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Le Vie dei Mercanti

Carmine Gambardella

WORLD HERITAGE and DEGRADATION

Smart Design, Planning and Technologies

La Scuola di Pitagora editrice

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Collana fondata e diretta da Carmine Gambardella

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Conference topics:

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Memory
Documentation
Management
Communication for Cultural Heritage
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WORLD HERITAGE and DEGRADATION
Smart Design, Planning and Technologies
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Peer review

Scholars has been invited to submit researches on theoretical and methodological aspects related to Smart Design, Planning and Technologies, and show real applications and experiences carried out on this themes.
Based on blind peer review, abstracts has been accepted, conditionally accepted, or rejected.
Authors of accepted and conditionally accepted papers has been invited to submit full papers. These has been again peer-reviewed and selected for the oral session and publication, or only for the publication in the conference proceedings.

Conference report

300 abstracts received from:

Albania, Benin, Belgium, Bosnia and Herzegovina, California, Chile, China, Cipro, Cuba, Egypt, France, Germany, Italy, Japan, Jordan, Kosovo, Malta, Massachusetts, Michigan, New Jersey, New York, New Zealand, Poland, Portugal, Russia, Slovakia, Spain, Tunisia, Texas, Turkey.

More than 550 authors involved.
212 papers published.

Preface

The theme of the XIV Forum “Le Vie dei Mercanti” is an international discussion on the disciplines of architecture, design and landscape through the presentation of research and operational projects on the conservation and valorisation of World Heritage and “smart” regeneration of degradation, with analyses and proposals ranging from the design at all scales, to architectural assets, the territory, infrastructures and the landscape. Academics, along with professionals who have a role in the governing, managing and controlling of public agencies, institutions and the business world are invited to submit papers related to design objects, architecture and landscapes. This is with the aim of conserving and recovering, valorising and regenerating, managing and designing (or re-designing), for the more general improvement of the quality of life, in an innovative and contemporary relationship between man and the environment, through “beauty”, while respecting the history, traditions, identity and principles of sustainable development, as well as being attentive to the needs of our and future generations. Internet of Everything, smart design, planning and technologies, building information modelling, in this age of globalization, have become operational tools – that alongside the traditional ones of the profession – for the protection and promotion of the World Heritage, are considered as well as shared by the whole of Humanity, and the regeneration of the degradation and the “Minor Heritage”, in all aspects, and as contemplated by the UNESCO Conventions on tangible and intangible assets and the European Landscape Convention. The event aims to create a critical transversal dialogue, open to cultural and “unlimited” influences, in a logic of integration between the skills that extends, and is not limited, to the following disciplines: anthropology, architecture, archaeology, history art, cultural geography, design, ethnology and folklore, economy, history, landscape, museum management, philosophy and political science, urban history and sociology, cultural tourism, planning and integrated management. The location is exceptional. Campania, with six sites included in the World Heritage List, two UNESCO Man and Biospheres, two sites on the List of Intangible Heritage, is one of the richest regions in the world for cultural and landscape heritage.

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New techniques for land surveying, monitoring and environmental diagnosis: a comparative analysis.

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Abstract
The use of GIS allows the analysis, the evaluation and the measurement of the condition of a territory and its sensitivity to specific phenomena, in order to be able to direct programmatic strategies and planning actions in order to address the action of territorial government on the basis of the emerged issues. The greatest efficiency of these systems can be achieved only by using constantly updated data both in the time domain component and in the space domain component. The modern survey techniques made with UAV (Unmanned Aerial Vehicle), better known as Drones, represent the new frontier of the sciences and of the environmental engineering, because they allow high speed and accuracy in the acquisition of information, and they give the possibility to compute, in real time, a wide amount of data. The possibility to obtain 3D high resolution model (HRM) in short time periods, open a new way of considering land survey, by making UAV essential instruments in diagnosis and environmental monitoring. The main objective of this work is to analyze the integration between GIS–UAV systems through an overview of the most used software, both for the acquisition stage of the primary data and its processing. With this analysis it is possible to highlight the main advantages and disadvantages, by tracking the new analytical skills and environmental monitoring that were made possible thanks to the advent of highly sophisticated but easily accessible instrumentations.

