RESEARCH FOR THE POSSIBILITIES OF DIGITAL PHOTOGRAMMETRIC METHODS FOR CLOSE RANGE STEREOSCOPIC PHOTOGRAPHS, APPLIED ON THE RUINS OF TRANSEPT AND CHANCELOF THE CHURCH OF AULNE ABBEY (THUIN, BELGIUM)

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ABSTRACT:

There has always been a need of documents, metric or non-metric, that give an overview of the state of buildings with a certain historical, archaeological or cultural importance. This is certainly the case for the old church of the Aulne Abbey, Thuin, Belgium. The goal of the project, described in this paper, was threefold. First of all there was a need for orthophotoplans of certain parts of the church for archeological purposes. Second, and very close related to the first goal, was obtaining a three dimensional model of the church ruins. This model is to be used in a later project, concerning the 3D visualisation of the site. The last, and most important objective was to obtain a methodology for similar projects and sites in the future.The method described in this paper, covers the whole workflow from fieldwork, over photogrammetric processing to orthophoto plans. The main problems that arose in the development of this methodology was the presence of false parallaxes caused by doors and windows in the walls, and the angle by which the photographs were taken. In some cases a solution was found by treating the photographs in a different way, accordingly to the position of the camera at the moment of exposure. In a second project new photographs are taken in a perpendicular way for the purpose of the planning of the restoration of the ruins.

1. SITE DESCRIPTION

The history of Aulne Abbey starts in the second half of the seventh century. In that era monks raised the first buildings of the Abbey near the river Samber. Very few of the buildings are left today as they once were, and what rests are mainly ruins. The abbey is located in the City of Thuin in Belgium.

Figure 1. View on from the south on the old Abbey church

There is a need of extended documentation on this ruins, because the Belgian government is planning consolidation of the site as it is now, rather than restoring the site in its original state, starting with the transept and the chancel of the old abbey church. One type of document that is required is an orthophotoplan.

2. METHODOLOGY

2.1 Data acquisition and fieldwork

2.1.1 Artificial Ground Control Points:

For a number of reasons the choice was made to put artificial marks on the wall, which serverd as ground control points (GCP) for absolute orientation. Up to a height of seventeen meters pieces of cardboard of six by six cm were collated to the walls. For the higher parts of the walls, other ground control points were selected, such as corner of stones, the top of an arch.

The main reason to use artificial GCP is that they are easier to locate, both on the terrain for the topographical survey, as on the photographs.

2.1.2 Photography:

The photographs were taken with a Rollei 6008 metric camera, with a 40 mm lense. A total of 65 stereopairs were made on 6 by 6 diapositives. Where possible the photographs were made with the optical axis of the camera perependicular to the surface of photographed the wall. In some cases an elevator was needed because the opposite wall didn't allow to stand far away from the walls.

In some cases there was no other solution than to take the photographs with a certain inclination angle, up to 45°. Nevertheless, it was taken care of that within one stereopair the optical axis of the camera were parallel to each other to avoid large differences in inclination angles.It was ensured that on each stereopair a minimum of 6 GCP was well visible.

2.1.3 Topographical Survey:

A Leica TCR307 reflectorless total station was used to measure the X,Y and Z coordinates of the 320 GCP. All points were measured in one local reference system, which allows to know the position of any of the GCP relative to any other point.
The GCP other than the artificial GCP needed more extended documentation with drawing, photographs and a description of the point and its direct situation on the object.

2.2 Processing of the topographical survey

The reference system in which the GCP are measured is not suitable as reference system for the photogrammetric orientation. For each stereopair a transformation was needed to simulate a reference system similar to the situtation for aerial photographs. This is shown in Figure 2.

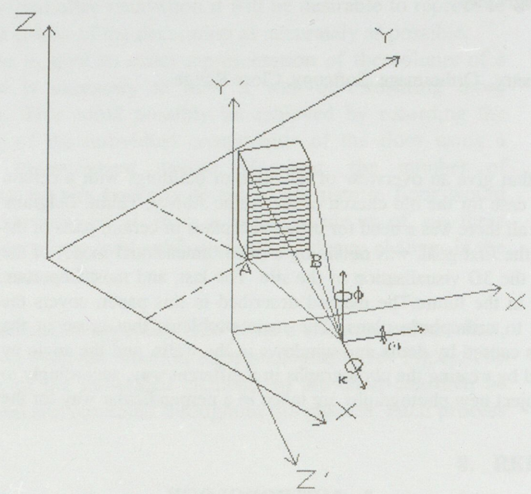

Figure 2. Coordinate transformation form local to photogrammetric reference system

The X, Y and Z axis show the local reference system, while the X', Y' and Z' show the reference system for the stereopair of one particular object.

