An Automatic Approach for documentation and recovery of rupestrian paintings using Multisperspectral Remote Sensing

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Abstract: - Today the majority of the research on rock art projects are based on the material remains in the form of painting and engraving. What exists now are not but the remains or part of that which the hand of man drew or recorded in the past. The combined action of natural and anthropogenic phenomena have been generating processes of deterioration which have led to the loss, on many occasions, an important part of the representations. Preserved signs are that make up the visible remains visually and therefore are the object of study by specialists. The implementation of a new mathematical techniques that work from data obtained using current of image acquisition, and mature technologies allow the recovery of representations, to a state of "latent image" after their deterioration process remain on the surface glyphs support, but are in no way visible to the human eye, and is the tool base used in the last years to document and analyse these figures. This makes that a large part of the knowledge generated in this period is only based on a part of the set of representations, the visible.The current conceptual, scientific and technological capabilities provide us tools to retrieve non-visible representations, helping to set up new models that tend to contain all of the information shown, changing in a very significant way representations or models for the study and the dissemination of cave images sets, forcing us logically

Key-Words: - Rock art, New Technologies, Mathematical Algorithm, Remote Sensing, Hyperspectral Imagery, Robust Statistic, VNIR.

1.Introduction

The biggest problem on rock art research has been derived from the location of the iconographic representations, located in complex places, narrow sites, caves, or walls of the rock shelters; also the way in which these could be represented for its documentation. This distribution of locations never allowed easy access and much less provided a comfortable and thorough study.

The documentation and recovery of rupestrian paintings has been submitting to the painting and printmaking techniques of representation that science and art have been developing at every moment of history, although almost never have attempted to rationalize and standardize the method applied, as well as assess the ability of representation and distance with the reality from which it c omes the theoretical model.

Scientific research needs of specific methods and therefore all of these systems must be subject to a methodological consistency, to a capacity of qualitative and quantitative evaluation of the represented model and, if possible, be independent of the subjectivity of the operator of the system of representation. For other side, the development of systems and modelling techniques, mapping and image acquisition, have achieved that the representation of the rock art also becomes mathematical model of the represented object.

The main aim of this article consists of deploying new methodologies of documentation of art rock that exceeds the limitations of the technologies currently applied to this field of cultural heritage management.

Fig. 1: Example of training rock art scenery.

2.Methodology

2.1. Objectives of this work

The objectives of this project in relation with documentation and recovery on rock art are:

a) Determination of the deposits and decorated panels susceptible of analysis.
b) Establishment of measurement practices, depending on t he characteristics of the furnished study panels, will establish the corresponding measurement protocol, ensuring the proper conservation of rock art.
c) Data collection campaign which include field work and raw data computer processing.
d) Development of new technologies. New mathematical approach using multisperspectral remote sensing.
e) Analysis and evaluation of results, approval of the methodology experimental developed or, if not, the failure detection of the applied procedure and implementation of the adjustments or improvements needed.

2.1. Radiometric measurements

The methodology used to reach our aim has the following parts: the first one would be to know the spectral answer of different land bodies.

First of all, we have to know the spectral response of some representative bases. The radiometric measures were made with an analytical spectral devices–full resolution (ASD-FR) spectroradiometer, equipped with optical fiber cables.

The ASD-FR was provided by the Centre of Studies and Research of Public Works (CEDEX), belonging to the Spanish Ministry of Public Works and Economy.
The main variable, remote sensing reflectance, was obtained following NASA's protocols (Fargion *et al.,* 2000) and applying the corrections for specular reflections (Mobley, 1999).

Fig. 2: ASD-FR Spectroradiometer working in field.

2.2. Multispectral data acquisition

The capture of multispectral information has been using a prototype camera developed by the GIM Geomatics company in collaboration with a german company.

Fig. 3: IRCAM-GIM Sensor.

Different wavelengths were recorded in field campaigns. The first configuration was aimed at the capture of data in the infrared, where appear mixed reflection and emission processes in variable percentage in function of the part of the spectrum where it is observed. For the observation was employed a objective of an alloy of MgO of 50 mm of focal length which presents a window observation between 2000 and 4500 nm. The wavelengths used were 2200 nm, 2500 nm , 3050 nm , 3800 nm and 4600 nm.

Also study panels have been captured using a digital camera Sony Alpha 700.

2.3. Geometric Characterization of the cave.

The geometry of the training zones characterization has been using a laser scanner photon of FARO which is capable of topographically recording the cave with a precision of 3 mm.

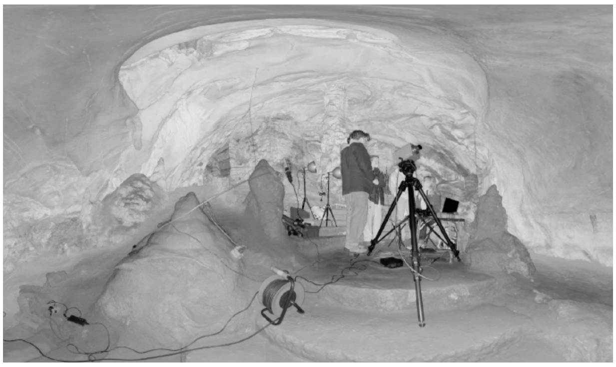

Fig. 4: Scanning made with laser scanning.

