
CONAE

Work Plan: Advanced classification techniques for urban areas using optical and SAR images

Author: Fabricio Herrera

Maestria en Aplicaciones de Información Espacial
Instituto de Altos Estudios Espaciales “Mario Gulich” – CONAE/UNC

Introduction

The increase of the global population affects the environment through the growth of population in urban zones and the corresponding increase of natural resource consumption. The precise monitoring of these changes is fundamental for the implementation of effective decision making processes.

Methodology

Since the goals of the work is procude update urban maps using VHR optical and SAR data, fusion methodologies aimed at classification will be considered and compared. To this aim, parametric and non-parametric approaches will be considered, with particular stress on deep learning, Hierarchical Binary Decision Trees, multi-kernel SVM, and other update machine learning algorithms. The target is to use the full potential of multitemporal SAR and optical data sets by using SPOT and COSMO-SkyMed images, thanks to agreements in place between CNR, ASI and CONAE. In addition to improve the classification algorithms currently used to analyze heterogeneous multitemporal data sets, this research will also be important to understand whether it will be possible and viable to use for urban mapping purpose the images provided by the prototype UAV (SARA) in development by INVAP.

Image/Sensor: Satellite data

Study zone: City of Cordoba, Argentina.

Optical images: Data from SPOT 4 and 5 will be used in order to classify built up areas in Córdoba city for two different dates. Table 1 shows two images from Córdoba city which were download from CONAE catalogue.

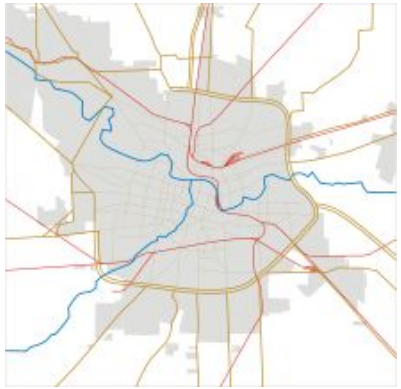
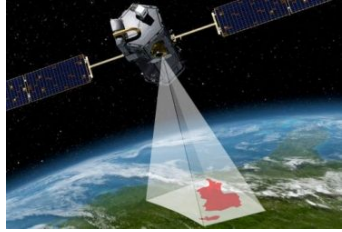


Table 1: Optical images to be used for Córdoba city classification

Date	Source	Product name	Resolution	Place
11-Mar-2012	SPOT4	SPOT4_HRVIR1_2012-03-11_13-58-44_M+I_685_413	10 m	Córdoba
11-Mar-2015	SPOT5	SPOT5_HRG1_2015-03-11_13-12-44_J_684_413_S0_L2A	10 m	Córdoba

Image/Sensor: Satellite data



Cosmo-SkyMed

Request and reception of the images Cosmo SkyMed of the city of Cordoba. Between the years 2010 to 2017. The acquisition mode is STRIPMAP.