Keywords: GIS, UAV, Real time sensing

1. Introduction
Land information systems represent a fundamental aspect in environmental diagnosis and an essential tool capable of providing the government with practical directions concerning land surveying and monitoring on the basis of analyzed issues (Borri et al., 1998; Geneletti, 2003; Las Casas & Murgante, 2004; Diamantini & Geneletti, 2005; Graci et al., 2008; Zullo, 2016). Therefore, the availability of highly detailed geographic knowledge and information, along with progressively less expensive and more performing IT equipment, have made these systems widespread in scientific, economic and institutional sectors (Borruso, 2013). Numeric cartography has totally superseded the production and diffusion methods of the old cartography. The new technologies, the Internet and the increasingly fast data transmission systems have led to the democratization of geographic information - as defined by Goodchild (2007) - linked to the concept of “sensor” citizens and voluntary geographic information (Eisnor, 2006; Hudson-Smith et al., 2008; Hudson-Smith & Crooks, 2008, Borruso, 2010). In practice, these geographic tools have become widespread also among non-professionals and academicians. In other words, the availability of digital geographic information at different levels (national, regional and urban) has produced, in these recent years, an important transformation in the use of land and locational data, with important advantages for organizations, institutions, governments (both regional and local), public and private operators in the sectors of economics and services (Stefanini, 2006). These geographic data are used, explicitly or implicitly, by most of the public and private activities and organizations. Moreover, their use rises global interest at all levels, from decisional processes to operational realizations. Currently, owing to the remarkable progress in

technology, land sciences have an important tool capable of collecting information on medium-small areas, in a remarkably reduced time frame and with costs definitely lower compared to those of the methods used up to now. This tool - UAVs (Unmanned Aerial Vehicles) or more commonly known as drones - is a radio-controlled aerial device capable of delivering photos, videos, orthophotos, point clouds (already manageable through several GIS software tools) and digital models of the surface of a given area with a level of geographical precision and image geometrical resolution within the order of centimetres.

