Architecture & nature.

Workflow for the virtualisation of historic gardens and their vegetation. Historical Garden of the Arguijuela de Arriba (Cáceres, Spain)

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Abstract: There are historical spaces that are very little known to the general population. for this reason, it is of great importance to ensure that these are known known throughout the world. For this, there are new informative techniques that allow you to visit places without the need to go to them. For this, the complete virtualization of space has been proposed, combining photogrammetry techniques with traditional survey techniques. That all of them together make up a complete model of the location its topography, layout, buildings, vegetation and the environment that surrounds it. With this, the architectural survey of the historic garden of Arguijuela de Arriba is propose), located in the province of Cáceres, (Spain) in an area of great importance due to its defensive nature during the time of the reconquest. With all this, it has been possible to combine different techniques to obtain a digital copy of the enclave, on which it has been possible to project an intervention that improves accessibility. and its conservation.

Keywords: photogrammetry; architectural survey; heritage conservation; RPAS systems; vegetation, accessibility.

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1. Introduction

It is intended to show a workflow for the virtualization of historical gardens that allows us to document the topography architectural elements and plant species. For this photogrammetry traditional model and proxys Models have been combined. This digital model has finally been used to develop a universal accessibility proposal (digital) and for a traditional accessibility proposal. For this, different objectives have been set.

Objective 1: Virtualisation through photogrammetry of the historic garden [Jiménez Puerta, C., and Ramón Alamús esteban integración de los datos obtenidos con dron en el parque natural de la sierra de collserola. 2019].

- Milestone 1. Survey virtualization
- Milestone 2. Layout virtualization

Objective 2: Virtualisation of architecture

- Milestone 1. Survey of buildings
- Milestone 2. Survey of elements of the environment

Objective 3: Inventory and virtualisation of nature.

- Milestone 1. Inventory of vegetation.
- Milestone 2. Positioning of vegetation.

Objective 4: Creation of a single parametric model.

- Milestone 1. Combine the different surveys.
- Milestone 2. Design an accessibility intervention. [Romero, M.L.H., Inocencia Garcia y Becerra Raquel Nodar proyecto de educación integral casa del anfiteatro. Concurso de la ciudad monumental, historico-artistica y arqueológica de medida, julio de 2018].

2. Locate

The objective of this survey is the historic garden of La Arguijuela [Cruz Franco, P.A, and a. Rueda Marquez De la plata, el castillo de la Arguijuelas de Arriba, la necesidad de valorar el patrimonio desde un punto de Vista global] IV congreso internacional de castellologia. 2012. Madrid, españa] de Arriba, located in the province of Cáceres (Spain). The exotic garden of the 19th century [Cruz Franco, P.A. and A. Rueda Marquez de la plata, los caminos como parte esencial del paisaje fortificado al sur de Cáceres, in XI Congreso Internacional de camineria hispanica. 2012: Madrid, España]. Located in the castle of la Argüijuela de Arriba from the 19th century in the style of French chateaux (French castles) which implied a great work of engineering and design that was truly unique in Extremadura. To irrigate the garden, a pond is projected that will function as the head reservoir of the irrigation

Figure 1 | Aerial photograph of the garden.

Figure 2 | Historic gazebo.

Figure 3 | Greenhouse.

system by the flood method; the canals, the design of flower beds and the introduced vegetation, are part of the fashionable types of geometric French gardening. In addition, the greenhouse is from the same period, located at the end of the garden at kilometre 568 of the n-630 road. This is located 3.8 km from Valdesalor and 14.6 km from the city of Cáceres. Within its enclosure there is an exotic garden.

3. Importance and historical character

Since roman times, this has been the southern access to Caceres with the silver route (la ruta de la Plata). Later, after multiple reconquests of Cáceres, it became necessary to protect this access so that the city would not fall back into Almohad hands. For them, a series of defensives barriers made up of towers and fortifications were built between the 12th and 16th centuries, one of these fortifications is the one from which the castle that belong to us evolves. In one of its multiple extensions in the 19th, century it is when the French-style garden with its building was built.

4. Starting hypothesis

At the origin of the project, the objective of carrying out a complete survey of the site using RPAS systems (Remotely piloted aircraft systems) was established, but after carrying out the first data collections and processing them with the Software (Agisont metashape), it was detected that adequate results were not obtained for this project.

