3D MODELING TECHNIQUES FOR THE RESTORATION AND CONSERVATION OF HISTORICAL BUILDINGS

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***Abstract**: In the restoration and conservation of historic buildings and monuments, for verification and repairs of any kind, accurate information on shape, size and architectural details are of utmost importance. The field of photogrammetry plays an important role in this process, through the possibilities of 3D modeling and representation of historical buildings and monuments. At present, there are a series of photogrammetric software with expertise in image processing algorithms, with digital photogrammetric techniques that establish the direction of development of the applied instruments. The process of photogrammetric modeling uses terrestrial and aerial images of the building attached to the solid model, obtaining a 3D realistic model. This is easily visualized, analyzed and modified by users, even in other fields, such as architecture or history. The advantage of the "multi-view 3D reconstruction technology" is the possibility to use images no matter the shooting distance, as long as each two images contain common points.*

***Keywords:** restoration and conservation of historic buildings and monuments, 3D modeling and representation, terrestrial and aerial images, digital photogrammetric techniques, multi-view 3D reconstruction technology*

1. Introduction

Historical buildings and monuments are part of the national cultural heritage, constituting real estate owned by the state, being significant for culture and civilization. Historical buildings and monuments are inventoried and systematic records are made, from a technical, economic and legal point of view, measurements are performed in order to represent them on cadastral plans and maps, their registration in cadastral registers and registration in the land book [1].

As a case study for this paper, we chose the "Ierihon" Building in Alba Iulia (Fig. 1), a historic building built in 1756. This building was destroyed in unknown circumstances, being rebuilt after 1900 [1].

Fig. 1. The "Ierihon" Building in Alba Iulia

2. Materials and Methods

The historic buildings and monuments objectives are a fundamental part of culture and civilization. For this reason, the activity of restoration and conservation of these objectives is of great importance. This is done based on accurate information on the shape, dimensions and architectural details of the objectives.This information can be obtained by photogrammetric methods, with high accuracy, maximum efficiency, and relatively low costs [2], [3].

The photogrammetric equipment used for taking terrestrial and aerial images for 3D modeling and representation of the chosen building was: Sony DSLR Alpha 350 camera and DJI Phantom 4 drone (Fig. 2). In addition to taking terrestrial and aerial images, topographic measurements would be performed to accurately define the shape, dimensions and spatial position of the objective [1].

Fig. 2. The photogrammetric equipment

For digital 3D modeling and representation based on the captured images, Agisoft PhotoScan software was used, obtaining the three-dimensional model of the studied building. It is a standalone software that performs photogrammetric processing of digital images and generates 3D spatial data that can be used in various fields, such as GIS applications, for indirect measurements of objects at different scales etc. [4], [5].

In order to take the images, a connection with the object-space must be ensured [2]. In order to make this relationship possible, control points have been established in the field. These control points represent the basis for taking terrestrial and aerial images and their processing. The spatial position of the control points was determined by GNSS methods [1].

