The Microtopography of Rapa Nui's Petroglyphs

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Introduction

Rapa Nui, also known as Easter Island, with its rich and extensive archaeological resources, has been the site of many archaeological surveys. The purpose of this project is to enhance our understanding of the archaeological record of Rapa Nui by determining a methodology for visualizing microtopography of rock features. The method developed was used to identify and document petroglyphs that are visible, and those are no longer visible to the naked eye.

For seven years, CSULB has participated in research on Rap Nui. This project is an extension of CSULB's research and was part of the Hiva Hiva survey. The Hiva Hiva survey was conducted over the western side of the island, north of Hanga Roa. The rock facing features collected came from Hiva Hiva survey area "B", "K", & "L" (Figure 1).

Figure 1. *Site locations on Rapa Nui*

Data and Data Sources

Data for this project consisted of 901 photos collected using a Pentax Optio and Ricoh 6.0 cameras, at no more than two-and-a-half feet from the surface of the rock. Structure from motion (SfM) photogrammetry methods were applied to generate digital surface models (DSMs) of the microtopography present on the rock features. Five rock features which had petroglyphs carved onto them, ranging in size from two square meters to three square meters, were photographed. GPS location points were collected using a Trimble Geo7x unit. Each SfM photo collected, the generated outputs, and the GPS data were organized based on the feature name and the data processing method, visualization technique, or analysis being performed.

Table 1. *List of data and data sources used in the project*

Dataset	Source
Rock feature photographs	Collected in field
GPS points	Collected in the field
Rapa Nui base map	Esri's aerial imagery

Methodology

The methodology for this project involved two components: data collection and analysis and data dissemination.

Photos collected in the field were loaded into Pix4D, an SfM software. An orthomosaic and DSM were generated for each rock feature. The orthomosaic was used to find and document any petroglyphs that were clearly visible on the surface.

The methodology used to identify features was based on that developed by O'Neal (2011). Using the DSM, five hillshades were generated, each using different input parameters. These five hillshade outputs were then placed into a principal component analysis (PCA) in ArcGIS, which allowed underlying features to become more apparent. Using the orthomosaic and PCA, petroglyphs that could be seen were digitized for visualization purposes. For further visualization purposes a video flythrough was created of each feature consisting of the orthomosaic, DSM, and PCA.

To disseminate the data, the video flythrough, along with the orthomosaic, DSM, hillshade, PCA and all petroglyphs digitized, were uploaded into Google's MyMap.

