Fundamental Tools for Photo-Interpretation in Mountainous Rocky Areas: Photogrammetry and Ground-Truthing

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Abstract. How could we approach mountainous rocky landscapes in the absence of detailed cadastral maps, if the 1:5.000 maps do not depict hydrography to support the understanding of soil-marks and geological erosion, if crop-marks (or "scrub-marks" of the typical Mediterranean macchia) are undistinguishable, if the over-exposure of some military photos hides shadow-features, if a road can produce a similar signature as a wall or a fault in different geological setting a few meters away, if the monumentality of some ancient constructions means that scale does not work well as a discriminating factor, …? These are amongst the challenges of creating a specific protocol in archaeological photo-interpretation of mountainous rocky areas. Taking the mountainous terrain of East Crete as a demonstration case study, a simplified cadastre has been produced according to the aerial photographical evidences with the 4th coordinate as the time changes. On this generated map, the known archaeological features were placed: a data mining analysis is carried out to understand why a particular archaeological feature was visible from the ground and if and how its position influenced the recognition itself. The description of every single anomaly via abstraction levels, groups homogeneous elements in a bigger category. On the base of these first subdivisions, the comparison of similar recurrence of combination of colour/contrast allowed the description of dubious cases or the definition of "false-features". The availability of an extensive architectural field-survey with accurate digital measurements, such as the Digital Crete Archaeological Atlas, allowed to improve the feature recognition and to address a higher number of archaeological questions. This paper discusses some results that arose from Cantoro's PhD research and their later enhancement through the further refinement of interpretation. A combination of remote sensing and ground-truthing was exploited for the specific geomorphology of the area of Eastern Crete, trying to extend it even further to other geographical contexts.

Keywords. Remote sensing, photo-interpretation, photogrammetry, landscape archaeology, protocol, mountainous rocky areas, Crete, Greece.

1. Introduction

In the present study, the application of aerial archaeology to mountainous rocky areas, together with basic ground-truthing techniques, is presented. Case studies from the selected area of Eastern Crete in Greece show the importance for the creation of a specific protocol for such a kind of geological and morphological settings, since the traditional approach may fail to provide meaningful results.

Even if aerial archaeology is far from being a new discipline for (ancient) landscape reading and understanding, its application in mountainous areas is still lacking of scientific publications. A quick view over the evolution and the development of aerial photo interpretation (API for short) will be provided here with the purpose of highlighting the reasons that makes "non-flat" landscape a still unexplored field. A possible approach and the results of its application to a test area will be presented as well.

The first use of aerial photography (even if not for archaeological purposes) dates back to 1858, when Gaspard-Félix Tournachon (or Nadar, as he liked to call himself) captured with a photograph a small village (Petit Bicetre) close to Paris from his "manned" hot-air balloon, 80 meters above the ground [1][2]. In 1855 he had patented the idea of using aerial photographs in mapmaking and surveying, but it took him 3 years of experimenting before he successfully produced the very first aerial photograph. Experiments and trials of manned balloons were often coupled with model balloons over the years and balloons were sided by the use of other systems like kites: E.D. Archibald - English meteorologist- was among the first to take successful photographs from kites, in 1882, even if no photographic proofs of his pioneer activity are available; in Labruguiere in France, Arthur Batut took an aerial photograph from a kite in 1889; in California, the devastation of San Francisco after the 1906 earthquake and fire, was captured by G. R. Lawrence. Singular tests with pigeons [3] and rockets (Alfred Maul in 1904) were conducted as well. The main goal to be achieved with the use of those devices (unanimated or animal) was generally to spy or have a look over the enemies' lines during the world wars in the last century [4]. Finally in 1909, the first aerial photography was taken from an airplane by Wilbur Wright (or, more precisely, by L.P. Bonvillian, which was passenger in the Wright's airplane).

