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USING 3D MODELLING IN THE VALLEY OF TURU ALTY (SIBERIA, RUSSIA) FOR RESEARCH AND CONSERVATIONAL PURPOSES

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Abstract:

Since 1999 the Department of Archeology and the Department of Geography of Ghent University undertake field surveys to the Altai Region in Siberia, Russia. This region is a very important archaeological heritage area in the world. Scattered throughout the region are hundreds of frozen tombs, ritual monuments and petroglyphs. Research of these relics helps to understand the life of Eurasian nomads in the 4th century BC. Even more important, due to upcoming touristic activities and climate change, the documentation of the frozen tombs is imperative. A traditional archaeological survey consists out of a basic description, a drawing, one or two pictures and the GNSS location of each monument. With support of the department of Geography several topographical maps are created based on satellite images (IKONOS, Pleiades) and measurement of Ground Control Points (GCP) on site. Furthermore, since 2012 the use of 3D realistic photo modelling is being applied to survey the monuments in higher detail. The method of photo modelling proves to be successful and cost-effective. Besides their high detail, the almost real-life virtual representation of the monuments makes these techniques less abstract than a traditional archaeological survey. During the field campaigns in the summer of 2014 and 2015 this method was implied to record hundreds of monuments in the valley of Turu Alty (Siberia, Russia). Using 3D modelling software the models are created to document the monuments and petroglyphs of the study area for research and conservational purposes.

Key words: Russia, Siberia, Altai, digital archaeology, cultural heritage, 3D reconstruction

1. Introduction

The Altai Mountain region in Siberia, Russia (Fig. 1) is known to contain a very high amount of archaeological heritage, e.g. burial mounds, ritual surface monuments and rock art sites. These monuments date back to the late Neolithic (3200 BC) (Plets *et al.* 2012a). The archaeological finds date back to the 1920s, it was then discovered that because of the frozen grounds in the permafrost, the tombs of the Scythian civilization are very well preserved. The tombs contain mummified bodies and textiles, wooden objects, weaponry and even food (Bourgeois *et al.* 2007). Since 1999, extensive areas of the Russian Altai have been surveyed by Ghent University, using satellite imagery and Global Navigation Satellite Systems. Since 2012 the use of 3D realistic photo modelling is being applied to survey the monuments with more detail. Exceptional monuments with striking variations, decorations, or a complex typology can be documented with a very high level of detail.

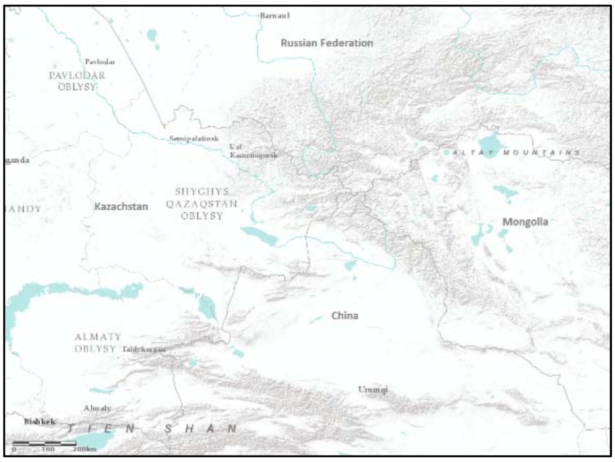

Figure 1: The Altai Mountain Region, Siberia, Russia.

2. Macro scale: using satellite images to create a geographic base map

High resolution satellite images have been used since the beginning of the project for the detections of

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archaeological remains and for mapping purposes. In the beginning the geographic mapping was based on the photogrammetric processing of CORONA stereoscopic high-resolution satellite images (Goossens, *et al.* 2006). With the help of ground control points (points on the images whose exact coordinates are known), digital terrain models (DTM) and reliable topographic maps are produced based on the CORONA stereo pairs. However the CORONA images are more than 40 years old. In 2015 the decision was made to also implement Pleiades-1 satellite imagery. The imagery is from the European company Airbus Defence and Space and provides sub-meter geometric resolution for panchromatic imagery.