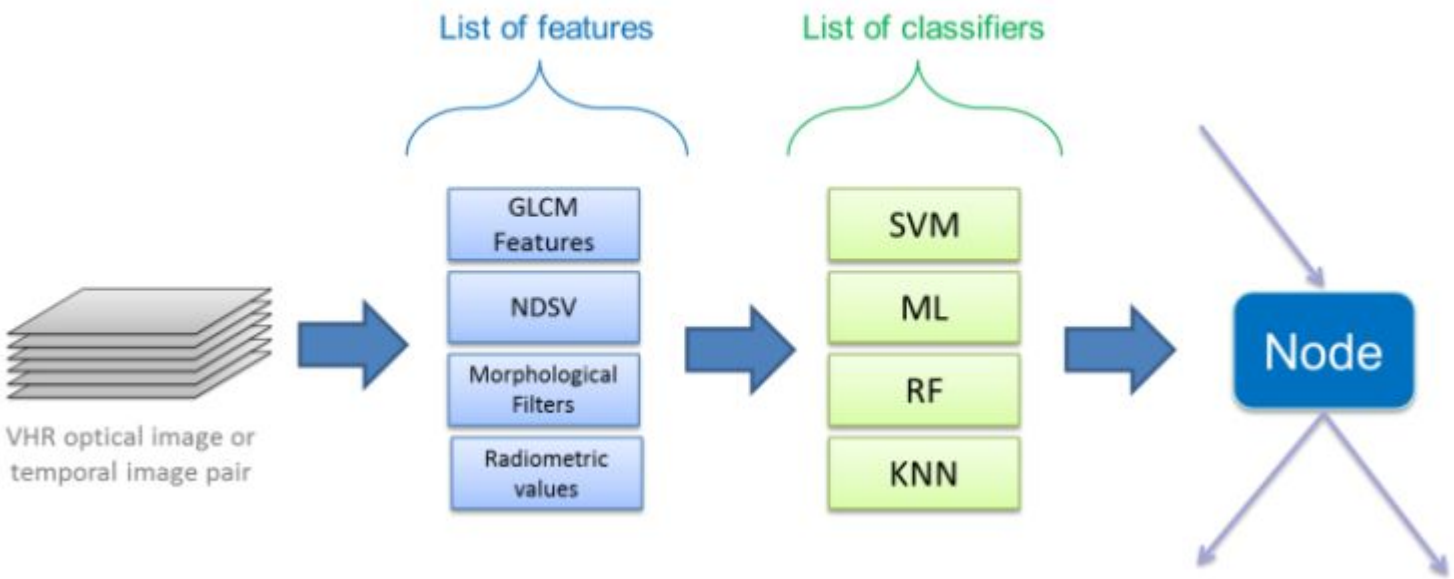
Number	Quick Look ID	Satellite ID	Record Number (Imágenes de archivo)	Fechas	Zona	Modo	Ang.	Polariz.	Dir. Orb.	Enfoque	Nivel
1	10108150	Cosmo-SkyMed 4	101599274	2017-01-31	Córdoba	STR_HIMAGE		HH	Ascending		SCS
2	9641777	Cosmo-SkyMed 1	101491794	2016-09-29	Córdoba	STR_HIMAGE		HH	Ascending		SCS
3	9370790	Cosmo-SkyMed 4	101442821	**2016-07-07**	Córdoba	STR_HIMAGE		HH	Ascending		SCS
4	8954413	Cosmo-SkyMed 2	101366604	2016-03-01	Córdoba	STR_HIMAGE		HH	Ascending		SCS
5	8295824	Cosmo-SkyMed 4	101246393	**2015-07-05**	Córdoba	STR_HIMAGE		HH	Ascending		SCS
6	7794852	Cosmo-SkyMed 4	101160788	2015-01-10	Córdoba	STR_HIMAGE		HH	Ascending		SCS
7	7385757	Cosmo-SkyMed 1	101123974	2014-09-08	Córdoba	STR_HIMAGE		HH	Ascending		SCS
8	7174605	Cosmo-SkyMed 2	101104456	**2014-07-14**	Córdoba	STR_HIMAGE		HH	Ascending		SCS
9	6276494	Cosmo-SkyMed 1	101019051	2013-11-24	Córdoba	STR_HIMAGE		HH	Ascending		SCS
10	5727202	Cosmo-SkyMed 1	100962592	**2013-07-19**	Córdoba	STR_HIMAGE		HH	Ascending		SCS
11	5301287	Cosmo-SkyMed 1	100916466	2013-03-29	Córdoba	STR_HIMAGE		HH	Ascending		SCS
12	4873281	Cosmo-SkyMed 4	100881967	2013-01-04	Córdoba	STR_HIMAGE		HH	Ascending		SCS
13	4536307	Cosmo-SkyMed 4	100845486	2012-09-30	Córdoba	STR_HIMAGE		HH	Ascending		SCS
14	4332374	Cosmo-SkyMed 4	100822086	**2012-07-28**	Córdoba	STR_HIMAGE		HH	Ascending		SCS
15	3865476	Cosmo-SkyMed 4	100770448	2012-03-06	Córdoba	STR_HIMAGE		HH	Ascending		SCS
16	3569067	Cosmo-SkyMed 2	100738424	2011-11-27	Córdoba	STR_HIMAGE		HH	Ascending		SCS
17	2144737	Cosmo-SkyMed 2	100626584	**2010-07-14**	Córdoba	STR_HIMAGE		HH	Ascending		SCS