It was concluded that these errors were due to the presence of a lot of vegetation, both in the garden beds and around the architectural elements. This vegetation added to the meteorological component of the wind that caused the movement of the vegetation, resulted in

Figure 4 | Pergola.

Figure 5 | Discarded shot.

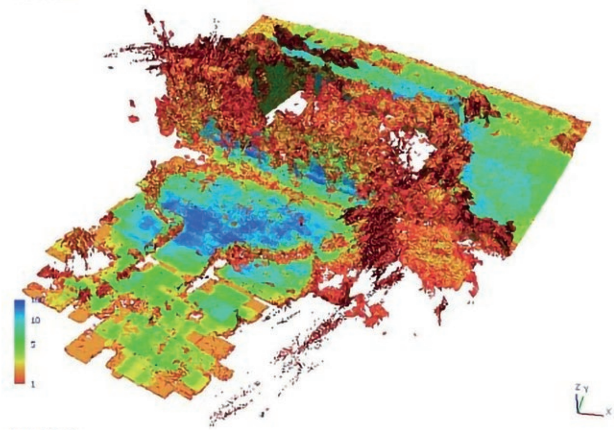

Figure 6 | Point cloud confidence level.

poor processing of the images taken, as the software was not able to locate similar points between the different images due to the wind on the foliage of the plants.

It was concluded that these errors were due to the Presence of a lot of vegetation, both the one located in the flower beds of the garden and the one surrounding the architectural elements. Said vegetation added to the meteorological component of the wind that caused its movement. This triggers a bad processing of the images taken, since the software (Agisoft metashape) is not capable of locating similar points between the different images, due to the winds on the foliage of the plants.

5. Final methodology

Knowing the problems that this starting methodology would cause, if the complete survey was carried out in this way and taking into accounts the low resources that were available for the realization of this project, a mixed procedure was proposed, which would allow the application of different survey techniques, to obtain the complete digital model. This procedure consists of:

1. Survey of the historical trace.
2. Survey of the buildings and architectural elements.
3. Inventory and vegetation po.
4. Creation of a unique model.

5.1 Survey of the historical trace

The first architecture survey necessary to obtain the compete model, is to obtain the historical layout and its temporality. For this, the original approach of the project has been respected. It has been done by drone photogrammetry.

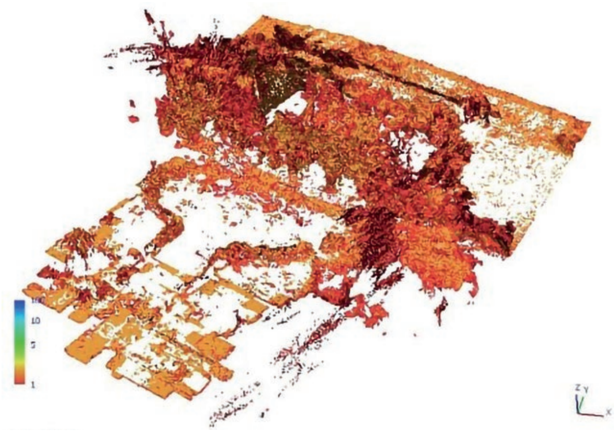

Figure 7 | cloud points with low confidence level (Model poins) is caused by the high presence of vegetation.

5.1.1 Previous performances

A preliminary analysis of the location is carried out, making a sketch of the distribution. On this, the programming of the different flights to be carried out is proposed, given that due to the size of the enclosure, it would be impossible to do everything in one shot. The criteria for making these divisions by flight will be to try to create closed flights, where it ends at the same starting point, in order to make it easier for the software (Agisoft metashape to later match images, avoiding deformations caused by not being closed polygons and also trying to that these flights overlap at some point, to later be able to join they at a later stage.

