8. Title   INPE-3896-PRE/938

VISUAL AERIAL PHOTOGRAPH TEXTURE DISCRIMINATION FOR
DELINEATING HOMOGENEOUS RESIDENTIAL SECTORS:
AN INSTRUMENT FOR URBAN PLANNERS

10. NO of pages: 06

11. Last page: 04

12. Revised by

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14. Abstract/Notes

This paper presents a method for the definition of a geographical reference system to be used by planners in urban residential area analysis. The purpose of the method is to exploit, in the diagnosis, the spatial component of the town which is the concrete result of the interactions between its physical and social elements. The assumptions made are: a) the urban residential areas in Brazilian towns are extremely differentiated as a result of the social stratification existent in the country; b) there is a strong association between physical aspects of these areas and the socioeconomic characteristics of their resident population. The method preconizes the use of panchromatic aerial photographs at a scale of 1:10000 for the delimitation of homogeneous residential sectors. The procedures described are based on the human visual capability to descriminate different textures. In order to test its validity, survey data obtained through its application to São José dos Campos, SP, Brazil, were analysed using cluster analysis technique. The results of the work showed that photointerpretation, besides being a quick and economical instrument for urban analysis, may be usefully applied for delineating homogeneous residential urban sectors, to be used by urban planners.

RESUMO

Este trabalho apresenta um método para a definição de um sistema geográfico de referência para ser usado pelos planejadores na análise de áreas residenciais urbanas. O propósito do método é explorar, na fase de diagnóstico urbano, o componente espacial da cidade, que é o resultado concreto das interações entre seus elementos físicos e sociais. As suposições feitas são: a) as áreas residenciais nas cidades brasileiras são extremamente diferenciadas, como resultado da estratificação social existente no país. O método consiste no uso de fotografias aéreas pancromáticas na escala aproximada 1:10000 para a delimitação dos setores residenciais homogêneos. Os procedimentos envolvidos baseiam-se na capacidade humana de discriminar texturas fotográficas diferentes. A fim de testar a validade do método, foram analisados dados de campo resultantes de sua aplicação a São José dos Campos, SP, Brasil, através da técnica de "cluster analysis". Os resultados do trabalho mostraram que a fotointerpretação além de ser um instrumento econômico e rápido para a análise urbana pode ser usada, com utilidade, para delinear os setores residenciais homogêneos a serem usados por planejadores urbanos.

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ABSTRACT: This paper presents a method for the definition of a geographical reference system to be used by
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spatial component of the town which is the concrete result of the interactions between its physical and social
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1 INTRODUCTION

Urban planning, as any decision-making process,
depends   on an efficient information system for
support. Urban system related decisions,
specifically, require the availability of a wide
range of information, particularly those associated
with an appropriate geographic reference, that allows
the orientation of specially located actions.

Among these types of information we would mention
that related to the residential differentiation on
urban soil, the corresponding distribution of the
different populational segments on this soil, as well
as its socioeconomic features. Such information is
essential for the planning of residential areas that
involve, among others, decisions related to the
placement of locally used urban equipment, as well
as to the distribution of determined urban services.

The present paper suggests a method for defining
the urban residential sectors aiming at assisting
the planner in the analysis of the town residential
areas that directs him towards the study of problems
which require all of the above mentioned information
at the same time.

This method was developed having in mind the
Brazilian towns with their extremely diversified
compositions of residential areas resulting from the
pronounced stratification of their society

2 DESCRIPTION OF THE METHOD

This method is based upon visual photograph texture
discrimination over panchromatic aerial photographs
on the scale of 1:10.000. When town areas of
residential use are investigated, the sectors with
similar textures are delineated, thus forming urban
units for data collection, analysis and storage.

Its result is a mosaic map, built up from small
differentiated parts, in which neighboring sectors
will show different textures.

This proposal is based upon the hypothesis that to
these neighboring homogeneously textured sectors
correpond different physical residential
environments, to which correspond populational
segments also differentiated according to their
socioeconomic features.