First Results

We expect to obtain a series of classification maps useful to analyze the growth of new built-up areas. and develop new techniques to fully exploiy multitemporal series of optical and SAR adat, understanding how many images are useful to achieve useful results, and how the data should be combined to improve the mapping results.

Method Hierarchical binary decision tree (HBDT) processing results

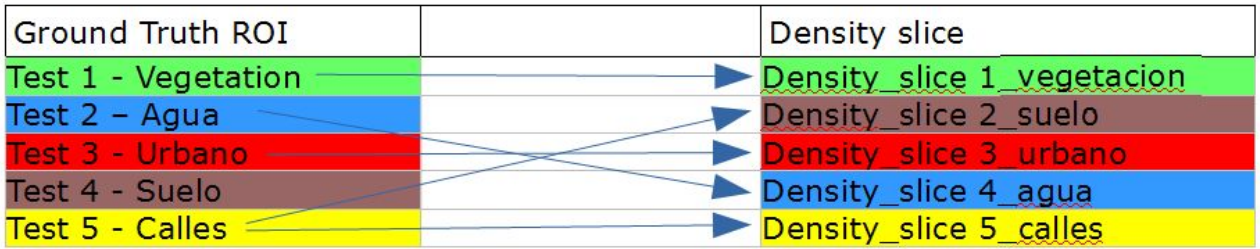
Overview of the method. The best pair, composed by a feature ṡet and a classifier is assigned to each node of the HBDT.



Method HBDT processing results

Training classes:

Vegetation (833 pixels), water (811 pixels) , urban (797 pixels), soil (833 pixels), streets(726 pixels).



Method HBDT processing results

To make the confusion matrix, we proceeded by code using the Python language, obtaining the following results from each of the simulations performed.

Simulación 0					
Overall Accuracy = (8109/9643) 84.0921%					
Kappa Coefficient = 0.7674					
Duration = 32 min					
	1	2	3	4	5
Vegetación 1	1238	1345	0	0	43
Agua 2	0	3975	0	0	0
Urbano 3	0	40	1020	0	62
Suelo 4	0	0	0	73	3
Calles 5	0	41	0	0	1803
Totals	1238	5401	1020	73	1911

Method HBDT processing results

Result of the first simulations:

Results of the simulations			
N# Simulations	**Overall Accuracy (%)**	**Kappa Coefficient (0-1)**	**Duration (min)**
Simulación 0	84,0921	0,7674	32
Simulación 1	55,2214	0,4476	44
Simulación 2	67,7590	0,5698	34
Simulación 3	59,8569	0,4914	43
Simulación 4	51,0318	0,4043	43
Simulación 5	58,9547	0,4792	34
Simulación 10	62,8020	0,5205	39
Simulación 40	57,3991	0,4676	47
Simulación 50	46,7800	0,3694	36
Simulación 75	55,8540	0,4522	37
Simulación 99	54,0807	0,4316	47
Simulación 100	71,9382	0,6190	31
Average	**60,4808**	**0,50167**	**38,92**

Method HBDT processing results

New results obtained: With parameter settings. He was given to take all the training data. Longer times to obtain results.