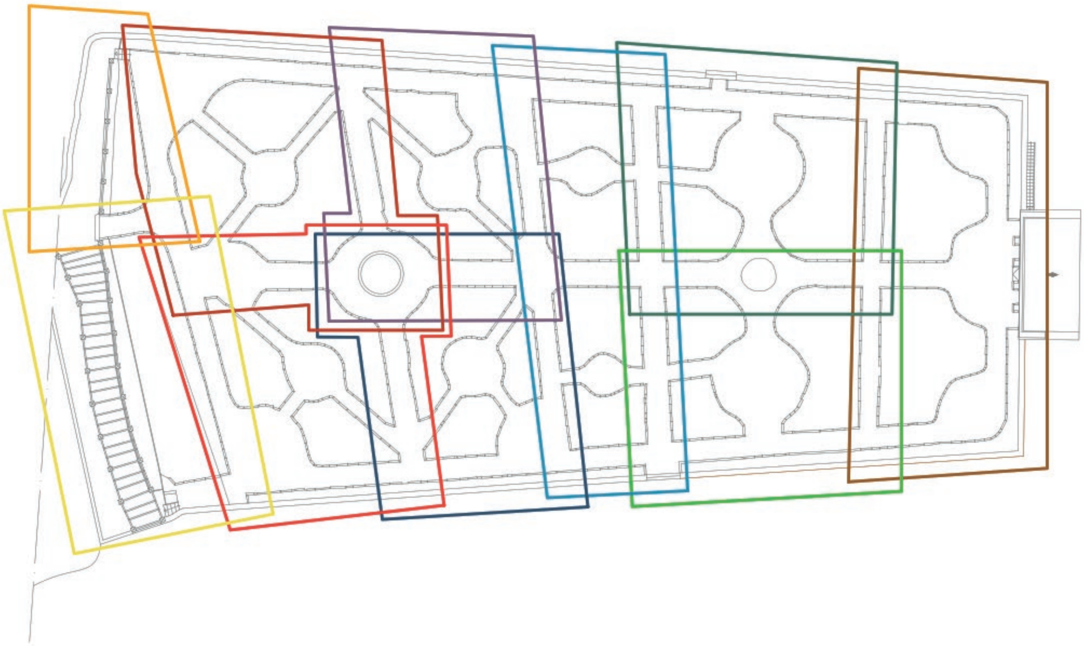

Figure 8 | Flight scheduling.

This division of flights entails an additional job of placing identification targets, strategically distributed throughout the surface, ensuring that they are found in the overlapping areas of the different shots.

The function of these targets is to allow the union of the different models obtained in each data collection, in order to obtain a complete model. In addition to the targets distributed inside the garden, another external target mesh was placed that would allow us, in the event of losing the internal references, to be able to use these external ones.

5.1.2 Data collection

The photographic data collection was carried out with a drone, following the planning of the flights. The measurements were carried out with a pre-established criterion and order, which established a strict criterion and order for data collection, which allowed organized and optimized work both in the field and in the office. These were taken in the form of a grid, ensuring that there was a wide overlapping space between image and image and that, in addition, the areas that required more detail, due to the difficulty of their geometry, had a greater density of images.

Since the data processing was carried out after each flight, it has allowed defects from the previous flight to be corrected, the following day or on subsequent flights that to some extent overlapped the defective one.

The data collection consists of 16 flights carried out between September 21 and November 20 2020. A total of 6.949 photos were taken on these flights. The work area was divided into a total of 10 sectors, of which only 9 were used for the final model (Figure 8). The yellow delimited area was discarded for taking it by drove, due to the complexity of flying in said area. This will be done later by traditional survey.

5.1.3 Photogrammetric processing

As already mentioned, when data collection is carried out on various flights, the processing will be divided in the same way. This is due to the fact that the program would not be able to link all the images (6,949 photos) at the same time, due to reasons as varied as the time difference of the shots (which causes the variation of the orientation of the shadows). Variation of the meteorology Cal state or variation of season.

Individual processing of the different shots in Agisoft metashapet will be done following this workflow (Figure 9).

Once all the processing of the different shots has been completed up to this point, the process for the fusion of the different shots is carried out and thus be able to

