ANALYZING CANARIAN ARCHAEOLOGY HERITAGE THROUGH HYPERSPECTRAL IMAGE ANALYSIS

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***Abstract*—Hyperspectral imaging is an emerging technology for the archaeologists' investigation. In this research work, a multidisciplinary team formed by archaeologists and engineers present a proof of concept on the use of hyperspectral imaging analysis to determine the origin of different obsidian rocks used by the ancient inhabitants. In order to capture the hyperspectral information from Gran Canaria and Tenerife obsidians rocks, an acquisition system based on two hyperspectral cameras coupled to a scanning platform to move them linearly has been developed. Introductory results of applying two different supervised algorithms (Random Forest and Support Vector Machine with two types of kernels: linear kernel and radial basic function kernel) to the hyperspectral database to check the discrimination capabilities between Gran Canaria and Tenerife obsidians rock at different classification levels (island, municipality and deposit).**

***Keywords*—Classification levels, Experiments, Hyperspectral Imaging, Remote Sensing, Random Forest, Support Vector Machine.**

I. INTRODUCTION

Hyperspectral imaging (HSI) is typically defined as a spectral sensing technique which takes hundreds of contiguous narrow waveband images in the visible and infrared regions of the electromagnetic spectrum. The image pixels form spectral vectors which represent the spectral characteristic of the materials in the scene. Each material has its own interaction with radiation, which is possible to measure by its reflectance or absorbance values. The discrimination between different types of material within the same image is possible through the spectral signature, which is the reflectance value to different wavelengths for a single material. The result of the data collected by a hyperspectral (HS) sensor on a certain scene can be represented as a data cube (HS cube), and it stores all the spatial and spectral information enclosed in a scene.

There are a few types of HS cameras, depending on the way that they capture the HS cubes. In this research work, a push-broom camera was used. These systems record a whole line of an image as well as spectral information at the same time corresponding to each spatial pixel in the line.

The application of HSI in the field of archeology and mineralogy is emerging more and more currently. The option of being able to carry out research without maintaining direct contact with the material to study is the main advantage that HSI allows us. A variety of studies shows that HSI is a helpful tool in the mineralogy and archaeological field[1], as visualization of under drawings and pentimenti in paintings[2], the characterization and mapping of pigments and inks in painted artifacts and drawings[3] or the study of minerals and gems[4].

The amount of data found in a hypercube is too high, so in order to extract relevant information from the HS cubes, to data mining process is required. For this reason, some supervised classification algorithms haven been used. Random Forest and Support Vector Machine (SVM)[5] with two types of kernel (linear kernel and Radial Basic Function, RBF, kernel) were chosen. In this paper both approaches will research if an automatic discrimination between Gran Canaria and Tenerife obsidian rocks can be performed using HSI.

II. METHODOLOGY AND DEVELOPMENT

A. Image acquisition

The acquisition system consists in two cameras: the SWIR camera and the VNIR camera. These two cameras are coupled to a scanning platform and a light system to illuminate the samples in all the spectral range. Figure 1 presents this acquisition system, where there are one illumination source (1), one SWIR camera (2), one VNIR camera (3) and one linear displacement (4), where the cameras move along the line.

(a) (b)

Figure 1. (a) Acquisition system (b) Work area

After the capture process, it is necessary to apply a data labeling of HS images. This process consists in four phases: calibrate the image, crop each obsidian separately from the original image, obtain the mask and the number of pixels of each obsidian and obtain the spectral signatures and labels of each obsidian. Figure 2 show an example of this process.

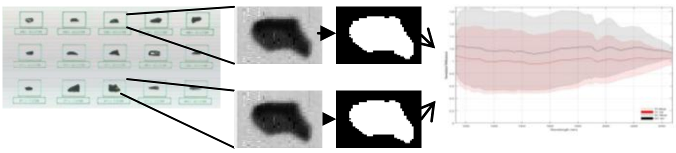


Figure 2. Labeling data process

B. Collected database

In this research study, all obsidians were provided by the Canarian Museum and the Department of Historical Science of the la ULPGC.

It is necessary to prepare a database with all the information provided by the archaeologists,such us the different classification levels (deposit level, municipality level and island level) of each obsidian sample. The classification levels are different scales where the different samples are classified. Figure 3 shows the obsidian samples were grouped into three different levels.

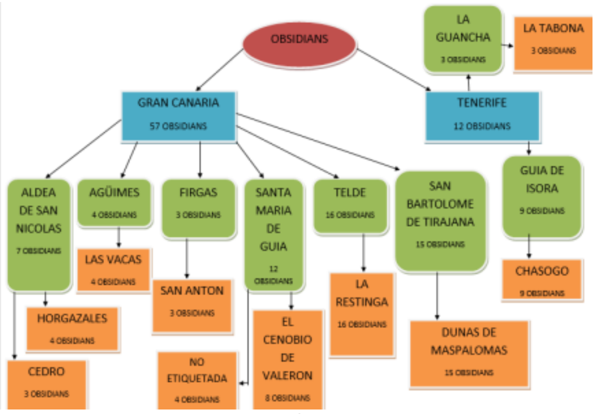


Figure 3. Organization scheme of the obsidian sample database.