Simulación_.0					
Overall Accuracy = (6781/9643) 70.3204%					
Kappa Coefficient = 0.5946					
Duration = 89 min					
	1	2	3	4	5
Vegetación 1	1230	400	0	0	2
Agua 2	0	2582	0	0	0
Urbano 3	0	406	1020	0	32
Suelo 4	0	0	0	73	0
Calles 5	8	2013	0	0	1877
Totals	1238	5401	1020	73	1911

Method HBDT processing results

Summary of new simulations:

.

The first 4 simulations were done with the data of Training, but with taking all the set of them, visualizing a greater precision at the cost of other times.

N# Simulations	Overall Accuracy (%)	Kappa Coefficient (0-1)	Duration (min)
Simulación_.0	70,3204	0,5946	89
Simulación_.2	69,1486	0,5865	103
Simulación_.5	70,2271	0,6001	87
Simulación_.100	70,1856	0,5996	114
Simulación_.2T	72,4357	0,6582	62
Simulación_.5T	81,5475	0,7692	137
Simulación_.10T	89,7684	0,8719	75
Average	**74,8048**	**0,66859**	**68,41**

Method HBDT processing results

The method was adjusted and optimized, obtaining only the values of the matrix of confusion and of the measurers.

Test set 50% - Training set 30%

	Test Set 50% - Training Set 30 %			
Types of Data	***Overall accuracy***	***Average accuracy***	***Kappa***	***Processing time (sec)***
HBDT_SAR	88,43	84,92	0,8491	1309
HBDT_Multiespectral	93,13	91,57	0,9107	1347
HBDT_SAR+Multiespectral	99,3	99,31	0,9941	1269

Method HBDT processing results

The method was adjusted and optimized, obtaining only the values of the matrix of confusion and of the measurers.

Test set 50% - Training set 20%

	Test Set 50% - Training Set 20 %			
Types of Data	***Overall accuracy***	***Average accuracy***	***Kappa***	***Processing time (sec)***
HBDT_SAR	88,32	84,8	0,8477	1394
HBDT_Multiespectral	92,99	91,31	0,9089	1404
HBDT_SAR+Multiespectral	99,26	99,28	0,9904	1285

Method HBDT processing results

The method was adjusted and optimized, obtaining only the values of the matrix of confusion and of the measurers.

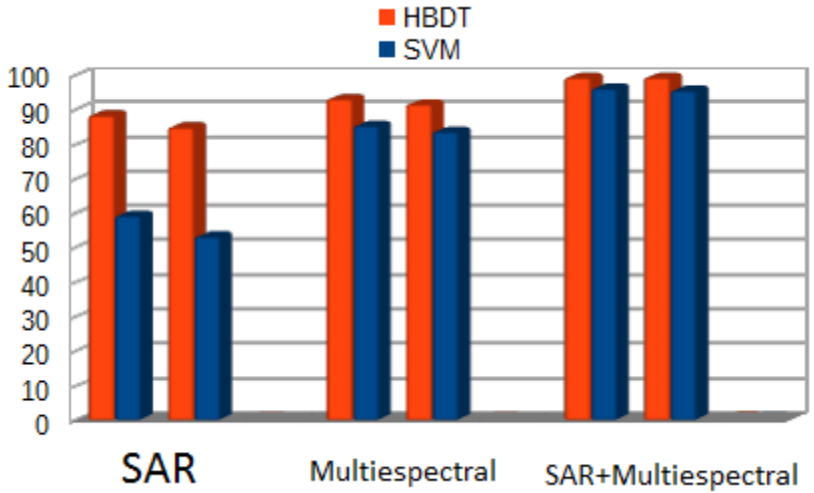
Test set 50% - Training set 10%

	Test Set 50% - Training Set 10 %			
Types of Data	***Overall accuracy***	***Average accuracy***	***Kappa***	***Processing time (sec)***
HBDT_SAR	87,64	84,11	0,839	1495
HBDT_Multiespectral	92,49	90,61	0,9023	1517
HBDT_SAR+Multiespectral	98,88	98,82	0,9854	1333

Method HBDT processing results

The HBDT is compared with the SVM method, where the following values are observed.