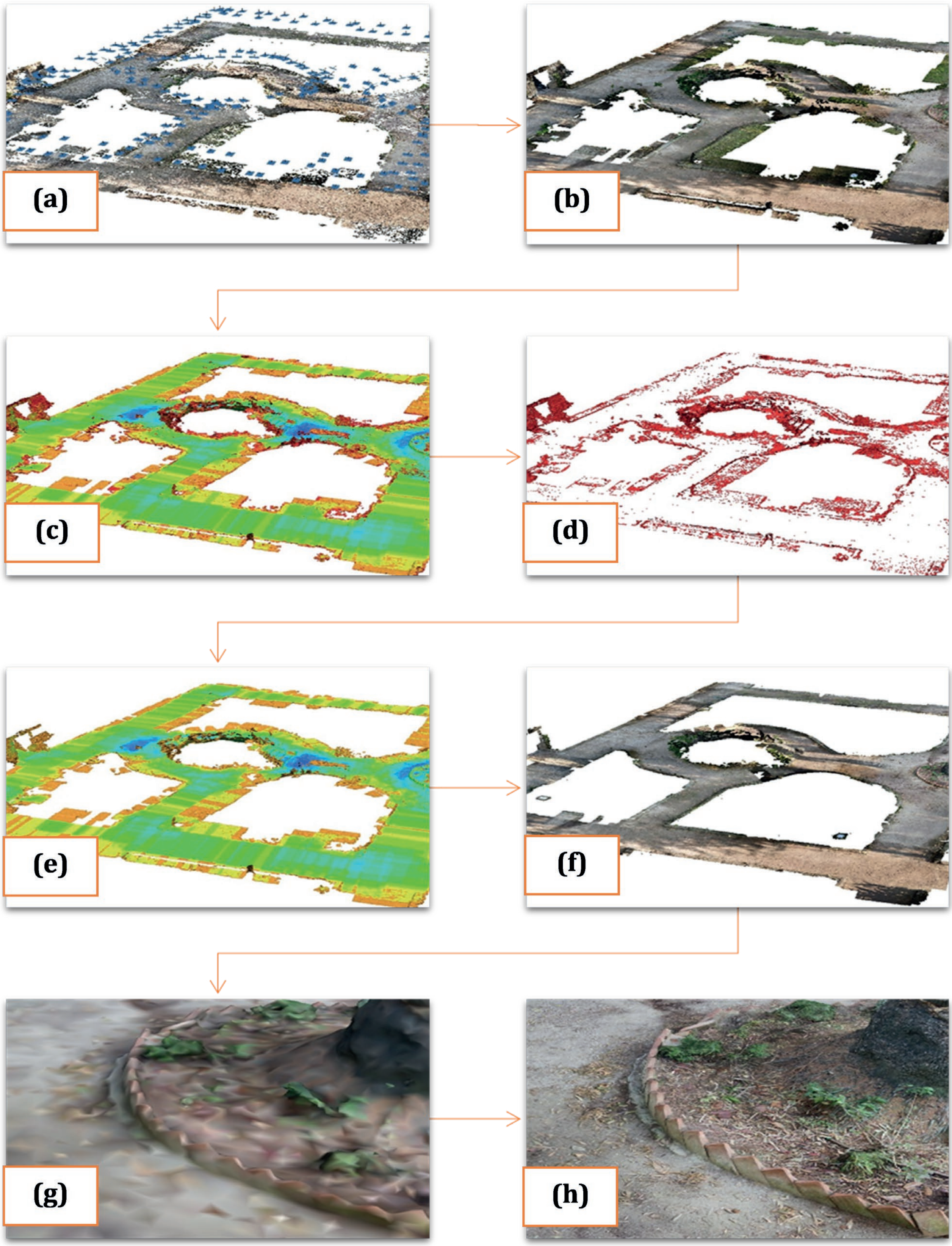

Figure 9 | (a) Orientation of the images taken with a drone and creation of a scattered point cloud (related points between the different images), (b) Dense point cloud. (c) Quality of the cloud of points obtained. (d) Point cloud noise. (e) quality of the cloud of points having eliminated the noise. (f) Clean point cloud having eliminated all the information not necessary for the final model. (g) Untextured mesh creation (h) Texture final mesh.

Figure 10 | Historical trace model.

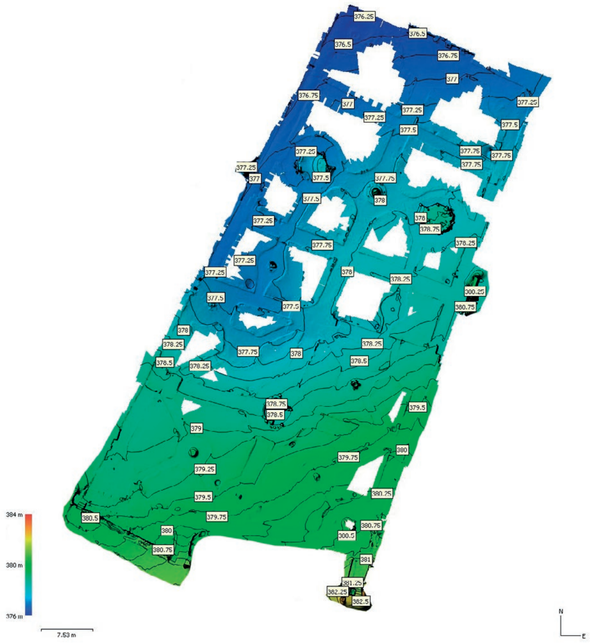

Figure 11 | Digital elevation model.

