Digitization issues in documenting cultural heritage with drones: case study of Foinikas, Cyprus

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ABSTRACT

This paper will examine the use of traditional photogrammetry and LIDAR for documenting cultural heritage site. The case study area was Foinikas village, in the Limassol district of Cyprus, which dates back to the 11th century and has been abandoned from 1960, following the construction of the nearby Asprokremmos dam. Traditionally, photogrammetry has been used for documentation, by processing aerial images acquired from UAVs. However, with the recent development of new lightweight LiDAR scanners, it is now possible to mount professional grade LiDAR sensors on UAVs, which can be used to document areas with high accuracy. In this study, the abandoned village of Fionikas was documented using both photogrammetry using an RGB camera and a LiDAR scanner attached to a UAV. The results of the study found that both methods used provided high accuracy in the documentation of the site.
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Keywords: UAV, photogrammetry, LIDAR, Cultural heritage, documentation

1. INTRODUCTION

LiDAR and Photogrammetry technologies can be used to document cultural heritage sites. Photogrammetry use captured images to make measurements[1]. Traditional photogrammetry uses two different images of the same area on the ground, which are displaced by a ‘baseline’, allowing one to use triangulation to discern elevation [2]. The weakness of this is that to measure elevation, a “ray” from each of the two images had to converge at the ground point to be measure. Photogrammetry can only create points based on what the sensor of the camera can detect illuminated by ambient light, essentially taking a complete ‘snapshot’ of the scene at one moment [1-3]. LiDAR (Laser Imaging, Detection and Ranging) laser scanning use lasers to enable measurements. The lasers are distinguished from other light sources by their coherence, which is typically expressed through the output being a narrow beam of light. UAV LiDAR scanners has the distinct advantage of requiring only a single ray to measure elevation. The main advantage of LiDAR is its ability to penetrate through vegetation, which is nearly impossible using traditional photogrammetry [1-4]. UAV LiDAR is also required to successfully model narrow objects such as transmission lines or sharp edge features, such as roof edges, even though recent photogrammetry algorithms can provide much denser models as well as natural color point clouds. Lidar laser scanners can be attached to a UAV to measure the height of points in the landscape below the UAV and can capture hundreds of square kilometers in a single day. By measuring 10-80 points per square meter, a very detailed digital model of a landscape can be created. However, LiDAR works by scanning progressively through the scene, so any discrepancy in its movement during the scan will distort the resulting data [2,3].

In this paper, the Eratosthenes Research Centre of the Cyprus University of Technology and the LidarUSA company documented an abandoned village through the use of traditional photogrammetry using aerial images and with LiDAR scanners attached to UAVs in order to determine which method was more effective. The study area was the abandoned village of Foinikas in the Limassol District of Cyprus, which dates back to the 11th century. Foinikas village was a military command centre for the Knights Templar during the 12th century. The recent series on the History Channel “Buried- Knights Templar and the Holy Grail” features the village of Foinikas and focuses on its importance for the Knights Templar (figure 1). The study was conducted parallel to the filming of the episode featuring the village of Foinikas as a potential stronghold of the Knights Templar in Cyprus.

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WHAT REALLY HAPPENED TO THEM?
BURIED
KNIGHTS TEMPLAR AND THE HOLY GRAIL

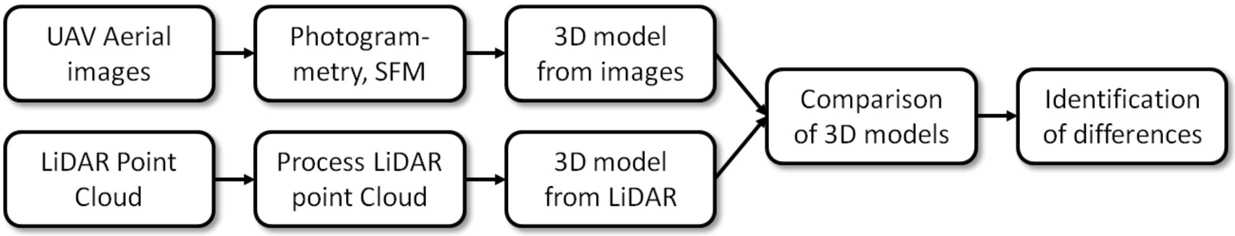

UAV Aerial images
Photogram-metry, SFM
3D model from images
LiDAR Point Cloud
Process LiDAR point Cloud
3D model from LiDAR
Comparison of 3D models
Identification of differences

