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Multirange Data in Cultural Heritage: Technologies, Formats and Visualization †

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Abstract: In this paper we briefly analyse the integration into web access of data recorded from the archaeological area of Khatm al Melaha (Emirate of Sharjah, United Arab Emirates), combining different geomatic techniques at different scales from a broad yet technical perspective. In order to improve scientific analysis, the documenting process should always consider every aspect of recording as well as preventive control, conservation and interpretation. Along these lines, some open–access, web–based 2D and 3D JavaScript libraries have been created to unify, simplify and analyse their different uses through a web platform called *threeDcloud*.

Keywords: archaeology; open-air rock art engravings; 3D models; web mapping; open-source libraries; aerial and terrestrial photogrammetry; WebGL

1. Introduction. Connections between Open-Air Rock Art and Landscape Topography

The use of new technologies for recording and identifying open-air rock art in nature is so diverse and the techniques applied are often so complex that they hinder interdisciplinary understanding, failing to provide a standardised methodology. New development techniques are hence needed. Procedures should be standardised to provide scientific analysis, as well as dissemination and understanding of the generated data and its possibilities.

Three geometric surveys were carried out between 2015 and 2018 in the archaeological area of Khatm al Melaha (Emirate of Sharjah, United Arab Emirates) along the Gulf of Oman, led by the *Departamento de Ingeniería Topográfica y Cartografía, Universidad Politécnica de Madrid* (Spain). More than 370 rock art engravings were documented in this area close to the southwestern border with the Sultanate of Oman.

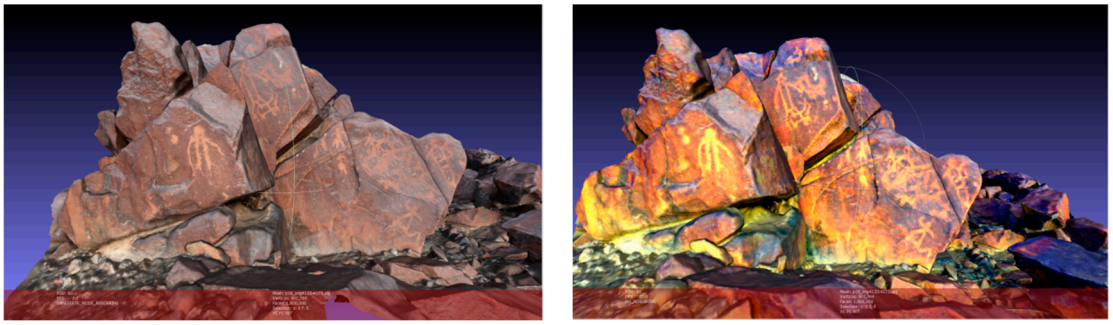
The engravings were carved on 149 stone blocks of different dimensions and morphologies spread along a 58-meter high isolated slope. Some of those decorated boulders are in secondary condition, having rolled down the hill (natural degradation processes) or having been used for some of the modern human structures documented in the area (Figure 1).

Despite the high concentration of rock art panels, associated archaeological finds were scarce: only two small undecorated handmade pottery fragments, a couple of flint flakes, and a hand mill fragment were found in an examination of the surface area. In order to understand this rock art concentration from a visual perspective, in its location it's easy to see the N-S communication route parallel to the Gulf of Oman, as well as the E-W route to the interior through the Wadi al-Hilu, currently connected by the Sharjah-Kalba highway.

Apart from those artefacts, a large shell midden was found at the foot of the hill facing East, and some circular structures (in varying conditions) mainly along the Eastern side of the slope but also at

the top of the elevation and on the western side. Even though they haven't yet been defined as funeral graves, some other nearby rock art areas have, as it is the case of Fujairah [1].

Despite being in its preliminary phase, the project has so far seen the following achievements: 1) the creation of a wide catalogue of documentation with strong possibilities of dissemination, such as a 2D and 3D online repository data; 2) the integration into web access of interrelated models at different scales; and 3) the integration of Geomatic techniques for preventive control, conservation and interpretation of open-air rock art.