2. UAV Technology and photogrammetry

In the last years, the technologies connected to the development of Unmanned Aerial Vehicles (UAVs) have undergone an exponential evolution. Data collection from UAVs represents the latest frontier for geographic information. The new technologies at disposal enable to acquire data more quickly and more precisely, and to process an extremely high amount of information that can always be updated. UAV is a photogrammetric platform that operates autonomously, semi-autonomously or through remote control without crew on board. Its flight is piloted through various typologies of flight control systems managed remotely by pilots on the ground. It is possible to equip the drones (payload capacity) with various sensors such as super-high resolution digital cameras, as well as thermal and hyperspectral sensors (RGB, IR and thermal). In these recent years, the potential applications of drones have gone beyond all expectations and are still in phase of development. The most requested geomatics applications concern the following sectors: agriculture (precision farming) (Zhang et al., 2012; Candòn et al.,2013; Honkavaara et al., 2013); archaeology and cultural heritage (documentation and 3D modelling) (Russo et al., 2011; Piani, 2013); geology (hydrogeological risks, etc.); controls in urban environments (thermal dispersions, photovoltaic potential, events, safety); monitoring of the environment; remote sensing and photogrammetry. By flying over urban areas, UAVs can produce “3D city models” and update the existing cartography. Moreover, they can carry out photographic surveys for documentation purposes (panoramas, real estate sector, etc.) or are useful in controlling borders, coasts and seas. One of their points of strength is the possibility to integrate different typologies of sensors (cameras, thermal cameras, laser scanners) capable of acquiring different kinds of data. Each sector of interest is committed in developing new procedures and innovative technologies through increasingly sophisticated sensors. Owing to the GNSS positioning and navigation systems, these devices represent the latest step forward in the field of photogrammetry. Installed on board, the GNSS allows to follow a pre-established trajectory (mission planner), to record and deliver the trajectory actually carried out through specific software, and to provide orientation in real time on the basis of a local or global system of reference. The surveys carried out through these devices produce a series of georeferenced photographs of the territory. Photography, as known, represents a fundamental tool in almost all survey operations and is employed in all of the phases of data collection. In some cases, photography constitutes a useful support for obtaining fundamental information aimed at establishing the metric of elements. Through “metric” photography it is possible to acquire both quantitative (stereometry, morphology, geometry) and qualitative information (matter, chromatism, decay). Photogrammetry represents one of the sciences that has evolved the most owing to the new technologies, both hardware (as the drones) and software. These have produced a higher level of automation and new tools for improving work modalities and quality, such as the new compact digital cameras and the most efficient GPS systems. Therefore, besides aerial and land photogrammetry we can talk about UAV photogrammetry, whose characteristics together with the comparison with the previous two are shown in Table 1. It is exactly owing to these new technologies that real time sensing and real time control have been introduced in the last years (Ambrosia et al., 2003; Kingston and Beard, 2004; Kim et al, 2006; Remondino et al., 2011). The main advantage in using UAV systems consists in the possibility to fly at heights definitely lower compared to those of the classical aerial photogrammetric systems with the possibility to obtain high resolution georeferenced images. The latter are obtained owing to a Ground Sampling Distance (GSD, size of the pixel on the ground) in the order of centimeter against the dm/pixel of the institutional cartography, such as that generally produced by public administrations. Of course, the areas that can be surveyed by drones are much more limited compared to those scanned through aerial flight, also due to flight autonomy. Moreover, remote sensing techniques generally entail high costs due to the systems used (aerial platforms that require sophisticated sensors, etc.), while UAV systems constitute a valid and low-cost alternative. With reference to laws and regulations related to UAVs in Europe, the European Aviation Safety Agency (EASA) legislates in this ambit being one of the most qualified authorities in aviation safety regulations throughout the European territory. In Italy an analogous role is carried out by ENAC (Ente Nazionale Aviazione Civile). On 29 October 2015 the European Commission approved the “Guidelines for rules on commercial and recreational uses” of drones, submitted by EASA, while ENAC on 16 December 2013 had already issued its first regulation, modified afterwards with resolution dated 16 July 2015, then amended on 21 December of the same year.

	Aerial photogrammetry	Terrestrial photogrammetry	UAV
Planning	(Semi) automatic	Manual	Automatic and manual
Data collection/flight	Assisted, manual	Autonomous, assisted, manual	Autonomous, assisted, manual
Size of area	km^2	mm^2 - m^2	m^2 - km^2
Ground Sampling Distance	cm - m	mm - dm	mm - m
Distance from objects	100 m - 10 km	cm - 300 m	m - km
Geometry intake	Normal case, also inclined	Normal case, also inclined	Normal case, also inclined
Number of pictures	10 - 100	1 - 500	1 - 1000
Applications	Small-scale maps	Large-scale maps, industrial and architectural survey	Large-scale maps, relief in dangerous areas, real time sensing

