were imported into Unreal Engine 4. Out of the four models, the first one placed into a scene was the general overview of CA. This allowed for an easy estimation of the scale of each of the individual models that needed to be merged with respect to the overview model. The three separate models were manually rotated, scaled, and translated into position in their corresponding location.

With each of the models in place, the general view model was opened in the mesh editor within Unreal Engine 4. Due to the lower

Figure 8. Photogrammetric recreation of the east retaining wall. Photos by A. Burbano, processed by Z. Meyer, 2020.

Figure 9. Photogrammetric recreation of upper central terrace. Photos by A. Burbano, processed by Z. Meyer, 2020.

Figure 10. Photogrammetric recreation of the west retaining wall. Photos by A. Burbano, processed by Z. Meyer, 2020.

fidelity of the general view model, the mesh contained penetrating points between the separate meshes. Areas where overlap occurred between two models were first deleted on the overview model. This increased the fidelity and quality of the overall scene as the lower quality meshes could not be seen or rendered by Unreal Engine. Each model was then inspected manually to determine the ideal places for the polygonal mesh to be deleted.

The detection points for collision on each model defaulted to a simple collision mesh that left the playable character floating away from the mesh, near the top of the tree line. The collision detection for the mesh was calculated using the existing mesh for each 3D model so as to fix the issue of not being able to interact more closely with the environment. The default first-person character in the Unreal Engine was edited. The character size and run speed were then scaled down to fit the scene so that the user is at a more realistic pace and height in the environment.

5. Discussion: Heritage, Technology and Digital Media

As mentioned in section 3, one of our goals with this research is to additionally establish a strategy to preserve at-risk, remote archaeological sites through digital artifacts. At present, several ancient *Tairona* settlements in SNSM are at imminent risk of physical damage due to the growth of tough roots between the stone structures, falling trees and erosion. Additionally, though somewhat rare, human activities also jeopardize the integrity of the sites due to irresponsible tourism and sporadic looting. Most notably, a significant risk is the indifference and ignorance regarding such sites. The above conditions could be improved with projects like this pilot carried out in CA. Mapping the archaeological sites in SNSM with RST is crucial to preserving pre-Hispanic cultural heritage and contemporary indigenous cultural identity in the Americas.

In the case of CA, we are compelled to examine the implications of digitally representing and reinterpreting an ancient construction technology. This process involves turning physical places into digital spaces and models. Therefore, emerging research opportunities, such as those presented in this paper, involve a re-conceptualization of the observation techniques applied to objects, architectural space, and maps.

Regarding the *architectural space* and its digital depiction, it is essential to reflect on the transition from direct observation to computational processing. From on-site work to geospatial data portability, as well as from sketches to 3D models (Wilmott 2020), this project approaches the *Digital Twin* philosophy (Del Curto et al. 2019). Data processed through code and translated into parameters that work with georeferencing constitutes the new analytical environment used in this project. To a large extent, archaeology and architecture are disciplines of physical space. In this context, the implementation of the mixed methodologies of physical space and codified space is called to define the present and future of research. By articulating social studies concepts with the understanding of computer processes (including computer imaging), in this research we are able to apply the concepts that may one day become a «new normal» for research in these fields (VanValkenburgh & Dufton 2020).

6. Conclusions

Among the concepts referring to the use of contemporary technologies to study, interpret, preserve, and document archaeological sites such as «digital archaeology» or «remote sensing archaeology,» we think that the term «Cyber-Archaeology» as defined by Maurizio Forte (2019), provides an integral vision of the components, stages, theoretical and practical problems that we develop in projects like the one described in this paper. Cyber-archaeology addresses the importance of these types of reconstructions to study archaeological sites with computational and digital tools. For instance, having precise information on the longitude and latitude coordinates in the past implied using techniques such as total station theodolite to determine the GPS coordinates of a few points.