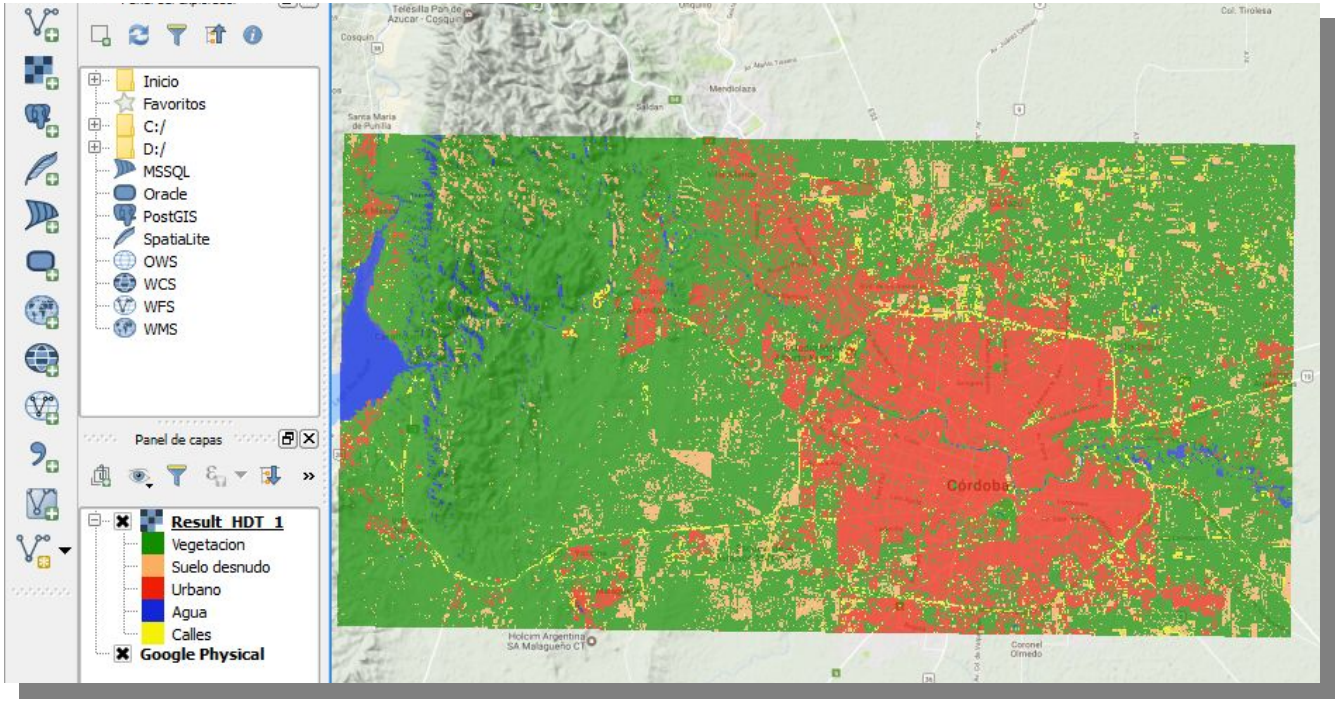
Comparison between classifiers			
Type of Data	**Measurers**	**HBDT**	**SVM**
SAR	Overall accuracy	88,43	59,31
	Average accuracy	84,92	53,24
	Kappa	0,8491	0,4548
Multiespectral	Overall accuracy	93,13	85,38
	Average accuracy	91,57	83,69
	Kappa	0,9107	0,8095
SAR + Multiespectral	Overall accuracy	99,3	96,18
	Average accuracy	99,31	95,59
	Kappa	0,9941	0,9504



