APPLICATION OF CLOSE-RANGE PHOTOGRAMMETRY TO CULTURAL HERITAGE

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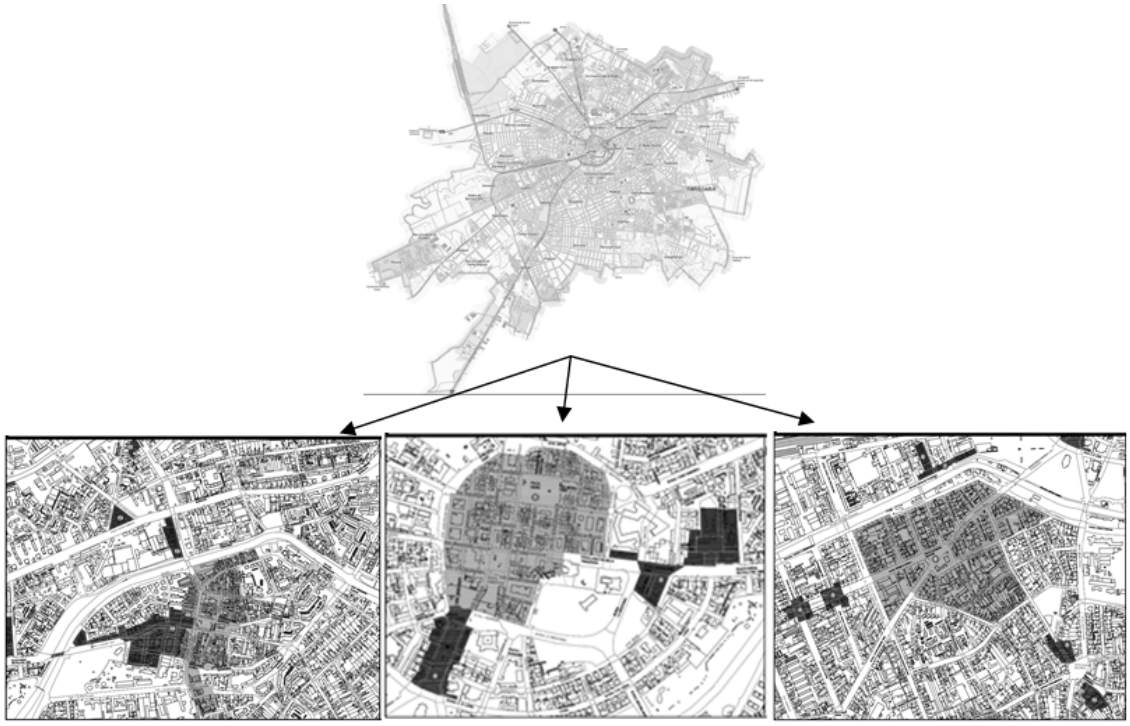

Fig. 1. Map of Timişoara where highlighting show the areas with historical buildings

In this context, it is obvious that an efficacious urban planning must include 3D modeling of heritage sites for purposes such as: documenting historic buildings and monuments for reconstruction or restoration if they are destroyed, creating education resources for history and culture students and researchers, simulation of new buildings, updating and keeping cadastral databases current, visualization from viewpoints that are impossible in real world due to size or accessibility, interaction with objects without risk of damage and virtual tourism. [2], [3]

The high level of topicality on 3D technology is demonstrated on one side by the increased interest of both scientific and industrial sectors of producing 3-dimensional models of major cities, and on the other side by the development of solutions to capture, display and manipulate this type of data by the global technology companies. [4]

3D models can help to create the master plan of any populated area by designing a dynamic framework for planning and development. While they are generally used to simply visualize the built environment, there are early signs of them being used as 3D interfaces to more sophisticated simulation models. [5] That is why, in recent years, more and more engineers worldwide have approached this relatively new field, the three-dimensional modeling, preferring 3D design systems instead of the traditional 2D drawing. [6], [7]

A 3D model is composed of objects, materials, layers forming a complex structure. In it we can visualize certain parts separately or all the elements together. Objects and materials have easy to highlight properties, called visual properties such as colour, light reflection, contrast or albedo. As a final product we can obtain the facade of buildings, their roofs or 3D models. A wide variety of applications demonstrate that 3D models allow the user to process different information contents from a digital representation of the reality. [8]

3D modelling represents a first reference for Geo-3D modeling and data analysis, with applicability for studies on many important directions and in various fields, such as: geophysics, mining, hydrology, environmental protection etc. [9]. 3D modeling offers multiple advantages, namely correcting heights, interconnecting the object's components, creating a new product based on the primary elements. Thus, the designing process is

facilitated together with an effortless manipulation of the complex data. Finally, the data can be integrated and exported to other programs specialized in a particular field, such as: design, urban planning, tourism, real estates, police and security etc. Dimensional models can be, in turn, very helpful in specific analysis, but can also be sources for the implementation of another product.