To engage with a contribution to the ongoing discussion, we propose new elements that may add to the domain of cyber-archeology and incorporate aspects of profound importance. One of those elements is the use of computational analysis with software platforms such as GIS and BIM, which go beyond representation and add analytical components such as spatial analysis of the site configuration (Gattiglia 2015: Richards-Rissetto 2017). Another new element we propose is the study of digital objects and digital spaces on their own. Concepts such as *Space Syntax* (Hillier 1989, 2007) or, more recently, the *Transduction of Space* (Kitchin Dodge 2014), are some of the practical-theoretical frameworks that have been proposed to account for the interactions between physical spaces and the digital spaces created to study them.

The photogrammetry-based 3D model created for the Virtual Interactive Experience of the central terraces and structures of CA not only offers a non-invasive and non-destructive way to explore CA, but also reveals valuable archaeological insights. Physical accessibility to such areas is difficult, resulting in ignorance, disinterest, and oblivion. Furthermore, physical and emotional distancing can cause sites such as CA to continue to be vulnerable to looting, destruction, and contemporary transformations.

Virtual Interactive Experiences can provide more comprehensive access to the public in general by making history-focused exhibits available through an embodied experience. This functional prototype could be useful for curators, historians, anthropologists, artists, scientists, and technologists, thus making the results of this research more readily available to the general public.

Acknowledgments

We would like to express our gratitude to the School of Architecture and Design at Universidad de los Andes, the Vice Presidency of Research and Creation at Universidad de los Andes, 100 000 Strong in the Americas Innovation Fund; Nexo Global; and Fundacion Pro-Sierra Nevada de Santa Marta.

References

Baaske, Ben, and Robert Warden. *Digital heritage documentation of structures at the Maya sites of Birds of Paradise-North and Tz'unun in Belize*. 2020.

Cadavid, Gilberto, and Luisa Fernanda Herrera. «Manifestaciones culturales en el área Tairona.» *Informes antropológicos* 1 (1985): 5-54.

Del Curto, D., A. Garzulino, Federica Allegretti, and Serena Mazza. « GIS or BIM? A comparison applied to the conservation management plan of a 20th century architectural heritage.» *International Archi-*

ves of the Photogrammetry, Remote Sensing & Spatial Information Sciences (2019). DOI: https://doi.org/10.5194/isprs-archives-XLII-2-W15-365-2019

Forte, Maurizio, and Nevio Danelon. «Cyber-Archaeology.» Oxford Bibliographies Ma, February 27, 2019. https://www.oxfordbibliographies.com/view/document/obo-9780199766567/obo-9780199766567-0207.xml.

Gattiglia, Gabriele. «Think big about data: Archaeology and the Big Data challenge.» *Archäologische Informationen* 38 (2015): 113-124.

Giraldo, Santiago. «Nuevas aproximaciones al urbanismo tairona en la Sierra Nevada de Santa Marta». In *Historia de Santa Marta y el Magdalena Grande, del período Nahuange al siglo XXI*, Elías-Caro, J-E., Viloria de la Hoz, J. (Eds.), Editorial Universidad Sergio Arboleda y Unimagdalena. pp 101 – 128, 2018. DOI: https://doi.org/10.2307/j.ctvb4bsr8.7

Hillier, Bill, and Julienne Hanson. *The social logic of space.* Cambridge university press, 1989.

Hillier, Bill. *Space is the machine: a configurational theory of architecture.* Space Syntax, 2007.

Kitchin, R., & Dodge, M. (2014). *Code/Space: Software and Everyday Life.* The MIT Press.

Lee, Jungil, and Byungyun Yang. «Developing an optimized texture mapping for photorealistic 3D buildings.» *Transactions in GIS 23*, no. 1 (2019): 1-21. DOI: https://doi.org/10.1111/tgis.12494

Lin, Albert. «El Dorado City of Gold.» Episode. *Lost Cities*. National Geographic, 2019.

Pavelka, Karel, Lenka Starková, and Karel Nováček. «Using terrestrial and aerial photogrammetry in archaeology.» *International Multidisciplinary Scientific GeoConference: SGEM* 19, no. 2.2 (2019): 679-686. DOI: https://doi.org/10.5593/sgem2019/2.2/S10.084

Reichel-Dolmatoff, Gerardo. *Arqueología de Colombia: un texto introductorio.* Presidencia de la República, 1997.

