AERIAL MAPPING OF AMYAN

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Introduction

In September 2021, the second part of the topographic study initiated in 2019 was carried out.[2] The previous study had been carried out on the site in order to provide the first reconnaissance, and this second mission was carried out using a drone. Using the overhead images of the site of Amyan and the peripheral sites previously recorded by the LoNAP team,[3] together with the results of the work done in 2019, the objective was to produce a topographic map of the entire area. The drone work was carried out on site by Jonathan LISEIN, photogrammetric expert at the University of Liege, with the kind help of Omar SHAREF, archaeologist from the Directorate of Antiquities in Akre, and Muhammad Aziz KARIM, mokhtar of Amyan.

The mapping operations were performed with a small Unmanned Aerial System (drone) over the Amyan archaeological complex (Iraqi Kurdistan). The Amyan site group is a cluster of ten sites spread over a distance varying between 400 m and 1200 m from the main Amyan mound. The use of the UAS (here a Parrot Anafi drone) has many advantages over terrestrial mapping. UAS has been used for some years now in archaeology, as this technology can adequately replace traditional topographic measurements that are extremely time-consuming. Due to constraints related to security reasons, the survey had to be completed in a short time; hence, the use of a UAS was particularly convenient. The survey's goal is to deliver a topographic map of the site complex, with a focus on the terrain levelling by photogrammetry. During this survey, 13 flights were made and about 1200 aerial images were recorded. Oblique views and videos were also taken to illustrate the environment of the archaeological sites.

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[2] For the report of the first topographical survey, see Couturaud & Bechetoille 2020.
[3] See Morandi Bonacossi 2020.

Methodology of the Photogrammetric Survey

The Parrot Anafi drone is a very lightweight multirotor drone (320 gr) which has a flight duration exceeding 20 minutes (Fig. 1). The sensor is a wide-angle camera with a focal length of 35 mm, equivalent of 23 mm. It delivers images of 21 Mpixels. The ground control station consists of the remote controller and an android-powered CROSSCALL smartphone. This unmanned aerial vehicle is designed by a French company and is one of the smallest civil drones that are appropriate for this kind of survey. The image exposure is set automatically by the drone firmware.

Flights were performed either manually in First Person View mode (i.e. piloting based on video retransmission), which requires manual triggering of the images, or with a flight plan application (pix4D capture) that enables the automatic covering of an area with constant flight altitude and image overlap. An image overlap of at least 75% was maintained as often as possible. Flight altitude was chosen as a trade-off between the individual image footprint, the size of the area to cover and the required Ground Sample Distance (i.e. image resolution).

Due to the size of the mapped area, which is a rectangle 2300 m long and 1700 m wide, flights were done at an altitude of 250 m above ground level, which is quite a high altitude for this UAS model. A high altitude was chosen in order to cover a large area over a short period. Secondly, flights at a lower altitude were also performed, but only above the mound of Amyan.

Georeferencing and camera calibration is a crucial step of the photogrammetric workflow. Here the methodology used for the survey is summarized. Every single image is geotagged by the drone GPS. Although this information is not very accurate, the redundancy (1200 images means 1200 GPS positions) ensures quite a good performance in planimetry (X and Y axis). Considering that GPSs are not very accurate in altimetry and that a poor camera geometric calibration may result in inaccurate altimetric measurements, the only way to provide accurate photogrammetric measurements of the elevation is to use additional ground levelling information (Fig. 2). Thus, eight ground control points that were measured with a total station were used. Four of them consisted of targets (black and white wooden board) that were placed on the mound prior to the flight. The rest consisted of objects that are easily recognized in the aerial images, mostly corners of the roofs of the village buildings. The photogrammetric levelling technique is thus an approach which combines three different technologies: information from the image bloc, measurements from the drone GPS and topographic measurement on the ground.

Photogrammetric processing was done with Agisoft Metashape 1.7.2. Alignment quality was set to medium mode, with a maximum number of images featuring 10,000 tie points with a threshold of 1000 tie points. Dense matching was performed on images resampled with a factor 8 (low quality mode) on 512 images. The photogrammetric dense matching delivers a digital surface model, which is a map of the altitude for every position. This DSM was used for the contour generation (level curve with 1 m interval). Computation of the orthophotomosaic aims at generating images with a resolution of 20 cm per pixel.

