Classification Efficiency according to the distance of Mahalanobis with the superior order statistics and the stochastic models: two methodologies with two examples for the case of Spot-HRV1.

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INTRODUCTION

You surely knew the frustration of investigations in the urban space after the results of a radiometric classification. It is about here, really a factor limiting inherent to the statistical treatments, that find his foundation in the maladjustment of algorithms to the urban semantics. It is true that the improvement of the resolution satellite images, contributed a decisive manner to the heightening of the segmentation sharpness. These being said, it agrees however to recognize, that this progress didn't eliminate confusions break completely. The mixture of classes is the expression of a weak taken in charge of tools facing the meticulous work required by the supervised classification.

One of solutions to the instrumental limits consist in the improvement of radiometric segmentation outputs through a device of textural, structural and contextual plans. In this sense, they are put to contribution notions of spatial frequency and connexity in a whole of relation of neighborhood and proximity. These relations will intervene to separate the graphic objects, that appear the most often confused in their radiometric unit.

In this work, we are going to expose two methodologies improvement outputs for a classification according to the distance of Mahalanobis while inserting texturals parameters under shapes of derivative neo-channels. It is here about matrixes of cooccurrence for gray levels and the specter of texture as first group of improvement treatment. The second group, will be based on the combined Hough transformation with an fractal analysis and an extraction of linaireses with the help of the mathematical morphology.

Materials and methods

This present work will be developed on a image of the satellite Spot-HRV1 for 1994 of an urban sector of the Mexicali city, Baja California. Mexicali like the more part of cities borders, she is characterized by a strong demographic growth, that comes with an urbanistic pressure (See figure.1). The model of propagation of this city, show a tendency to display to get round constraints of the real estate speculation and the weakness of the internal fundamental offer (Delavaud and Toudert, 1997). In this sense, to have an idea on the distribution of the peripheral urbanization homes, appears like a necessity to undertake focalised studies in order to know structures and the degree of insertion of these new cores in the cloth of the city. The classification of image in different urban themes, constitute one of solutions, that instrumental limit beyond can bring some applicable approximations.

In the first place, to undertake this work, we operated a classification according to the distance of Mahalanobis (Richard, 1993), whose square is determined by the following formula:

$$d^2 = (X, Mj)^T C^{-1} (X - Mj)$$

$(X1, X2, ..., Xk)^T$: radiometry of pixels for which every channel respectively.
Mj And **C**: the middle vector of gray levels for the j class and the matrix variance covariance of classes.

The location and the extraction of classes are operated with the help of a no-supervised classification according to the method of them K-means convergent, follow-up of a classification with neo-channels derivative from a décorreleted transformation of Hotling (Belhadj-Aissa and al, 1997). This whole of treatments, has us to clear a segmentation of the image in 9 thematic classes (to see figure.2). confusion and the mixture of classes of this segmentation, watch well the necessity of corrections that we thought to bring back through two derivative treatment groups (see tableau.1, method 1).

This first group of treatments is based on relations between gray levels in a determined pixel neighborhood. To initiate this count, we tried to clear the dependence of these levels then through the matrix of cooccurrence, on the basis of the concept of texture units, us introduced this plan with radiométric information for the count of a adjusted segmentation. The dependence of gray levels is deducted as a function of probabilistic density joined *F(i, j / d,q)* whose terms are next one:

$$F(i, j / d, \theta) = \#\{(x_1, y_1), (x_2, y_2) \in D / G(x_1, y_1) = i, G(x_2, y_2) = j \text{ for } d \text{ et } \theta\}$$

d: the window of the treatment, whose measurements depend on the analyzed image.
(x_1, y_1), (x_2, y_2): positions of pixels treaties and separated by the d distance.
i and *j*: levels of gray for the functions $G(x_1, y_1)$, $G(x_2, y_2)$.
θ: the direction that takes the treatment.