The earliest aerial photographic record for archaeology dates back to 1882, when Persepolis, the major sites in Fars (modern Iran), was captured by Stolze and Andreas [5]. Few years later, in 1899, the first aerial archaeological photography took place to the Forum of Rome by Boni [6]. From the end of 1900 until today, balloon and kite photographs have been largely adopted in archaeology, also in extensive archaeological aerial recognition campaign like the one of 1970, when Whittlesey [7] reported on the use of a tethered balloon for archaeological documentations[1], which he started in 1967; more recently, the Aerial Atlas of Ancient Crete by Myers and Myers [8] documented a number of known sites from a balloon in 1992. In this lapse of time, found its place also the work, which is emblematic in our excursus, of an English archaeologist: Osbert Guy Stanhope Crawford. During the First World War he served first in the London Scottish, then in the Survey Division of the Third Army, and from 1917 as an observer with the Royal Flying Corps[2]. Thanks to the roles he covered in the Army, he was able to enter in contact with a number of maps and aerial photos in which he could apply the same principles [9] identified and adopted by Antoine Poidebard [10], [11] in Syria, few years before him, in the interpretation of oblique photos with the eye of an archaeologist.

Surely during World War I, aerial photography had replaced sketching and drawing for the aerial observers: they were often producing battle maps entirely from aerial photographs and it has been estimated that by the end of the war, the entire front (in both sides) was recorded at least twice a day. Even the production of cameras, including thermal infra-red detectors, was oriented toward their use in war airplanes, trying to face and attenuate the obvious problems connected with stability, vibrations and shutter speed.

From the above quick overview, it is quite clear the military connotation aerial photography interpretation had since its beginning. Photointerpretation is still linked with the first pioneer scholars-aviators [12], for its systematic approach to aerial photography as real document which is able to describe every single aspect of the depicted landscape[3]. This obviously influenced the development of consciousness of the high potential of the look from above (even if with specific topic orientation at first) and also it influenced the rapid development of cameras (and sensors, generally speaking) and the technology behind them. If from one side this granted a different point

[1] Whittlesey starts his contributions stating that "Numerous archaeological studies were completed over the past three years using balloon photography for various expeditions in Turkey, Greece, Italy and Cyprus" (p. 181).

[2] His aircraft was shot down in 1918 and he was held prisoner at Holzminden until the end of the war.

[3] Nowadays, photointerpreters tend to give more importance to the diachronic square represented in the photo frames: a number of hidden features belonging to different epochs may coexist and become "visible" only after an accurate interpretation of every trace left and/or modified on the landscape surface during time.

of view on several anthropic activities barely recognizable and understandable with traditional field researches, on the other side it locked most of the information under the "military secret". It still happens so that for this reason -in many countries, not only in Europe- most of the (Army) photographic collections from the First and Second World War are still inaccessible for the great number of researchers. Even since the beginning of aerial photography, researchers have used all kinds of devices ranging from pigeons, kites, poles and balloons to rockets in order to take cameras aloft and remotely gather aerial data needed for a combination of research goals, the same obstacles arise when one wants to take new photos from a manned aircraft (and sometimes also with Remote Controlled Aircrafts).

As said, a great part of the (nowadays) available historical photos is still unknown or underestimated and not fully explored. One of the world's largest photo archive, the TARA and MAPRW (Mediterranean Allied Photo Reconnaissance Wing) collection, has a considerable number of sorties from the Second World War (mainly) partly ignored by European researchers. International projects (see recently the ArchaeoLandscapes project - www.archaeolandscapes.eu), are more and more trying to make these archives available for a wider research community, with the consciousness that in many parts of Europe archaeological air photography has brought to light more previously unknown heritage sites than any other method of exploration, and the full potential of aerial archaeology is still not fully explored in many country, such as Greece.

The development of IT applications to archaeology augmented the attention to new kind of information and new sets of data. Between them, a wider context for archaeological features brought to the need of more precise measurements of material data, from small (artefacts and finds) to big scale (structures or landscapes). This paper will try to show how the innovative combination of the old and consolidate tradition of air-photo interpretation, with the modern photogrammetric techniques for 3D analysis in mountainous archaeological contexts, has been successfully applied in Crete.

The particular project synthesises the current experience and innovative technologies in aerial and satellite imagery, landscape mapping, spatial image processing and photogrammetry, in order to build a protocol for the application of aerial photography in remotely accessible areas, where archaeological landscape studies encounter severe difficulties.

The focus on new approaches for the reconstruction of the archaeological palimpsest in a specific challenging environment such as the Cretan one, comes from the observation of the unsatisfying results after the traditional –and in a way "codified"– API approach. Indeed, "reading" of photos, without geographical information, can be sometime unsuccessful. At the same time, geographic location of photo-sorties may be a challenge, because of time/money needed (TARA archive holds photographs from several hundred missions and each mission contains several hundred photographs, a number of which is still un-located for the mentioned reasons), but also because the finding aids are often separate from the photos. Starting from the above statement, the following is a kind of schematic synthesis of the traditional API and its unsuccessful output.