To make restitution possible the groundcontrol points need to be selected. These points have to be searched on site and have to be accurately measured, with the aid of a GNSS receiver. In a remote area as the Altai Mountains this is a challenging task. The C-Nav 2050 (Fig. 2) was chosen as the GNSS device. This system receives correcton signals on the L-band. The corrections are received from the Inmarsat geostationary communication satellites (http://www.cnavgnss.com/). The accuracy of the device is of decimeter-level.

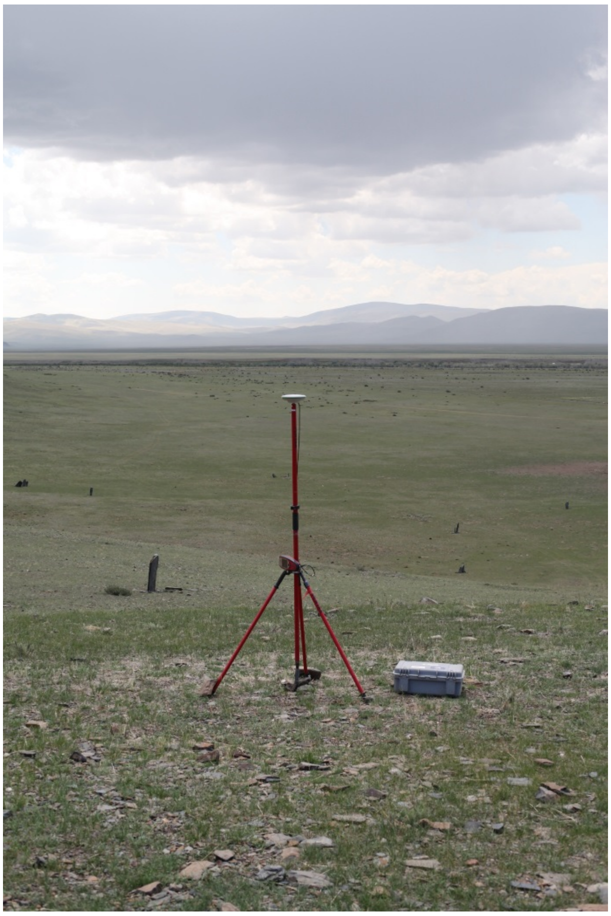

Figure 2: Using the C-Nav 2050 system to measure ground control points to make restition of satellite images possible.

To restitute the Pleiade images a total of 27 ground control points were selected on site in July 2015. These ground control points and the Pleiade images are imported in the software Erdas Imagine 2015 ® (Fig. 3).

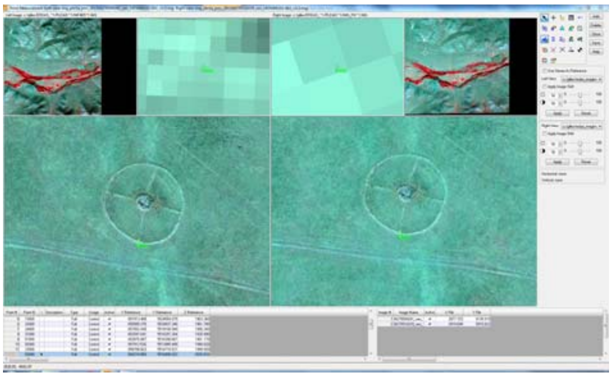

Figure 3: Importing ground control points to the Pleiade images.

After refinement and triangulation an RMS of 0.7 pixels was obtained. After this process the eATE (extended Automatic Terrain Extraction) module can be used to produce first the Digital Elevation Models and afterwards orthofoto's, if needed.

In Figure 4 the first results of the point clouds are shown.

