Google Earth.

The Good, the Bad and the Ugly.

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Abstract: Google Earth (GE) is becoming a common playground for archaeological research. There are a number of applications that span from the actual presentation of archaeological data, cultural heritage management or even detection of new sites. Having the ability to carry out research in places that are not easily accessible or capturing the regional settings of a site, the high resolution maps of GE (or of similar applications) have become an integral part of archaeological surveys. The particular paper presents a small overview of examples on the use of the freely accessible maps from Google Earth or other internet based providers and examines the way that they have been used to address specific archaeological questions or ways that they have been coupled with other datasets for disseminating the archaeological information and monuments to make them more attractive to the general public.

Keywords: Google Earth, Web based maps, Satellite Remote Sensing, GIS.

Introduction: The Complexity

Satellite remote sensing offers great perspectives in archaeological research and has been increasingly used in the recent years. It covers the whole surface of the earth; it is less expensive per square km compared to other types of archaeolandscape studies (e.g. conventional archaeological survey or geophysical prospection survey) and provides a fast documentation at different time windows. On the other hand, satellite or aerial remote sensing cannot be considered as a panacea in archaeological research. The application of remote sensing in archaeology is not easy at all, but on the contrary it is constrained by the environmental conditions, the vegetation coverage and the natural settings of the area, the nature, dimensions and preservation status of the subsurface monuments, the time of image acquisition, a.o. Furthermore there is an increased spatial complexity of the terrain with the fractal dimension to dominate depending on the scale of the research. Similarly, we can talk for the fragmentary picture of the monuments and the sites and at the same time for the spatial cohesion of settlement and occupation within a continuum of land-use that is characterized by a spatial diversity which does not allow the results deduced in a specific region to be applied in other areas without due consideration.

There are just a few suggestions about the inspiration of Google Earth: One of them is related to the 1957 book "*Cosmic View*" of Keens Boeke, which in 1968 inspired the "*Powers of Ten*" film, where a cosmic journey is followed from the outer space falling into the microcosmos of our atomic subsistence, through a continuous zooming and magnification. The other suggestion is related to *Earth* software, mentioned in Neal Stephenson's work *Snowcrash*, and which was responsible for zooming in and retrieving detailed mapping and image information at any geographic location of the earth

(http://www.pasthorizonspr.com/index.php/archives/07/2011/google-earth-archaeology*)*. Independently of where the inspiration of Google Earth came from, the technological advances in the Asynchronous JavaScript and XML (AJAX) and in image tilling techniques for GIS-based 3D visualization, established Google Earth as an indispensable tool of retrieving, searching, mapping of information based on their geographical attributes.

The same effect was observed in the archaeological community, where many people started looking for the "*holy grail*" (meaning the superb discovery) through internet published remote sensing maps and images. Since the early days of Google Earth, when the Italian computer programmer Luca Mori discovered the remains of a Roman villa by looking at the satellite images of GE at the town of Sorbolo (ADAM 2005), many more discoveries have been carried out through the help of GE and its parallel software. It was the first time, that a friendly and easily accessible software provided numerous images to the non-specialists (BECK 2006).

The Analysis and the Detection

Since the beginning of GE, numerous applications have been reported, most of which were concerned with the discovery of new archaeological sites. In a recent example, Kevin Daly from Bucknell University explored the GE images in an effort to look for the ancient forts in the suburbs of classical Athens. Looking to the west of Athens, and close to the Mt. Trikeraton/Kerata, he discovered the outline of a structure that extended for about 100x50m at the top of the mountain. Driven by the satellite imagery, Daly's team visited the site and made a detailed topographic map of what it is believed to belong to the ancient fort's architecture.

But of course the major breakthrough of the usage of the images that are available in GE is coming from the study and monitoring of areas that are mainly inaccessible due to extreme environmental conditions or conflict regions. As an example we can see the case of the ancient city of Ur (Tell el-Muqayyar) in Iraq and how it was influenced by the construction of an US military air base in 2003 (DEBLAUWE 2005) (http://bayourenaissanceman.blogspot.gr/2011/09/google-earth-reveals-more-long-hidden.html).

