Photogrammetric low altitude fieldwork in "Neolithic Thessaly (Greece)": potentials and issues

Abstract

Thessaly is a region of mainland central Greece characterized by fertile plain-lands, made by alluvial soils, particularly good for the production of grain, cattle, and sheep. In this region, **hundreds of "magoules"** –prehistoric settlements known elsewhere as mounds or tells– were identified, dating from Early Neolithic period until Bronze Age.

Neolithic Thessaly is traditionally an interesting area for understanding human partitioning and territoriality of the landscape by non-hierarchical, 'egalitarian' human groups and it was therefore chosen as experimental area for further non-destructive large-scale archaeological investigations.

The goal of the research project "Innovative Geophysical Approaches for the Study of Early Agricultural Villages of Neolithic Thessaly" which is implemented under the **"ARISTEIA"** Action of the "Operational Programme Education and Lifelong Learning" and is co-funded by the **European Social Fund (ESF) and National Resources**, is the development of methodologies for the registration and mapping of the specific Neolithic settlements through geomorphological and aerial remote sensing approaches.

In November 2013, a field campaign has been undertaken in selected number of sites where different kind of systematic geophysical measurements were collected simultaneously with UAV photogrammetric sessions.

The paper will focus in first results of the **photogrammetric campaign**, showing achieved goals, **UAV performance assessment** and lessons-learned during the low altitude aerial survey. Particular importance is given to archaeologically meaningful outputs.

The Project

"IGEAN-Neolthic Thessaly" is a project aimed at increasing the understading of **prehistoric mounds** in central Greece by means of non invasive remote sensing techniques.

Hundreds of these mounds have been identified in previous field researches (Fig1) and their chronological framework has been defined with ceramic studies.

Very few of them have been excavated and so little information are still availble about the architectural structure and organization of these stratified villages.

Outstanding results are coming from the analysis of the data from the new geophysical investigations in combination with the UAV (Unmanned Aerial Vehicle) photogrammetric riconstruction.

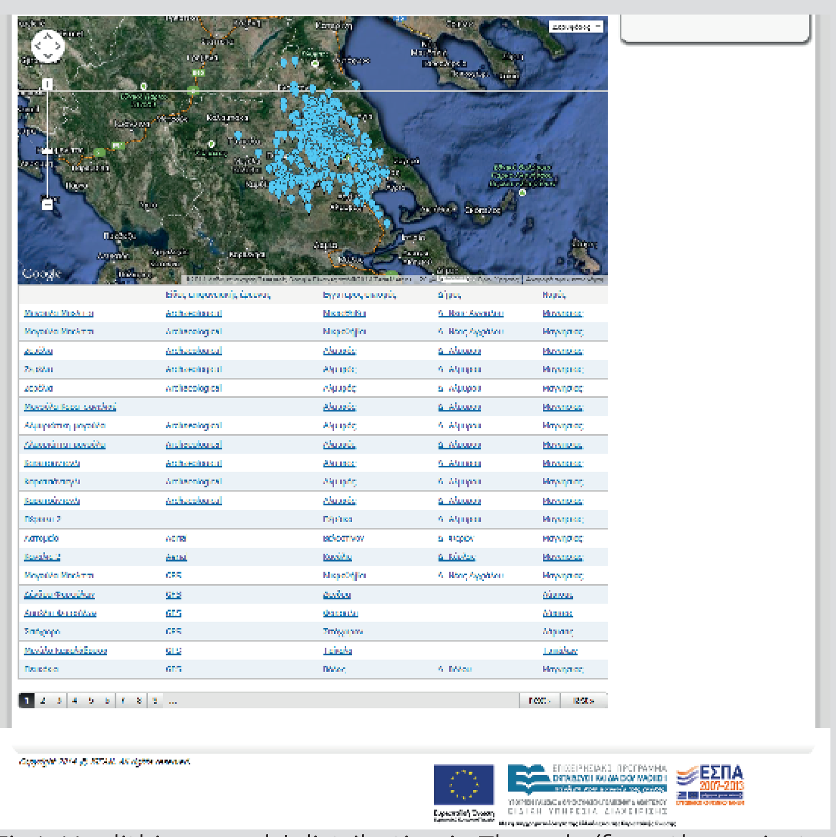

Fig1. Neolithic mounds' distribution in Thessaly (from the project website http://igean.ims.forth.gr/)

Preliminary results of the low altitude aerial photography and photogrammetry are presented here with a special highlight on the **flying device** system employed in the project.

Equipment & Goals

The flying platform (Fig2) used for the photographs acquisition of the Thessalian magoules was a "**Droidworx CX4**", an electric powered (two sets of LiPo batteries, for a flight autonomy of around 18 to 20 minutes in optimal conditions) multi-rotor with onboard "**DJI Wookong M**" stabilization and navigation system. The platform has been equipped with a compact lightweight Canon camera – Powershot S100, which allows for firmware update and functions expansions through the **CHDK** system– on a 2D gymbal, with built-in **GPS** tagger/logger. The camera was set to capture one photograph every **3 seconds** in continuous mode, regardless to the actual UAV position. These settings were the outcome of different tests with other similar equipment and resulted in being the optimal and easiest solution for photo-collection for different purposes, within an average of up to **200m flight altitude** above the ground.

The stabilization and navigation system offered a **smooth and stable flight** experience, even in **inconsistent windy conditions**, with low vibrations and quick responses in cruise velocity. The add-on of **real-time telemetry** visualization both on the LCD screen of the transmitter and on the GUI software on the computer, highly **simplified** the flight and as a consequence the full coverage of the desired area at the preferred altitude. The gained experience in flying at stable altitude and along specific path (estimated on the base of the camera ground coverage and approximate overlapping), allowed to create **ortho-photos and DEMs** with a final ground resolution between 3 and 10cm.