Figure 4. LiDAR HDL-32E laser scanner attached to UAV

3.3 Photogrammetry

Nearly 200 aerial images were captured with the camera loaded onto the UAV and were then processed using photogrammetry. The first step in the program's procedure is called Structure from Motion (SFM). At this stage the software analyses the dataset, detecting geometrical patterns in order to reconstruct the virtual positions of the cameras that were used. Figure 5 indicate the location of the image, while Figure 6 features a thumbnail view of the image that was used for the particular point.

The second step involves the creation of a complete geometry of the scene using a dense multi-view stereo reconstruction. At this stage the dataset of images are employed to produce a high- resolution geometry of the surface. This step successfully creates a 3D model, also known as a Digital Surface Model (DSM). The processing began with the ortho-mosaic production from multiple images, that was then used for DTM production from which a contour map can be generated. The completed alignment is then used to develop a dense point cloud which uses it to create a surface which allows draping of the imagery over the model by creating and building a texture from the original images and overlays the imagery onto the model mesh [8]. The software then builds a polygon mesh and calculates a texture for the mesh.

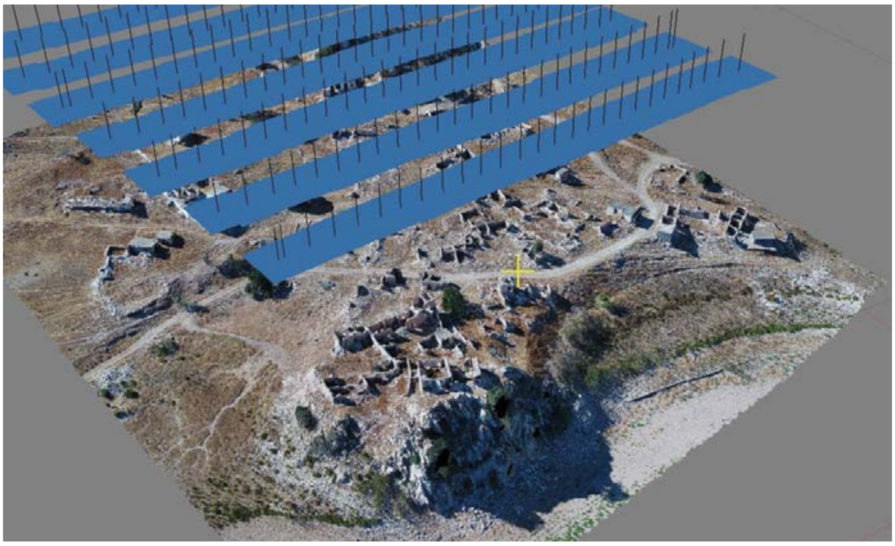
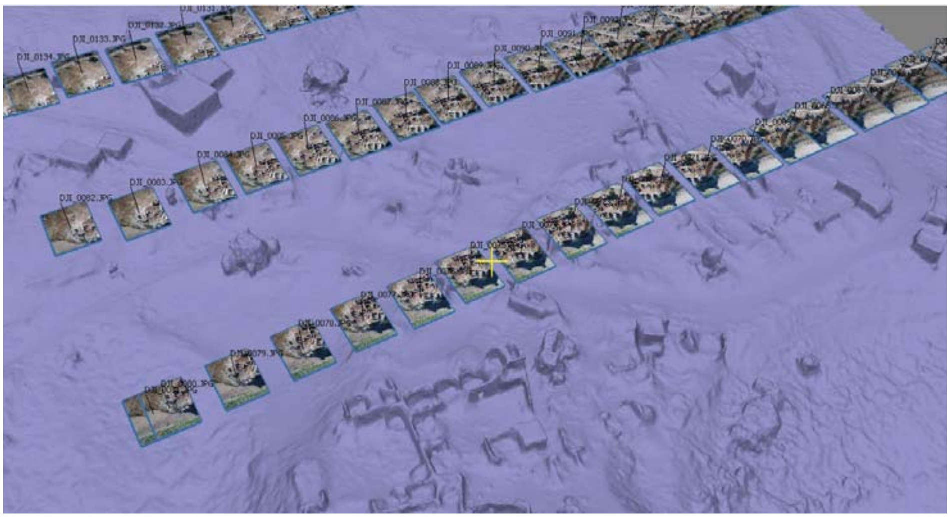
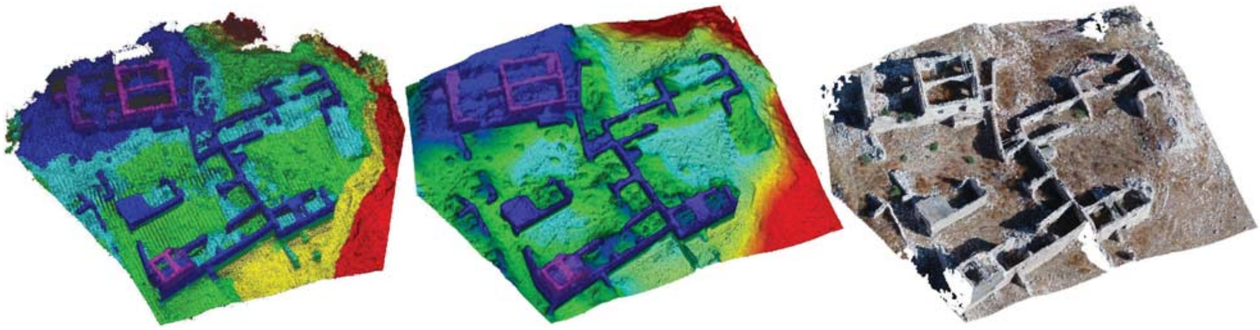
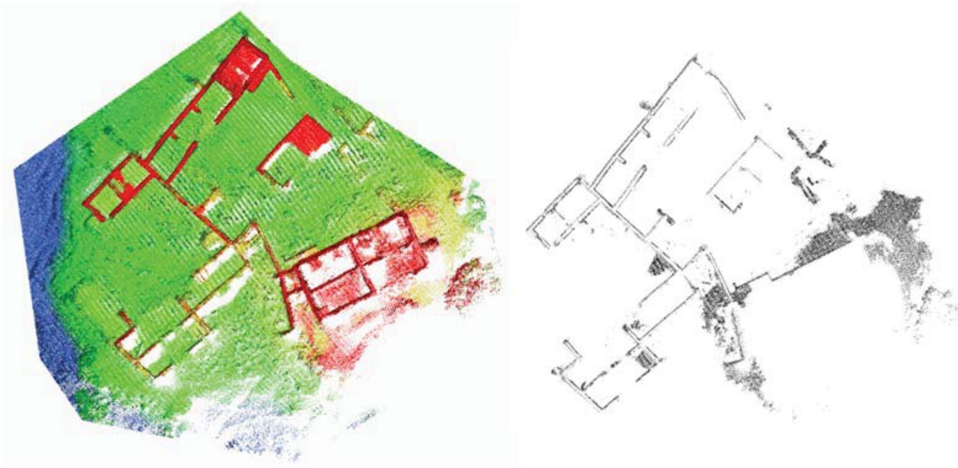
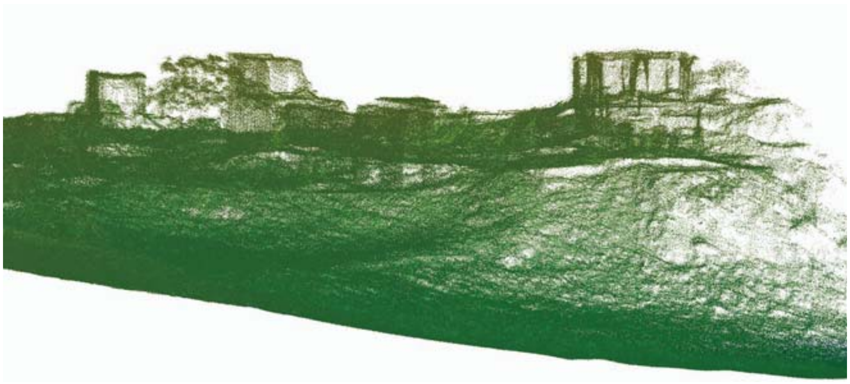