1.1. Cadastral maps and geographic map

One of the first steps in every research based on photo interpretation is the collection and systematic organization, validation and organization of archive material, in shape of vertical or oblique photos from national archives, bibliographic material, maps, locally available archives and oral traditions. These were also the guidelines behind the Digital Crete Project (digitalcrete.ims.forth.gr), where thousands of publications have been reviewed and information has been converted in geographical database, at least 5000 sites have been measured and mapped through surface surveys (DGPS) or digitization processes, a number of unpublished sites has been added to the database (with a protective filter that does not allow the external access of them through the Internet) as a result of remote sensing satellite images processing. The importance of this freely available source of valuable information will be clearer afterwards in this paper for the validation of the API data results.

The most useful map for archaeology is the one where all the cadastral units are depicted, and this is for many reasons: because it is usually in a suitable scale; because it provides historical information about field boundaries (and shape/size changes during time); because it gives information about lands owners and land use; because sometimes it gives also information about urban planning and area destination of use. In a way, in a simplistic "circular" view of API, the research starts from maps and we end-up with maps, since the final result of the photointerpretation tends (usually) to be a map with the depiction of identified features.

In the specific case study of Crete, the historical cadastre is not available and a modern one is undertaking a digitizing process in the very last years. Until 1853, a recording system from French derivation was used. It was a system essentially based on the owner, on a list of proprietors and transactions. Every record stored the legal transaction of one person. The description of a land was, for this reason, inverse and was passing through the examination of every single record (obviously not within a modern computer database). In 1970 the project of implementation on a national scale of a cadastre, started with detailed maps derived by zooming at aerial photography. This project covered around 28700 km^2 (around 22% of Greece). The Ministry of Agriculture started a new project in 1987 for mapping the vineyards (1650 km^2) and olive threes (8000 km^2). The project for a modern cadastre started around 1994 under the name Ktimatologio (Κτηματολόγιο is the Greek word for Cadastre, pursuant to No. 9400/2007 Ruling of the Greek Minister for the Environment), comprising the registration of fields, property rights and their holders all over Greece.

The basic layer for any archaeological landscape study is usually considered to be the geographic map[4], even if sometimes they are lacking of important details. For instance, temporary rivers are often not represented. It is also true that, most of the time, river beds are easily used as pathways during the dry seasons[5], and this is something that could have been valid even for ancient times. At the same time, a limited number of field properties are visible in the cartographic schematic representation, especially when field boundaries were (at least in the past) delimited by dry-walls.

1.2. Archival aerial photography

Greece has quite a good aerial coverage provided by the Geographical Service of the Army (GYS is the Greek acronym for this). The following table shows the list of images used for the investigation of the area of study in Eastern Crete.

Table 1. List of GYS aerial photo frames and resolutions used for the case study in Eastern Crete.

Year	Frame ID	Scale
1945	213092; 213093; 213099	1:42.000
1960	162-163	1:15.000

[4] The scale 1:5000 is the most accurate and rich in details. It is based on the metric ellipsoid of Bessel (1841) with Hatt projection; in same cases this projection is replaced by the so-called EGSA87 or GGRS87 or they both coexist on the same paper. The contour lines are every 4 meters and this makes them not suitable for detailed 3D models from vector interpolation or for landscape studies based on altimetry or iso-elevation variation.

[5] Even the cartographic representation of seasonal rivers looks like the one for the pathways and sometimes the distinction may be hard.

1960	1556	1:30.000
1965	318-319; 343	1:43.000
1968	23712; 23719; 23705; 23707; 23680; 23681; 23683; 23685	1:8.000
1989	196685; 196877	1:30.000
1991	06076-78; 06136-138	1:20.000
1992	220.386-387; 389; 391; 393; 397; 399-410; 466-467; 469-471; 473-477; 479; 481; 484; 486-487; 489-490; 492-93; 495-496; 499-501	1:8.000
1994	226443; 226522; 226531; 226575	1:15.000
1995	232628-31	1:30.000
2004	274008; 274012	1:8.000

This high number of frames allowed us to work with a wide chronological coverage for the selected area as well as a variable level of detail and overlapping between photographs. See paragraph 2.3 for the three dimensional reconstruction obtained with photogrammetric free software (thanks to the overlapping of frames and their different point of view).