The camera was set to "cloudy" **white balance**, and 1/800 or 1/1000 seconds exposure time, in order to reduce the chances of blurry images, at the expenses of less saturated image colors. Indeed all images resulted being well sharp and in focus. The availability of built-in GPS, beside the drawback in battery consumption, provided a quite accurate position for each frame; this was valuable information for **archiving purposes** but also for the initial **geo-positioning** of the **photogrammetric 3D models**.

Performance Assessment

The overall **percentage of successful flights** and usable photographs obtained and processed was very high and this information can be used to estimate general system/settings performance to be considered for **future mission planning**.

Considering the variable weather conditions experienced in the field during this mission, the obtained values can be easily extended to most other future fieldworks, keeping in mind a possible and physiological decrease in battery performance (to be expected in medium/long term).

Thus, assuming similar geomorphological conditions and visibility (in terms of clear sky and the possibility to fly in line of sight), similar altitude and compatible camera lenses, one should expect coverage of around **1 hectare per minute**.

The linear velocity of the device may be increased considerably to cover larger areas, but of course, this may affect the quality of images and consiquently the final output.

Site INDEX	Merged photogrammetric patches (hectare)	Hectare coverage per minute
Almiriotiki	20.7	0.56
Almiros 2	8.12	0.78
Belitsi	11.73	0.42
Karatsagliou	13.07	1.58
Karatsantagli	12.39	1.04
Zerelia	32.2	0.90

Fig3. Archaeological sites photographed with the aerial remotely controlled platform and the approximate hectare per minute coverage

Fig2. Basic equipment for the field (UAV) campaign: the CX4 Droidworx, DJI navigation system and the compact camera.

Data Processing & Lesson Learnt

All the images have been downloaded on a daily base on a computer as raw data and organized in folders. No renaming of files or folder has been undertaken in order to preserve as much as possible the original input format. For each archaeological site photographed, a **specific photogrammetric project** has been created. All photos (excluded the one collected when the UAV was still on the ground, waiting for satellite coverage before take-off) have been processed and the GPS data recorded in the **EXIF** of each image have been used to geo-reference the entire model. The main two final products, an orthophoto and a Digital Elevation Model, were exported as raster GeoTiff in LatLong WGS84 coordinate system and then they were added to the master GIS project.

One of the features of the platform, already present but still not fully explored and surely beneficial for the mission management, is the **flight plan** via a photogrammetric interface, that allows one to **bind the area to be surveyed** and the specific settings of the camera to obtain the required result.

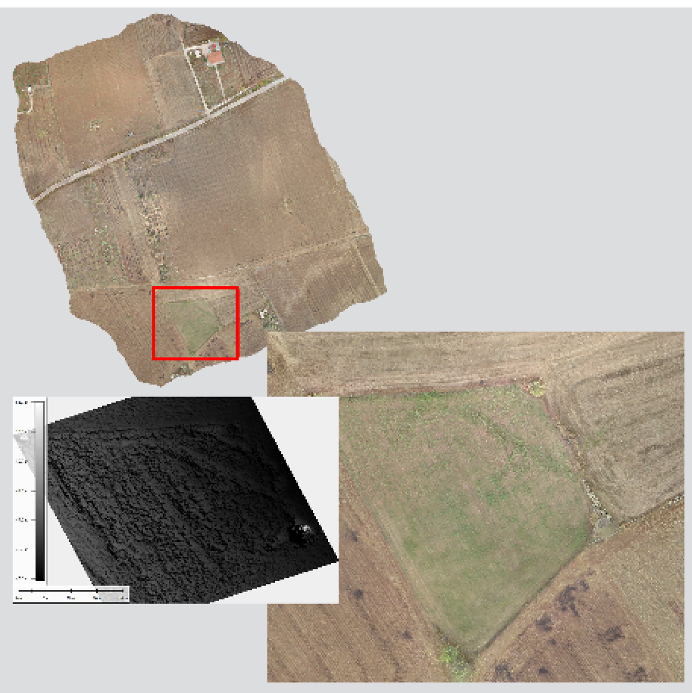

Fig4. Almiriotiki: orthophoto of the neolithic site (top) and detail of a cropmark (bottom right) with its hillshade representation (bottom left).

The possibility to add a **second servo** to the gimbal may facilitate a three dimensional stabilization of the camera, but tests need to be undertaken to estimate the gained value despite the battery consumption. It has to be considered that, especially in mountainous landscape, a **slight oblique inclination** of the camera may be beneficial for the photogrammetric reconstruction.

Considering the availability of real time navigation and the ease of piloting the UAV, another possibility to be explored is to remove the LEDs (attached to the arms of the quadro-copter to facilitate the understanding of the platform orientation); this operation may indeed **save some battery** in favor of flight time.

The navigation system on the **ground station requires an internet connection** (basically for the background google map), so it may be difficult to use it in certain conditions where fast wireless connection may not be available.

Another possible improvement consists in attaching **two different cameras** contemporarily working on the flying platform, e.g. visible color and NIR, so that the photo-interpretation could benefit from further tools such as **NDVI** indexing (or stereographic view in case of same sensors in two cameras).

For a matter of time optimizing and velocity in the field, ground control points were not positioned and measured, but a system for better image positioning should be explored to avoid some of the misplacement of 3D models.

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