Evaluation of advanced classification techniques for the generation of high-resolution mapping in the Natural Reserve of the Dunes of Maspalomas

Judit C. Viera Santana, Gustavo Marrero Callicó
Institute for Applied Microelectronics (IUMA)
University of Las Palmas de Gran Canaria (ULPGC)
Las Palmas de Gran Canaria, Spain
jvsantana@iuma.ulpgc.es, gustavo@iuma.ulpgc.es

F. Javier Marcello Ruiz
The Oceanography and Global Change Institute (IOCAG)
University of Las Palmas de Gran Canaria (ULPGC)
Las Palmas de Gran Canaria, Spain
javier.marcello@ulpgc.es

***Abstract*—This paper presents a comparative study of advanced classification techniques allowing to obtain a mapping of vegetation and substrate of the Natural Reserve of the Dunes of Maspalomas. The goal of this work has been achieved with the use of a high-resolution image provided by the satellite WorldView 2, supervised classifiers such as SVM and finally, using unmixing techniques. Using the original image and a post-classification, SVM provides an overall accuracy of 96.80% and a Kappa coefficient of 0.957.**

***Keywords*— Remote sensing, Support Vector Machines (SVM), Maximum Likelihood (ML), Linear Spectral Unmixing (LSU), WorldView 2.**

I. Introduction

Since its beginnings, remote sensing has provided a valuable source of data for studying land surfaces at different spatial and temporal scales [1]. It becomes very difficult to establish a starting point in the history of remote sensing because the first systems were military. Early reviews come to us from 1960, when the United States put into orbit the first Earth observation satellite. Over the years they have been developed, among others, high spatial resolution satellites and hyperspectral sensors (hundreds of spectral bands).

The purpose of remote sensing in the optical-IR spectrum is to identify and characterize the materials of the Earth's surface and the processes that take place, from the electromagnetic radiation from the Earth's surface, which is obtained as the reflected of the radiation reaching from the Sun.

On the other hand, remote sensing also includes all processing and interpretation work done retrospectively with the captured images [2]. After eliminating the errors of the image applying radiometric and geometric corrections, it is possible to perform, for example, the efficient classification to discriminate the different coverages that include the image.

This paper describes and analyzes the optimal classification methodology for the area of interest. The methodology is discussed in Section II. Section III summarizes the results of the different design variants and, finally, some conclusions are given in Section IV.

II. Methodology and Development

The methodology developed is included in Figure I. It has seven main modules.

A. *Radiometric and atmospheric correction*

Radiometric and atmospheric errors are specific to the acquisition stage of the image. These errors must be eliminated before working with multispectral and panchromatic images.

B. *Optional fusion stage*

In this optional stage, the Gram-Schmidt (pansharpening) image fusion technique is used to improve the final results.

C. *Mask*

It is necessary to generate and use a mask covering the area of interest to reduce computation times and obtain statistics of each class over the protected area of interest.

D. *Class definition, ROIs generation and separability study*

This stage requires more dedication time because the correct and optimal assignment will be crucial to the classification results.

E. *Supervised classification and Linear Spectral Unmixing*

Main stage that generates the final mapping from the ROIs designed in the previous stage.

F. *Optional Majority filtering*

Optional stage to smooth the classification results.

G. *Accuracy assessment and results analysis*

Evaluation and analysis stage of the obtained mappings.

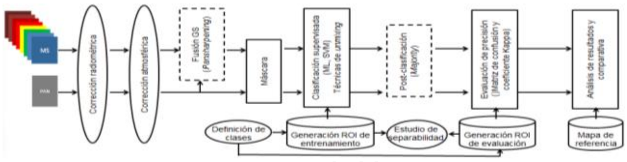

Figure I. Methodology

III. RESULTS

The explained methodology has been developed using the Environment for Visualizing Images (ENVI).

After executing each of the variants, in Figure II the overall accuracy obtained for each case is presented. In this figure we can observe that the results of Linear Spectral Unmixing (LSU) are far below compared to the rest of classifiers, so it has only been performed the study with the fused image.

On the other hand, and analyzing the other results, we can appreciate that are quite similar. However, for the original image, the Support Vector Machine (SVM) classifier [3] obtains an overall accuracy which is slightly higher than Maximum Likelihood (ML) classifier [4]. The original image and the best mapping of each case are shown in Figures III, IV, V and VI.