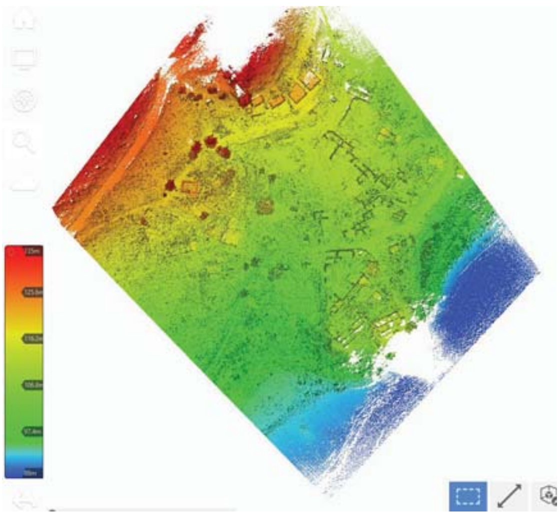
Figure 5: Positions of the camera over study area











Photogrammetry is able to generate full-color 3D and 2D models (in the various light spectrum) of the terrain that is easier to visualize and interpret than LiDAR. The main outputs of photogrammetric surveys are raw images, ortho-photos, DEM and 3D points clouds created from stitching and processing hundreds or thousands of images. The outputs are very visual with a pixel size of 1cm. [6]. Figure 11 features the DSM and the ortho-photo of the Foinikas study area which were generated using photogrammetry.

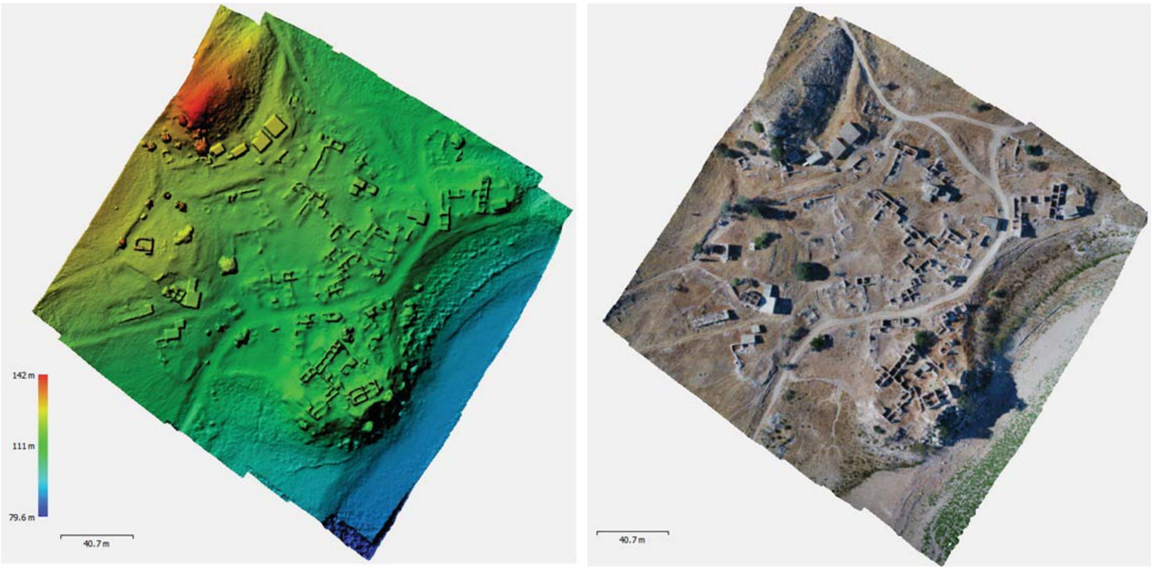


Figure 11: Left - DEM of study area; Right - Ortho-photo of study area

The completed orthophoto of the study area is featured in figure 12.