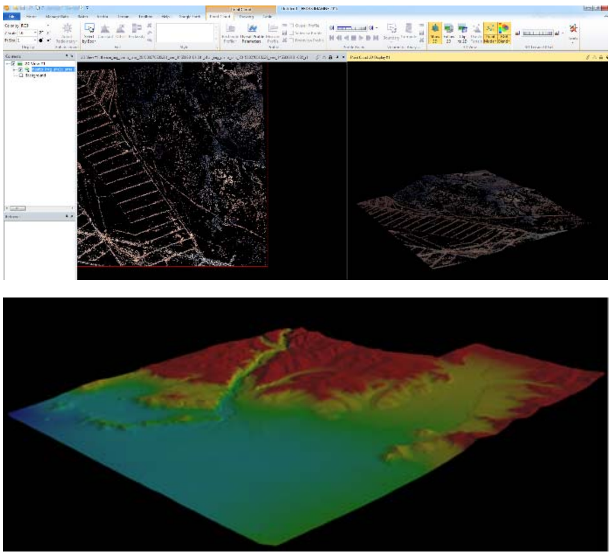

Figure 4: Resulting pointcloud in 2D (top left), 3D (top right) and 3D model colored with the elevation data (bottom).

3. Meso scale: using helium balloons to map the valley of Tury Alty in high detail

Next to the geographic mapping of the Altai mountains, the valley of Turu Alty is of particular interest to archaeologists, the valley has a high account in petroglyphs and burial mounds. During the campaign of July 2015 an experimental use of helium balloons (Fig. 5) was exploited to map the entire valley in higher detail. Since the use of a drone was not possible, was chosen to work with helium balloons. The use of helium balloons as a low cost and straightforward alternative for UAVs has been described by Lonneville *et al.* 2014. The helium balloons carry a non-metric camera of 16.1 megapixels, Sony Nex 5-R.

The procedure involves two operators walking around on the site, on which artificial ground control points (GCPs) have been placed (black-and-white targets). Of the more than 3000 photographs a selection needs to be made and then processed using Agisoft Photoscan Professional. Agisoft Photoscan will be used to combine the photographs into a mosaic. The aerial triangulation with camera calibration and subsequent model generation is mostly an automated process, the process is described in section 4.

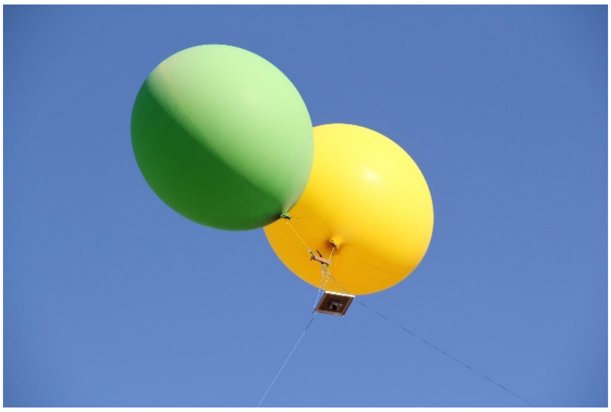

Figure 5: he use of helium balloons to map the valley of Turu Alty.

To georeference and orthorectify the photomosaic the artificial ground control points are used. To achieve the best positional accuracy, the GCPs are surveyed with a total station (Fig. 6).

Figure 6: Using a total station to measure the ground control points.

4. Micro scale: using 3D modelling to reconstruct archaeological monuments

As mentioned above the area is known for the abundance of archaeological monuments. The GNSS Leica SR20 devices are used in the field to create a location for each monument. One unit serves as a reference station and a second unit is carried around as a rover in the field to collect location data. Location is determined with an accuracy of ca. 30 cm. Next to a location the monuments are photographed using a Canon 5D Mark II camera. The 2D images are taken in such a way that they allow the reconstruction of 3D models using the photogrammetric software Agisoft PhotoScan Professional. Since the final result largely depends upon the texture present in the imagery, it is best to mask those image areas which lack texture, e.g. sky and shiny objects. The masked areas will be excluded from the calculations (AgiSoft LLC 2016).

After the masking, the photographes are aligned.Using the Structure from Motion algorithm the relative orientation of each photograph is determined and a 3D sparse point cloud is created of the object. In this step the internal camera orientations (principal distance, principal point location, skew, radial and tangential distortion coefficients) are computed.Consequently it is not obligatory to calibrate the lenses used (Verhoeven 2011). In the next step, the geometry of the model is built. The result of this step is a meshed 3D model with low-detail texturisation (Figs. 7 and 8). Following this, the 3D model can be texturised based on a selected photograph or a blend of various (selected) photographs.