2.4. Mathematical Algorithms

The algorithms of digital image processing applied for this study are available in the package LIBRA.

LIBRA is a MATLAB Library for Robust Analysis which is developed at ROBUST@Leuven, the research group on robust statistics at the KU Leuven.
It contains user-friendly implementations of several robust procedures. These methods are resistant to outliers in the data. Currently, the library contains functions for univariate location, scale and skewness, multivariate location and covariance estimation (MCD), regression (LTS, MCD-regression), Principal Component Analysis (RAPCA, ROBPCA), Principal Component Regression (RPCR), Partial Least Squares Regression (RSIMPLS), classification (RDA, RSIMCA), clustering, outlier detection for skewed data (including the bagplot based on ha lfspace depth), and censored depth quantiles.

We have also tested other algorithms implemented by the research department of GIM Geomatics.
All these algorithms are implemented in the R language (R: A Language and Environment for Statistical Computing).

3.Results

3.1. Methodology

The method of observation and analysis has been the integration of three technologies, the information on c olor captured by a digital camera Sony Alpha 700, t he prototype of IRCAM-GIM multispectral sensor, with a different configuration steps of band and optical as well as laser scanner 3D Faro Photon, with a length of wave is 785 nm.

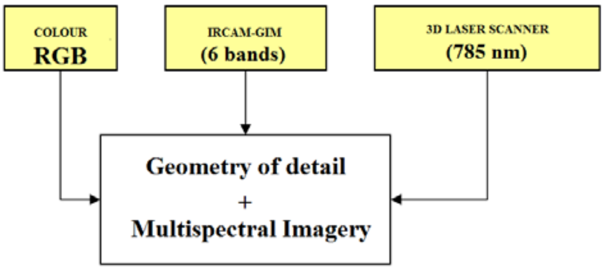

Fig. 5: Methodology for capturing information.

We captured information in the visible, infrared spectrum near and medium, using for different instrumentation in order to be able to create a s et of data that analyze altogether. Spectral responses were recorded to identify differences in pigments and to determine the amount of different employees. Other analyses were treated determine excess paint, you touch-ups, break when recording, superimposition of paintings, extraction of boundaries blurred or covered with calcite, characterization of bases and paintings on them.

A number of methodologies has been developed, tested, inspected and validated using the recommendations of the archaeological team.

These methodologies allow to analyze the signal of the spectral information captured, for be able to draw conclusions about them.

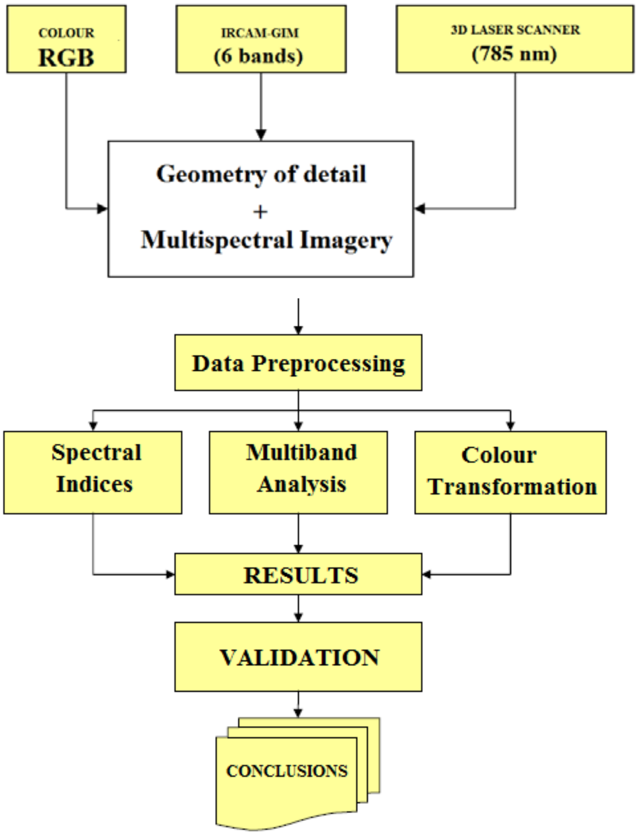

Fig. 6: Workflow of this study.

3.2.- Recognition of colouring matter

Traditionally the study of the composition of colouring matter needed to be taking samples, so this involves catching action. The reading of the images worked to different spectral amplitudes can differentiate clearly compositions different from the coloring materials used. It is an important milestone.

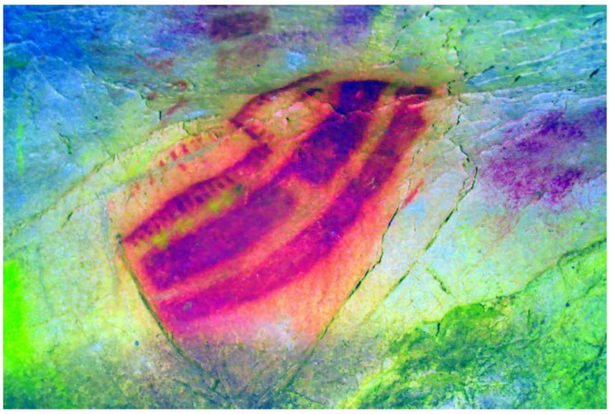

Fig. 7: Recovery of pigments.