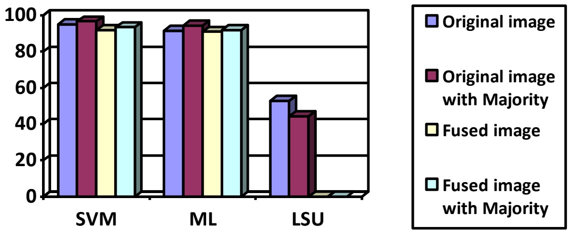

Figure II. Overall accuracy for each case

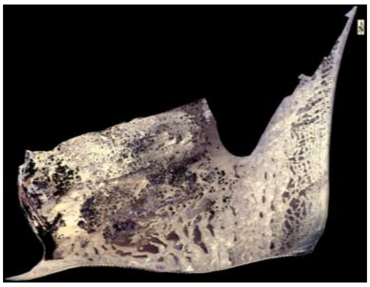

Figure III. Multispectral original image

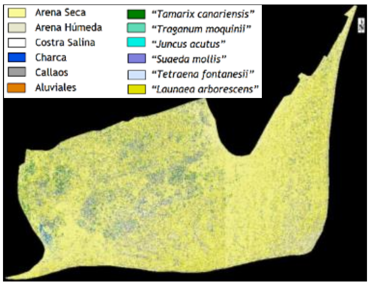

Figure IV. Linear Spectral Unmixing

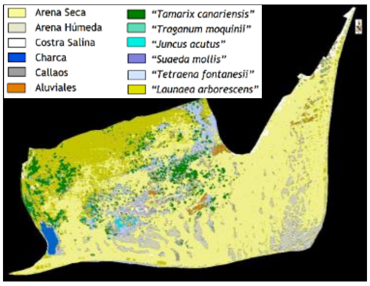

Figure V. Maximum Likelihood with original image and Majority

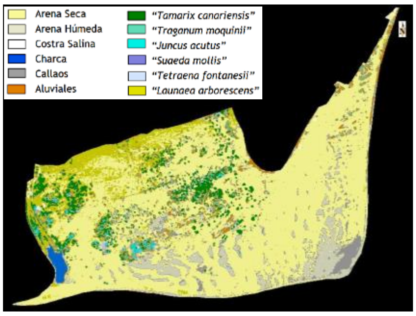

Figure VI. Support Vector Machine with original image and Majority

These figures allow us to appreciate that the best classes to be discriminated are corresponding to the substrate. By contrast, classes corresponding to vegetation have been the worst for its small size. Analytically, these conclusions can be extracted from Figure VII that exposes the confusion matrix obtained for the best classification: SVM.

Regarding image fusion, it improves the visual quality of the mappings but it worsens the analytical results. For these reason, the best results were obtained using the original image.

Class	Arena seca	Arena húmeda	Costra salina	Charca	Callaos	Aluviales	"Tamarix canariensis"	"Traganum moquinii"	"Juncus acutus"	"Suaeda mollis"	"Tetraena fontanesii"	"Launaea arborescens"	Total
Unclassified	0	0	0	0	0	0	0	0	0	0	0	0	0
Arena seca	1457	3	4	0	0	12	1	1	0	5	0	0	1483
Arena húmeda	1	953	0	0	0	1	0	0	0	0	1	0	956
Costra salina	0	0	35	0	0	0	0	0	0	0	0	0	35
Charca	0	0	0	423	0	0	0	0	0	0	0		423
Callaos	0	0	1	0	94	0	0	0	0	0	0	0	95
Aluviales	3	29	0	0	0	106	0	0	0	0	0	0	138
"Tamarix canariensis"	0	0	0	0	0	0	211	10	8	0	5	0	234
"Traganum moquinii"	0	0	0	0	0	0	0	159	0	0	5	0	164
"Juncus acutus"	0	0	0	0	0	0	0	0	37	0	0	0	37
"Suaeda mollis"	0	0	0	0	0	0	0	0	0	9	1	0	10
"Tetraena fontanesii"	0	0	0	0	0	0	0	0	0	17	2	0	19
"Launaea arborescens"	0	0	0	0	0	0	0	0	0	9	0	48	57
Total	1461	985	40	423	94	119	212	170	45	40	14	48	3651

Figure VII. Confusion matrix for SVM (ground truth (pixel))

IV. CONCLUSIONS

This paper presents the optimum methodology to classify the Natural Reserve of the Dunes of Maspalomas from very high resolution multispectral imagery. The best result was obtained using the original image without applying the pansharpening stage, the optimized classifier SVM and a Majority filter. Numerically, this result corresponds to an overall accuracy of 96.8% and a Kappa coefficient 0.957.

REFERENCES

[1] Assefa M. Melesse, Qihao Weng, Prasad S. Thenkabail and Gabriel B. Senay. Remote Sensing Sensors and Applications in Environmental Resources Mapping and Modelling Sensors.

[2] Chuvieco, Emilio. Teledetección Ambiental. La observación de la Tierra desde el espacio. 1ª Ed. actualizada, Planeta, S. A., 2010.

[3] Vapnik, V. Estimation of dependences based on empirical data [in Russian]. Nauka, Moscow. (English translation: Springer-Verlag, New York), 1979.

[4] Lillesand, T.M. and R.W. Kiefer, Remote Sensing and Image Interpretation, Ch. 7, Digital Image Processing, J. Wiley and Sons, Inc., 2000.