Figure 12 | Orthophoto.

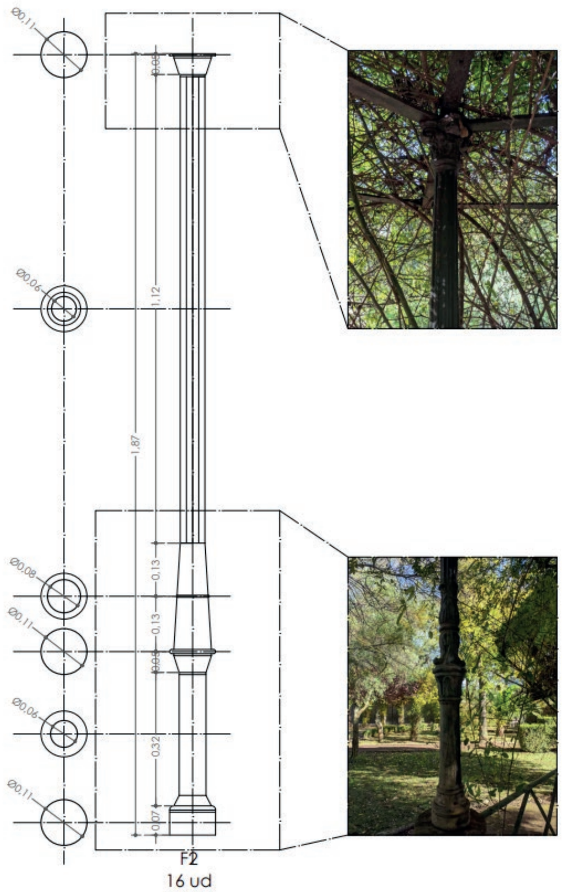

Figure 13a | Detail of wrought iron support.

obtain a complete model, orthophoto and digital elevation model with contour lines.

5.2 Survey of the buildings and architectural elements

The historical complex of the garden, has different well differentiated architectural elements, which can be separated for their individualized architectural survey. The set has two gazebos, a greenhouse, a pergola and its enclosure.

5.2.1 Process

Through data collection at the foot of the field, alternating different traditional architectural survey techniques, the geometry of the greenhouse, the gazebos, the pergolas and the perimeter fences of the enclosure have been

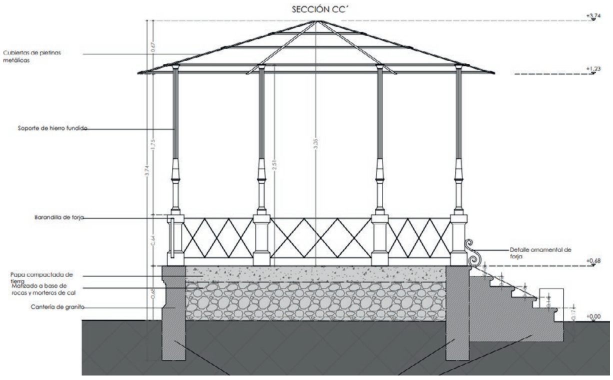

Figure 13b | Construction section of a gazebo.

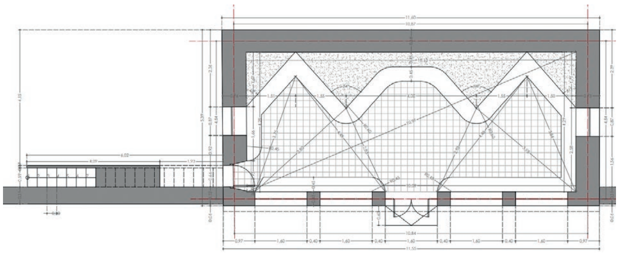

Figure 13c | Greenhouse ground floor.

obtained. These data have been digitized and drawn on a plan (Autodesk AutoCAD).