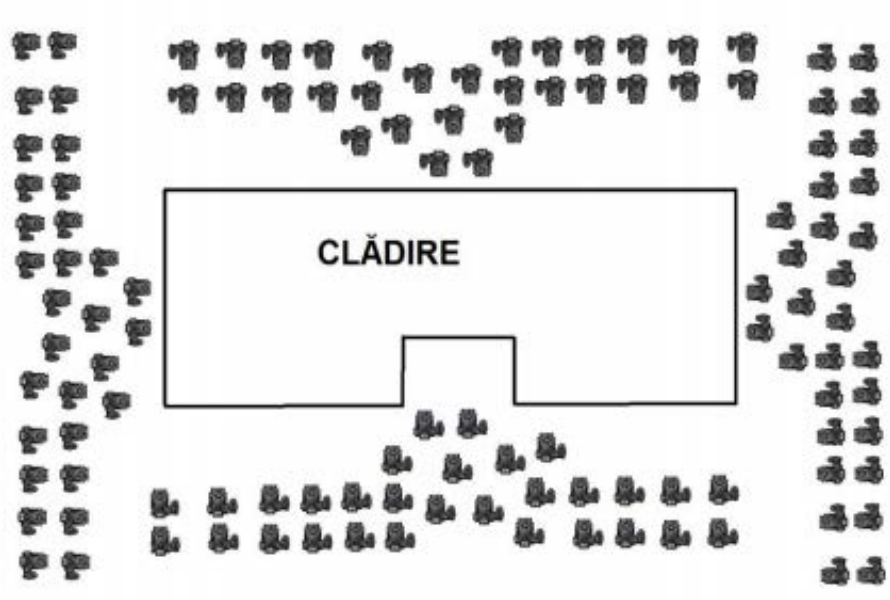

Fig. 3. Taking terrestrial images

When establishing the photogrammetric bases, in addition to the general technical conditions (the photogrammetric bases parallel to the building facades; avoiding obstacles and hidden areas; the distance between the photogrammetric bases and the objective established according to the scale of the final photogrammetric product and the visibility conditions; the length of the photogrammetric base determined according to the maximum and the minimum distance from the objective; taking pictures at the time of day with the best lighting; image coverage of at least 30%, etc.), a series of particular technical conditions were adopted, in order to meet the requirements of accuracy, in the conditions of the surrounding area: for the main facades of the studied building, several rows of photogrammetric bases were established, at different distances from the objective, in order to capture both overall images (Fig. 3), but also as many detail images as possible (Fig. 4) [1].

