ASSESSMENT OF MULTIRESOLUTION SEGMENTATION FOR EXTRACTING GREENHOUSES FROM WORLDVIEW-2 IMAGERY

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1.- Introduction and Objectives

This work is in the framework of the **GreenhouseSat** State Research Program with reference **AGL2014-56017-R** (**https://www.ual.es/Proyectos/GreenhouseSat/**). Its final main goal is the identification of horticultural crop under agricultural greenhouses through an OBIA approach from VHR imagery (i.e., GeoEye-1, WorldView-2/3) and Landsat 8 time-series.

This research is focused on the first and crucial stage in OBIA: the image segmentation. This step is decisive because the resulting image segments form the basis for the subsequent classification. In this way, eCognition Developer's proprietary multiresolution segmentation (MRS) has proven to be one of the most successful image segmentation algorithms in the OBIA framework. Scale, Shape, and Compactness are the main parameters available to users that affect the performance of the algorithm. To help the users with the selection of these parameters, unsupervised methods such as Estimation of Scale Parameters tool for multiband images (ESP2 tool) have been proposed. Also, supervised methods based on the measure of dissimilarity between segmentation results and user-generated (e.g., hand digitized) reference objects have been used to identify the optimal combination of parameter values among all examined.

The main objective in this work is to analyze the optimal parameters of the MRS algorithm (i.e., Scale, Shape and Compactness) included into eCognition software for delineating plastic greenhouses in OBIA environment from WorldView-2 multispectral (MS) orthoimages.

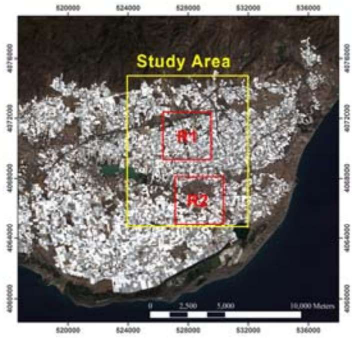

Fig. 1. Location of the study area (yellow rectangle) and two subareas (red squares).

2.- Study Site and Datasets

2.1. Study Site

This investigation was conducted in a greenhouse area of Almería, Spain, known as the "Sea of Plastic". It comprised a rectangle area of about 8000 ha (**Fig. 1**). Inside the study area, two square subareas or repetitions (R1 and R2) with sides of 3200 m were extracted.

2.2. WorldView-2 Data and Reference Greenhouses

A single WorldView-2 (WV2) ORS2A image taken on 30 September 2013 over the study area was acquired (PAN; 0.4 m + MS; 1.6 m) From this two orthoimages were generated: (i) a pan-sharpened image with 0.4 m GSD and 8 bands was attained using Geomatica 2014, and (ii) a MS atmospherically corrected (ATCOR) orthoimage with 1.6 m GSD and the full 8-band spectral information.

In each of the two subareas showed in **Fig. 1** (R1 and R2), 30 greenhouses (60 greenhouses in total) were manually digitized working on the aforementioned WV2 pan-sharpened orthoimage **(Fig. 2)**.

Fig. 2. Reference greenhouse polygons in red digitized on R1 (left) and R2 (right) subareas.

3.- Methodology

3.1. Image Segmentation

The image segmentation algorithm used in this research is the so-called multiresolution segmentation (MRS) included into the OBIA software eCognition v. 8.7. The outcome of the MRS algorithm is controlled by three main factors: (i) the **Scale** parameter **(SP)** that determines the maximum allowed heterogeneity for the resulting segments, (ii) the weight of colour and shape criteria in the segmentation process **(Shape)**, and (iii) the weight of the compactness and smoothness criteria **(Compactness)**.

3.2. Segmentation quality metrics

The supervised discrepancy measure **Euclidean Distance 2 (ED2)**, recently proposed by Liu et al. (2012), was the quality metric used to compare the segmentation outputs to 30 manually delineated reference polygons representing greenhouses **(Fig. 2)**. **ED2 (Equation 1)** considers both the geometrical discrepancy (by mean of the potential segmentation error (PSE), defined as the ratio between the total area of under-segments and the total area of reference polygons) and also the arithmetic discrepancy between image objects and reference polygons (by using the number-of-segmentation ratio (NSR), defined as the absolute difference between the number of reference polygons plus the number of corresponding segments divided by the number of reference polygons) **(Fig. 3)**.