Documented spectrally different zones, in the 5 image may be related clearly with colouring matter of different mineralogical composition.

The development and deepening of this area will allow, in the medium to long term, gain knowledge, at least relative, of coloring without composition to conduct sampling.

3.3.- Recognition of superposition of forms

Art studies Rock, and conditioned by the State of conservation of the figures, the reading of overlapping strokes or figures is one of the more pronounced problems.

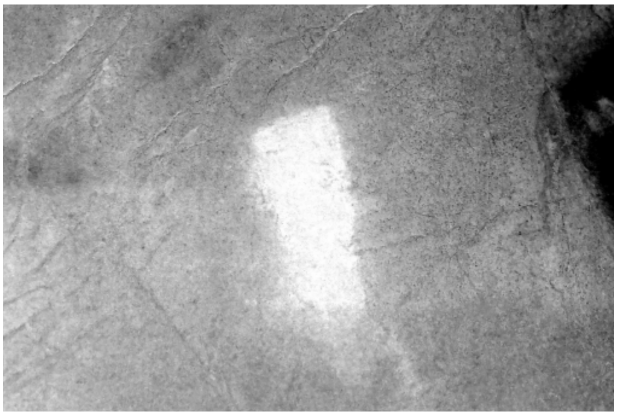

Fig. 8: Visible adquisition.

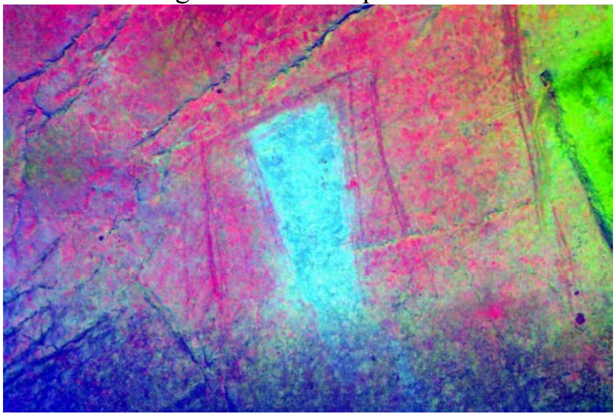

Fig. 9: Superposition of forms using automatic approach.

The employee system has enabled the overlays in at least three (fields: to) between strokes of a same figure in those cases in which the composition of colouring matter is different; (b) between engraving and painting, since they discriminate spectral and perfectly each one of the technical actions; (and, to a lesser degree, c) the overlap between recorded strokes of the same figure, allowing the reconstruction with some reliability in the process of execution of a motive, although this is an end which must be deeper.

3.4.- Reconstruction of the cave grounds

Most of the figures located in the interior of cavities are subject to tafonómicos to cause loss of colouring matter or the erosion of etched surfaces to they involve a reading, in many cases, little defined reason.

Fig. 10: Area to rebuild.

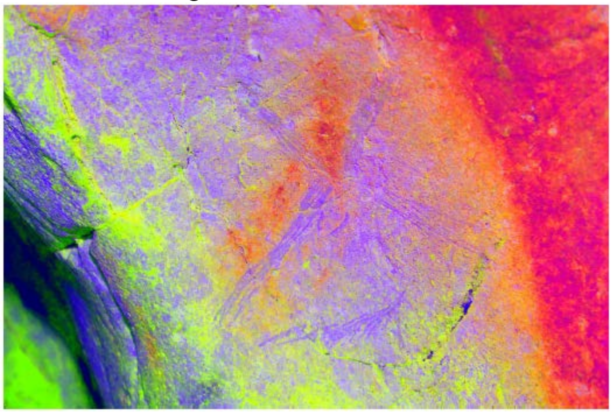

Fig. 11: Reconstruction of the art rock.

The application of the technique has allowed to define accurately the original morphology of some figures, both recorded as painted in different colors (and most likely reasons different chemical composition).

Fig. 12: Discrimination of the pigments and reconstruction of the motive.

In particular, it is possible to define with accuracy the outlines of the figures, recognize with precision anatomical parts or areas of figures concrete and, accordingly, to obtain images posed by reconstruction highly reliable painting or the original print.

In addition, the technical application proposal has enabled a v ery precise reading (for the differentiation with the support) of the figures recorded, to the point of defining with full accuracy discrimination among the engraved grooves and fissures, cracks, etc. of the support.

Thus, figures that in currently presented difficulties of display can be "rebuilt" and this mode allow precise formal studies or even serve as efficient support for the realization of facsimiles.

4. Conclusions

The application of the data capture system to the scope of the Archaeology, and in particular of rock art, presents a high-potential applications in documentation, technical analysis and implementation process and in conservation. In addition and as a result, is an important tool for the reconstruction of "images" of the rock art of the moment in which the figures were laid down so it It involves in the enhancement of this heritage.

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