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Model reconstruction for 3d vizualization of cultural heritage sites using open data from social media: The case study of Soli, Cyprus

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ABSTRACT

Given recent military conflicts, terrorism and natural disasters, many cultural heritage sites are increasingly being destroyed. As well, several of these sites are difficult to monitor due to their inaccessibility and remoteness. As aerial surveillance using drones and/or low altitude systems is more common, there is a vast amount of open data now available on social media, which are posted every day on the internet. Many of the videos posted do not include any information on the equipment that was used to acquire the video. Such media can be used to create 3D models and ortho-images of cultural heritage sites in order to monitor and document their existing status. Using open data that is available on the internet, this study used a range of imaging technique to estimate 3D landscape features from 2D image sequences subtracted from video, as well as applied image distortion correction and geo-referencing. The 3D models can be viewed using Google Earth and also be used to create ortho-image, drawings, and digital surface modeling for cultural heritage and archaeological purposes in remote or inaccessible areas. Such 3D models can be used to monitor and geo-reference cultural heritage sites. Social media can be used as a new source of information by archaeologists and cultural heritage experts to monitor and document cultural heritage sites that are in inaccessible areas, due to conflict, terrain or natural disasters.

1. Introduction

There has been a significant loss of cultural heritage sites due to natural disasters, wars, military campaigns, and terrorism (Maschner, 2016). Archaeologists and cultural heritage experts have traditionally used airborne and satellite sensors as well as 3D recording technologies to document sites. However, these traditional methods are expensive, time-consuming and often require expert knowledge for operation (Rinaudo et al., 2012; Schoning and Heidemann, 2015). During the last 20 years, cultural heritage and archaeology have experienced a technical revolution (Macheridis, 2015) as researchers use the combination of aerial imagery for 3D reconstruction of the cultural heritage site. These techniques provide a set of new tools for cultural heritage experts to capture, store, process, share, visualize and annotate 3D models in the field (Ioannides et al., 2013; Themistocleous et al., 2014, 2015a, 2015b, 2015c, 2015d; Fiorillo et al., 2012; Eisenbeiss, 2009). The implementation of image based 3D modeling provides a time- and cost-effective manner for digital documentation (De Reu et al., 2013, 2014; Dellepiane et al., 2013; Verhoeven et al., 2012).

Advances in 3D scanning techniques, drone use and tourist's online postings and videos are giving cultural heritage experts and archaeologists a new set of tools to prevent the permanent loss of cultural artifacts and landscapes. Indeed, there are several projects that incorporate open data to promote the digital preservation of lost cultural heritage using crowd sourced data in a cooperative, open-source project, including Project Rekrei (http://projectmosul.org), The Zameni Project (http://zamaniproject.org), the Democratization of Sciences project (http://aist.usf.edu) and the digital reconstruction of the Bamiyan Buddhas (Grun et al., 2004). It is now possible to use video imaging from social media such as YouTube, Facebook and Twitter to create 3D reality based models of cultural heritage architectures and monuments (Alsadik et al., 2015). 3D images can be incorporated into a BIM model and then geo-referenced (Rogers, 2015). However, there are several difficulties in using video to create 3D models. These include the low resolution of video images as well as the need to process a large number of short baseline video images and blur effects due to camera shake on a significant number of images (Alsadik et al., 2015).

There is a vast amount of data now available on social media, which are posted every day on the internet. However, there is confusion regarding if such data is considered fair use, public domain, creative commons or copyrighted. Indeed, social media such as Facebook, Twitter, Instagram and YouTube have different regulations regarding ownership and republishing images and videos. The fair-use doctrine permits others to use copyrighted material in a reasonable manner without the owner's consent for purposes such as teaching, scholarship and research. As well, fair use also applies if the original image is repurposed or transformed in such a way that there is a complete change in

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Fig. 1. Snapshot from the video from YouTube.

meaning and purpose. In this study, the original media was not used nor modified in any way. Rather, series of images were captured from the video, thereby changing the media. Following, the captured images were repurposed and transformed by digitally changing the distortion, balance, tone, exposure, contract and clarity and create a new purpose, which is the 3D model. As a result, the original media was transformed and bears no resemblance to the 3D model created in this study. Even though the fair use is acceptable practice, in this study, the author acknowledged the creator of the source media for potential copyright purposes.

In this paper, an video of a cultural heritage site was used to create a geo-referenced 3D model, ortho-image and a digital surface model (DSM). The site was inaccessible by the researcher and was never visited. In order to test the accuracy of the model, existing drawings were used and the model was imported into Google Earth for verification. The information necessary to create a 3D model and ortho-image, including camera angle, altitude, resolution, were unknown. As all the parameters necessary to create a reconstruction of the model were unknown, the information necessary had to be estimated according to an empirical method. This technique is difficult, as using low resolution video imagery to create 3D models is difficult even when all information about the camera resolution, camera angle, altitude is known. The technique discussed in this paper can be used on videos of unknown origin and is especially useful when any other means are not available, especially in areas that are remote or inaccessible to archaeologists or cultural heritage specialists. As detailed geometric documentation and monitoring of the monument cannot be done, the results of this study can only be used for 3D visualization and information purposes.

2. Case study

A video from YouTube was used to create a quality geo-referenced digital surface model (DSM) using images extracted from a low resolution video for visualization purposes. The YouTube video of the Ancient City of Soli in the area of northern Cyprus (https://www.youtube.com/watch?v=UvfNq62zCrc), uploaded on 2/9/2015 by Engin Deniz Vehbi, was selected (Fig. 1). The amphitheatre located on the slope of a hill was used as the area of interest.

Soli, also known as Soloi, located near the village of Karavostasi in the northern region of Cyprus (Fig. 2), on the Bay of Morphou, was one of the ten ancient city kingdoms of Cyprus. The ancient city of Soli covered an area of ca 30 hectares extending almost 1 km inland from the sea. The northern half of the site is on a coastal flat, with up to 10 m contour, while the southern half was built on steep terrain with a peak at ca 70 m above sea level (Wright, 1992). Soli was built in the 6th century BC. It was destroyed during Arab raids in the 7th century A.D. The city was designed by the Athenian statesman Solon, during his 10 year trip to Cyprus. The city had great economic significance

Fig. 2. Map of Cyprus, including the city of Soli in the North-west region.

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