In the case of our survey, we operated the convolution count on two sizes of window (5X5) and (8 X8) and established a middle matrix for four directions (0°, 45°, 90°, 135°) with a distance d=1. The count of the ACP on the three original SPOT channels, has us to choose the first two componentes to initiate the count of textures notably to clear the entropy (*ENT*) and the inertia (*INT*). It is two texturals parameters defined by the following expressions:

$$ENT = -\sum_{i=0}^{Ng-1}\sum_{j=0}^{Ng-1} F(i, j/d, \theta) x \log\{F(i, j/d, \theta\}$$

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The inertia evolves according to the spatial frequency of objects expressed in levels of gray. Indeed, if the passage of a gray level to another is important, the inertia increases. The entropy on the other hand, measure the confusion of the passage of a level of gray toward another. These two images so calculated in an interval understood between 0 and 255 for the integration of this textural plan to the others datas. This treatment constitutes for so to say the first variant of integration (method 2), the variable second takes foot on the basis of the texture specter while integrating levels of gray in expressions of texturals parameters (Wang and Hey, 1990; Hadj-Aissa and al, 1997). This second variant articulates on the in three levels of gray (0,1,2) of the first ACP componente using a window of convolution of 3 X 3. The assignment of these new values obeys to the following conditions:

$V_i = 0$ if $ng_i < Ng_0$
1 if $Ng_i = Ng_0$
2 if $Ng_i > Ng_0$

Ng_i (i = 1,...8): levels of gray around the central pixel.

V_i: ensue of the following distribution function:

$$U = \sum_{i=1}^{8} V_i X\ 3^{i-1}$$

The specter of texture is defined by Lx.Ly> 3X3 that represent the frequency of occurrence $F(U_k/Ng_0)$ of an unit of texture U_k (k= 0,1,...6560) associated to a level of gray Ng_0 in Lx.Ly (Kourgli and Belhadj-Aissa, 1996). from these parametres are calculated two texturals aspects, to know the absolute symmetry (*SA*) and the symmetry of oriontation (*SO*) as follows:

$$SA(Ng) = \frac{\{1 - \sum_{k=0}^{3279} |F(k, Ng_0) - f((6560 - k), Ng_0)|\}}{\sum_{k=0}^{6550} F(k, Ng_0)}$$

$$SO(Ng) = 1 - 1/4 \sum_{m=1}^{4} \frac{\sum_{k=0}^{6560} |F(k, Ng_0) - F_{m+4}(k, Ng_0)|}{2X \sum_{k=0}^{6560} Fm(k, Ng_0)}$$

The descended neo-channels of last two counts put in relief the structural organization of the different units of the image. They will also be inserted with channels of Spot to generate another improven classification (méthode3).

Second group of treatment:

This second group of treatment is put in room around a device of improvement algorithm of transformed it of Hough (Loumi and al, 1995). through this gait, it is searched for the separation of roads and linaireses in the diffuse urban context. In this sense, fractale dimension, d-dimensions in association with the mathematical morphology permitted to operate a separation of linaireses. The utilization of the formula of Richardson, permits the realization of this objective and to break the peripheral limit confusion in junction with the agricultural middle (Loumi and Sansal, 1994).

$$I(X, S) = Ks^{d-D}$$

I (X, S): Intensity of the pixel to the S ladder;
d: dimension topologique of the metric space;
D: dimension fractale;
K: d-dimension fractale.

While using the method developed by Alilat Loumi and (1997), are chosen four structurals elements to sweep the image in the four directions. The result of this last treatment is segmented to clear one plan of our interest. Segments generated in this second group of treatment will be taken as in amount to improve the classification of Mahalanobis done during the first stage of this work (method 4).

For all groups of treatments, tecxturals results integrated very well by the mediator improvement of decision rules for the affectation of pixels, either by addited integration or soustracted of some determined themes. This gait is given back absolutely necessary by the spectral data incompatibility and texturales since it is two measures are drifted of two different measure spaces.