5.3 Vegetation inventory and positioning inventory and positioning of the vegetation

The third element that makes up the final model is the vegetation, it is the most important part of the enclave, but the most complex to survey with photogrammetry, for this reason, a referenced positioning of the different plant species has been carried out, which will later be placed in the final model, through parametric proxy elements.

5.3.1 Previous performances

In order to position the different plant species, it was necessary to obtain a precise planimetry of the enclave from the previous data collections. To obtain it, the orthophoto obtained from the survey of the trace is taken, which is vectorized to obtain a 2d geometry in cad format with Autodesk AutoCAD. This together with the geometry of the different architectural elements outlined individually, allows to obtain a single plan of the geometry of the enclosure. For the union of these elements, it was necessary to carry out data collection

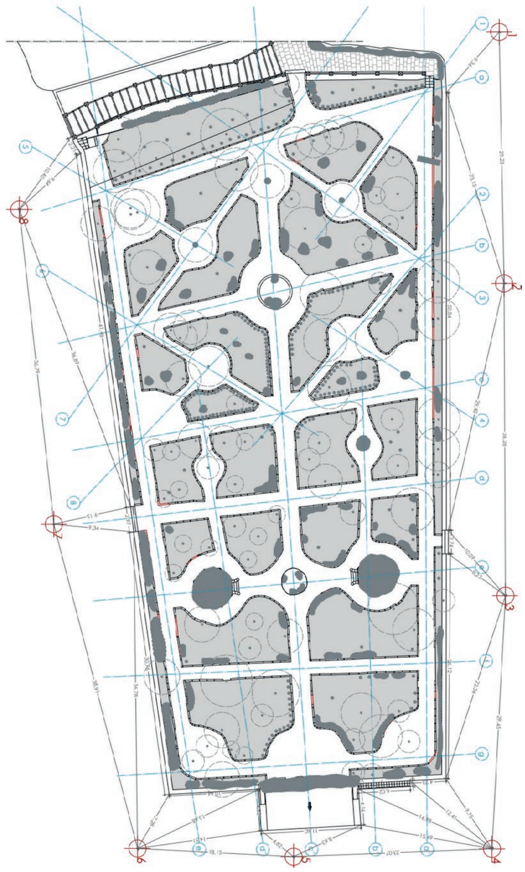

Figure 14 | General geometry of the enclosure.

in the field, triangulating the different components that make it up.

5.3.2 Data collection

For this process, we had a specialist in the field, the person in charge of caring for the garden. The procedure consists of identifying and positioning individually by triangulation each one of the floors of the enclosure, in the planimetry previously obtained.

In this process, a total of 63 different species were inventoried, coming from different parts of the world such as Asia, south, America, North America

5.3.3 Data processing

With the data taken in the field and the geometry obtained; the information is digitized. The vegetation information is added to the cad planimetry with Autodesk AutoCAD, using the same technique as for data collection.

Figure 15 | Vegetation Inventory.