In a similar way, researchers from Australia are making a virtual flight through various parts of the world to make further discoveries of new archaeological sites. Hundredths of newly discovered sites including fortresses, reservoirs, settlements and tombs have been revealed to the researchers of the La Trobe University through GE images, allowing them to make detailed drawings and plans of them. Even though the ground verification of finds suggested from the sky is undoubtedly necessary, this has not obstructed the team of Prof. D. Kennedy from the University of Western Australia in Perth to study hundreds of square kilometres in the area of Saudi Arabia pinpointing to more than a thousand potential archaeological sites, some of which are manifested with magnificent earthworks on the earth's surface (http://www.pasthorizonspr.com/index.php/archives/07/2011/google-earth-archaeology) (KENNEDY 2011, MOSES 2011). The same team is actually responsible for the Aerial Photography Archive for Archaeology in Middle East (APAAME), an ambiguous project that has been able to collect numerous aerial and satellite

photos of archaeological sites and monuments that elucidate the evolution of settlement history in the Near East (http://www.apaame.org/). Circular funerary monuments, kite shaped stone structures, trumpet like burial tombs, strange shaped settlements and domestic dwellings and other exciting surface and shallow subsurface relics have been revealed from the study of aerial and satellite images from various places of the Middle East increasing significantly the number of cultural heritage monuments that exist in the area (http://www.smh.com.au/technology/technology-news/google-unearth-aussie-discovers-new-treasures-from-the-past--from-his-office-20110923-1kol7.html).

A lot of times, this kind of observation and study of the GE images, in correlation to other archaeological evidence is possible to support or reject specific archaeological hypotheses and advance the research. In a recent article , Uchida and Shimoda (2013) were able to delineate a transportation network of canals joint together with small sections of roads and rivers, extending for a distance of tenths of kilometres and leading from stone quarries to Ankor, Cambodia. This allowed the researchers to suggest of a possible way of transporting large blocks of sandstone over large distance to be used for the construction of the Hindu temple of Ankor Wat.

The Discovery in Question

This does not mean that all these discoveries need to be archived without further investigation or ground truthing. This need has been manifested by various examples that have found especially the light of public media. Very recently for example, tell sites (CORRIE 2011), mounds and lost pyramids in Egypt (LORENZI 2012) have been reported to have been found through the study of images from GE and other satellite images. Even though Egyptologists have confirmed that the shape and the alignment of these features are very similar to those observed by similar pyramids at the Giza Plateau, excavations are necessary to verify if the particular findings have an archaeological value or if they are actually natural geological formations.

Some other instances have provided researchers with a different stimulus and expectations than the actual finds. After concluding that a section of an Egyptian limestone could hinder residues of a fossilized whale, a team of the University of Michigan tried to trace back the origin of it by considering the trade routes that lead from the city of Sheikh Fadl to the surrounding quarries. Having no maps available, GE images were used to sketch the road network and possible limestone quarries within a radius of more than 75 miles from the city that led the researchers to arrive to an area that consisted of small fossilized remains of animals which seems to have been trapped into caves. This was one of the first evidence of the presence of mammals in Africa (SANTENS 2011).

In another case, the study of the deep sea floor through images of GE (or better of Google Ocean) raised rumours for finding evidence of the architectural relics of ancient Atlantis. Grid type patterns on the sea bottom extending for more than 160Km off the coast of Africa were suggested to outline the road network of the sunken city, while others suggested that these features may originate from trawler lines or may have been by-products of overlapping datasets. It was necessary for GE itself to update its images in order to

correct the blunders and artifacts presented originally (PAPPAS 2012). Without a doubt, features visible in GE images cannot be taken for granted but they constitute just a starting point for further investigation.