The macroscopic autoptic analysis of the frames highlights peculiar printing problems connected with the specific geo-morphological formation and vegetation of the island. Indeed the proximity of deserted or sandy areas (producing light colour on the camera film) with densely vegetated or bushed zones and the sea (which produces dark to black colours in the black and white prints), makes very difficult to find a good equilibrium and balance in the final output available at the GYS offices. Indeed it is not rare to notice large differences in different prints of the same negative (Figure 1).

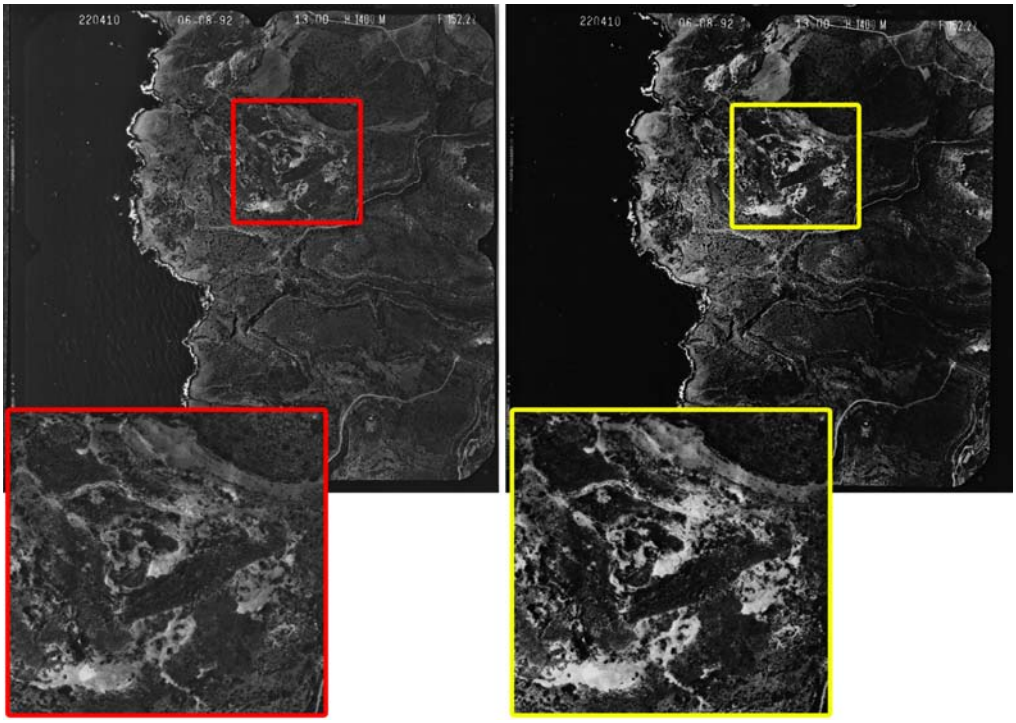

Figure 1: Two prints of the same negative (ID #220410) for two different orders and details of both.

Figure 1 clearly illustrates the number of details that may disappear for a less accurate exposure and print from negatives[6]. This is more evident for the dark area occupied by the sea (left side of each print above) and in light clearance areas (zoom detail inside the squares in Figure 1).

2. Methods

The whole world is a sample, following an illuminating paragraph of the still fundamental publication about statistics in archaeology [13], and every project is based on a sampling strategy. The selection of case studies for this specific project followed some important directives carefully chosen to cover as many variables as possible. The direct experience/knowledge about the island was essential in finding the more responsive or more promising areas on the side of the other still unexplored areas to be investigated.

Since the experimental aspect of the project was preponderant, the selection of areas to be studied has been undertaken in the first steps by trials and errors in a problem-solving perspective. Interrogation, interpretation and information were used as guidelines, in a circular loop, for a best-practise in the selection of case studies. The objective was to identify, together with some complex contexts (i.e. characterized by high vegetation, sudden slopes, dense urbanization, or with small amount of usable reference points), a number of locations where optimal conditions could co-exist. This allowed to isolate single problems and to evaluate their influence on the overall process.