Tab. 1: Main characteristics of the photogrammetric techniques

3. A new frontier: GIS UAV integration

The use of drones in environmental diagnosis is totally changing the world of Land Information Systems owing to their versatility and capability to collect data. The need to acquire information on the territory in the least time possible, at reasonable costs, has finally found a valid support in UAVs. These new systems represent the natural evolution of aerial photogrammetry, with a higher qualitative answer compared to the classical topography. A three-dimensional survey can be carried out through different tools and techniques. The indirect survey is based on techniques that use two different types of sensors, that is: active or range-based sensors (laser scanner) which emit an electromagnetic signal, recorded by the device, so as to derive a distance measure; and passive or image-based sensors that exploit the light present in the environment to acquire images to be processed. Among the techniques that use passive sensors, the 3D images (digital photogrammetry) is the one that has undergone the most important technological development in these years with a particularly profitable cost/profit relationship. Digital photogrammetry allows to obtain a three-dimensional survey starting from a set of bi-dimensional images making use of SfM algorithms (Structure from Motion) completed by stereo matching algorithms. It is a solution that, from many points of view, results extremely effective. In fact, it allows to quickly realize three-dimensional surveys with the use of low cost hardware and software solutions or Open Source, without renouncing to accuracy and quality. SfM is a calculation technique that enables to reconstruct the shape of objects through the automatic matching of points from a set of photos. Based on computer vision algorithms, SfM extracts the significant points from the single photos, gathers the photographic parameters and crosses the recognizable points on various photos, finding the coordinates of the points in space. From surveys carried out through these procedures it is possible to process super-high resolution orthophotos and Digital Surface Models (DSMs) that integrate easily in any GIS software. The use of these operational technologies drastically affects the time and methods for realizing territorial analyses, as well as the methodologies for processing the same. The complete integration between UAV and GIS allows to combine two fundamental aspects for the diagnosis of territorial phenomena, that is: the high resolution and fast data acquisition of the drones, together with the great processing capacity of the geographic software. The new GIS-UAV systems have manifold applications since, besides introducing new technologies and typologies of data in the sector, they also renew the potentialities of the tools and procedures currently in use through information characterized by super-high resolution. The peculiarities of these tools make their use transversal. In fact, they provide operational perspectives in almost all of the scientific sectors involved in the knowledge of the territory and of the environment at all levels. Also the sector of geographic information systems adapts to the new technologies through tools and utilities specifically aimed at processing data delivered by UAVs. During the years, new tools have been created for GIS software owners (for example, Drone2Map for ArcGIS) as well as for open sources (Drone Planner, Video UAV tracker for QGIS) whose use allows to integrate the two systems, thus increasing the efficiency and explorative capacities of the combination. This new integrated approach allows to carry out controls, simulations, comparisons, calculations of very complex indexes. Therefore, both the technician and the political-administrative decision-maker are provided with new and reliable information (that depends on the rough data

available) concerning the territorial realities analyzed, making analyses and decisional processes much more objective. All this can lead to a level of efficiency such that, in a not very distant future, it will be possible to talk about an actual "adaptive control in real time" of many of the territorial decisional processes (for example, territorial planning, strategic environmental assessment, environmental impact assessment, etc.) both at local level and as regards projects. Of course this will require higher precision when inserting data and processing the information available. Consequently, it will also require a considerable amount of human, technical and financial resources that, owing to the use of new UAV technologies, can certainly be optimized.
Therefore, the UAV systems are a powerful means for acquiring data, processed through specific photogrammetry software (for example, Photoscan, Pix4D, etc.) and then reprocessed (through GIS software, such as ArcMap, QGIS, etc.) so as to support many thematic scopes. Hereafter, an analysis is provided of the main software necessary for acquiring images and producing orthophotos and digital models of the ground.

