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USING OF UAVs IN 3D MODELLING IN ARCHAELOGY

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В статье представлен проект сайта, наполненный визуально привлекательными и реалистичными моделями, которые могут использоваться для информирования и привлечения широкой общественности и туристов. Учитывая текущие разработки в создании археологической 3D ГИС, полученные 3D-модели могут даже получить большее значение в ходе будущих исследований и облегчить понимание исследователем археологических явлений посредством тщательного компьютерного анализа
Ключевые слова: 3D моделирование, археология, БПЛА

The article presents a project of site which filled with visually attractive and realistic models which can be used to inform and attract the General public and tourists . Given the current developments in the creation of archaeological 3D GIS, the result of 3D models may even gain more importance in future research and facilitate the researcher's understanding of archaeological phenomena through careful computer analysis
Keywords: 3D modeling, archaelogy, UAV

Recently, 3D representations of real-world objects have gained a significant importance. This results from both increasingly accurate acquisition methods, such as laser scanning and photo modelling, improved computer performance and availability of processing software. Multiple disciplines such as geology, civil engineering and archaeology benefit from these 3D models and their applications. Considering the destructive nature of archaeological excavations and the spatial component of archaeological finds, such 3D models significantly contribute to the conservation of archaeological information. They allow archaeologists to revisit the site in a virtual space after the excavation has been concluded.

Any researchers consider that the method of creating of 3D models of real-world objects the photo modelling is a cost-efficient and accurate method. The use of drones or helium balloons usually creates significant added value. This parcel was established in the presented research. Photo modelling has proven to be a very cost-efficient method, as the main costs involve the purchase of a camera, a powerful computer and software licenses. In comparison to laser scanning, where a powerful computer and software licenses are required as well, the initial cost for the scanner is significantly lower. Moreover, photo modelling enables a fast acquisition and processing. Based on the configuration of the research team – one person for photographic recording and two persons for topographic measurements – one day should suffice in order to acquire and process buildings with similar dimensions. By this time-efficient character of the method the cost-efficiency is even increased. Secondly, during this case study it is proven that this method generates highly accurate 3D models. The quality assessment indicates a 3D mean absolute error of 1-2 cm for the locally referenced models, which lies within the a priori established subdecimeter accuracy limit. Consequently, photo modelling is clearly a valuable method that can be introduced into the archaeological workflow and offers archaeological researchers

several advantages, among which its cost- and time-efficiency and accuracy. Furthermore, the deployment of airborne platforms forms a substantial advantage during this research. Both platforms – motorized hexacopter and helium balloons – create the possibility of recording aerial imagery and thus generating qualitative 3D models. This was essential, as the site contains several complex structures (e.g. stairs). The drone proves itself to be the most promising platform, given its flexibility and reliability. During low-cost, short term projects, however, the use of helium balloons might be considered. National legislation might also limit the import and usage of a UAV. Moreover, both platforms are susceptible to weather conditions, whereas a laser scanner is less subject to these circumstances. Nevertheless, both platforms were indispensable during this particular project and have proven to be important additions to archaeological research. In conclusion, it has become apparent that acquisition through photo modelling and the use of airborne platforms such as drones and helium balloons are promising techniques which might aid and enrich archaeological research. Considering the often limited time and budget archaeologists are granted, they enable a cost-efficient and accurate acquisition of the site and allow archaeologists to revisit any archaeological site in its original configuration. Furthermore, these visually attractive and realistic models can be used to inform and involve the general public and tourists. The developed project website takes a first step in this direction . Given the current developments in the creation of archaeological 3D GIS, the obtained 3D models may even gain more importance in future researches and facilitate the researcher's understanding of archaeological phenomena through careful computer analysis.

The UAV based survey of archaeological monuments and historic buildings has been among the most prevalent applications from the early days of these application in archaeology and heritage management.

From the experience accumulated so far it is possible to identify some general feedback. A first aspect concerns the choice of aerial platform for initiating the recording work. While fixed-wing UAVs are very efficient at surveying large areas to produce orthophotos, maps and 3D landscape models, multi-rotor systems are more suitable for the recording of individual sites and monuments because of their inherent characteristics. Multicopters can record both horizontal and vertical or sloping surfaces with equal facility, as required in the modelling of facades and architectural details. Another common feature of working with these applications is the need to integrate the results of UAV survey with ground-based photogrammetry and laser scanning. Among the main benefits remarked on in the scientific literature so far are the relative speed, economies of cost, levels of accuracy and ability to record elements that are not readily visible from the ground or from available vantage points.