In addition to the mapping of the archaeological complex, flights at a lower altitude of 140 m over the mound of Amyan were also made. Relief can thus be represented by contour curves which are more precise. An orthophotomosaic of a resolution of 10 cm has been computed.

Results and Perspectives

After a few days of flight and aerial surveying, a first topographic map of the archaeological complex of Amyan was delivered, with colour gradients to illustrate the elevation of the ground surface (Fig. 3). Above the mound of Amyan, some flights at lower altitude provided more accurate orthophoto and contour level curves than flights over the whole Amyan cluster (Fig. 4).

The resulting digital elevation model and orthophotomosaic will be very useful for the localization of all visible features of any interest. For example, roads, trees, rivers and house may be digitized in order to create maps. More importantly, the absolute location (X, Y, Z) of any points can be determined from this model.

Bibliography

Morandi Bonacossi D., 2020, "The Amyan Archaeological Complex Survey by the Land of Nineveh Archaeological Project", *in* Couturaud B. (ed.), *Archaeological Expedition in Amyan. Report of the First Campaign (2019)*, Erbil, 14-26.

Couturaud B. & Bechetoille S., 2020, "First Reconnaissance and Topographical Survey of the High Mound", *in* Couturaud B. (ed.), *Archaeological Expedition in Amyan. Report of the First Campaign (2019)*, Erbil, 27-35.

FIG. 1: The Parrot Anafi drone (Dottensm)

FIG. 2: Illustration of topographic ground measurements, one of the ground targets (left) and Omar Sharef operating the total station prism at a roof corner of a modern building (MAA)