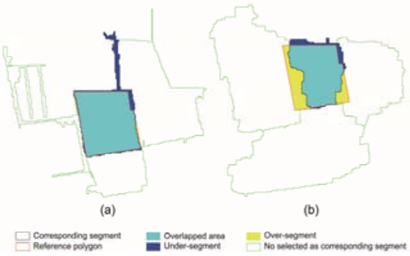

Fig. 3. Geometric discrepancies between reference polygons and candidate-corresponding segments: a) SP=50, SH=0.1 b) SP=62, SH=0.9

Equation 1: $$ED2 = \sqrt{(PSE)^2 + (NSR)^2}$$

3.3. Analysis workflow

Different combinations of Shape and Compactness parameters were tested in this work. Concretely, five values {0.1, 0.3, 0.5, 0.7, 0.9} were selected as alternative weights for both Shape and Compactness parameters, so meaning 25 possible combinations. For these 25 combinations, the **ESP2** tool (Dragut et al., 2014) was run into eCognition over the R1 and R2 subareas using the 8-band WV2 MS orthoimage in order to attain the SP values.

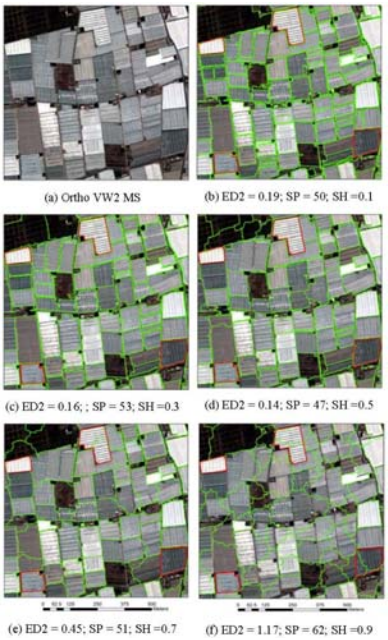

Fig. 4. Details of segmentation results

Shape	Compact.	R1		R2	
		SP	ED2	SP	ED2
0.1	0.1	55	0.34	50	0.09
0.1	0.3	55	0.23	49	0.18
0.1	0.5	50	0.19	52	0.08
0.1	0.7	55	0.17	55	0.08
0.1	0.9	38	0.53	48	0.21
0.3	0.1	42	0.29	48	0.24
0.3	0.3	64	0.41	52	0.11
0.3	0.5	53	0.16	47	0.08
0.3	0.7	45	0.13	57	0.13
0.3	0.9	42	0.15	49	0.15
0.5	0.1	50	0.21	35	0.27
0.5	0.3	51	0.22	47	0.04
0.5	0.5	47	0.14	42	0.18
0.5	0.7	66	0.37	43	0.30
0.5	0.9	54	0.31	44	0.34
0.7	0.1	51	0.21	38	0.06
0.7	0.3	51	0.26	52	0.11
0.7	0.5	51	0.45	79	1.15
0.7	0.7	62	0.78	66	1.09
0.7	0.9	43	0.78	24	2.97
0.9	0.1	72	2.62	46	0.41
0.9	0.3	75	2.65	66	1.74
0.9	0.5	62	1.17	86	3.08
0.9	0.7	82	2.65	63	1.09
0.9	0.9	68	1.19	72	1.84

Table 1. Values of ED2 and SP

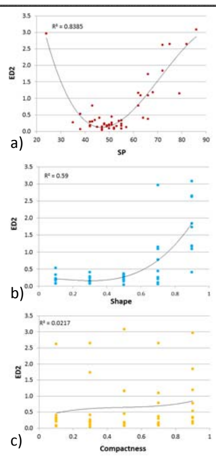

Fig. 5. Parameters importance

4.- Results

Table 1 shows the SP and ED2 values attained for each of the 25 combinations of parameters (Shape and Compactness) used in both study areas (R1 and R2).

Figure 4 shows the graphical representation of some segmentation results for the subarea R1. The best segmentations, both visually and according to the ED2 value, were attained for Shape parameters ranging from 0.1 to 0.5 **(Fig. 4b, Fig. 4c and Fig. 4d)**. Moreover, the segmentations with Shape of 0.7 and 0.9 **(Fig. 4e and Fig. 4f)** presented the highest discrepancy between segment (green) and reference polygons (red).

Figure 5 shows the evolution in both tests (R1 and R2, i.e., 50 repetitions) of ED2 with SP, Shape and Compactness respectively **(Fig. 5a, b, c)**. SP turns out to be, without any doubt, the most important parameter controlling multiresolution segmentation. Values of Shape parameter higher than 0.5 (that is penalizing spectral information or colour) should be avoided for plastic greenhouses segmentation. Finally, Compactness parameter did not have considerable effect in the creation of meaningful greenhouse objects.

5.- Conclusions

ESP2 tool worked quite well on plastic greenhouses multiresolution segmentation, estimating correct values for the SP parameter. The very similar shape and size of the greenhouses located at the study area likely positively influenced the good performance of ESP2 tool. **ED2 metric** presented a very good relationship with the visual quality of the greenhouse segmentations. Summing up, the recommended way to compute these segmentation settings could be based on obtaining the SP parameter from the ESP2 tool by fixing the Compactness in 0.5 and testing two values for Shape (0.1 and 0.3).

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