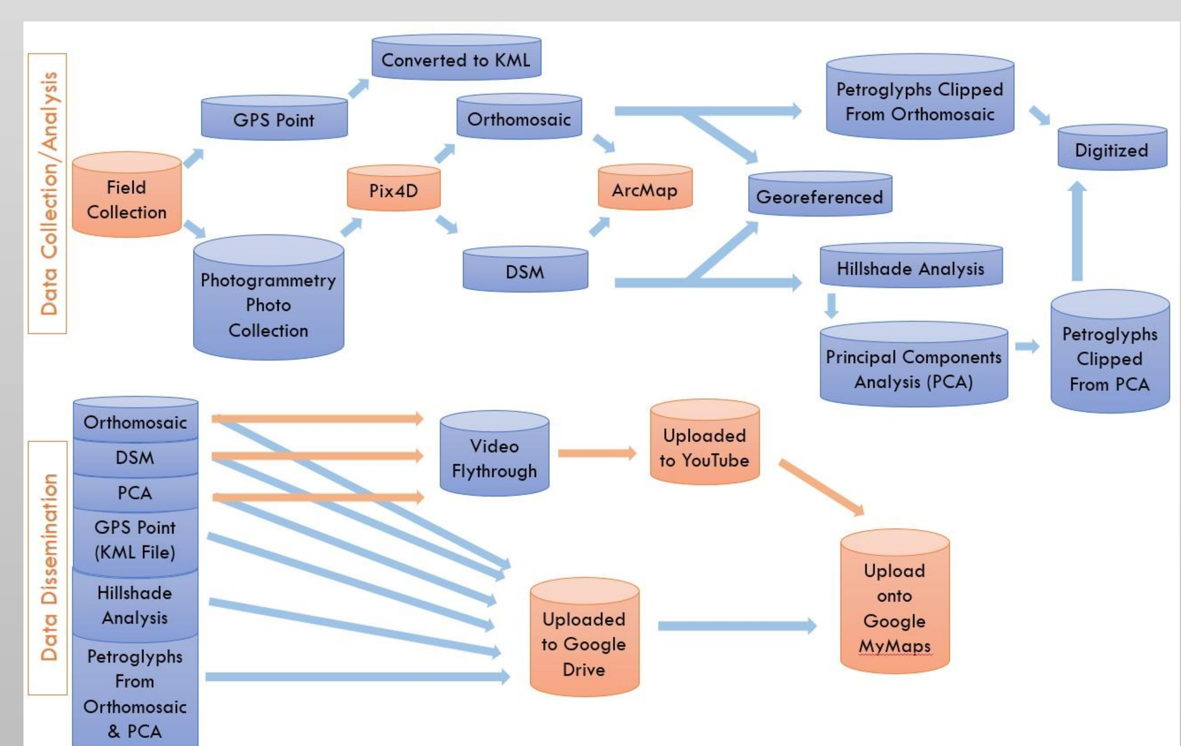

Figure 2. *Methodology workflow*

Timeline

Table 2. *Applied research project timeline*

Date Range	Accomplishment
January 2016	Rapa Nui field collection
February 2016	Process imagery
February –May 3, 2016	Write Literature Review Start digitizing petroglyphs from orthomosaics
May – July 31, 2016	Write applied research paper (ARP) Finish creating and performing methodology Create video flythroughs Create an interactive web map
August 1- 10, 2016	Complete details of the ARP

Results

Petroglyphs that were visible on the surface of each rock feature were identified. Additionally, the method enabled the identification of petroglyphs that were not visible on the surface anymore (Figure 3). Once identified, these were documented. The results demonstrate the effectiveness of this methodology in capturing and recording petroglyphs at a microtopographic scale. A total of 901 pictures were collected over five rock features, and used for the creation of an orthomosaics and DSMs. From the orthomosaic a total of 23 petroglyphs were found on four of the rock features. The DSM was used to create hillshades needed for a PCA. The PCA revealed an additional eight features. Table 3 shows the number of petroglyphs found for each rock feature visible on the orthomosaic and the number revealed through the use of PCA.

Table 3. *Number of petroglyphs found*

Feature	Orthomosaic	Principal Component Analysis (PCA)
B16	1	0
B17	7	1
K1.1	5	3
K1.2	0	1
Poly L	10	3

An interactive web map consisting of ten individuals layers was developed to visualize and disseminate results. One layer held all the static outputs from the analyses: the orthomosaic, DSM, hillshade, PCA, and the digitized petroglyphs (Figure 4). The second layer provides a link to the video flythrough created for that petroglyph.

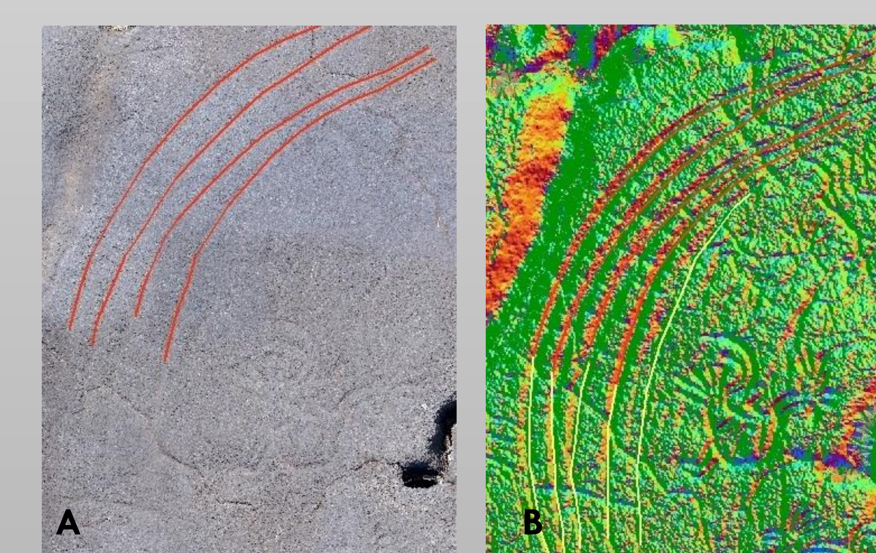

Figure 3 A and B. *3A: Orthomosaic shows the petroglyph which is clearly visible (outlined in red). 3B: the PCA reveals that the petroglyph from the orthomosaic actually continues (outlined in yellow)*