4. Data acquisition and processing: analysis of related problematic aspects

The acquisition of data through UAV is a process that can follow various paths. To obtain a set of information qualitatively valid it is necessary to use automated flight systems using specific software generically called "mission planners." The mentioned software allows to send flight plans to the flight datasheets of the drones carrying out pre-established actions. These systems, also called platforms, are frequent for "assembled" UAVs, devices whose management requires knowledge and high technical skills. In the last years, though, ready to fly drones have become increasingly frequent on the market. These devices are characterized by a reduced size (weight and bulk), defined semi-professional and very interesting for their great versatility and easiness to use. In fact, various iOS and Android applications are available for the automatic acquisition of data through these drones. Image acquisition in itself is a quite simple operation from a practical viewpoint, but it presupposes technical knowledge of a certain relevance. Owing to the various applications available, it is possible to acquire photos automatically through point cloud processing. A necessary preliminary operation on the drone is the calibration of its electronic compass. This is usually carried out by using the software of the companies that produce UAV systems. The following phase requires the use of an app capable of defining flight plans for the area to survey. The apps described in this work are Pix4d Capture Mapper, produced by Pix4D, and DroneDeploy, a web-based system for photogrammetric reconstruction. Through the A-GPS technology present on any smartphone or tablet, the position of the device (and with it also that of its operator) is visualized on the screen together with a circumference indicating the possible positioning error (the basic cartography is that of Google). At the same time, also the position of the drone is identified using different symbols. This allows to identify - with a certain easiness and unequivocally - the area to survey through a polygon (rectangle/square for Pix4D Capture) whose size/position can be modified (3 anchoring points per side). Within this grid, the "flight strips" carried out by the drone covering the entire area of interest are visualized, as well as the points where the mission begins and ends. The amount of flight strips depends on two parameters: the flying height and the percentage of overlapping. Moreover, it is possible to set the speed with which the drone will carry out the survey (if too high there can be problems in the acquisition of several portions of the territory) and the film angle of the camera (set perpendicularly to the ground) (fig.1). It is very important to make sure that the GPS of the drone receives the signal of a high number of satellites in order to carry out the survey in total safety. To this aim, the drone is equipped with a lighting system that informs the operator of the occurred acquisition of the signal. This parameter is constantly monitored by the application (indication of the number of satellites with which the drone is connected in that moment) as well as the horizontal distance from the controller, the horizontal speed (in m/s) and the height with reference to the point from which the taking off occurred (this point is given the value 0). A very important parameter is the time necessary to conclude the mission. This is shown in the lower part of the screen together with the size of the area to survey. In fact, one of the problems concerns the duration of the battery which limits its use in vaster areas. In this phase the application provides control systems that allow to block the execution of the flight if the area to survey is too vast, if the flight level chosen is too low or if the drone is more than 150 meters from the take-off point. A further control system put at disposal by the application is a drone takeoff checklist shown in Figure 1, on the right. The system analyzes the checklist automatically making sure that all parameters were considered/set correctly before carrying out the mission. The green tick indicates the correct setting, while the red cross indicates parameter errors. In the latter case, the flight is not carried out until the error is properly corrected/modified. During the flight, the images are acquired directly on the mass memory mounted on the drone (several applications allow to archive simultaneously also on the smartphone or tablet connected to the controller). At the same time, the application reports the progress of the mission and the correct taking of photos.

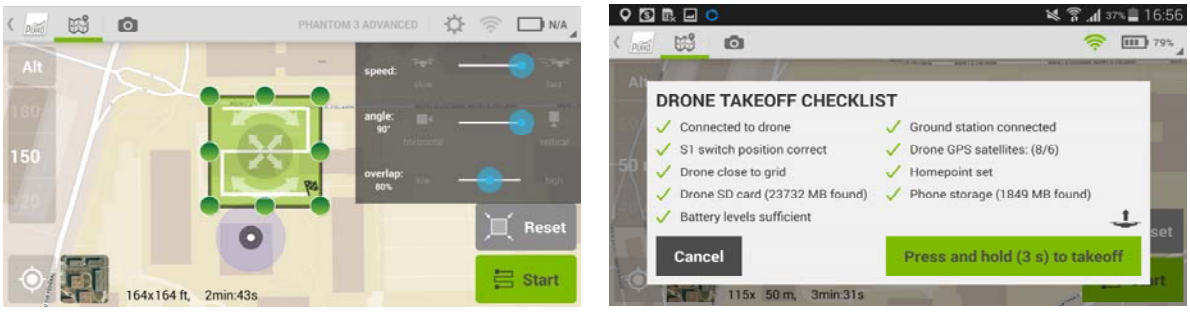

Fig. 1: Selection of the area to survey and of flight parameters (on the left), drone takeoff checklist (on the right) (Pix4DCapture Mapper)

As mentioned, the survey is carried out automatically through a pilot whose role is to visually monitor the device and the telemetry shown on the app. In case of problems during the flight, the pilot can decide if to end the mission making the drone return to the point from where it took off or assume its control directly. The DroneDeploy application presents a series of substantial differences compared to what illustrated previously. It is a cloud web based system that offers the possibility to pilot hundreds of drones virtually through web browser. The area to survey can even be irregular, and it is always possible to add or remove anchoring points. Moreover, the possibility to organize missions and flight plans directly on the computer and then send them to the drone through cloud is very interesting. From the settings of the app it is possible to recall the mission via web. In this case, the flight level - set with reference to the starting point for Pix4D capture mapper - can be set with reference to the country level so that the drone carries out the survey at a constant height from the ground. Whatever the application used, a fundamental parameter is a good Internet connection. In fact, all these systems are based on the visualization of Google cartographies. Therefore, it is necessary to be able to upload the cartographic element and confirm the position of the drone and of the controller. The lack of this condition does not stop the mission, but the impossibility to evaluate possible areas in which there is the risk of collision (surveys on very steep slopes) could create problems.