C. Processing framework

The proposed processing framework is based on a typical supervised classification scheme. This way, the inputs of the classifier are the measured spectral signature from all obsidian samples. The first step consists on a pre-processing chain that aims to compensate the effects produced by both the environmental conditions and the system response of the capturing system during the acquisition of the HS cubes. To the next step, the supervised classification, two experiments have been defined to test the capabilities of the classification algorithms: experiment 1, where all available data are processed together and experiment 2, where the obsidian data are classified using a model created with the data of the other obsidians. For that process, three different classification algorithms are used: SVM with linear kernel, Random Forest and SVM RBF. In addition, the models are validated using 10-fold cross validation or Hold-Out, according to the experiment. In Figure 4 shows a block diagram of all the process.

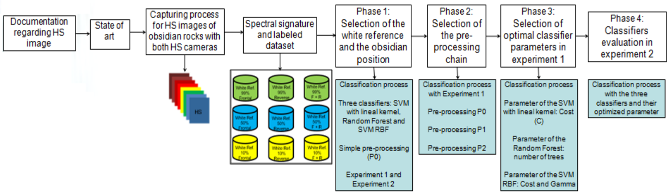
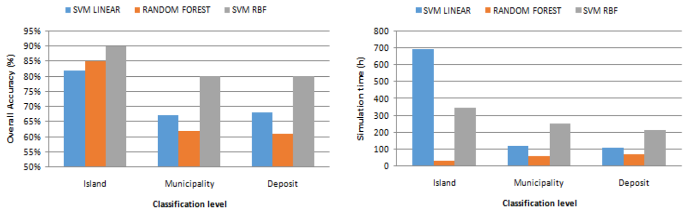


Figure 4. Block diagram of all the process

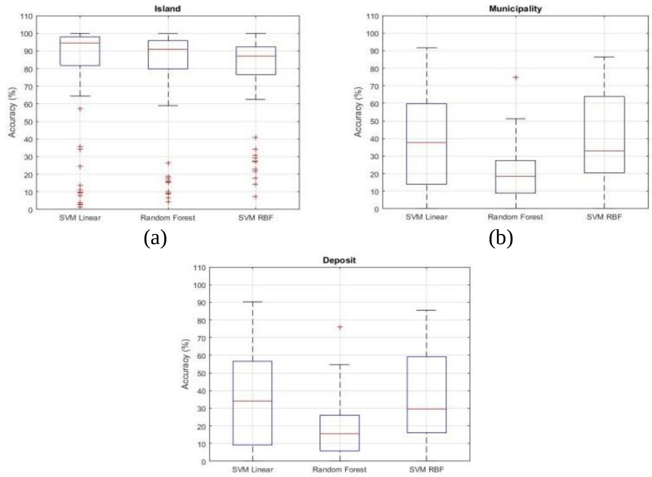
III. RESULTS

The created database has been classified using supervised classification algorithms in order to determinate if it is possible to distinguish between Gran Canaria and Tenerife obsidians rocks at different classification levels. Figure 5 shows the classification results and computational cost in the experiment 1 and Figure 6 shows the boxplots with the results in the experiment 2 at different classification levels.



(a) (b)

Figure 5. Results comparison between the three different optimized classifiers in terms of accuracy (a) and computational cost (b).



(a) (b)

(c)

Figure 6. Boxplots to observe the results obtained in experiment 2, after the pre-processing P1, with the three classifiers: (a) Island level (b) Municipality level (c) Deposit level.

IV. CONCLUSIONS

Preliminary results show that it is not possible to discriminate between Gran Canaria and Tenerife obsidians rocks obsidians at any level of classification by only looking at their spectral signatures. On the other hand, good results have been obtained in the discrimination between the obsidians of Gran Canaria and the obsidians of Tenerife at the island level but not at municipality and deposit level, especially in Experiment 2. This may be due to the fact that the obsidian number of Gran Canaria is different from the obsidian number of Tenerife.

REFERENCES

[1] C. Fischer and I. Kakoulli, “Multispectral and hyperspectral imaging technologies in conservation : current research and potential applications,” *Rev. Conserv.*, no. 7, pp. 3–16, 2007.

[2] L. W. MacDonald *et al.*, “Assessment of multispectral and hyperspectral imaging systems for digitisation of a Russian icon,” *Herit. Sci.*, vol. 5, no. 1, 2017.

[3] A. Hernanz *et al.*, “Spectroscopy of Palaeolithic rock paintings from the Tito Bustillo and El Buxu Caves, Asturias, Spain,” in *Journal of Raman Spectroscopy*, 2012, vol. 43, no. 11, pp. 1644–1650.

[4] V. Miljković and D. Gajski, “Adaptation of industrial hyperspectral line scanner for archaeological applications,” in *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives*, 2016, vol. 41, pp. 343–345.

[5] T. G. Dietterich, “Ensemble methods in machine learning,” in *International workshop on multiple classifier systems. Springer Berlin Heidelberg*, 2000.