RESULTS AND DISCUSSION

To be able to quantify results of classifications according to the four methods proposed by this work, we are going to resort to the matrix of the mistake by thematic class. Indeed,

here he/it is about seeing the erroneous distribution rate by class. In the case or the mistake is near of 0, it means that the redistribution of pixels in this class is very near of training sites. In the contrary case, the class in question is characterized by an important segment of foulness screw to screw of the witness in question.

In this setting, we enumerated the thematic classes of class1 on the right to class9 according to the decreasing order of left of the legend of the figure.2. methods of treatments on the other hand, are enumerated of 1 to 4 according to their stated in the part «materials and methods» of this present work. It is two variable are organized in a matrix to double entrance, where they are calculated mistakes of the 9 classes in an interval of 95%. confidence

TAB.1: Matrix of distribution mistakes by class and by methods of treatment.

	Class1	**Class2**	**Class3**	**Class4**	**Class5**	**Class6**	**Class7**	**Class8**	**Class9**	**Cofidence interval**
Method 1	0.112	0.205	0.256	0.115	0.341	0.268	0.003	0.124	0.191	+/- 0.0134
Method 2	0.015	0.106	0.098	0.003	0.155	0.15	0.002	0.08	0.123	+/- 0.0075
Method 3	0.008	0.007	0.003	0.001	0.004	0.05	0.002	0.08	0.107	+/- 0.0015
Method 4	0.003	0.007	0.003	0.001	0.003	0.05	0.002	0.08	0.001	+/- 0.0007

In the global, the reading of tab.1, watch that the level of the mistake lowers vertically while going of the treatment 1 method until the last treatment. In the case or results of the traitement1, 2, and 3, are taken as of improvements of the sharpness of the classification according to the distance of Mahalanobis (method 1), we observe that these methods bring an approximation every more important time to the training site. The gait that wants to generalize the performance of texturales adjusters to all thematic classes, remain however without no foundation. Indeed, it is absolutely necessary to distinguish themes, that are sufficient himself rightly to radiometric treatment as the water-class for the method 1 (class 7) and the other classes where the intervening of textural plan of the method 2, improve results considerably as in the case of classes 1, 3, 4, 7, 8. Brings in these two considerations, exists classes, that have need in addition of radiométric plan and textural, a structural plan to make the effect of theme association take out again the internal particularisms as it is the case of classes 5 and 6. The last treatment (method 4), by the nature of algorithms developed, he puts more in value linaireses, that translate in our case the urban theme of the landfill.

As you can note it on the tableau.1, for some classes, the passage of a treatment to another doesn't change the content of the mistake. The adoption of these themes through addited synthesis in the classified plan of exit of the following treatment. In this sense, the improvement of radiometric classification outputs is conceived like a process of addition performance without to provoke a loss of information owed to the successive adjustments as much.

Results of this work, watch again once the necessity to solve the physically detectable variable passage toward the semantic plans in uphill of the interrogation process. He decorated us of straightaway, that this problem should solve itself while taking in consideration the nature of associations and laws that govern their spatial distribution. As

you can note it, treatments chosen rependent to the different treatment logics, even though they have in common the objective to improve radiometric classification. texturales Plans, bring a sharpness there where the spatial frequency is important, the mathematical morphology in association with the analysis of shapes will help us on the other hand, to clear the oriented geometric plans, as it is the case of roads and the other urban sizes closed.

CONCLUSION

The improvement of radiometric segmentation with the derivative plans, constitute one of the possible solutions for the treatment of high resolution images as those of Spot-HRV1. If textural and structural integrations, seem to bring sharpness further in the urban theme definition, they don't constitute however an applicable absolute solution to all cases. The definition of treatments and their combination in a constructive logic, inaugurate already in uphill the maximisation of outputs classification, whose variable the most often escape their initial physical size after the semantic transfer.