Fig. 2: Selection of the area to survey and of flight parameters (on the left), drone takeoff checklist (on the right) (Dronedeploy) drawn from: https://geosensornetworks.wordpress.com/2015/03/31/mobile-mapping-with-dronedeploy/.

An interesting solution is represented by the software licensed by UgCS, a system that provides a platform for planning the flight via notebook enabling to manage complex flight plans and send them through app to the drone. It is also possible to choose a ready to fly UAV configuration, such as for example DJI Phantom 3, or to realize a customized one.

Once acquired the photographic datum, this has to be processed through specific software or specific tools within the GIS systems. The number of photos acquired depends on the size of the area surveyed, on the characteristics of the sensor, on the flight level and on the percentage of overlapping of the flight strips. Passing from bi-dimensional to three-dimensional modelling takes place through a technical workflow common to all the software that operate in the field. The first phase consists in aligning images by processing the SIFT (Scale Invariant Feature Transform) as well as the matches for the calculation of the homologous points among the photos acquired. Then, the automatic reconstruction of the sparse dense cloud is carried out, that is of a “low density” point cloud obtained through the reconstruction in space of the points identified by the system for the internal and external orientation of the camera. Finally, through specific algorithms, the sparse point cloud is “densified” to obtain a three-dimensional model made of millions of points, allowing the representation of the area analyzed in the minimum details. Moreover, from the dense cloud it is possible to obtain a series of output products such as the digital models of the surfaces and orthophotos. The choice of the quality of the reconstruction of the dense cloud is a quite delicate operation because it is starting from here that all the final products are produced. Therefore, the higher the quality, the higher the level of detail with which the surface surveyed will be presented. This kind of operation also depends on the technical characteristics of the hardware (RAM and processor), and affects the time necessary for the realization of the same. As indicated above, the possibility to fly at heights definitely lower compared to the classical aerial photogrammetric systems, together with the characteristics of the cameras mounted on board, allow to obtain images with a super-high geometric resolution, thus with a Ground Sampling Distance (GSD, size of the pixel on the ground) of the order of one centimeter (fig.3).