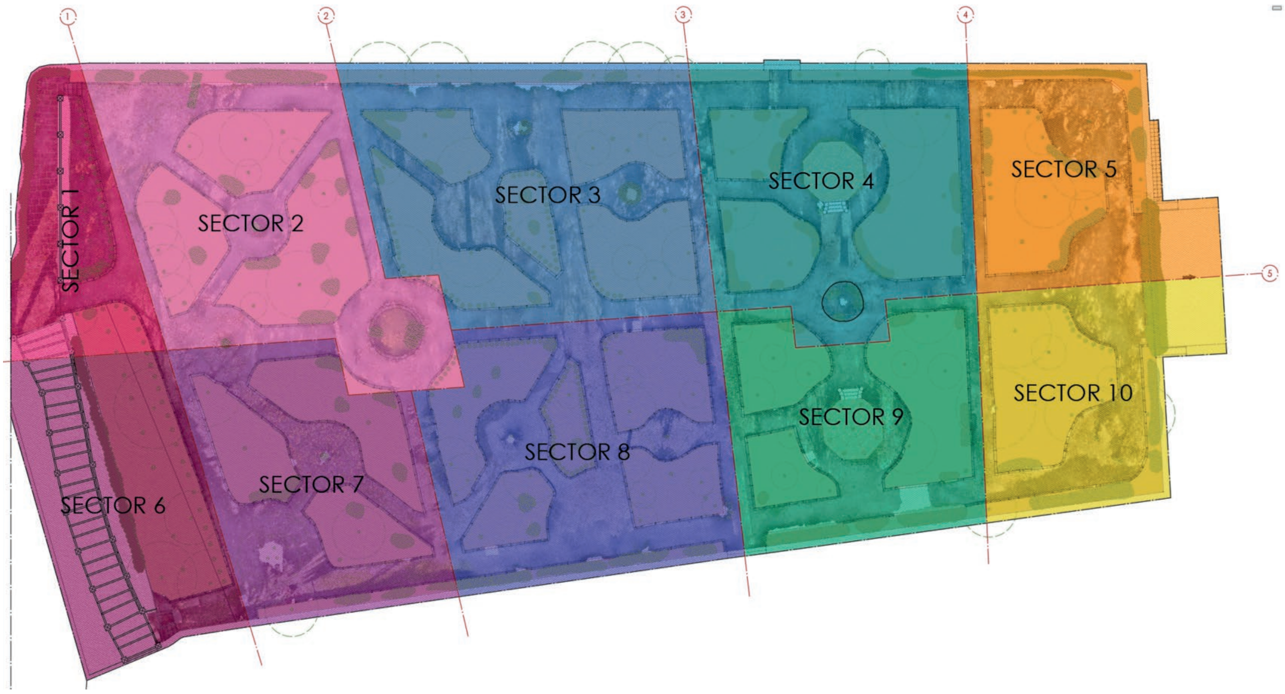

Figure 16 | Division by sector.

Figure 17 | Inventory sheet and positioning of the vegetation in one of the sectors.

5.4 Creation of a unique model

Until now, separate independent surveys have been carried out, the objective set is to achieve a unique parametric model.

5.4.1 Modelling of components

With the data and measurements obtained from the survey carried out in previous sections, the 3d model has been made using SketchUp. For this enclosure has been divided into components or proxy elements and they have been modelled separately.

5.4.2 Components union

The union of different components (as was done when the planimetry was obtained, that is, by triangulation) has been carried out by combining the different proxies and thus being able to form a single model with all the architectural elements.

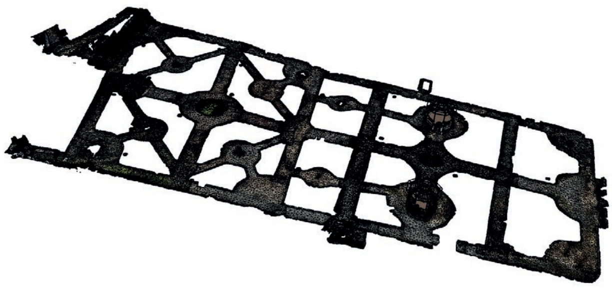

Figure 18 | Model of the original trace exported in DAE format from the photogrammetric survey.

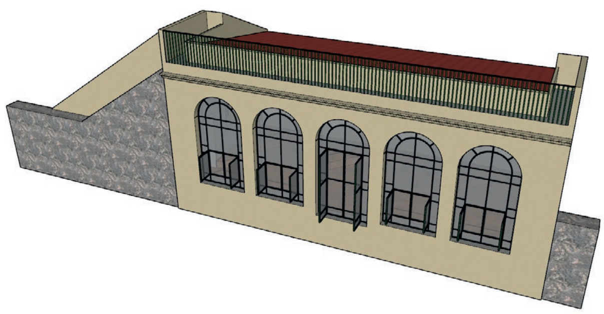

Figure 19 | Model of the greenhouse.

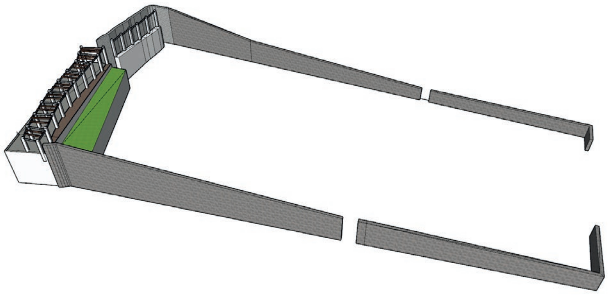

Figure 20 | Model of the enclosure and pergola model.