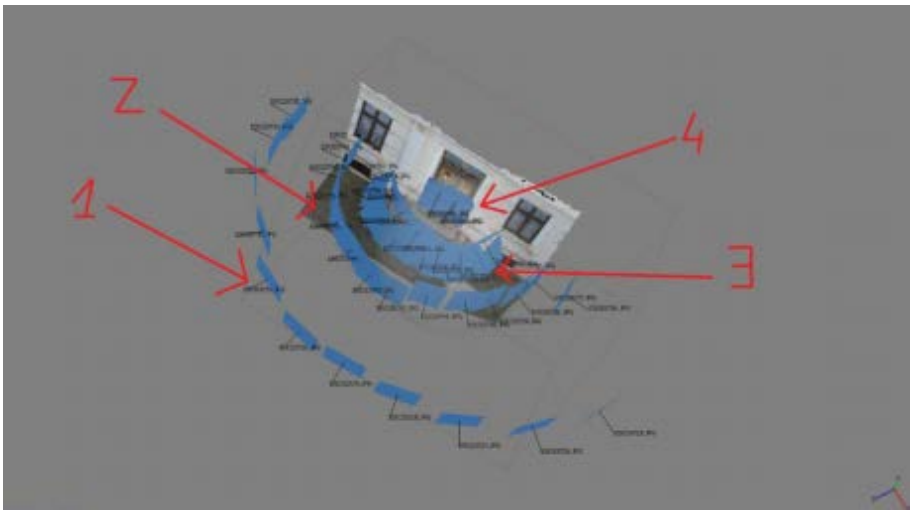

Fig. 4. Taking terrestrial detail images

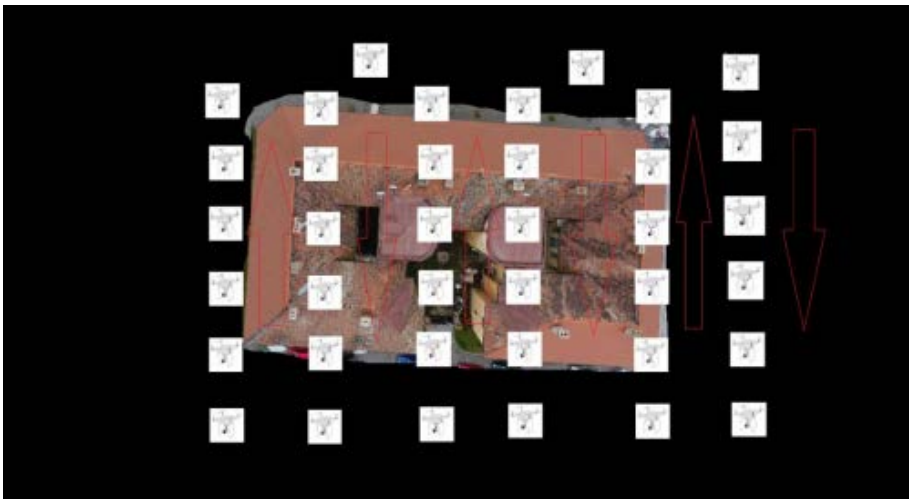
Fig. 5. Taking aerial images

Digital modeling of the studied building, based on the taken terrestrial and aerial images, was performed using Agisoft PhotoScan photogrammetric software. After importing the taken images and inspecting them to identify useless images and delete them, the next step is to align the photos. The software processing algorithms look for common points in the

uploaded images, identifies them and matches them. As a result, a set of common points is generated, also determining the exact position of each image (Fig. 6) [1], [2], [3].

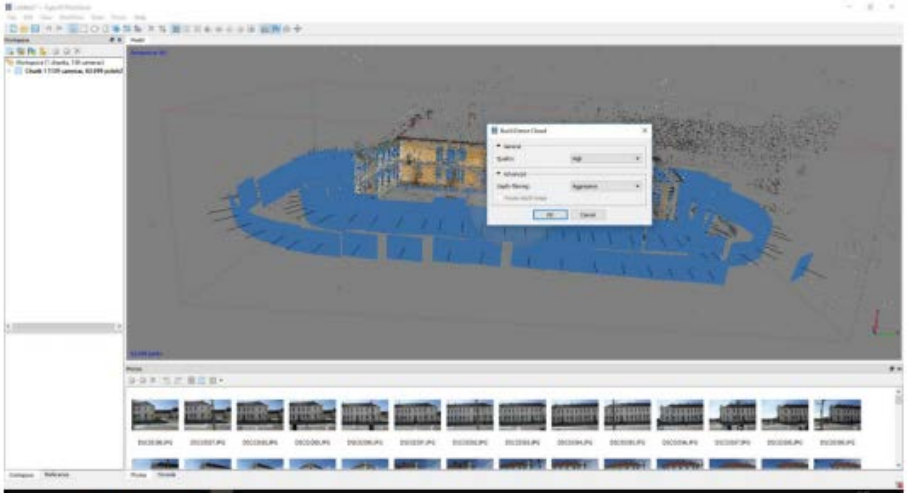

Fig. 6. Images alignment

The modeling process is all the more difficult as more images are loaded for processing, but it increases the accuracy, the degree of realism and reduces the distortions of the resulting model [3].

Based on the process of images alignment, a point cloud will be generated, and by joining the points, a surface will be generated that represents the surface of the objective, close to the real one, called mesh [1], [2].

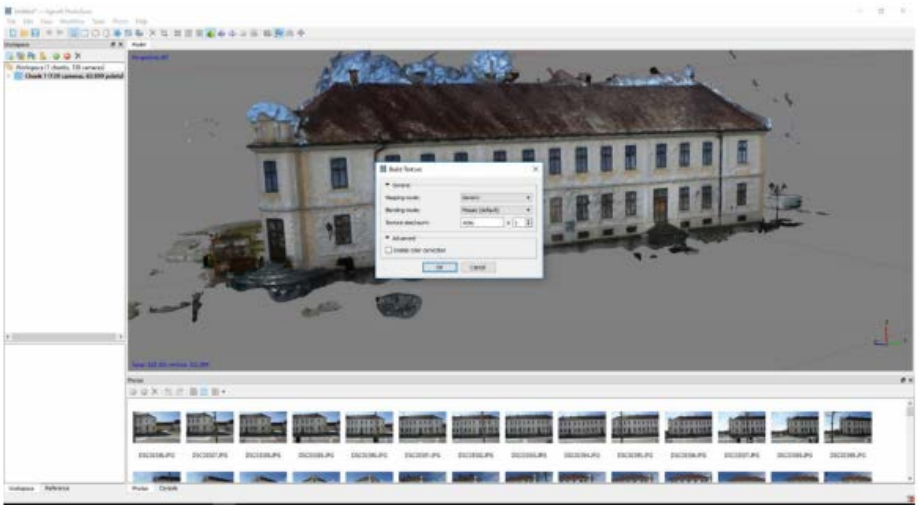

Fig. 7. Creating mesh geometry

Adding texture is a function that helps to improve the appearance of the processed digital model.

