METROPOLITAN MORPHOLOGY AND DISCONTINUITIES

Remote Information Integration with Statistical Data on the Lisbon Metropolitan Area (AML)

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The main purpose of this research consists in the development and validation, through the application to a case study, of new methods for the definition of territorial discontinuities and morphologies, using the most recent scientific and technological developments that have been made in the fields of remote sensing, geographical information systems and statistics in general. These methods should allow the development of applications for environmental planning and land management. Due to its large dynamics and constant mutation, the Lisbon Metropolitan Area (AML) was chosen as a case study. This research is being conducted in the Geography and Regional Planning Department of the New University of Lisbon (DGPR/UNL) in a close direct relationship with the AML.

KEYWORDS: GIS, Remote Sensing, Census Data, Regional Morphology and Discontinuity

INTRODUCTION

The application of the methods under development and the integration of information with a diverse nature, originating in different sources, in the decision-making instruments, land use and environmental management constitutes the first goal of this research, for example, by defining recommendations and evaluation criteria for the Land Use Plans, such as the Municipal Master Plans. In this way, it is aimed, to make a contribution for a greater sensitisation of the interving people (technicians, decision-makers and the general public), viewing the need of a planning and land use that take into account the vulnerable and dynamic character of the territory.

The growing need to achieve quality and cheap answers in a short time, allows remote sensing to be a powerful solution for the gathering of information concerning soil coverage. The recent technological developments in this area, made available to the scientific community, has shown the ways in which remote sensing is more and more efficient and undoubtedly uncompared when the research is on a regional scale.

The Geographical Information Systems (GIS) have made it possible to integrate information from a variety of sources. With this, the main goal relates to the creation of new statistical data and the improvement of the existing ones in order to improve the soil-use morphologic (Morphology is a very common term, in urban context, when the subject drives about shape, pattern, and organisation of land uses) identification and analysis in the AML.

For this purpose, our work started with a SPOT XS (Fig. 1) multi-spectral image and a panchromatic SPOT P (Fig. 2), both dated 1995, as well as the data from the 1991 census, referred to the statistical subsection and the Spatial Referencing Basis (BGRE).

Figure 1 – AML SPOT XS IMAGE (Colour Composite 123 SMIG/AML)

METHODS

The classification of satellite images is traditionally used to map the land use, where, in the most common examples urban areas are represented by a uniform and continuous spot. Nevertheless, although this form of stratification is generally sufficient in the majority of the cases, it is not the case in such areas where rural/urban fringe is felt more intensively.

Precisely to provide an answer to this more detailed classification, in which the classical methods of classification (supervised and non-supervised) are not enough , information designated as collateral has been used, which can be defined as the one acquired by means not related with remote sensing but being applied on a latter stage in the classification of remote information.

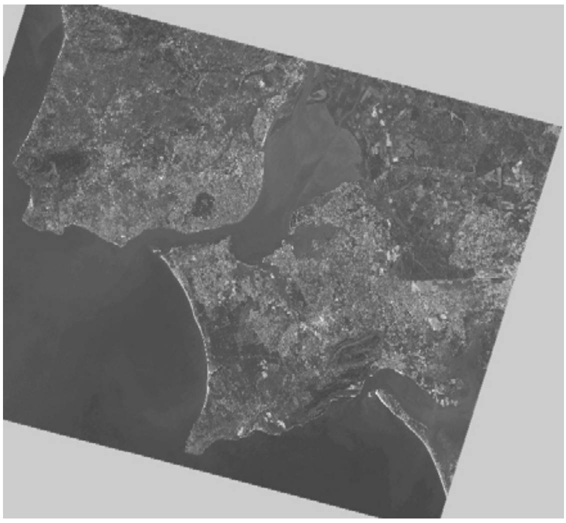

Figure 2 – AML SPOT P IMAGE (SMIG/AML)

In 1992, after submitting three groups of data (classified satellite images, census data and population density) to an analysis by main components, Weber and Hirsch [6] verified that the results obtained presented clear resemblance's. In fact, in all of the cases, the first three components hold 80% of the total information. It was also possible to identify a significant relationship between the urban areas and the urban green structure obtained through the remote data and several variables directly or indirectly extracted from the census data, namely, the number of buildings with several households, level of family income, percentages of house-owner and single family constructions. It is concluded thus, that the existing strong relationships between both types of information may allow its interaction to improve the urban areas analysis.

Following the same line of thought, by relating the classical land use information gathered through remote sensing with the census data, we have aimed to significantly improve the quality of the final result and to better identify the types of land use and occupation. The followed procedure for analysis and information treatment is depicted in Figure 3.

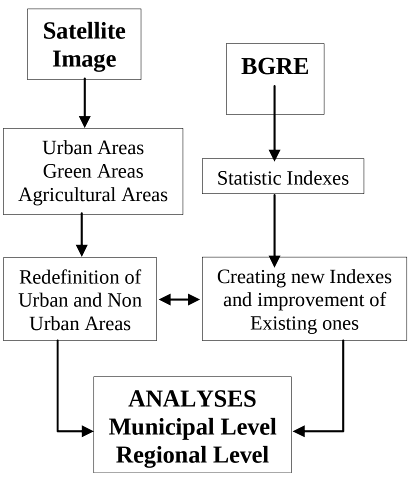

Figure 3 – Methods schematics

SATELLITE IMAGING PROCESSING

Due to the previously established criteria and the proposed objectives, an vegetation index was used to define the urban green areas and to isolate the mineralised space.