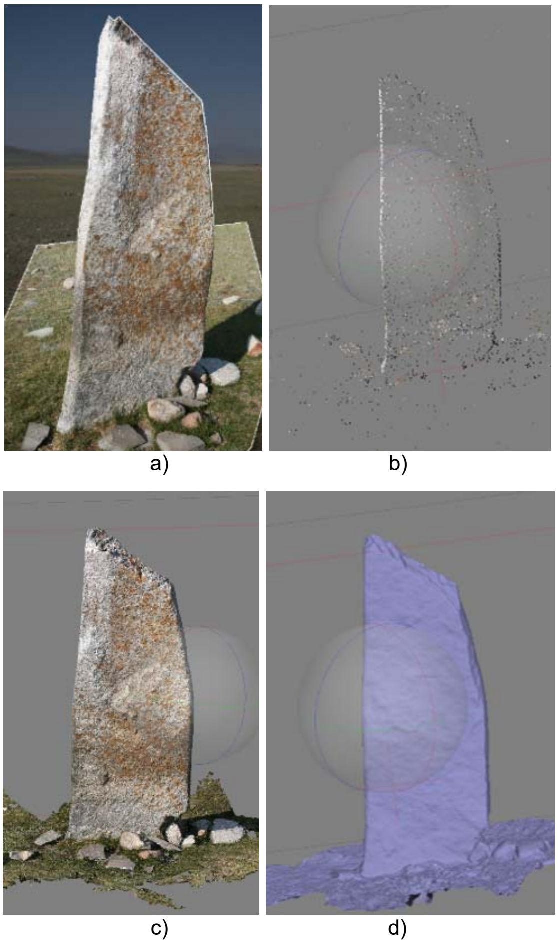

Figure 7: a) masking of the photographs; b) sparse point cloud of the model; c) dense point cloud of the model; d) mesh created from the dense point cloud.

expressed in a local coordinate framework.To make this relative model metric, different approaches can be followed (Plets *et al.* 2012b). One option is to georeference the model in an absolute coordinate framework using at least three ground control points of which the X, Y and Z coordinates are known. Alternatively, one can define a distance between two reference points. Although this approach does not geo-reference the 3D model, it initialises a scaling of the model so that real-world metric information can be extracted. A comparison of the remaining reference distances with those deduced from the 3D model enables the assessment of its accuracy. This absolute 3D model can subsequently be exported to different exchangeable formats (OBJ, 3DS, VRML, PLY, DAE, DXF and U3D), which can be easily accessed outside Photoscan Professional using both commercial and free-ware 3D packages.

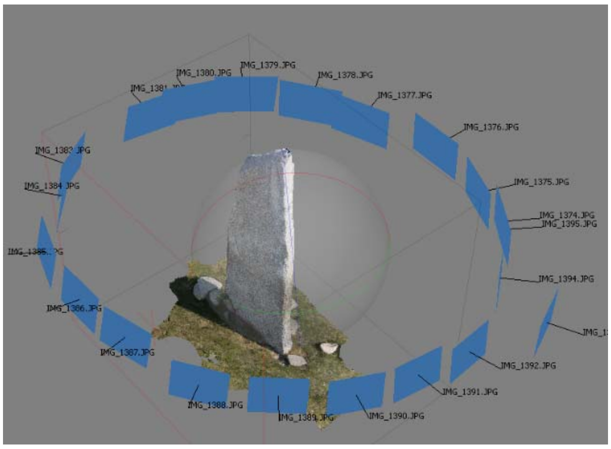

Figure 8: Agisoft PhotoScan Professional.

At this stage, the reconstructed 3D scene is still Discussion

When all models are available, the site can be virtually visited. Archaeologist can use the data for further research without having to go to the remote area. The research can also be used for conservational purposes, since some monuments may in danger due to climate change and the upcoming tourists in the region. If the consequences of global change are detectable on individual tombs, methods have to be considered to preserve the graves in their frozen condition. Obviously, still more research is to be realised here.

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