Richards-Rissetto, Heather. «What can GIS+ 3D mean for landscape archaeology?.» *Journal of Archaeological Science* 84 (2017): 10-2 DOI: https://doi.org/10.1016/j.jas.2017.05.005

Schröter, Jens. *3D: History, Theory and Aesthetics of the Transplane Image.* Bloomsbury Publishing USA, 2014.

Serje, Margarita. «Organización urbana en ciudad perdida.» *Cuadernos de Arquitectura* 9 (1984).

Shih, Naai-Jung, Huey-Jiun Wang, Chen-Yan Lin, and Chai-Yuan Liau. «3D scan for the digital preservation of a historical temple in Taiwan.» *Advances in engineering software* 38, no. 7 (2007): 501-512. DOI: https://doi.org/10.1016/j.advengsoft.2006.09.014

VanValkenburgh, Parker, and J. Andrew Dufton. «Big Archaeology: Horizons and Blindspots.» *Journal of Field Archaeology* 45 (2020): S1–7. DOI: https://doi.org/10.1080/00934690.2020.1714307

Wilmott, Clancy. *Mobile Mapping: Space, Cartography and the Digital.* Amsterdam University Press, 2020. DOI: https://doi.org/10.5117/9789462984530

CV

Andres Burbano
Universidad de los Andes
aburbano@uniandes.edu.co

Associate Professor in the Department of Design at Universidad de los Andes, in Bogota, Colombia. Burbano holds a PhD in Media Arts and Technology from the University of California, Santa Barbara, and is visiting professor at the Danube University in Krems, Austria and at the Potsdam University of Applied Sciences, Germany. «Burbano, originally from Colombia, explores the interactions of science, art and technology in various capacities: as a researcher, as an individual artist and in collaborations with other artists and designers. Burbano's work ranges from documentary video (in both science and art), sound and tele-communication art to the exploration of algorithmic cinematic narratives. The broad spectrum of his work illustrates the importance, indeed the prevalence, of interdisciplinary collaborative work in the field of digital art.»

Eduardo Mazuera
Universidad de los Andes
emazuera@uniandes.edu.co

Associate professor at the Department of Architecture, Universidad de los Andes, Colombia. Architect (2000), Anthropologist (2002), Master in History (2015), Universidad de los Andes; Master in Architectural Restoration (2003), Universidad de Alcalá de Henares, Spain; Postgraduate Degree in Museum Exhibitions (2003), Universidad Politécnica de Cataluña, Spain. Experience in construction projects, renovations and restorations. Assessment for the Direction of Cultural Heritage, Colombian Ministry of Culture (2004-2006, 2010-2011). Editor of *Dearq Journal of Architecture* (2011-2016). Member of the Colombian National Council on Cultural Heritage (2014-2016). Instructor for IFR (Institute of Field Research) course, at the Ciudad Perdida Archaeological Park (2016-2017). Member of the conservation team of Ciudad Perdida Archaeological Park. Member of ICOMOS (International Council on Monuments and Sites) – Colombia. Member of the research group *Las Formas de la Producción en Arquitectura*, Universidad de los Andes. On-going research about pre-Hispanic architecture and the relation between these ancient settlements and the landscape of Sierra Nevada de Santa Marta, Colombia.

Zachary Meyer
Purdue University
meyer204@purdue.edu

Graduate Student and Graduate Teaching Assistant in the Department of Computer Graphics at Purdue University, USA. His research is primarily focused on the body language of virtual characters. He earned a B.S. in Animation from Purdue University in 2018 and is currently working towards an M.S. in Animation, also from Purdue.

Esteban Garcia Bravo
garcia0@purdue.edu
Purdue University

Associate Professor in the Department of Computer Graphics Technology at Purdue University, USA. He explores computational arts as a researcher, a practitioner and as an educator. He earned his MFA from Purdue University in 2008, and a Ph.D. in Technology, also from Purdue, in 2013. His research has been featured in the annual meetings of international organizations such as SIGGRAPH and ISEA, as well as in the publication, Leonardo Journal of Art, Sciences and Technology. His artwork has been displayed internationally in media art festivals, exhibits and artist-in-residence programs.