Management, Monitoring and Promotion of Cultural Heritage

Despite the above, everybody would indisputably accept that the major contribution of GE is towards the management of cultural monuments and the promotion of cultural heritage. There is an increasing list of examples that make use of the time succession of images now available in GE to indicate the changes that have been imposed to the surroundings of known archaeological sites, or even on them.
Being familiar with the anomalies observed in conventional aerial images, it is possible to detect soil marks and crop marks related to subsurface relics. Still, the time series images now available in GE can be used in an indicative way to study the degradation of the preservation of archaeological sites due to anthropogenic activities or natural phenomena (Fig. 1). Such kind of examples have been provided by Rothwell (2011) for the remains of a Bronze Age Village near Barry Island in Wales which is threatened by off-road bikers and for the gradual deterioration of the Somerset's Priddy Circles due to bulldozing activities. This kind of monitoring becomes even more important when remote archaeological sites are concerned.

Although there are no frequent updates of its images, GE can also contribute to the monitoring of archaeological sites, especially those threatened by illegal looting activities. What has been originally suggested by Parcak (2009) and Kennedy and Bewley (2009), namely of the potential use of GE in site looting investigations, it was implemented by Contreras (2010) through his "new initiative in combating looting from the air" for the area of Virú Valley in Peru, using a time series of images from GE and other aerial photo archives (in the specific case 1940s images of Gordon Willey). Similar techniques were employed by Contreras and Brodie (2010a) for detecting looted areas in Jordan and based on the success of the above they arrived to the position of suggesting an interactive way (through Google Earth) of the contribution of the wider public to report and document such kind of activities (CONTRERAS and BRODIE 2010b).

And even if the above are obvious maters of importance to cultural heritage management, GE has also promoted cultural heritage by adding its spatial dimension to the monuments. Numerous customized applications have been constructed making use of GE APIs incorporating various archaeological databases. See for example the Near East Atlas, created by the Department of Linguistics and Philology of the Uppsala University, where a number of British, French, Russian, and Arabic maps, survey and excavation reports have been rectified to provide an integrated archive of the archaeological sites of Near East (PEDERSEN et al 2010) (http://www.anst.uu.se/olofpede/ANE.kmzss.pdf).

Fig. 1 – Top row: GE images of the archaeological site of Akrotiri at the island of Santorini in 2002 (left) and 2012 (right). Bottom row: GE images of the archaeological site of Knossos at the island of Crete in 2002 (left) and 2012 (right). The above images indicate the changes of the landscape (due to constructions and urban growth, changes in the cultivation practices, a.o.) in the surroundings of the archaeological sites.

And more Atlases of similar content (e.g. The Digital Archaeological Atlas of the Holy Land (http://daahl.ucsd.edu/DAAHL/) or ArchAtlas (http://www.archatlas.org)) emerge continuously. Of course the content of these applications cannot be taken for granted with respect to the quality and accuracy of their databases, but still they contribute to the dissemination and promotion of the cultural heritage in an attractive way to the wider public. For example, ArchAtlas is a web-based GIS application that couples Google Maps with a number of themes (e.g. agriculture evolution, settlement and urbanism, trade and other) that address specific archaeological questions and visualization methods (e.g. panoramas, 3D landscapes, satellite images and other) focusing to specific archaeological sites.

Final Remarks

Google Earth provides a window to the Earth, an image that was not available to us before and as such it has opened a number of opportunities, more yet to come. It is not just a means of presentation or documentation - although some of its capabilities like the 3D or even 4D imaging and the flying-through

navigation attract the interest of the wider public. The scientific community is increasingly relying of the capabilities of Google Earth and many WEB based applications implement its images.
The publication of archaeological sites in Google Earth may conceal some inherent problems in looting industry, but the gain of the public awareness of the cultural heritage is far higher. Furthermore, through its multiple layering overlay, it is possible to comprehend much better the environmental context of the architectural monuments, the spatial relation among the archaeological sites and the threats that are imposed by natural or anthropogenic risks.
Still, GE has not reached its full potential, namely to provide users with the capabilities of the spatial tools and analyses of the Geographic Information Systems (GIS) (ULLMAN and GOROKHOVICH 2006). And as Parcak (2009) adds, "Google Earth is an excellent worldwide tool for finding sites, but lacks many of the advanced analysis possibilities in use for remote sensing". It is generally expected however that these are to be anticipated, with more time series images, more diverse datasets, more archaeological information, more tools for analyses, more accurate and high resolution images, pushing the envelope even further and making what seemed to be science fiction a few years ago a real tool for archaeological research.

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