A NEW APPROACH IN REMOTE SENSING IMAGE ANALYSIS FOR NATURAL ENVIRONMENT CARTOGRAPHY

Frédéric Borne (1), Serge Guillobez (2)
Centre de Coopération Internationale en Recherche Agronomique pour le Développement

(1) CIRAD-GERDAT, Service Central Informatique, Analyse d'Images,
avenue du Val de Montferrand, BP 5035, 34032 Montpellier Cedex 1, FRANCE
Tél. (033) 67 61 56 63 Fax. (033) 67 61 56 70 E-Mail:borne@hpai.cirad.fr
(2) CIRAD-CA, Unité de Recherches Facteurs et Conditions du Milieu,
avenue du Val de Montferrand, BP 5035, 34032 Montpellier Cedex 1, FRANCE
Tél. (033) 67 61 59 39 Fax. (033) 67 61 71 43 E-Mail:guillobez@montp.cirad.fr

ABSTRACT

With numerical datas from Earth survey satellites, it is possible to build a cartographic outline with computer analysis. The proposed approach first consists in computing a classified image (directed or semi-directed). Then this image is interactively treated with "Papri" software, which gives an ordering in landscape units, and a new image close to a map.

The creation of the cartographic result occurs after vectorization, i.e. transformation of matrix coordinates into a "vector" format. In this format, small polygons and arcs not corresponding to natural units boundaries, are suppressed.

The final document is more satisfactory, and is comparable with a map. The operation may be renewed inside big landscape units in order to improve the cartography, in a general-to-particular approach. Results are compared to a visual interpretation of the image.

INTRODUCTION

Interprete a remote sensing image is both very simple and very tricky. It is very simple because it is visual: a photo-interpreter locate himself quickly and can give a first fast interpretation of the image. But it is also very tricky if we are looking for an objective and repeatable interpretation method, which can be useful for a specialist's interpretations, in fact a semi-automatic mapping method.

This dualism comes from the nature itself of the datas of the image: the recorded points mosaïc is a huge amount of raw informations, however, it is empty of any semantic, since a point is considered independently of its neighbours. Now, to create a map, a "pixelistic" vision of the image is not enough: each point is analysed alone whereas, on the contrary, we must outline big units in the image, it is what we call landscapes. This approach requires to study inter-pixels relations, the texture of the image.

Up to now, because of the lack of real efficient solutions, specialists (agronomists, pedologists, geologists, photo-interpreters...) could not approach numericaly the textural aspect. So they just utilized paper documents to visualy extract informations.

We present an original way for treating a remote sensing image, with the goal to integrate it in a GIS (Geographic Information System) as a map for the "Landscape Unit" layer. We tried to join both computer-aided interpretation and freedom of actions and decisions for the user.

PRESENTATION

Study Area Presentation

This region is located in the cotton fields area in the West of the Burkina-Faso. It was studied by the CIRAD/Irat for landuse mapping. So, it is a well-known area for some specialists; it is why we choosed it for our studies (Guillobez et al., 1993).

On the May 1987 Spot image (figure 1, 10 km x 10 km), outlines of landscapes of the area appear: laterite areas (right side and central part of the image) in dark colours, woodlands on the slopes of the laterite areas, fields which were cultivated are very light, tree savanna is on the left, peripheric basin and some hills present medium various lightly dark tints.

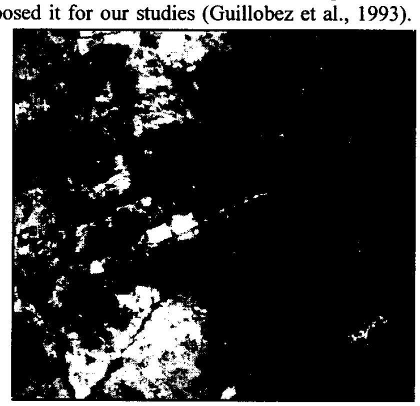

Figure 1. Spot Image, Boni (Burkina-Faso)

Presentation of the Application

Our goal was to individualize important landscape units and to create with them a GIS compatible mapping. However, the usual way in analysing a remote sensing image did not satisfy us: classification produces a lot of small areas which, after vectorization, do not present any interest in the global understanding of the image. We were looking for a cutting in big units

The adopted method is in three parts: Classification Texture analysis and GIS integration.

Classification The classification is an optionnal step, as we will see later. But it presents many advantages like integrating the knowledge of the specialist and saving computation time.

Landscapes and Texture Analysis We will consider the landscape as characterized by a special distribution of the colours constituing the image texture. These colours express radiometric responses on raw images, of passive sensors like those of Spot or Landsat satellites, or classes on an interpreted image.