2.3 Stereoprocessing of the photographs

2.3.1 Scanning the photographs

All of the 130 photographs were scanned at a 21 micron resolution. A 6 cm by 6 cm diapositive scanned at 1200 dots per inch (dpi) results in a 24 Mb file in tiff format. The stereopairs were processed without compression in VirtuoZo 3.1. This is a digital photogrammetric software pack.

2.3.2 Orientation

The interior orientation was possible because the calibration certificate of the camera and the lense was available. The cursor must be put manually on the fiducial marks.
In the relative orientation the PC finds between 60 and 200 tiepoints in a fully automatic way. After the manual absolute orientation, an area is defined for which epipolar images are resampled and the stereomodel is built up for.Once the orientation is done, all parameters of the exterior orientation are known and automatically calculated.

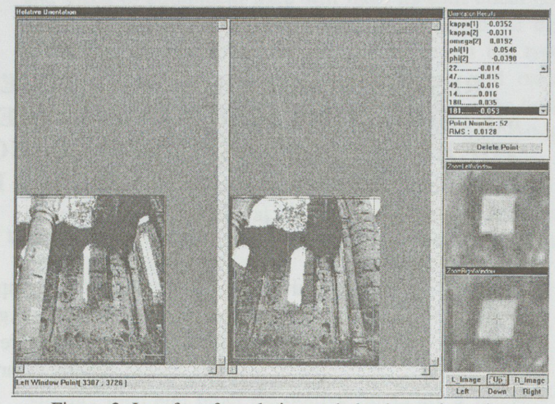

Figure 3. Interface for relative and absolute orientation

2.3.3 Parallax calculation

The parallax calculation in the stereopair is done fully automatic by image matching. The Least Squares Matching algorithm (LSM) is based on the minimazation of the squared differences of the grey values of the image patches [Schenk, 1996]. The image patches consist of 9 by 9 pixels or larger. If for example a large part of a wall is taken by a window or other cavities, larger image patches gave a better result.

2.3.4 DEM and orthophotogeneration

With the parameters of the exterior orientation and the results from the matching algorithm, the Digital Elevation Model and the orthophoto can be created. This happens automatically, and requires no action from the user other than giving the DEM spacing (10cm) and the orthophotoresolution (1cm).

2.4 Orthophotoplan

In the final stage the orthophotoplan is created. This is the result of putting one or more orthophotos together in a layout with some additional information which is useful and needed for an efficient and reliable interpretation of the result. Unlike a map or a line drawing, the orthophotoplan gives an non-generalised image of the object. Two scales are used : 1/25 and 1/50.

The following items are displayed on the plan :

- Orthophoto
- Scale : graphical and numerical
- Ground plan showing what part of the site is on the orthophoto
- The number of stereopairs the orthophoto is made of

An important issue is that it is possible to mosaic several orthophotos of one wall to one consecutive orthophotplan, without a visible edge between two orthophotos, other than differences in color or illumination.

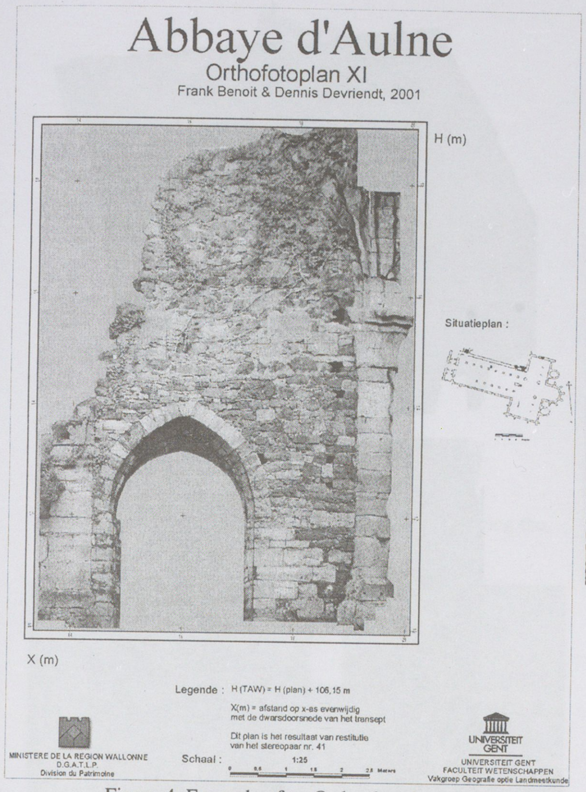

Figure 4. Example of an Orthophotplan

3. PROBLEMS IN THE METHODOLOGY AND POSSIBLE SOLUTIONS

The methodology described in the previous paragraphs suffers some problems. These problems can be divided in two main categories, according to the solution.