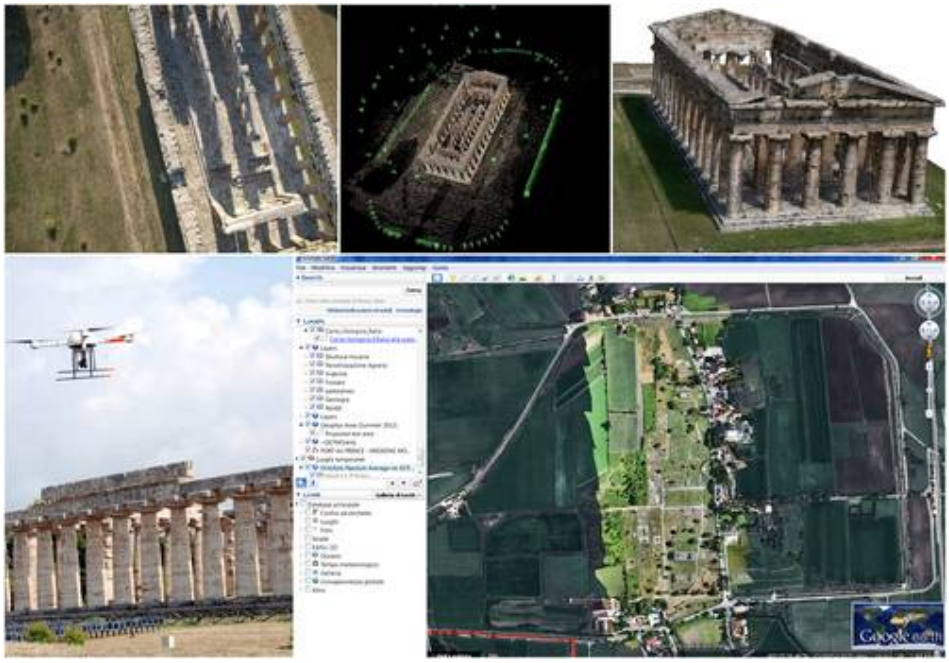

Fig. 1. Unmanned aerial vehicle (UAV) survey of temples and the ancient city of Paestum. Italy (courtesy of Fabio Remondino and 3DOM FBK Trento).
[Colour figure can be viewed at wileyonlinelibrary.com]

Although UAV systems of various kinds have been available for less than a decade, and are still very much in an experimental stage, archaeologist and applied scientists have already identified numerous archaeological applications in which aerial platforms of this kind could play an important and innovative role. The scale of the detail in which UAVs operate has always been somewhat problematic – relatively restricted in comparison with traditional systems based on conventional air photography or aerial photogrammetry but relatively large by contrast with terrestrial detection systems such as total station survey, global navigation satellite system (GNSS) and ground-based laser scanning. In a sense, however, drones offer the opportunity to fill a gap in the effective range and detail of low-altitude survey, with an effective coverage of between about 20 and 200 m fling altitude and the capacity to acquire data for landscape areas ranging from less than a hectare to as much as 300 hectares per day.

The geometric resolution that can be obtained is unprecedented, allowing the acquisition of images of excellent quality for both aerial photograph interpretation and 3D modelling. A further aspect, of great interest, lies the capacity of the UAV to take to the air at short notice, almost anywhere and at almost any time of day and year, increasing what might be termed the 'temporal resolution' of the instrument. This facility, compared with the difficulties involved in the hire of traditional light aircraft from perhaps distant airfields, introduces completely new opportunities for high-resolution survey, exploration and landscape monitoring, in some cases also providing access to areas or features that are inaccessible from the ground. These characteristics open up new scenarios not only for the monitoring of individual sites or monuments but also for archaeological conservation more generally in response to the many activ-

ities and development proposals that daily threaten the cultural heritage. Another significant aspect is the cost of the equipment. In recent years, these initial costs have been in sharp decline, although the purchase of a professional-grade system equipped with high-quality sensors and offering high reliability and good tolerance of variable environmental conditions still requires a significant financial investment. That said, the survey speed and data quality are so high that they will quickly prove cost-effective in the balance between resources invested and results achieved.

However, there are still several important problems to be overcome, though most of them are already some way towards solution. Drones are in most cases significantly weather dependent and are especially affected by strong or gusty winds. In many instances the lifting capacity needs to be improved, as does the tolerance of non-ideal weather conditions and the relatively poor on-board 'intelligence' of many of the available platforms – few drones yet have any significant capacity to respond independently to variable wind conditions or the presence of stationary or moving obstacles that lie outside the direct sight-line of the pilot. In these senses autonomy and reliability, both of which vary greatly with the type and capital cost of the UAV, represent key considerations for potential users, especially in the initial phases of research design. Reliability must also be a factor which is directly related to the search for safety of operation: serious accidents are thankfully rare but they *do* occur and any form of unreliability could become a contributory factor in future events of this kind. In addition to responsible behaviour and the observance of professional ethics, meticulous attention must also be paid to the regulations in force at the time and place of operation – the regulations, unfortunately, can be quite uneven and inconsistent between one country or context and another.

Ultimately the major methodological novelty of UAVs, beyond mere technical innovation, lies in their capacity to provide archaeologists with the opportunity to exercise direct and independent control over all aspects of the survey process: the platform, the sensors and the subsequent processing of the collected data. This capacity to control the process will give the researcher the freedom to develop applications and programmes of work that are directly related to the framing and answering of specifically archaeological questions, without having to deal (apart from the regulatory framework) with any non-archaeological intermediary. This kind of challenge has been a constant in the history of archaeology; the advent of drones and their increasing capacity to carry varying kinds of sensors, represents a major breakthrough that could in important respects revolutionize the future potential of archaeological survey, interpretation and problem-solving.

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