From a statistic point of vue, an image texture is the percentage of the different colours in each landscape and not their positions. In fact these positions have also an influence, but the natural (so rather hazardous) character of the phenomenons distribution makes very often distribution much more discriminant than positions. So we prefered the stochastic aspect (study of colours distribution) to the structural one (spatial relationships between colours).

The *Papri* method utilizes these Landscape and Texture notions to assist field-specialists in the interpretation of satellite image. The result is a landscapes image ready to be put in a GIS

GIS. Integration GIS integration occurs when big landscape units are identified on the image. The result of texture analysis is a raster image (a matrix). It is not really ready for use in a GIS Therefore it is vectorised and a content-characterizing attribut is assigned to big units: so we obtain the "Landscape Units" layer, here rather "Physical Environment" oriented. After some topological operations, it will constitute an important element of our informations base.

Interest of the Method This method has many advantages. At first it is relatively automatized. So the analysis is reproducible, independant of human effect which is always subjective. Meanwhile, we applied ourselves to preserve the flexibility and the easiness: the user can break in on each step, and modify parameters. He defines by himself characteristic polygons for landscape recognition, therefore he has an effect upon the treatments. For GIS integration, he also does the small polygons topological cleaning.

In image processing, the traditional methods follow a "pixelistic" approach because they generalize a local analysis on a few pixels to a much widder area, sometimes a million-pixel large or more. It is an *increasing* analysis. On the other hand, people involved in agricultural problems, follow an analytic *decreasing* method, from general to particular phenomenons. Our method keeps to this pattern of analysis.

PAPRI

Papri (PAysages définis a PRIori, which means Landscapes a priori Defined) segments an image according to its textural properties as previously defined. It gives a cutting of the image in texturally homogeneous areas, called "Landscapes Units". This product is nearer of a map than an usual classification: it proposes a synthetic fast and global understanding of the image. *Papri* was first designed to be applied to classified images but it is also efficient on greyscale images. We deal with both.

The different steps are the following ones, after a possible classification of initial image. For more details on the *Papri* method, see (Borne, 1992).

Calibration Polygons Choice

This first step is the calibration of the software, i.e. telling it what we try to recognize on the image. The field specialist draws on the image polygons supposed to delimit a homogeneous area, characteristic of a landscape to identify. The software compute then the distribution of this landscape, as the size of the characteristic polygon just drawn.

Landscape-Vector Computation

The landscape-vectors are computed. They reflect the mean composition of different calibration polygons for each landscape, and the computation takes also into account some other necessary informations like dimensions of polygons and thresholds of rejection choosen by the user.

Image Segmentation

Next, the image is analysed point by point. On each point, we compute the distribution in the neighbourhood and we look for the landscape with the nearest distribution. In fact we examine different sized neighbourhoods, and, depending on a quality index, we keep the best landscape for this point.

BONI AREA APPLICATION

With *Papri*, we get a simplification of the initial image. The image observation displays different types of landscape. For simplification, just four were retained: laterites and iron gravels soil, peripheric basin, tree savanna and fields which were cultivated.

We delimit many polygons (learning zones) included in these units and admitted as representative. Many scopes of windows sizes were compared: 3x3 to 11x11 pixels, 11x11 to 27x27 pixels, 3x3 to 27x27 pixels

Papri on a Classified Image Texture

Results from classified image are essentially more satisfactory than those obtained from greyscale image. However, some details are better settled from raw image. We choosed to keep results computed from classified image.

