UNIVERSIDAD DE LAS PALMAS DE GRAN CANARIA
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Máster de Tecnologías de Telecomunicación

Master Thesis

ANALYZING CANARIAN ARCHAEOLOGY HERITAGE THROUGH HYPERSPECTRAL IMAGE ANALYSIS

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Enero 2019

Abstract

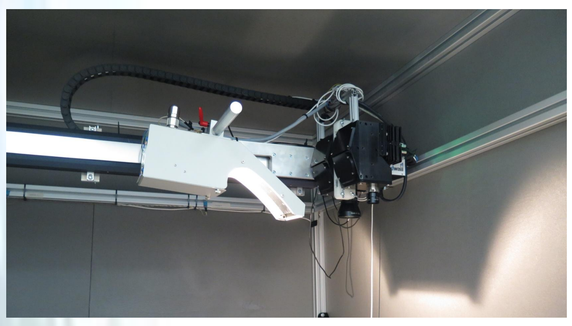
The objective of this Master Thesis is to propose and validate several classification models using data mining techniques in order to obtain an automatic identification tool for archaeological HSI. The samples were acquired from the Canarian Museum archaeologists and the Department of Historical Science of the ULPGC. The hyperspectral acquisition system consists of two hyperspectral cameras coupled to a scanning platform to move them linearly. One of the cameras works in the visual and near infrared (VNIR) spectral range (from 400 to 1000 nm). The other camera works in the short-wave infrared (SWIR) spectral range (1000 to 2800 nm). After the hyperspectral images acquisition process, the images where then processed to remove the effect caused by the acquisition system. Later, and based on the diagnostic provided by the archaeologists, a spectra dataset containing only labeled spectra from obsidian rocks belonging to Gran Canaria and Tenerife was created.

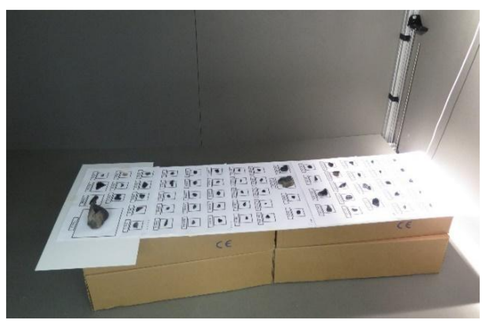
The data were then processed using three different supervised learning algorithms: Support Vector Machines (SVMs) with two different kernel types (Linear and Gaussian) and Random Forest. The capabilities of discriminating between Gran Canaria and Tenerife obsidians were evaluated in different phases (4 phases). These phases consist in different parameter optimization process and different pre-processing to obtain optimal results in the classification process.

Methodology

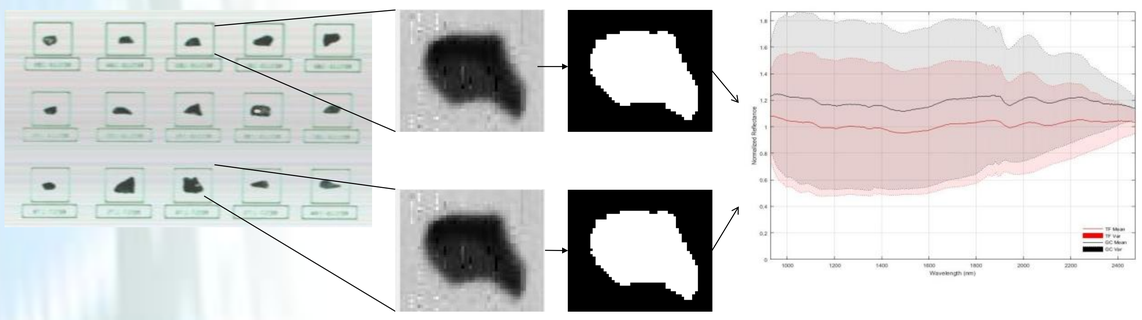
Image acquisition

- The acquisition system consists in two cameras; on the one hand, the SWIR camera and on the other hand, the VNIR camera. These two cameras are coupled to a scanning platform and a light system to illuminate the samples. These cameras are push-broom cameras.



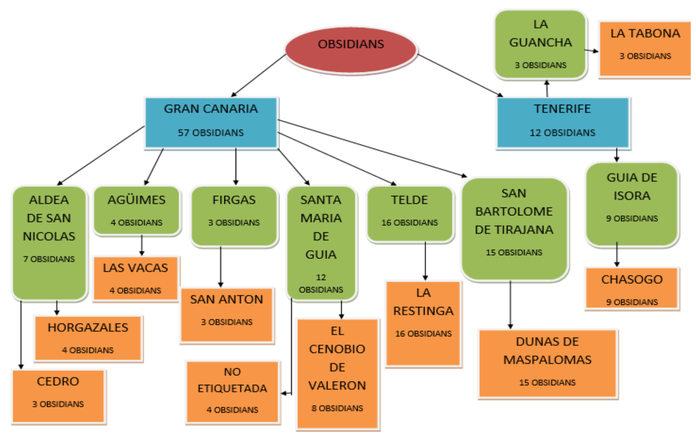


- After the capture process, it is necessary to apply a data labeling of HS images. This process consist in four phases:
  - Calibrate the image.
  - Crop each obsidian separately from the original image.
  - Obtain the mask and the number of pixels of each obsidian.
  - Obtain the spectral signatures and labels of each obsidian.