2. 3D modeling of the "Martyrs" monument using close-range photogrammetry

In general, digital photogrammetry is the art of using computers to obtain the measurements of objects represented in a photograph. Based on analysing one or more existing photographs or videos with specialized photogrammetric software, the topology of the objects can be determined. Although commonly used to create topographical maps, it may also be useful in a variety of industries such as architecture, manufacturing, engineering, police investigation and forensic applications, film gaming and animation and even plastic surgery. [10]

Normally, field surveys are more accurate than photogrammetric measurements; nevertheless they involve accurate and state-of-the-art specialized topographic instruments, more personnel and are time consuming. As most of the specialized software offers an automated workflow of the digital data, photogrammetric techniques have now become an efficient alternative to the classical building measurements and reconstruction.

Having in mind economic aspects regarding data acquisition and necessary equipment for data collection, close-range photogrammetric methods based on images taken with amateur digital cameras differentiate themselves with respect to other methodologies specific to terrestrial measurements' domain. A multitude of photographs of the studied object can be taken on field allowing the user to choose the most suitable ones in the processing stage. Before using the camera in the project, the camera needs to be calibrated, under required photographical conditions. For accuracy purposes, recovering 3D structure from images implies calibrated cameras, that is, the mapping between image coordinates and directions relative to camera is known. This mapping is determined by, among other parameters, the focal length and its pattern of radial distortion. After calibration there is a variety of programs that can be used to complete the project. [11]

The cultural heritage of Timişoara includes, beside the historical buildings, 12 monuments raised in memory of the 1989 Revolution that led to the falling of the comunist regime in Romania. The monuments are located in emblematic areas of the city, where people have died and pay homage to both the events, places filled with symbolic meaning, and to those who have paid with their lives in the tumultuous events of December 1989. The monuments are: "Opening", "The hero ", "The Bell of freedom", "The triumpher", "Evolution", "Target man", "The weeping church", "Martyr's fountain", "Reverential monument", "Saint George", "Martyrs", "Piety".

For the present project, an experiment has been conducted using close-range photogrammetric technique to generate the 3D model of the "Martyrs" monument. The camera used in the project is Leica C-LUX 2 digital camera, 7 megapixels, lens DC Vario-Elmarit 1:2.8-5.6/4.6-16.4 ASPH.

"Martyrs" monument (Fig. 2) was realized of bronze by the Romanian sculptor, Peter Jecza, in 1998 and is situated in Banat's Museum Park. It pays a tribute to the people that participated to the protest and that were killed and buried in a hurry, in the common graves from the Heroes Cemetery, following to tell their families that they run over the borders. If we look carefully at the piece, we can distinguish human heads, hands, a shocking image of bodies thrown one on top of the other.

Around the monument, 7 flagstones are positioned with date engravings: 15th December, 16th December, 17th December, 18th December, 19th December, 20th December, 21th December, each of them symbolizing a battle day until the victory. [12]

Fig. 2. The "Martyrs monument" in Timişoara

Agisoft PhotoScan is an advanced image-based 3D modeling solution aimed at creating professional quality 3D content from still images. Based on the latest multi-view 3D reconstruction technology, it operates with arbitrary images and is efficient in both controlled and uncontrolled conditions. Photos can be taken from any position, providing that the object to be reconstructed is visible on at least two photos. Both image alignment and 3D model reconstruction are fully automated. Generally the final goal of photographs processing by PhotoScan is to build a textured 3D model. [13]

The procedure of photographs processing and 3D model construction comprises four main stages:

- The first step consists in **data acquisition** on field, 33 photographs of the monument were taken and 2 distances (one horizontal and one vertical) were measured on it. The processing of the data started with choosing the area of interest, in the sense that the specialized program used allows processing of the images taken with the disadvantage that the point cloud will be very dense and will also contain the elements from the surrounding areas of the monument. Moreover, the processing will be time consuming and will require high usage of the PC's resources. Thus, creating the masks or cleaning the noise from the photographs – eliminating the vegetation and the buildings around the monument of interest (Fig. 3) – demonstrates its importance and must be performed before aligning the photographs.