Method HBDT processing results

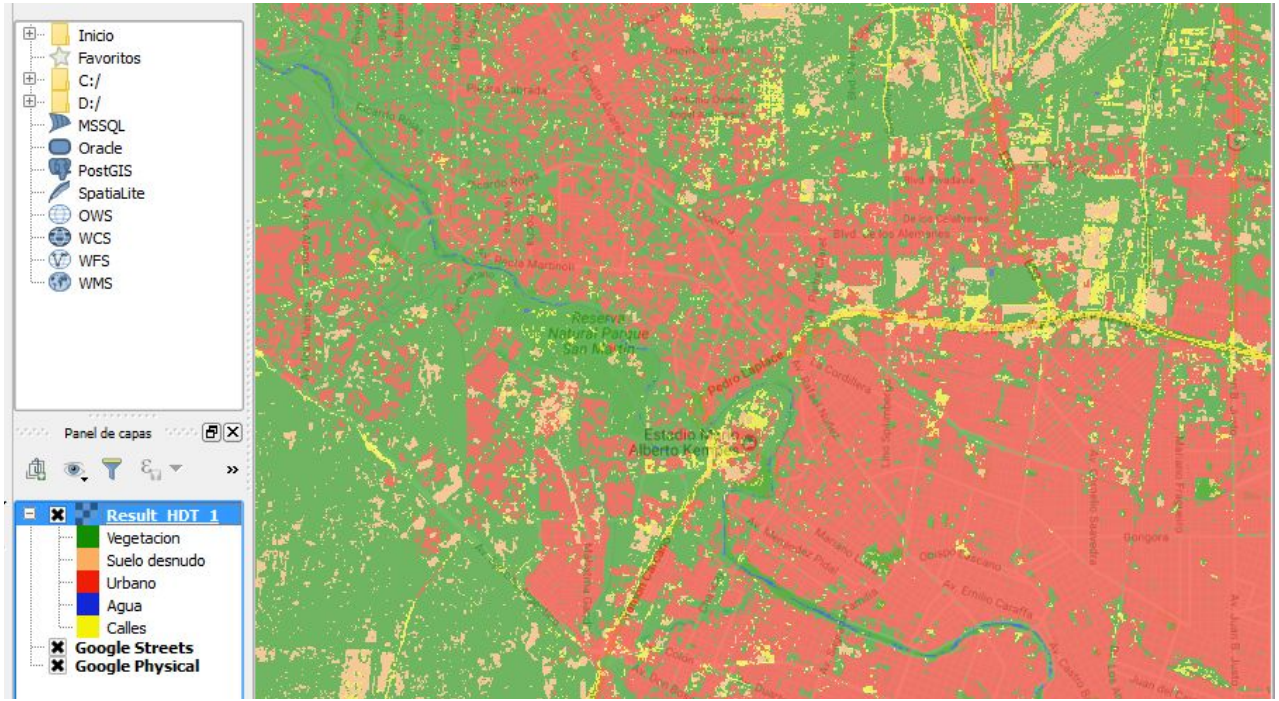
Map obtained from the HBDT classification

.



Method HBDT processing results

Map obtained from the HBDT classification. Visualization in nearer areas, with the Google streets layer.



Method Hierarchical binary decision tree (HBDT) processing results

Conclusions

The HBDT method obtained excellent results applied to the study area, obtaining greater results in the combination of data SAR+Multiespectral.

The times of computations allow to make multiple classifications in a single step.

References

G.C. Iannelli, G. Lisini, F. Dell'Acqua, R. Queiroz Feitosa, G.A.O.P. Costa, P. Gamba, “Urban area extent extraction in spaceborne HR and VHR data using multi-resolution features”, Sensor, doi:10.3390/s141018337, vol. 14, pp. 18337-18352, 2014.

G.C. Iannelli, P. Gamba, “Hierarchical hybrid decision tree multiscale fusion for urban image classification”, Proc. of IGARSS’16, Beijing (P.R. China), July 2016, pp. 1800-1803, doi: 10.1109/IGARSS.2016