[6] The two prints have been simply digitized at the highest resolution with a professional scanner, taking care of having the same color settings in the computer device and software. No editing has been done for the purpose of this demonstration. In same case, an accurate Gamma Correction can reduce the problem especially in dark areas; almost nothing may be recovered from the over exposed parts.

The result of the selecting phase was a specific area in Eastern Crete in Itanos (Erimoupolis) region. Here the concentration of modern researches by different institutes, the availability of a good amount of different sources of information, the slight urbanization, industrialization and agricultural exploitation, provided us with the best environment for intensive and extensive researches. We referred to the GYS aerial photographs coverage; the project could also profit on the availability of some aerial and oblique balloon photos (taken in the period of 2000-2004 by Max Guy), a targeted aerial survey (supported by INSTAP Study Centre for Eastern Crete and undertaken by Gianluca Cantoro), a LiDAR scan taken on April 2004 as part of the NERC Mediterranean Flight Campaign, the GYS 1:5.000 geographic maps, the 1:50.000 Geological Map from ΙΓΜΕ (National Institute of Geology and Mineralogy) and other information derived by field survey (see below the Digital Crete project) and excavations undertaken by various expeditions as they have been reported in a number of scientific journals.

The different phases of the project are outlined in the following paragraphs.

2.1. The platform

After all the available material has been collected, a GIS project platform has been created to manage the data and store the output produced by the interpretation of information.

For sharing and accuracy reasons, the default projection has been set to WGS84. Indeed, because of the low accuracy[7] of the representation system for the available cartography, we opted for a more international and easily convertible coordinate system. This way, maps, vertical and oblique aerial photos, orthophotos, survey vector files and LiDAR scans (and the output interpretation) share the same projection.

The above layers were integrated with those of Digital Crete with the double goal of extracting useful information for this new project and merge the result of the research to a unique output in a compatible format. Digital Crete project has implemented among others, topographic maps of the Geographic Service of the Hellenic Army (scale 1:50.000) the land use and land capability maps of the ministry of Agriculture, the hydro-lithology maps of the Region of Crete and the geological maps of the Institute of Geological and Mineral Exploration. The above were also fused with various satellite products, mainly from Landsat and Quickbird satellites and SPOT DEM, together with other environmental information regarding Statistical archives, meteorological data, a.o.

2.2. Image cataloguing and georeferencing

A specific issue in mountainous areas is the georeferencing of photographic materials. The geometric three-dimensional properties of aerial photography have to be projected and mapped to a 2D plane, and this process is influenced by a wide variety of factors: the topographic relief, the tilt of the camera axis and the distortion of the optics are most considerable. Geographical image registration tries to remove these factors in order to place each image pixel on its true location on the Earth’s surface.

Georeferencing is definitely a time consuming operation which gives the unique advantage to combine or to compare data from different sources or time period, searching for possible changes in the features under study. Several software packages available on the market allow rectifying an image, given a series of relative (input) and absolute (output) coordinates. Combine short processing time, precision and accuracy with manual user input are not easy (if not impossible). For

[7] Professor Konstantinos Katsampalos, of the department of Topography at the Aristotle University in Thessaloniki (Greece), estimated (personal communication) the accuracy of Bessel-Hatt in around 2 to 3 meters and he found a specific formula (and free software) to minimize this error.

this reason, two specific software –called “CataThumb” and “AutoGR-Toolkit”– have been created at the facilities of the Laboratory with the funding support of ArcheoLandscape Europe Project. Indeed, if the accuracy and precision of georeferencing of aerial images onto a relatively flat earth surface with user input points are traditionally considered “archaeologically sufficient” [14], the image displacements due to the topographic relief usually becomes as important as difficult, especially with sudden steep surfaces and low number of identifiable stable ground control points.

For the purposes of the present project, two steps have been followed for the API. The first involved the cataloguing of frames and the second their georeferencing; both achievements have been obtained through the use of the two aforementioned applications created for this purpose and shared with the scientific community on the webpage:

http://www.ims.forth.gr/index_main.php?c=90&l=e&d=7.

The cataloguing was completed with the very small and easy to use software, CataThumb. Given a computer folder with images (whether oblique and with GPS information or digital version of vertical prints), CataThumb automatically creates a basic database for the annotation of useful information on the side of the image preview. It basically extracts GPS information (if available) from the EXIF of each digital photo, it produces thumbnails (here the name: Catalogue Thumbnails) which are then stored inside an excel file with some other pre-filled cells (Figure 2).