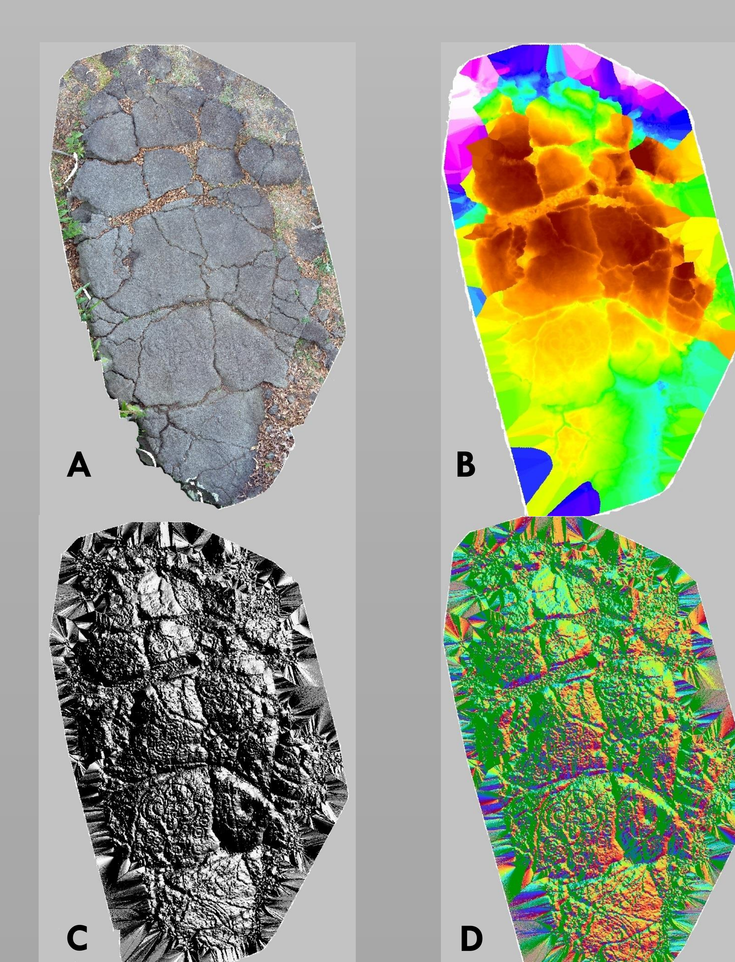

Figure 4 A-D. *Example of generated outputs from feature B17*

4A: Orthomosaic
4B: DSM
4C: Hillshade
4D: PCA

Discussion

The creation of orthomosaics and DSMs at the microtopographic scale not only allow archaeologists to record petroglyphs that are visible, but to create a more complete archaeological record by including petroglyphs that normally would not have been recorded, because they no longer are visible on the surface anymore.

The methodology is limited in that measurements of the rock facings were not taken in the field and it is thus impossible to create a true scale of the features.

The creation of an interactive web map and video flythroughs is a powerful way to share archaeological information. Interactive web maps allow archaeologists to spread information about the work being performed over a wide audience range and at little to no cost to the project. An interactive map is also a fun and interesting way to teach and create interest toward the culture that is being researched.

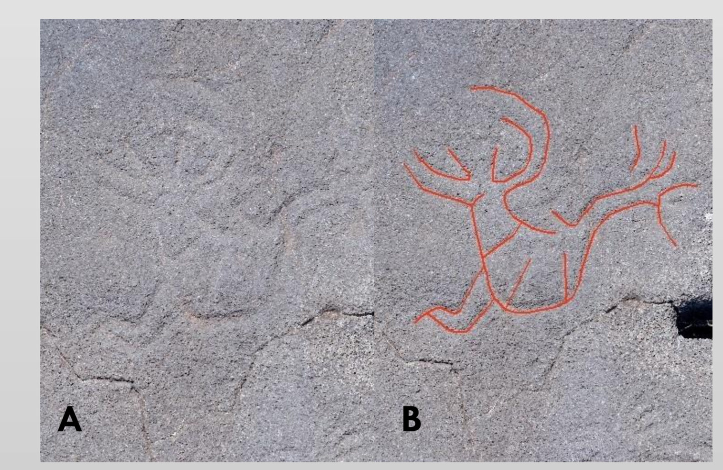

Figure 5. *Example of petroglyph from feature K1.1 which is clearly visible on the orthomosaic (5A) and has been digitized for better visualization (5B)*

Conclusion

The project shows that this methodology can be successfully used to find and record petroglyphs at the surface and sub-surface level. The unique application of this methodology demonstrates the ability of SfM to derive surfaces at a micro topographic scale. Terrain analysis techniques typically applied to larger spatial areas are used here for the first time to enhance our understanding of features at a micro scale.

In replicating this methodology, measurements of the initial feature being collected should be documented, so that a true scale can be rendered.

From this methodology more petroglyphs can be discovered and documented. As these petroglyphs are recorded, analysis on how diversified each type of petroglyph is around the island can be performed. Future work could center on the style of petroglyphs, where each style is found around the island, and the visibility of each petroglyph. This systematic documentation would further contribute to our understanding of the archaeological record on Rapa Nui.

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Rapa Nui access was permitted through Kehoe Studios Contract with Comision de Monumentos Rapa Nui and Consejo de Monumentos Nacionales de Chile.

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