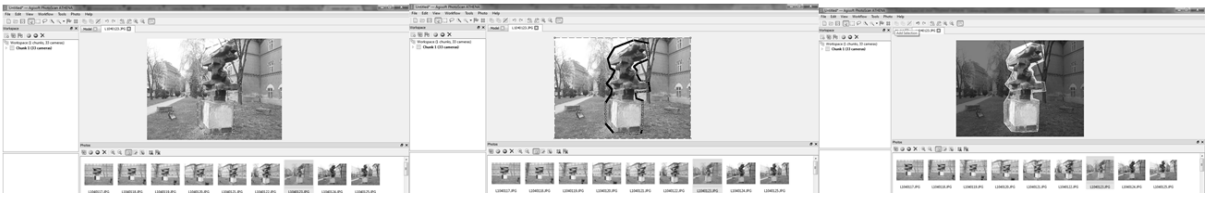

Fig. 3. Creating the masks

- The second stage is **photographs alignment** (Fig. 4). At this stage, the specialized software searches for common points on photographs and matches them, as well as it finds the position of the camera for each picture and refines camera calibration parameters. As a result a sparse point cloud and a set of camera positions are formed.

The point cloud represents the results of photos alignment and will not be directly used in the further 3D model construction procedure (except for the point cloud based reconstruction method). However it can be exported for further usage in external programs. For instance, the point cloud model can be used in a 3D editor as a reference. On the contrary the set of camera positions is required for further 3D model construction by PhotoScan.

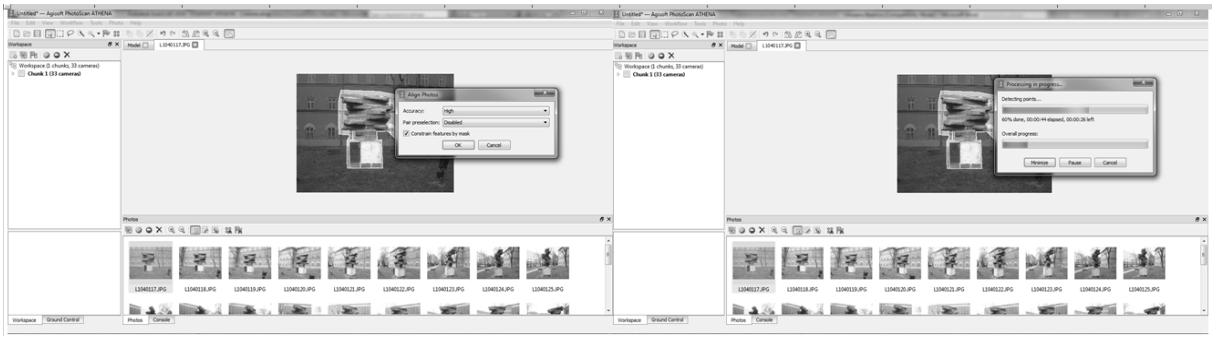

Fig. 4. Aligning the photographs

- The next stage is **building geometry** (Fig. 5). Based on the estimated camera positions and pictures themselves a 3D polygon mesh, representing the object surface, is built by PhotoScan. Four algorithmic methods available in PhotoScan can be applied to 3D mesh generation: Arbitrary - Smooth, Arbitrary - Sharp, Height field - Smooth and Height field - Sharp methods. Additionally there is a Point Cloud based method for fast geometry generation based on the sparse point cloud alone. Having built the mesh, it may be necessary to edit it. Some corrections, such as mesh decimation, removal of detached components, closing of holes in the mesh, etc. can be performed by PhotoScan. For more complex editing, one has to engage external 3D editor tools. PhotoScan allows exporting the mesh, editing it by other software and importing it back.

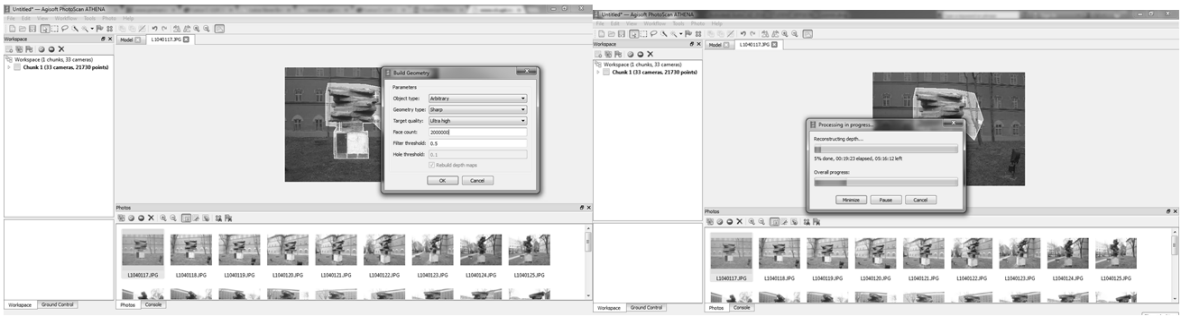

Fig. 5. Setting the parameters for building the geometry of the point cloud

- After the geometry (i.e. the mesh) is constructed, it can be textured and / or used for orthophoto generation. Several texturing modes are available in PhotoScan (Fig. 6).