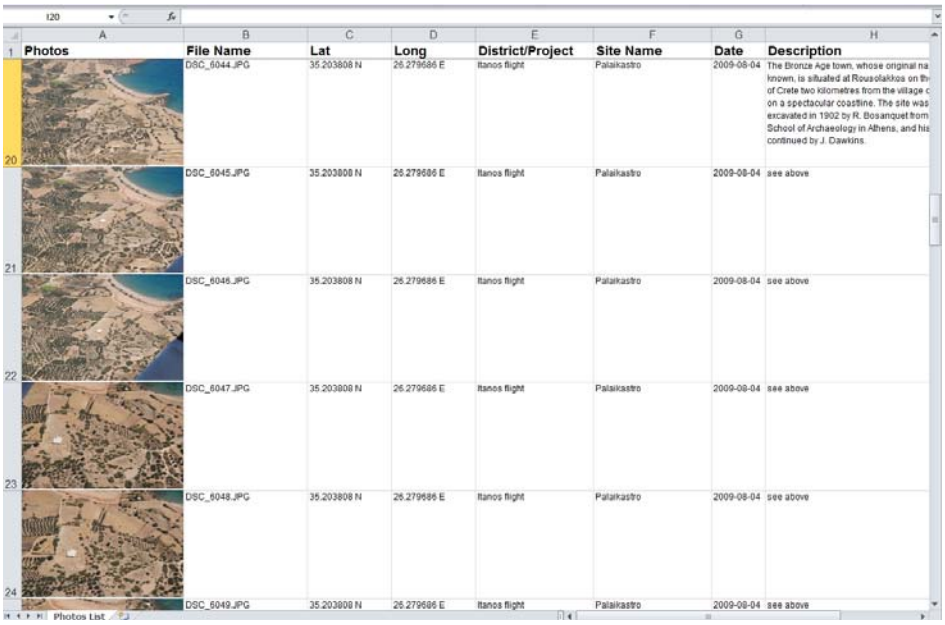

Figure 2: Screenshot of a sample spreadsheet file for cataloguing images produced by CataThumb.

CataThumb also generates a KML and a KMZ file to be viewed (and shared) with Google Earth (Figure 3).

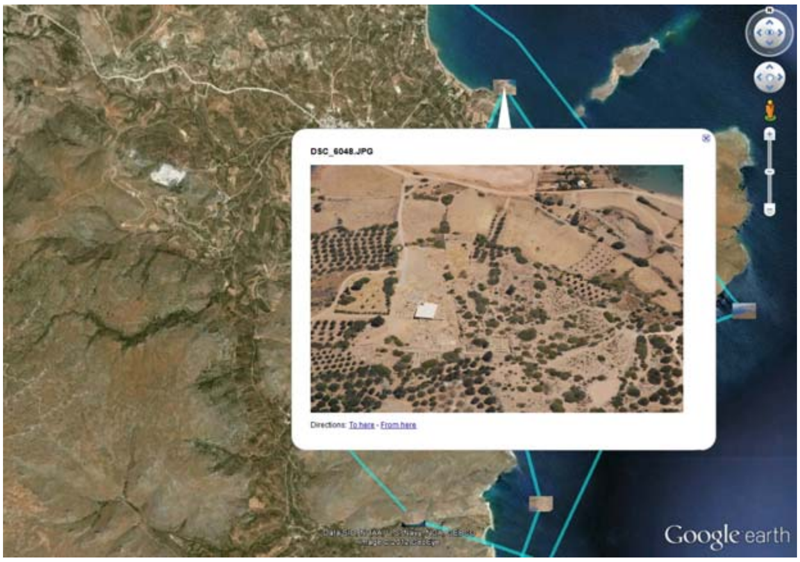

Figure 3: Screenshot from Google Earth with the flight track (in light blue) and the photo thumbnails in the place from where they were taken.

Once the XLS database has been filled in with all the required information, the next –and more complex– operation was undertaken: the georeferencing of each photo frame. In this phase the use of photogrammetry is introduced through the so called ASIFT algorithm embedded in AutoGR-Toolkit[8]. Considering that no accuracy and precision can be reached with manual point selection for georeferencing, because of the variable working scale, the resolution of the pointing device and the human error, the proposed software solution was oriented to automated point recognition and matching. AutoGR-Toolkit [15] minimizes or totally deletes the bias connected with manual entries and it matches couple of images by comparing the “local description” or unique fingerprint of each and every pixel in the input images.