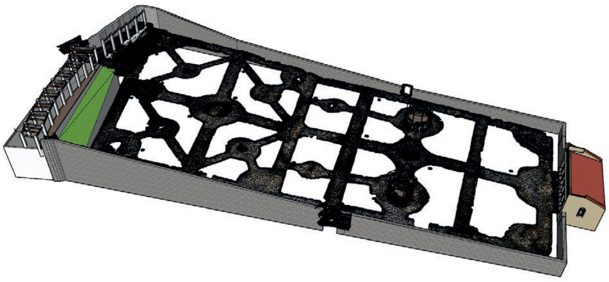

Figure 21a | Model of the architectural elements.

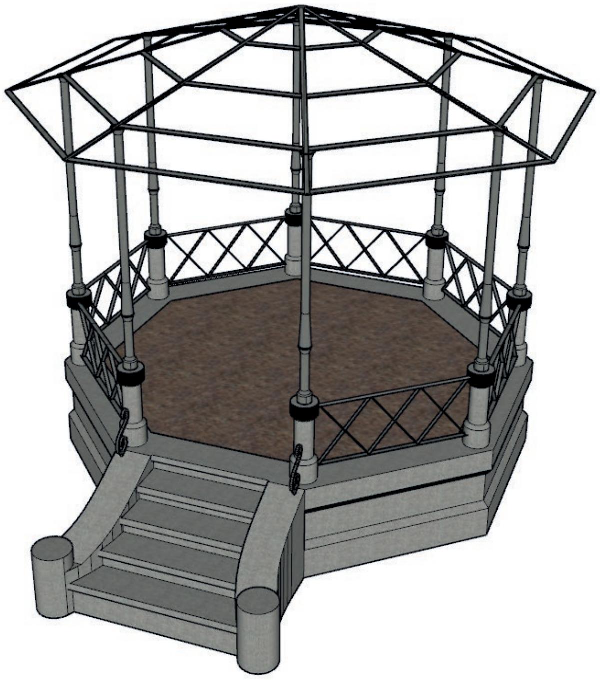

Figure 21b | gazebos model.

Figure 22 | General view of the vegetation of the ensemble.

Figure 23a | Interior view of the vegetation.

Figure 23b | View of the vegetation.

Figure 23c | View of the vegetation.

Figure 23d | QR of the video tour of the enclosure.

5.4.3 Incorporation of vegetation into the model

With the different geometries and buildings, the model is prepared for the incorporation of the most characteristic element of the garden: it's vegetation. This was achieved, thanks to the data collection obtained for its positioning and inventory, together with the existing parametric vegetation models of the different plant species in the Lumion software.

6. Results

With the use of this workflow, it has been possible to obtain a complete digital model of the garden.

This model serves as the basis for making this historical space known to the entire population, having created virtual visits, [Pérez Sendin, M., prototipado físico a partir de gemelos digitales aplicado a la torre de bujaco, en construcción - 2022, universidad de extremadura: caceres. P. 144}] rendered images and, in addition, has allowed the projection of a proposal for universal accessibility [Gomez Bernal, E., levantamiento planimétrico y propuesta de accesibilidad en la casa romana de la alcazaba de Merida, en diseño gráfico. 2021, Universidad de Extremadura: Cáceres. P. 144.] For the enclave, which facilitates even more its conservation and its use for events and visits. Complete accessibility to the entire garden area is achieved, including the adjacent renovated space. It is intented that the accessible route is completely integrated with the garden, in addition, this intervention will preserve the identity and geometry of the enclosure.

The way to integrate it will be through a path with little slope, which will follow the original shape of one of the flower beds, which in turn is one of the least representative and of least value, since it is an addition to the main geometry of the garden. With this, the pavements of the roads will be updated and improved, creating an accessible ramp and adaptation of the access stairs, all to facilitate accessibility for people with reduced mobility.

By using this workflow, a complete digital model of the garden was obtained.

This model serves as the basis for making this historical space known to the entire population, having created virtual visits [6], render images and has also allowed the projection of a proposal for universal accessibility [7] for the enclave to further facilitate its conservation and its use for events and visits.

Figure 24 | Refurbished state of the greenhouse and recreation of the current state of the greenhouse.

Figure 25 | Proposed accessibility of the site and Intervention in the greenhouse.

7. Final conclusions

It has been possible to verify this workflow, despite combining three methodologies for data collection, is fully functional. It allows obtaining a high-quality model, and lot of versatility, which depending on the resources available and the particular situation, being able to choose one methodology or another or combine them with each other, this being very useful, for the subsequent application of these data in the realization of architectural projects for the restoration and conservation of heritage.

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