3.1 Problems that can be solved only with other photographs

When parts of the wall on a photo are covered with vegetation, this results in a false DEM and according orthophoto. Although the surface beneath the vegetation can be interpolated, a more accurate DEM will be possible is the vegetation is removed before the photographs are taken.

Problems due to the central projection of the photograph and the relief of the object, e.g. occlusions, can only be solved by making photographs from other points of view.

As mentioned before, a number of stereopairs were taken with a certain inclination of the optical axis. This leads to a different resolution over the image. No quantitative analysis was done on the effect of tilt on the quality of the orthoimages. Although we can say that the absolute orientation is harder in the upper parts of tilted images, and the matching algorithm gives poor results in those areas, it is certainly possible to use tilted images up to a certain limit of the angles. In figures 5 and 6 the effect of tilt on the image geometry and the resolution becomes clear.

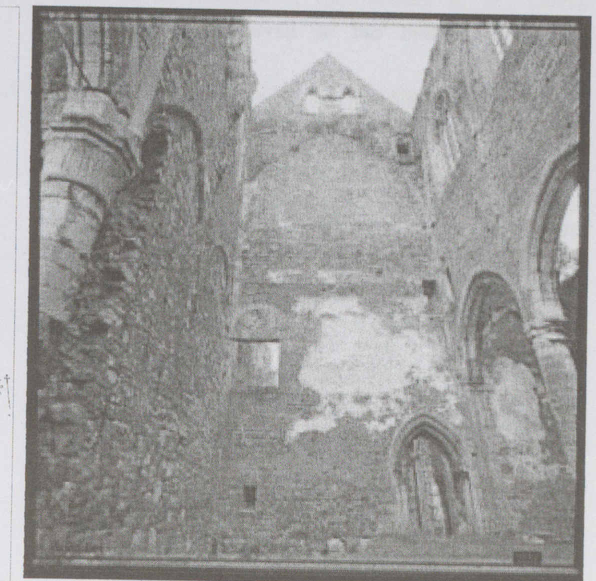

Figure 5. Left image of a tilted stereopair

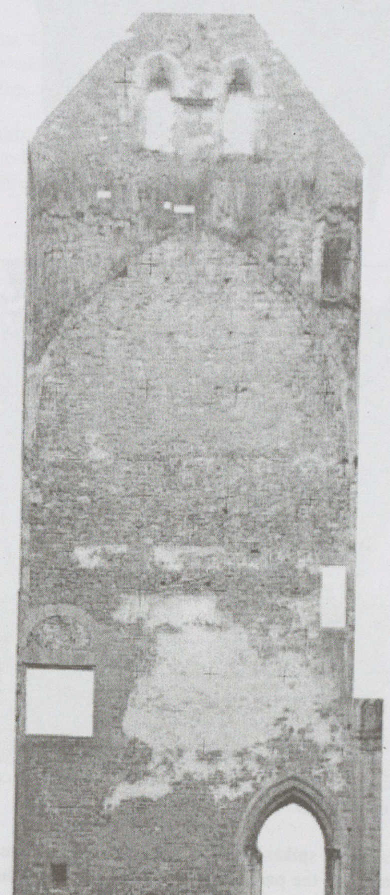

Figure 6. The orthophoto derived from a tilted stereopair

3.2 Problems that can be solved by readjusting the stereomodel

3.2.1 Problems due to innacurate planimetry or DEM errors
Erros in the DEM are shown most of the times very clearly in the orthophoto. One extreme value or a spike in the DEM may cause the whole result to be disturbed. By editing the parallax value of a single matched point or for a group of matched points this may be corrected.

3.2.2 Problems due to doors and windows in the wall
When making a DEM and an orthophoto of a wall, it may occur that parts of the images that are used, show the surface that is behind the wall. In some cases this is another wall, in other cases this may be the air. Either way, this causes large spikes in the DEM. The figures below show the effect of the spikes in the orthoimage.