If they depict the same area, even if from different points of view, with different light condition and in different time period, AutoGR is able in few minutes to match one image on the other according to the specific projection (if no projection is specified, a relative positioning is provided). If no other image is available for matching, AutoGR also provides a tool to capture a georeferenced Google Earth image which may be used as base for the automated and accurate georeferencing[9].

Thanks to the availability of some orthophotos from the Hellenic Ministry of Rural Development and Food at Athens (YPECHODE), together with Corona declassified and Ikonos satellite imagery, most of the verticals could be easily geo-positioned with the aforementioned software. Furthermore, the possibility of editing the list of produced matching points, allowed a successful application of the program also in cases where the coastline had been artificially deleted (Figure 4) by the provider (usually for security reasons).

[8] Both AutoGR-Toolkit and CataThumb are made freely available in the specific section “Downloads and Services” of the website of the Laboratory of Geophysical-Satellite Remote Sensing and Archaeoenvironment: http://www.ims.forth.gr/AutoGR and http://www.ims.forth.gr/CataThumb.

[9] Provided that the satellite image gathered from Google servers (according and in the respect of the user policy) is double checked otherwise for accuracy –because of the non-consistent error of the same imagery–, the final output is as accurate as it would be if georeferenced with other globally positioned images.

Figure 4: Detail of a GYS photo-frame with the coastline erased for security reasons.

Part of the research work was also devoted to the production of an accurate cadastral map, taking care of the 4th dimension of time, by extracting information from photographs taken in different time period and from the available cartography. Such a cadastre, indirectly interpolated, also includes vector information about the viability (road, pathways, transhumance cattle-tracks) land division, land use, hydrography. The above information has been entered into the created platform as well.

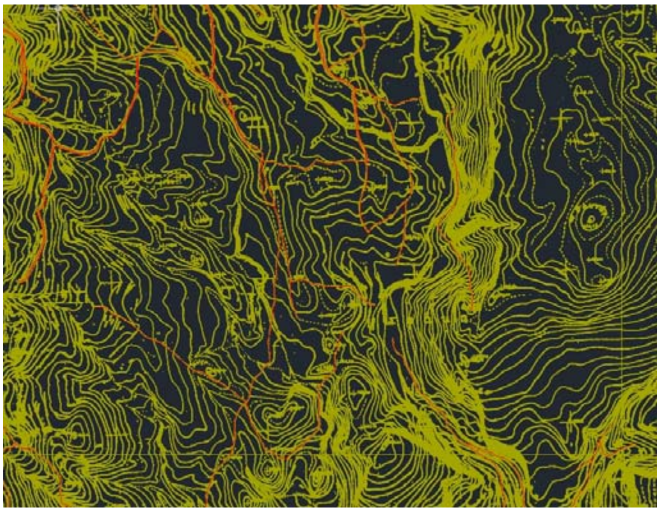

Figure 5: Portion of a 1:5000 map (in yellow) during the digitization of viability (in red).

2.3. Interpretation and mapping: the photogrammetric 3D surface reconstruction

If part of the interpretation can be achieved, as usual in API works, by comparing view of different time period for the same area, the real comprehension of possible archaeological features –and so their attribution to a more precise chronological period– can only be derived by the 3D (or 4D, if we put also the chronology as influencing factor) view of the environment under study. Indeed, if in traditional API of human-made artefacts the elevation is kept into consideration only when height of structure may be interpolated through the so called "shadow marks", in mountainous areas the specific settings and surroundings is a paramount. From here, the need for accurate 3D models to double check every identified feature. Just to give an example, an area such as Choiromandres[10],

[10] For the proposed photointerpretation, please visit the website:

around 4 km SW of Zakros in Eastern Crete, can be successfully photo-interpreted only with the information derived by the environmental configuration. The herringbone pattern of walls makes sense only with the 3D information and only if one can measure the real steepness of the valley.

In a way, the need for 3D models finds a parallel in the traditional stereographic view, but with the advantage of converting an optical perception in "measurable" landscape.

Even though an accurate 3D model (LiDAR) for the whole area of Itanos was available, the project tried to find an easy and fast way of extracting 3D information with photogrammetry.