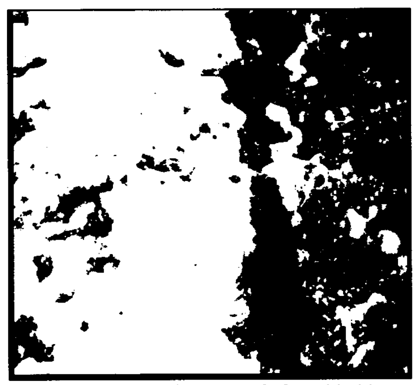

Figure 2: Result Image, 3x3 to 11x11

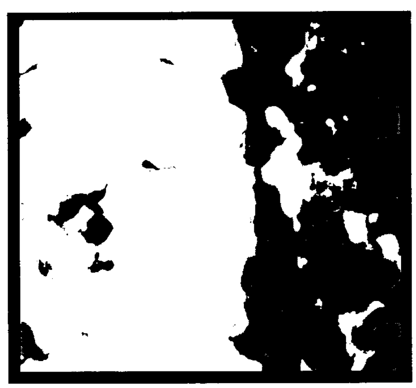

Figure 3: Result Image, 11x11 to 27x27

VECTORIZATION, SEARCH OF LIMITS

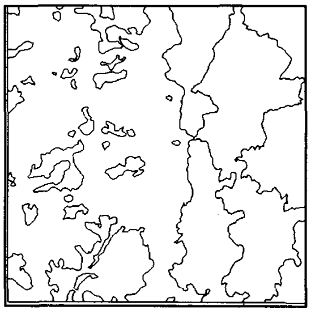

Figure 4: Choosen Landscape Units

Among different results, the most simple looking image (large homogeneous areas) is the one corresponding to higher sizes of windows. But some important limits are often well different of those on initial image; for example, fields of Boni farm (near the center of the image) are far from rectangular. The result with smallest sizes (3 to 11) have many small areas, especially in the peripheric basin, but it does not modify too much big units limits. This image was choosen and vectorized: this technique is used in automatic mapping, it is also called polygonization and consists in transforming a raster image in a set of points and vectors, characterizing the edges of the image. Then small polygons are deleted. The following operation consists in deleting arcs which are not interesting for the moment: they do not represent "strategic" limits.

Finally, the last interesting operation is the smoothing of obtained limits to take into account the difference of size between pixels of Spot image and the resolution of the GIS The result appears on figure 4.

QUALITY OF THE FINAL RESULT

The final document looks like a **map**, edges include large units. There is a good separation of the different characteristics of the landscapes: savannas, bare soils, laterites and iron gravels soils, peripheric basin.

Limits were superposed to the initial image on the screen. It is interesting to control the validity of the map. For example fields of Boni farm are well identified since they are in the "Cultivated Fields" landscape, the area of the zone is hardly different. We remark that the obtained limit is often correct but included in the visual delimitation. This is due to a fast use of *Papri*; working more accurately in sizing neighbourhoods and choosing learning polygons, it is possible to improve this representation. Other sectors also show some small defaults, like the limit *peripheric basin-laterite* which should have a ground-control.

These defaults are not important if we want a 1/200.000 map, but, for a larger scale like 1/50.000, *Papri* treatments must be more carefully done. But the evolution of the method, especially for the treatment of limits of landscapes, should improve these imperfections in order to get a good 1/50.000 mapping (and even more).

GIS INTEGRATION, FUTURE DEVELOPMENTS

The principal interest of this operation is to get a first segmentation of the image in *big landscape units*. The method presented here goes from the **general** phenomenons to the **particular** ones. The individualization in big units allows for following studies to work inside each one, and so to minimize for example the problem of radiometric mistakes (Borne, 1990).

The reverse operation of vectorization, the rasterization, is also possible. Then, it is easy to use found limits as masks and to continue the analysis with a remote sensing image processing software. Then, only datas in the interesting limits are used. The study then occurs unit by unit, with the same method than the one presented here and so on, until user's satisfaction and decision to stop the process.

Next steps will consist in a quantification of the quality of the results by computing a mistakes matrix, utilization of other results produced by *Papri* and yet unexplored (quality index and neighbourhoods size images), and by taking into account other factors to better describe a landscape, especially factors connected to the topology in the neighbourhood, still ignored.

CONCLUSION

Use of satellite numerical datas with *classical* image processing softwares is still less efficient than visual analysis of paper prints to produce a map. On the other hand, the proposed method has the advantage to be extensively automatised, while preserving man's decisions at each step: it combines, in raster mode, a semi-directed classification technique with a statistical treatment on classes, in order to define landscape units; the vectorization step allows to preserve just the really pertinent limits.

With texture analysis as we defined it, we can precisely map landscapes, providing that the variation scope of neighbourhoods sizes was well choosen.

Research still goes on for a complete integration of the different presented methods and for a better aid in some steps. For example, which is the impact of an automatic classification on the landscapes recognition? It seems presently that this method is good for some images. But of course, landscapes to be identified must be numericaly describable.

These methods allow to hope soon for a faster interpretation of satellite images and for documents better suitted to ground demands. Products are now geo-referenced, they just need a real mapping side, an interpretation of spatial organization of landscapes, which *Papri* proposes.

REFERENCES

Borne, 1990. *Méthodes Numériques de Reconnaissance de Paysages.* Thèse de 3ème cycle, Université Paris 7, France, 213 p.

Borne, 1992. Méthodes Numériques de Reconnaissance de Paysages in *XVII ISPRS Congress Proceedings*, Washington, U.S.A.

Girard M.C., Girard C.M. 1989. *Télédétection appliquée. Zones tempérées et intertropicales.* Mason. Paris, France, 260p.

Guillobez, S., F. Borne, P. Fol, Ch. Gounel, 1993, Des données satellitaires à la cartographie du milieu naturel. Utilisation de l'outil informatique, in *1er Colloque International AOCASS/WCASS Proceedings*, Ouagadougou, Burkina Faso.