After the structure of the digital model has been built, certain contextual adjustments can be made manually, such as impurities, the appearance of certain bodies that could blur the model. Once this stage is completed, it can be considered that the model is in the final stage (Fig. 8) [1], [2].

To complete the model obtained based on terrestrial images, a new chunk model will be generated, in which the aerial images will be uploaded and processed, similar to the one presented above. In the end, the two chunk models will merge into a single one [1].

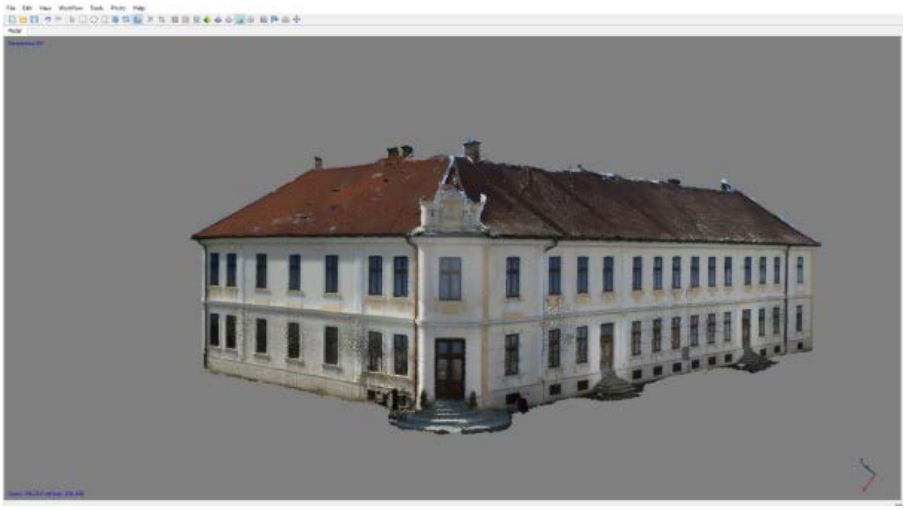

Fig. 8. 3D model obtained by modeling terrestrial images

In the digital modeling, after the processes of images alignment, geometry creation, texturing and finishing, the software also allows the generation of the georeferenced orthophotoplan (Fig. 9) [1].

Fig. 9. Orthophotoplan generation

3. Results and Discussion

The generation of the textured 3D model of the historical building Ierihon, Alba Iulia, using the equipment and working methodology presented in the paper, is relatively fast, does not require a large volume of work and does not involve high costs for the equipment and software used; instead, the result obtained falls within the requirements of precision and can be used successfully in the project of rehabilitation and conservation of historical buildings and monuments [1], [2].

The chosen method allows the generation of 3D models (wireframe, solid or photographic) made on the basis of a very large number of images, both terrestrial and aerial, which do not need to be rectified in advance. In addition, the user has a whole range of possibilities for editing images and the created 3D model [5].

4. Conclusions

The paper proposes a method for generating 3D models based on images, and the Agisoft PhotoScan software uses a new technology called "multi-view 3D reconstruction technology". The software allows images to be taken from any position, regardless of the shooting distance, as long as there are at least two common points on two images. Both images alignment and digital model generation are done automatically. All these advantages make the proposed method very versatile [4], [5].

The results obtained by such methods can be used successfully in fields such as architecture, urbanism, history or tourism, giving the possibility to make simulations and visualizations on a project, as well as reconstruction, renovation and conservation of historical buildings and monuments [2].

5. References

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