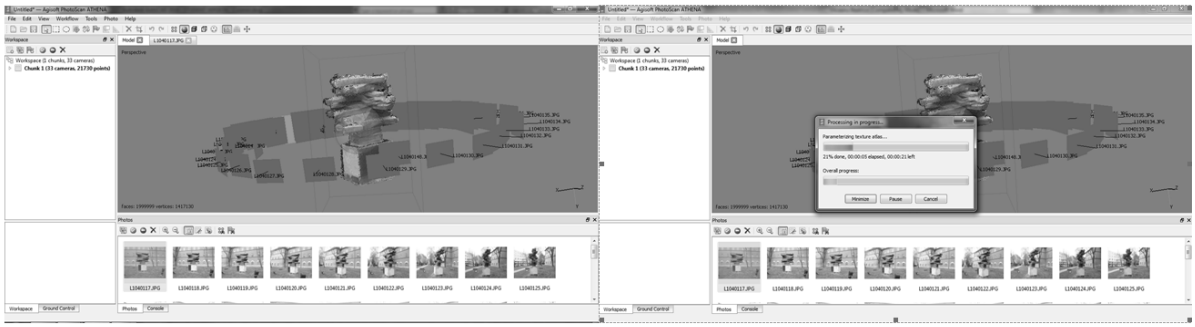

Fig. 6. The point cloud and the settings for applying the texture

Many applications require data with a defined coordinate system. Setting the coordinate system also provides a correct scaling of the model allowing for surface area and volume measurements and makes model loading in geoviewers and geoinformatics software much easier. Thus, the final step was scaling the model (Fig. 7) using the vertical and horizontal distances measured on field. This step required placed markers on the 3D model and also measuring other distance for accuracy purposes (Fig. 8).