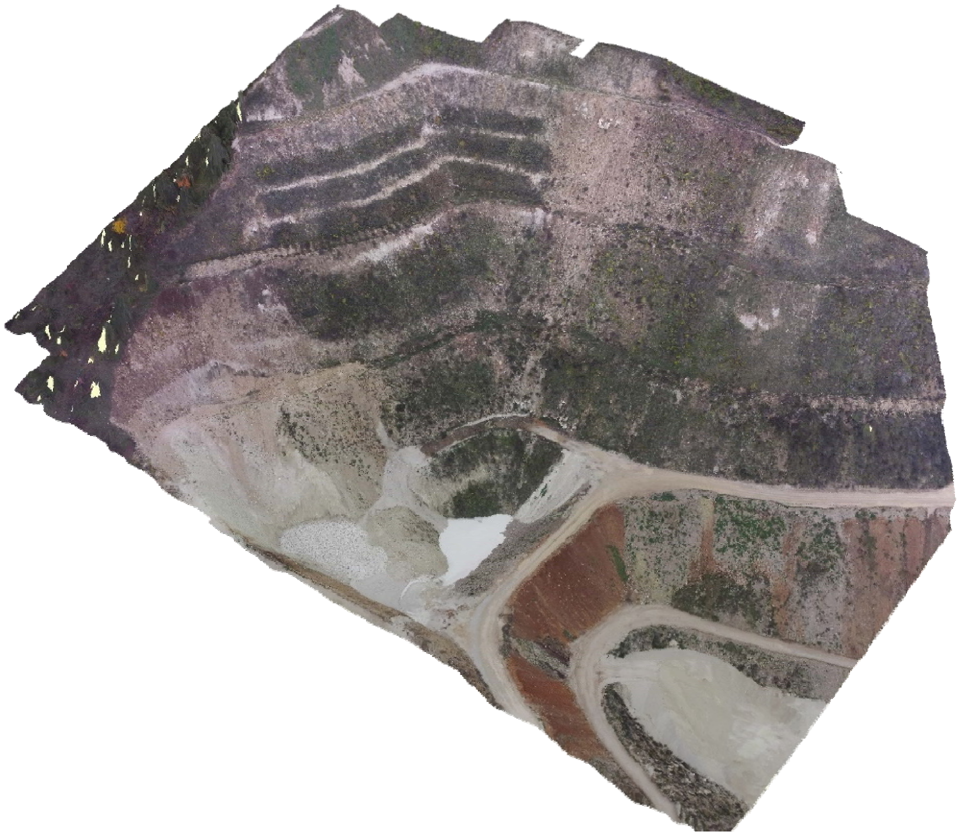

Fig. 3: Cave area surveyed through UAV techniques with a 2cm/pixel geometric resolution.

Moreover, specific attention needs to be given to the image georeferentiation process as it affects the accuracy of the output products. A metadata Exif file (Exchangeable image file format) is associated to each photogram. Said file contains the coordinates x,y (Latitude and Longitude) associated to a point placed in the centre of the same. The precision of the coordinates depends on the GNSS system mounted on board the UAV and also on the atmospheric/morphologic conditions that affect the number of connected satellites (precision of the order of metres). This entails problems - especially in the control and monitoring activities - when comparing data collected on the same area in different periods of time since they can present different accuracies and therefore a different positioning compared to a specific system of reference. For example, the control of variations concerning excavations and filling material within a cave area can generate calculation errors if the DSMs being compared have different accuracies. For this reason it is extremely important to use GCPs (Ground Control Point) of ground markers of known coordinates (to be surveyed with precision instruments) that allow greater precision and accuracy in the post-processing phase of the images.

5. Conclusions

Monitoring the territory for control or planning purposes requires constant procedural and technological innovations aimed at surveying environmental parameters. Remote sensing and GIS systems are in quick evolution as regards technologies and analysis methodologies, especially with reference to surveys and studies of the territory. In fact, increasingly specialized and geometrically more performing sensors make this a research sector always in phase of renewal. Therefore, the new techniques connected to real time sensing provide new horizons concerning possible applications and their use in processing environmental diagnosis and territorial planning. The possibility to obtain more detailed territorial data through UAV surveys and to process information within GIS environment with higher precision and in a rather short time frame, facilitates the comprehension of the dynamics of the phenomena that affect a specific environment. This allows to monitor and control various territorial realities in maximum safety also in case of areas hit by natural calamities such as landslides, earthquakes, floods or also areas in which there has been a leak or dispersion of toxic substances. Therefore, on the one hand there has been an increase in details concerning the processing and delivery of technical outputs (information and analysis), and on the other hand the awareness of the decision-maker has increased with reference to political actions and territorial management. However, UAV survey technologies present several limitations: first of all, the payload, that is the difficulty to use more cameras and sensors at the same time. Secondly, the quality of the GPS systems with reference to aerial navigation, the control of the orientation of the sensors and the georeferentiation of the datum acquired. Moreover, the small dimensions of the aircraft determine a higher risk of external interferences (for example, vibrations caused by wind and bad weather). These problems are linked to the type of UAV used and consequently to costs. In the light of what said, it is clear that the type of system configuration and equipment on board has to depend on the type of survey to carry out. Moreover, surveys carried out at very low heights entail the acquisition of a higher amount of photos, since the area covered by each photo is very reduced. This affects indirectly also the characteristics of the computers used for processing the data that therefore need to be increasingly performing to manage considerable amounts of information. Therefore, the solution to operational problems results to be a substantial part of the surveys. Even flight autonomy of these systems often represents a strong limit since the planning of the missions and data acquisition must last, for safety reasons, only a few minutes. Even with these technical problems, the current possibility to set up increasingly detailed geographic databases updatable with greater frequency cannot disregard their integration with UAV systems. Land sciences and engineering are provided with a new tool produced by this combination whose potentialities are in continuous evolution, owing to which land and environmental monitoring is becoming increasingly faster and more efficient.

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