Instead of moving to pre-compiled (and usually expensive) suite of software tools for photogrammetric 3D reconstruction, the project explored the accuracy and applicability of freely available tools (with the same spirit that brought to the creation of the programs described above). The best solution was identified in Bundler (version 0.4, by Noah Snavely) and VisualSFM (version 0.5.14 by Changchang Wu).

The point-clouds produced by that software, without any complicated configuration or parameters to be entered, were georeferenced and compared with the LiDAR point-cloud. The result, to be published shortly in a specific publication, allowed us to validate the accuracy this method and its applicability in other environments where no other LiDAR (or Ground Laser) scans would be available.

Indeed this step was essential in the definition of the protocol, since the accuracy of the generated 3D model could be compared with precise and extensive measurements from other devices.

3. Results

All the above mentioned steps in landscape archaeology approach for mountainous rocky areas have been condensed in a protocol that is now entering in the standard good practice and procedures of the Laboratory, in a continuous problem-solving oriented perspective. At the same time, the application of the same protocol to other case studies and research centres works is being entering in the testing phase as well.

The proposed protocol can be summarized in the following phases: collection of large and differentiated cartographic and photographic material; cataloguing of the basic information from every single frame (operation made fast and easy with CataThumb); georeferencing with precise and accurate system to minimize human intervention and optimize the result even with steep slopes (undertaken with AutoGR-Toolkit in short time); insertion of all the processed input in a uniform geographical system; extraction of 3D information (with Structure From Motion free software, such as VisualSFM) and reconstruction of measurable earth surface; interpretation and mapping of archaeological evidences in the generated 3D environment with the support of specific algorithms for feature highlighting: vertical exaggeration, light moving over hill-shade, sky view factor based visualization, colour enhancement, gamma correction.

The last part of the project involved the estimation of the accuracy of the photo-interpretation itself. To do this, we made use of a very valuable work undertaken at the same hosting Laboratory: Digital Crete [17]. This is a dynamic archive of the archaeological sites of the island of Crete constituting a central data warehouse to be used for information retrieval and the management of

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http://www.hydriaproject.net/en/greece-crete-water-management-in-zakros-area/importance3

For the main list of publications about the archaeological researches conducted by Dr. S. Chrysoulaki at the site of Choiromandres, please visit the following page at the same website:

http://www.hydriaproject.net/en/greece-crete-water-management-in-zakros-area/credits-resources1/ (Sites visited last time on May 10, 2012).

the cultural heritage of Crete. Being part of a much larger effort named ‘Digital Crete: Mediterranean Cultural Itineraries’, the project was implemented under the framework of the Greek Operational Program of Information Society, following the e_Europe initiative of the European Union. Until the end of 2006, more than 5,500 archaeological sites were entered into the database. More than 60% of them have been registered in a geographical context though surface surveys or digitization processes. A subset of the archaeological sites, concerning mainly unpublished sites, has been subjected to a protective filter that does not allow the external access of them through Internet. This valuable set of information has been used as direct feedback of aerial interpretation gathered through the described protocol. It also helped during the human training phase, always essential in photointerpretation.

As a result, a number of new potential sites have been identified in the small selected test area and in its immediate surroundings. Those spots, after a final ground checking, will be added to the already dense geographical database of Digital Crete.

4. Conclusions

The main advantage of the innovative approach comes when a great amount of different sources of information has to be compared in a uniform and structured platform. Indeed, in the specific project, a considerable number of un-located photos found the right geo-position, for an optimal chronological-stratigraphic view of every single spot in the selected area in Crete. Together with the information derived and generated by the image processing and GIS analysis, this produced a wider understanding framework of the landscape under investigation.

The aerial photographic survey has to be considered as a source of information as far as all the other research approaches are; it is also true that a validation process may be required for specific contexts where traditional approach may fail. This is the case of mountainous rocky areas, where a particular set of procedures has been studied and tested to maximize the extraction of information through non-invasive and inexpensive methods. The whole tasks, from the image acquisition, to their archiving and processing have been undertaken with the use of free and open source software, some of which appositely created at the facilities of the Laboratory of Geophysical Satellite Remote Sensing and Archaeoenvironment of the Institute for Mediterranean Studies of FORTH. The extensive application of the proposed protocol to larger areas and different contexts in mountainous locations will surely provide new sets of information to the scholar working in Crete and in analogous landscapes elsewhere.

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