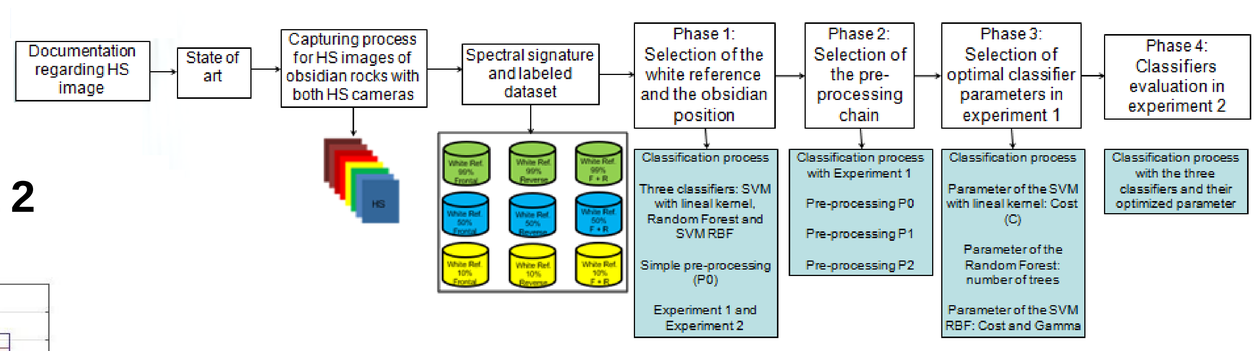
Collected database

- All obsidians were provided by the **Canarian Museum** and **the Department of Historical Science** of the la ULPGC. In total, there are 69 obsidians with different deposit origin.
- The labeling provided by the archaeologist was changed (maintaining a correlation with the original labeling) by a new labeling based on different levels to facilitate the processing of the images.



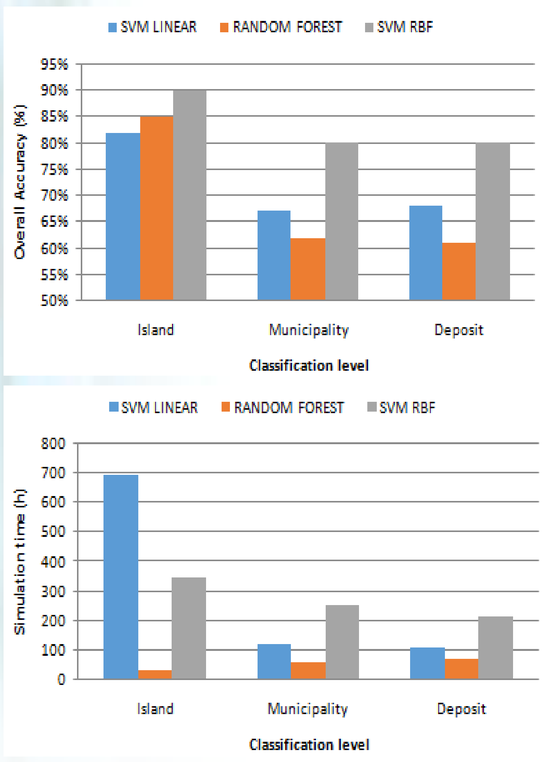
Processing framework

- Two experiments have been defined to test the capabilities of the classification algorithms:
  - **Experiment 1**: all available data are processed together.
  - **Experiment 2**: the obsidian data are classified using a model created with the data of the other obsidians.
- A standard supervised classification framework has been used:
  - The **pre-processing** tries to minimize the effects of the measurement system on the captured images.
  - Three different classification algorithms are used: **SVM with linear kernel, Random Forest and SVM with radial kernel**.
  - According to the experiment, the models are validated using **10-fold cross validation or Hold-Out**.

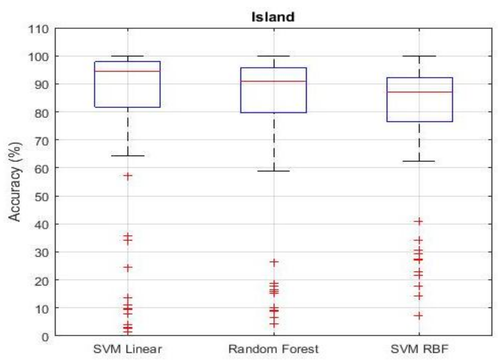


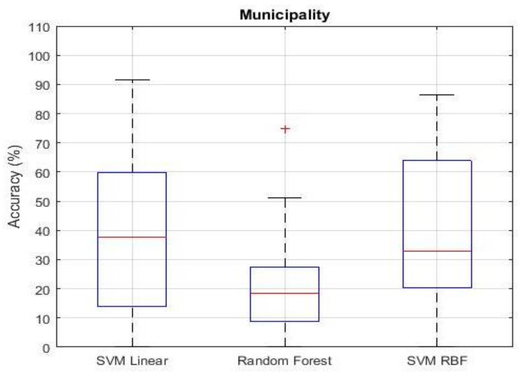
Results

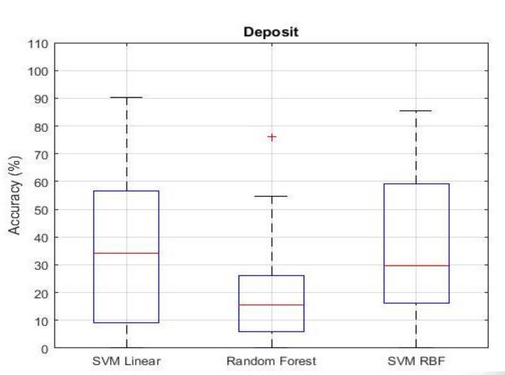
Experiment 1



Experiment 2







Conclusions

- It has not been possible to discriminate obsidians at any level of classification by only looking at their spectral signatures.
- The results in Experiment 2 are not so good at municipality and deposit levels. This may be due to the fact that the obsidian number of Gran Canaria is different from the obsidian number of Tenerife.
- 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.
- In the future, this tool can be used by archaeologists for their research.

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