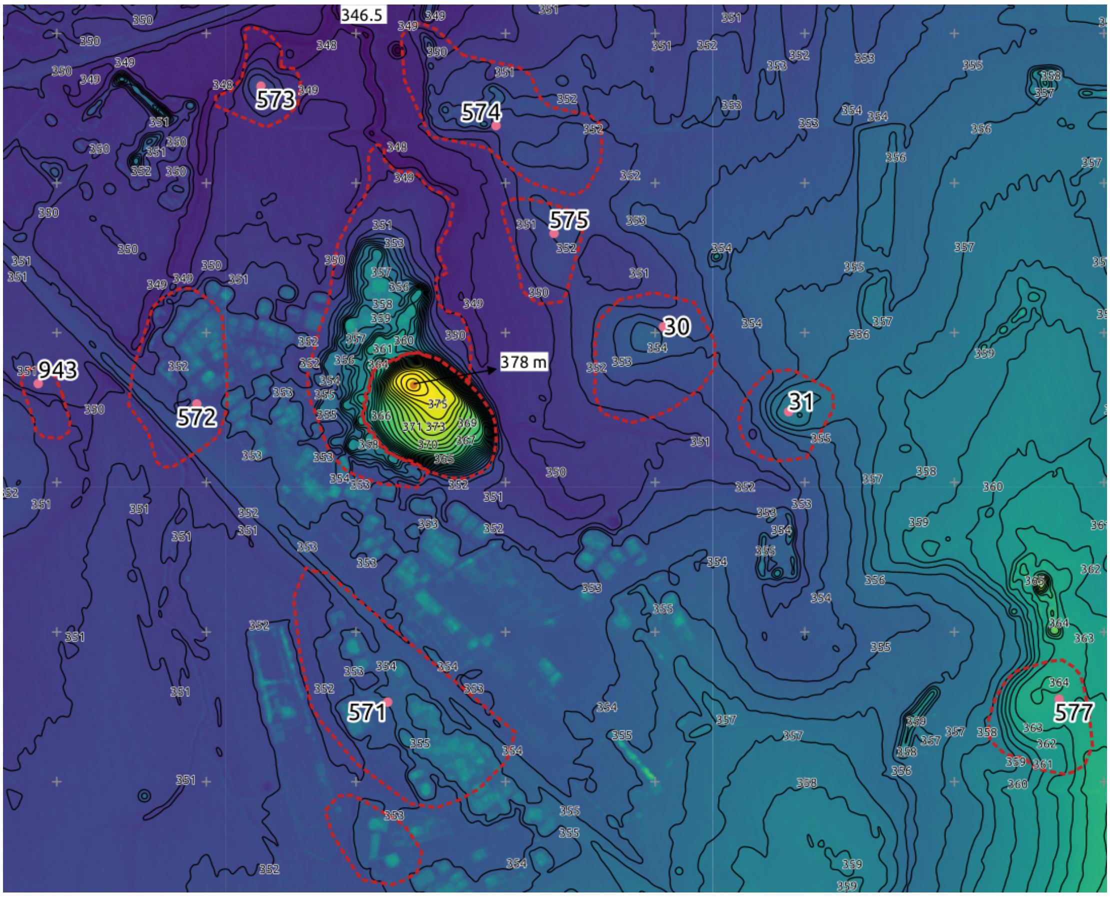

FIG. 3: Topographic map of the archaeological complex of Amyan, north being to the right (MAA)

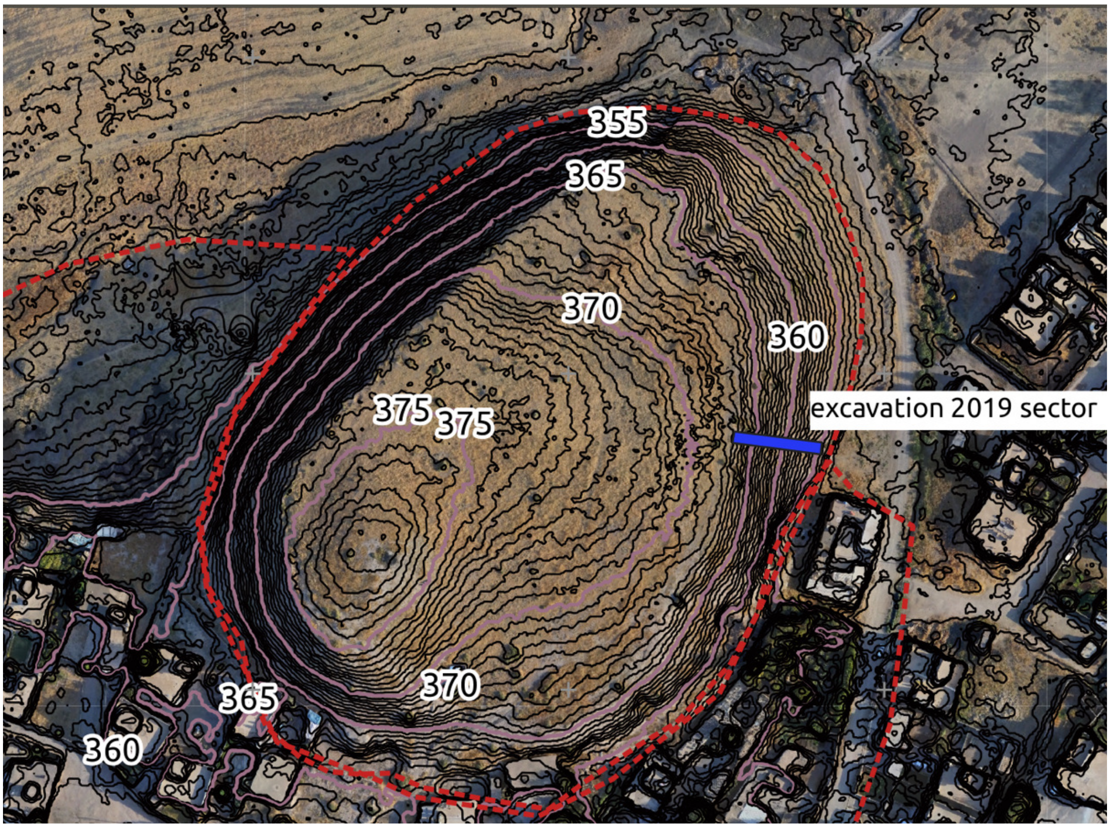

FIG. 4: Detailed view of the contour level curves on the main site of Amyan (MAA)