The choice was to use the Normalised Difference Vegetation Index (NDVI) which basically compares values pixel by pixel from the red and near infrared spectral bands. The SPOT image bands that follow the previous description are 2 (red) and 3 (near infrared) and the mathematical expression that materialises this index takes the following format

$$NDVI = \frac{IVp - V}{IVp + V}$$

Has a result an image is reached with values between $-1 < NDVI < 1$; with results being converted in the discrete interval [0,255].

Only upon completion of that operation has the geometrical correction of the image been performed. This option is based on the presumption that any analysis should be done on information that has not suffered geometrical transformation.

Anyway, when the warp was performed, on the topographic card (Hayford-Gauss projection) of the Army Geographic Institute on a scale of 1:25 000, a first degree polynomial due to the relatively low distortion it causes in the image, when compared to other of higher degrees. For the same reason, for the brightness values interpolation the algorithm of resample of the closest neighbour was chosen.

STATISTICAL INFORMATION

The data provided by the INE (National Institute for Statistics) and selected for the present analysis (Table 1) were chosen from four main groups: Buildings, Housing, Dwellings and Individuals.

Table 1 – Basis Statistical information

TABLE	FIELD	DESCRIPTION
Buildings	CMP01	Total
	CMP02/07	Construction date
	CMP08	Exc. housing
	CMP09	Mainly housing
	CMP10	Mainly non housing
Dwellings	CMP01	Total
	CMP12	Collective
Families	CMP01	Total
Individuals	CMP01/02	Residing population

From these data several indexes were extracted such as the percentages of buildings by date of construction, the percentage of buildings primarily aimed for housing purposes and others that serve other purposes, population density and the number of inhabitants by household.

Contrary to the majority of the cases, that relate only to simple percentages calculations (commonly used in demographics), the last two indexes, mentioned above, were established in a different manner. Thus, the number of individuals by household was renamed number of individuals by dwelling and calculated by the following form:

$$\frac{TRP}{TD - CD}$$

Where:
TRP – Total Resident Population
TD – Total dwellings
CD – Collective dwellings

Other indexes were established through the conjunction of remote and census data, such as the percentage of green and urban areas and the ratio between the two of them.

On the other hand, the population density was recalculated (Fig. 4) dividing the resident population by the urbanised area of the subsection instead of the total area, leaving the remaining empty space with a nil population density.

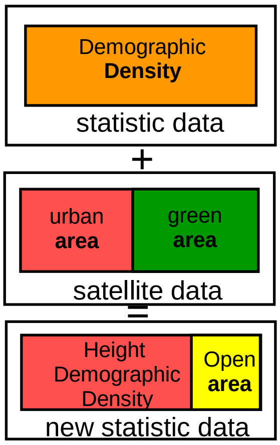

Figure 4 – Improvement of Census information

Figure 5 shows a scheme of a similar procedure as the one described but where the purpose is not the gathering of improved statistical data but rather an improved remote information. Thus, in rural/urban fringe areas the mixture of reflectance is improved by the use of census information, in order to discriminate the truly rural/urban fringe areas (diffuse urban) from those that show already consolidation signals (continuous urban).

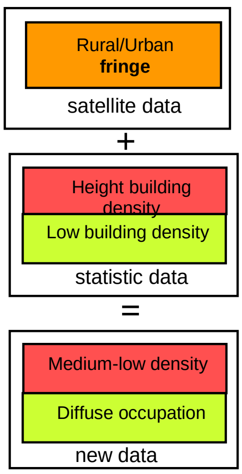

Figure 5 – Improvement of Remote Information

ANALYSIS

With this group of data it was possible to establish classification rules that allowed a more precise definition of the soil use image.

On a city basis the mentioned rules consisted in defining terms that point in a specific use. For example, areas close to the sea, with constructions and little or no inhabitants and housing buildings are probably port areas; subsections with no population and buildings, within the urban continuous, can either be free urban spaces or green urban spaces, with the distinction between them being possible to reach by the green area percentage.

On a regional scale, the general morphology of the territory is better defined. The large urban routes such as Lisbon-Amadora-Sintra, Lisboa-V. Franca de Xira, Lisbon-Oeiras-Cascais, and the riverside axis Almada-Seixal-Moita-Barreiro, are clearly defined and individualised; it is also possible to verify the urban discontinuities: green spaces, empty and expecting lands. Besides the large continuous urban corridors it is also possible to clearly view the isolated urban spots such as Setúbal, Sesimbra, Montijo and Mafra.
The large green spots are also individualised such as the cases of Quinta da Apostiça, Serra da Arrábida and Rio Frio/Barroca da Alva on the South bank of the Tagus and Serra de Sintra and neighbouring area on the North bank. Also clearly marked are the agriculture areas, forests and other construction-free areas or outside of the urban *continuum*, which together represent the non urban areas/open spaces.

These studies are greatly useful in the development of research and work of a metropolitan nature, such as the definition of "Green Corridors" [2], or land use studies for strategic planning [3].

Besides reaching an improved definition of the fragmented pictured that constitutes the territory morphology, this work has allowed a verification of the marks created by the communications network. The roads and railways, although sometimes may be physical barriers to the urban development (such as the case of the northern line in the AML), are at the same time the major cause and consequence of the AML urbanisation.

CONCLUSIONS AND PERSPECTIVES

The integration of data from a diversity of sources, especially the remote sensing, plays nowadays a major role in the geographical information of spatial character. The informatic tools in the GIS environment have allowed the use the applications of great usefulness in all the areas of the Social and Earth Sciences, but mainly constitute a vitally important instrument in the land use planning and strategic management.

This work only a partial draft of what is scheduled within our research project, under development at the DGPR/UNL in a close co-operation with the Remote Monitoring System of Land Use of the Lisbon Metropolitan Area (Metropolitan Area of Lisbon Board)

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