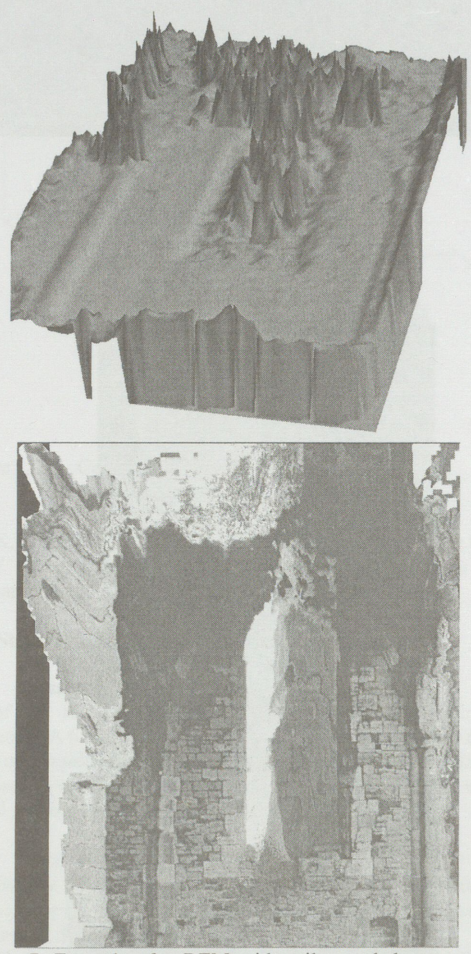

Figure 7. Example of a DEM with spikes and the according orthophoto

In the areas where spikes occur, the matched values are given the same height as the parts of the wall that surround the area. Off course, the part of the image that displays the inner part of the window will be shown deformed in the orthophoto, or as a double image, but the wall of which we want to obtain the orthophotoplan is no longer influenced by them.

Figure 8. The DEM corrected for spikes and the according orthophoto.

4. CONCLUSION

The total outcome of the project is 14 orthophotoplans, made of 30 stereopairs. The main part of the inner side of the transept is on 9 plans and the 5 remaining cover parts of the outside. No plans could be made of the chancel.
The full coverage of the transept was not possible due to the inclination of some stereopairs in combination with the quality of some of the GCP.
The reason why no plans are made for the chancel is the way the photographs were taken for this part. Where the stereopairs for the transept followed the modular structure of the building, this is not the case in the chancel. This means that for walls that are in different planes, a different stereopair is needed. In april 2003 a new project on this site started, in which plans for the chancel will be made, and where the photograps are taken perpendicular to the walls, and follow the modular structure of the chancel. This project is done under commission of the Buildingsagency of the Belgian federal government

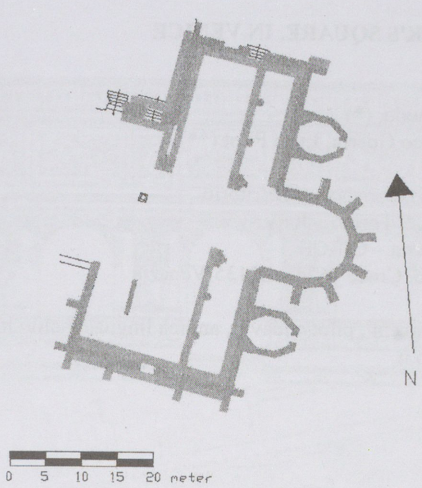

Figure 9. Ground plan of transept and chancel showing the availability of orthophotoplan

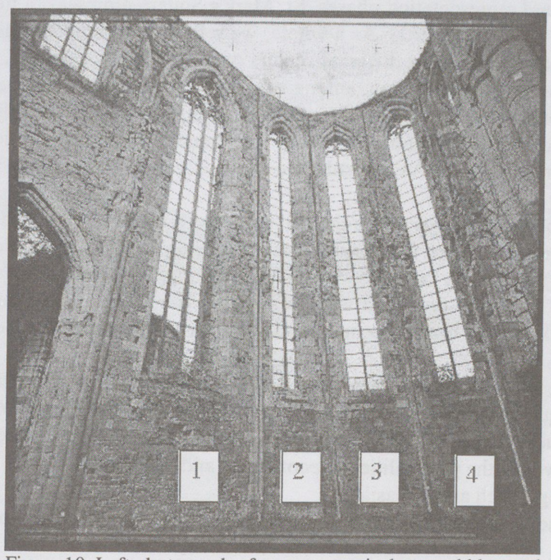

Figure 10. Left photograph of one stereopair that would be used to orthorectify four different modules.

The general conclusion about the methodology is that it is possible to generate orthophotos form tilted stereopairs, within certain limits. The use of artificial GCP facilitates the stage of absolute orientation and diminishes the chance of errors at this stage.
The availability of non-expensive digital photogrammetric tools such as VirtuoZo allow to set up a methodology and attain a certain level of operationability, regardless the ever changing circumstances in close-range photogrammetry.

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