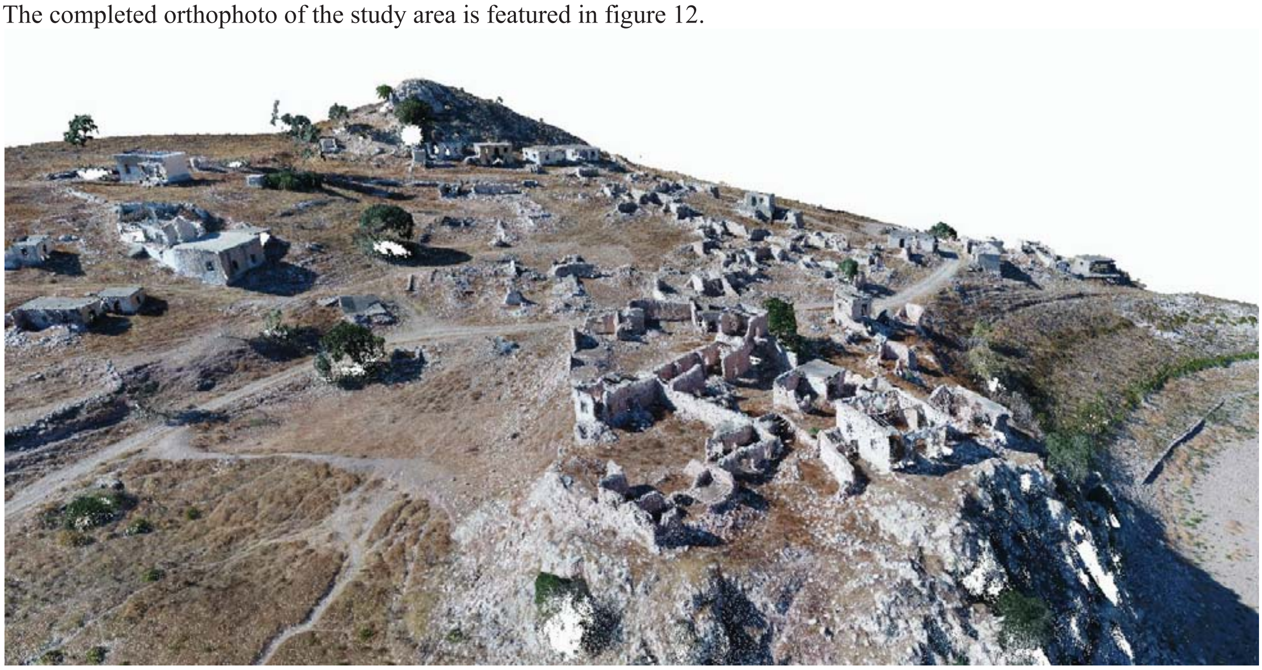


Figure 12: Ortho-photo of Foinikas site using photogrammetry

The two models were overlapped in order to identify any differences between the two surveys. In Figure 13, the red points refer to the model generated using photogrammery from aerial while the blue points refer to the model from the UAV LiDAR. It is evident that the LiDAR did not show the vegetation due to the ability of the laser to penetrate through vegetation and has less noise, as indicated by the blue points. This comparison indicates that even though both techniques can create an accurate 3D model, the UAV LiDAR was more accurate in documenting the study area.

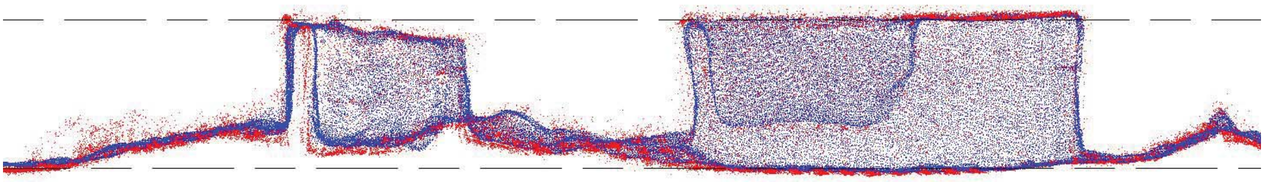


Figure 13. Comparison of two point clouds showing a partial section through the buildings

5. CONCLUSIONS

The aim of the paper was to compare the documentation of the study area using both UAV LiDAR and traditional photogrammetry. The results found that the UAV LiDAR provided more detailed and accurate documentation, especially in cultural heritage sites. An additional benefit of using UAV LiDAR for documentation is that the method is able to penetrate through vegetation to generate a precise documentation of the site. In this study, traditional photogrammetry had similar results as the UAV LiDAR, with the advantage that it is a more cost-effective method as it can be used with smaller UAVs. However, photogrammetry is not effective in penetrating vegetation canopies, of which the LiDAR system has as an advantage for archaeological sites that are covered in vegetation. Over time, UAV Lidar systems are becoming less expensive with additional capabilities and can be combined together with photogrammetry and other sensors for optimal documentation of cultural heritage sites.

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