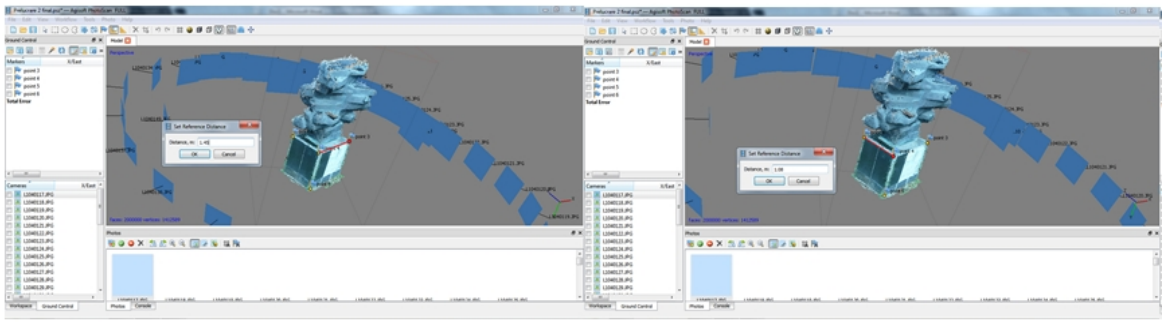

Fig. 7. Setting the reference distance for defining the model's scale

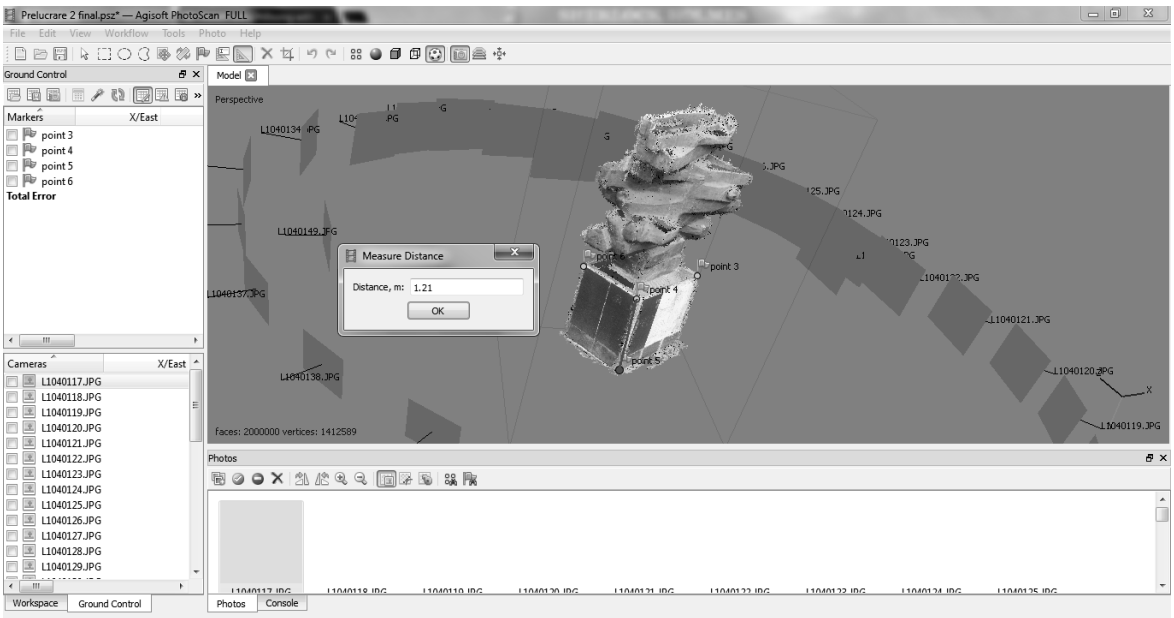

Fig. 8. Measuring distances on the 3D model

After the photographs are processed and the 3D model (Fig. 9) is obtained, the results can be exported in various representations. Sparse and dense point clouds, camera calibration data, 3D models, orthophotos and digital elevation models can be generated according to the user requirements. Point clouds and camera calibration data can be exported right after photo alignment is completed. All other export options are available after the geometry is built. In some cases editing model geometry in the external software may be required. PhotoScan supports model export for editing in external software and then allows importing it back. [13]

Some of the formats in which the specialized software PhotoScan supports exporting are Wavefront OBJ, 3DS file format, WRL, Collada, Stanford PLY, Autodesk DXF, U3D, Adobe PDF.

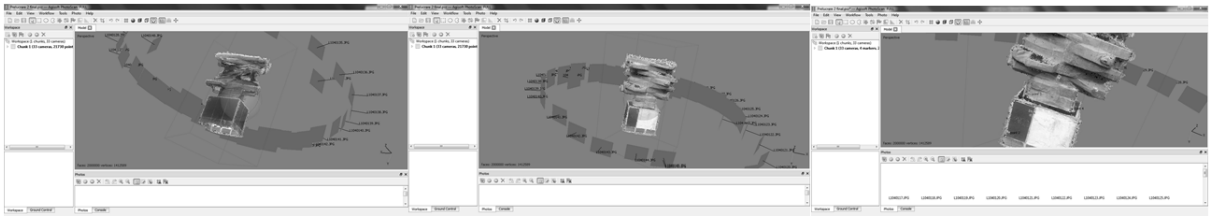

Fig. 9. The final 3D model of the "Martyrs" monument

3. Conclusions

Nowadays, due to the availability of digital cameras in the market at reasonable costs, Photogrammetry offers the best alternative technique to any other CAD based techniques used.

Realizing the project presented in the present paper included tasks such as observation, research and modeling of the "Martyrs" monument in order to process the photographs into a 3D model representation. This monument is part of an urban surrounding space, which protects it, but does not highlight it properly. One conclusion which emerges is that the monument needs some works for its restoration and the specialists should take into consideration monument integration in the surrounding area.

In particular, the approach presented has several advantages:

- develops easy-to-use authoring tools for cultural heritage 3D experiences,
- ensures access to cultural heritage 3D content,
- value-added functionality of a non-textual, semantic documentation and processing of cultural heritage 3D content,
- develops solutions for improved search, identification, re-use and integration of 3D datasets by end users in cultural heritage,
- provides solutions for an effective management of cultural heritage 3D content.

The above model demonstrates the importance of using digital close-range photogrammetric techniques in accurate 3D modeling and visualization for cultural heritage. The precision obtained in the 3D modeling corresponds perfectly to any further work like reconstruction etc.

As regards the specialized software, it is fully automated to create the point cloud, build the geometry and the texture of the object. User only cuts out the unnecessary points, which are not important for the modeling around the object. It is recommended to use PhotoScan for the objects with complicated geometry. The speed of the calculation depends on hardware capabilities of the computer.

4. References

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