To close this exposition, we prefer to interrogate us on the nature of report instruments and objectives of researches. As you certainly noticed, the weight of the model in the urban prospecting is required more and more by the treatment of high resolution images. These treatments are the most often out of the reach of researchers that we add and want to extricate the more of geographical information to our images is not still an easy enterprise. Limits that put radiometric and spatial resolution, pushes us to find shelter in complicated models to be explained to takers of decision. In this order of idea, we are the most often liveliness to complicate an instrument whose objective is to facilitate us work. This report, appears us of an absolute relevance to the same moment, exists on the market an offer of very high resolution image, that rependent to the majority of interests of our investigatings on cities. It would be maybe time to react facing these new data and to undertake the necessary researches to the exploitation of this new material, that seems very promoter in the urban study domain.

BIBLIOGRAPHY

Alilat, F. and Loumi, S. 1997. Transformé de Hough et morphologie mathématique: amélioration et performances. In télédétection des milieux urbains et périurbains. Ed AUPELF-UREF, p. 103-111.

Belhadj-Aissa, A, Belhadj Aissa, M. and Smara, Y. 1997. Segmentation d'images satellitaires par analyse spectrale et mesures texturales appliquées à des sites urbains algériens. In télédétection des milieux urbains et périurbains. Ed AUPELF-UREF, p. 93-101.

Delavaud, A C,. and Toudert, D. 1997. Apport d'une simple composition colorée à l'étude de l'espace urbain: cas de Mexicali (Mexique). In télédétection des milieux urbains et périurbains. Ed AUPELF-UREF, p. 249-257.

Krougli, A. and Belhadj-Aissa, A. 1996. Approche structurale de génération d'images de texture. International journal of remote sensing.

Loumi, S. and Sansal, B. 1994. Directional mathematical morphologiy for the textural segmentation of urban image, ISMM'94-58, centre de morphologie mathématique de fontainebleu, Paris.

Loumi, S., Alilat, F. and Sansal, B. 1995. Pattern recognition by mathematical morphologiy and Hough transform. Rss-95, Remote sensing society, 11-14 sep. 1994. University of southampton, southampton, united Kingdom.

Richards, J.A. 1993. Remote sensing digital image analysis. Sping-Verlag, Germany.

Wang, L. And HE, D-C. 1990. A new statistical approach for texture analysis. Photogrammetric enginneering and remote sensing, Vol. 56, num 1, P. 61-66.

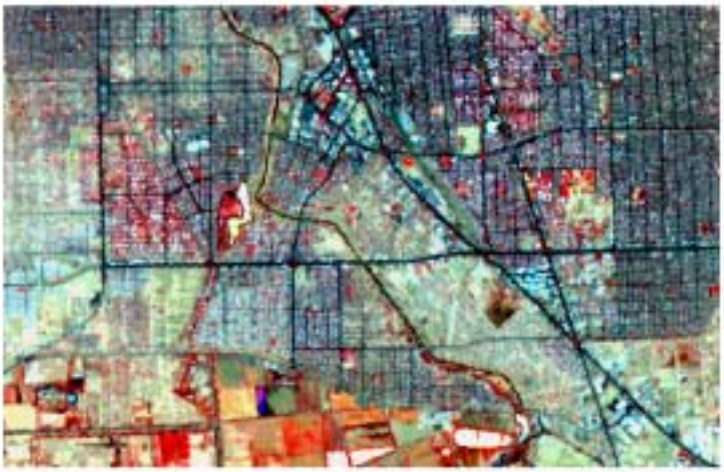

Figura. 1:

Composicion coloreada del sector urbano estudiado.

Azul: XS1
Verde: XS2
Rojo: XS3

Figura. 2:

Clasificacion tematica segun la distancia de Mahalanobis.

Leyenda

0 2 Km.

- Urbano denso
- Urbano medio denso
- Urbano de baja Densidad
- Sin urbanisscion
- Urbanizacion associada a la vegetacion
- Vegetacion urbana
- Agua y cuerpos de agua
- Agricultura perifirica
- Vias de circulacion