(**a**) (**b**)

Figure 1. Rock art engraving sample of site number 34 in Khatm al Melaha (UAE). Conversion of the 3D model in the open-source *MeshLab* from OBJ mesh to JavaScript formats (JSON). (**a**) 3D textured mesh from RGB; (**b**) 3D textured mesh from de-correlation view through *DStretch* plugin (enhancement YDT, gen purpose, yellows).

2. Objectives and Methodology

The main goal of this project is to establish a protocol for recording and preserving this group of engravings with the following actions:

A. Develop a multi-scalar documentation (Figure 2) in order to understand each rock art panel, the relationship among them as well as their logical geospatial location within the archaeological context. One of the three-dimensional digitalisation goals is to optimise time recording data and improve the results of both metric and graphic data. Credible data for testing and analysing is therefore obtained, while there is also a significant increase in the data obtained when recording. In order to develop the archaeological documentation for this site, the following Geomatic techniques have been used in all three completed campaigns:

- Photogrammetric tablet (2015). Some of the rock engraving panels were documented with a photogrammetric tablet EyesMap [2,3] so as to obtain different orthophotos and 3D models for the first analyses.
- Aerial photogrammetry with a fixed-wing drone (2016). We have used an eBee drone by senseFly, aiming to generate an orthophoto with a resolution (GSD) of 2-centimetre-pixel of the entire archaeological site, approximately 70 hectares (Figure 2a). This technique allows of a better spatial resolution to locate the different rock art panels.
- Close range photogrammetry techniques (2018). In 2018, an intensive archaeological survey was conducted in the entire archaeological site in order to document each rock engraving with close range photogrammetric techniques and a database. The results were the finding of 149 block stones with more than 370 rock art engravings.
- GNSS RTK – PPK (2015, 2016, 2018). All surveys were georeferenced with a GNSS RTK Leica GRX1230 by means of Post-Processed Kinematic techniques (PPK).

B. To launch a database that is interrelated and integrated into web pages in order to obtain a more detailed analysis of rock engravings. We have used the *epicollect 5* mobile & web application for data collection in field activities (2018).

C. Create and develop a web platform called *threeDcloud* [4] for visualising three-dimensional models and high-resolution images, allowing real-time interaction of the information. This web platform is based on *potree*, a free open-source WebGL to manage large point clouds [5], an open-source JavaScript library to adapt the orthophoto generated (*leaflet*), and a de-correlation view to analyse the 3D mesh of each Rock Art panel (*three.js, DStretch*).

(**a**) (**b**)

Figure 2. Example of a data base (**a**) through a web mapping linked to the different data (survey form field sketches, aerial and terrestrial pictures, 3D mesh, large point cloud, 360 immersive view, de-correlation view, etc.); (**b**) survey field texture documentation with a standardized colour chart.

3. Results

In order to put the technology into full effect, we need to create methods that can be easily spread through 2D and 3D databases in web settings. This kind of data allows for instant viewing and analysis, since it offers valid graphic and metric data from three-dimensional models. User-level interactive databases stored in JavaScript files in browsers (which integrate WebGL) favour free dissemination, since they provide more comprehensive aspects, both technical and scientific. The data is thus integrated, generating a 3D-cloud web platform (Figure 3):

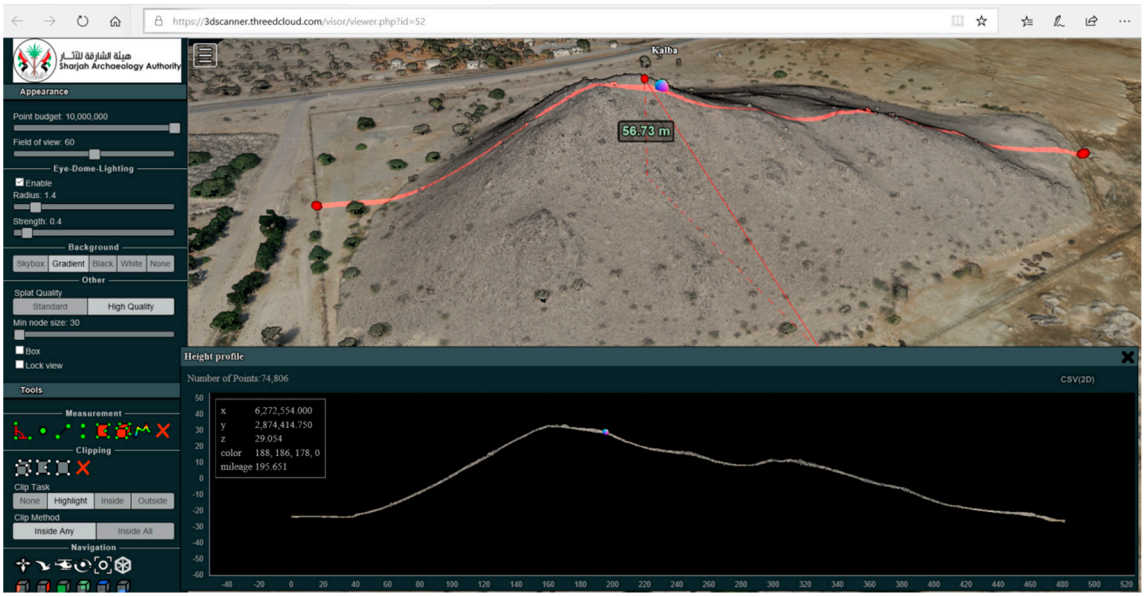


Figure 3. Point cloud of Khatm al Melaha (UAE) archaeological site visualized by means of a *potree* (free open-source Web-GL) adaptation in *threeDcloud* web platform. Large point clouds obtained by photogrammetry techniques with a professional eBee mapping drone (GSD = 2 cm/px.).

- A general 3D point cloud of the hill, as well as digital models for each engraved block. This is meant to visualize and render large point clouds based on WebGL, a standard for rendering 3D graphics from any browser that supports it. It is not only used as a viewer, but also has certain tools for processing and using point cloud, such as profiling, area, volume, distance and height measurements, elevations, classification of point clouds and layers division.

- Web mapping GIS with the integration of the orthophoto and each of the blocks documented in different layer types. This enables analysing the different styles and morphologies of the rock art stone blocks throughout the entire recorded archaeological site (Figure 2a).

- 3D Mesh with the possibility of digital enhancement with the de-correlation view based on *DStretch* (Figure 1b). This is clearly an improvement in the view over some representations.

- 360-degree spherical views from different points of the hill, in order to improve the spatial understanding of the archaeological site from an immersive perspective (Figure 2b).

4. Conclusions

Following on the preliminary phase of this research, in which we are integrating and analysing the data obtained in all three completed surveys, in this paper we propose the following. Firstly, we put forward an approximation to how to generate a 2D and 3D online repository data to study common stylistic patterns of engravings, dispersion models, and detailed analysis of each engraving through a common web page. Secondly, we propose a method that integrates interrelated models at different scales through a web platform (*threeDcloud*) without the need for additional software or plugins. Finally, we suggest that in combining these geomatics techniques will advance our efforts in preventive control, conservation and interpretation of the open-air rock art.

The success of a process that standardises techniques lies in simplifying systems, which is a common goal of current research. For a process to be fully implemented, it must allow public management of geometric results, through technical, scientific and intellectual property consensus. Data should be easily accessible both graphically and metrically, moving towards self-management and permitting the use of these tools in research [6]. Democratisation of technology has repeatedly taken place over the last 150 years in photography, aviation, computing, and currently in the use of drone or RPAS with geometric and graphic aims, applying remote sensing techniques in the recording of unexcavated archaeological sites. Nowadays, the challenge lies in the use of all this varied data in a recording process useful for both scientific research and dissemination in the field of Cultural Heritage.

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