The basic element of the aerial photographs for
delineating homogeneous residential sectors is the
texture, produced by the aggregation of small
details, no longer analysed individually, but as a
whole.

The capacity of the human visual system to
perceive differences between determined textures is
fundamental to the suggested sectorization process.

According to Haralick (1979) the texture is a
phenomenon of area organization and has two basic
dimensions:
- a) one that refers to the primary   elements that
composes it; and
  b) one that refers to the dependency among primary
components, i.e., their spatial organization.

This being so, texture variation is defined by
different primary components or by components of
different sizes, and also by the density of these
elements, their relative position and their spatial
distribution. In residential areas this means that
the textures of the sectors are type-depending:
mansions are different from small houses; one-storey
houses are different from apartment houses; high
density areas are different from low density areas;
arboreous areas are different from areas without
vegetation; areas for exclusively residential use
are different from mixed use areas. And so are their
textures.

Basically, the process of delineating homogeneous
sectors consists of the following:
a) Visual discrimination of the different texture
areas through an overall perception of adjacent
point sets.
b) Identification, within these areas, of the
primary components of the textures as well as the
spatial organization, investigating urbanistic and
architetonic details of their elements, such as
sizes of buildings and open areas, maps of the road
system, existence of natural greenery, building
density, nonresidential constructions.
c) Determination of whether there is
differentiation between textures of visually
discriminated areas based upon information collected
from item (b).
d) Outlining of the limits that define the
residential sectors of the same texture.

Figure 2.1 shows an example of the result of the
delineating process for residential sectors through
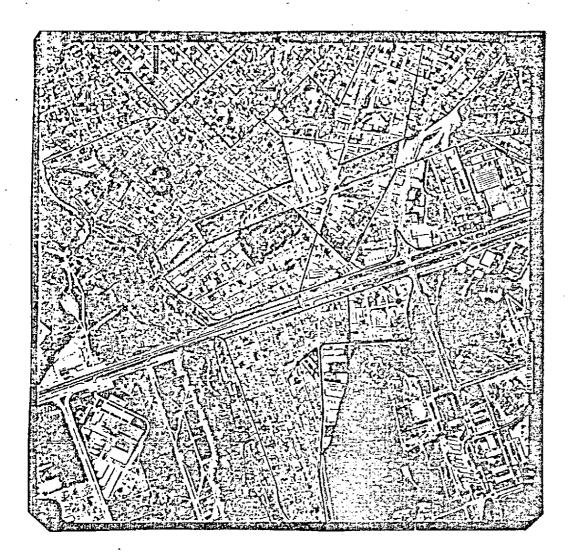the differentiation of the photographic textures.

Figure 2.1 Homogeneous residential sectors. São José
dos Campos, SP, Brazil, 1977.

This aerial photograph clearly shows the
differences between the textures 1, 2, 3 and 4 which
are marked and allow the definition of four urban
residential sectors.

Texture 1 is coarser than the other ones, i.e. its
primary elements are larger. It is defined by a few
large houses and large lots, many of which still
unoccupied, spatially organized along the streets
that constitute the road system of the sector that
is regular, with parallel lines ending up in
"dead ends".

Texture 2 introduces a more heterogeneous
composition as far as its component elements are
concerned. It is an urban renewal area in which can
be seen large-size apartment houses, side-by-side
with one-storey houses. Such elements are matched
according to a spatial organization pattern that
gives the area an overall homogeneous appearance.

Texture 3 is slimmer, i.e. made up from primary
elements smaller than in the preceding texture. It
is defined by one-family houses, smaller than the
ones in the areas of the previous textures. The
occupation is dense, not only because of the
relationship, per area, between constructed and
empty areas, inside the lot, but also because there
are hardly any unoccupied lots left.

Texture 4 is defined by the presence of slightly
larger houses than the ones described in the texture
3 area. Furthermore, there are many unoccupied areas,
as well as a great deal of arborization, which gives
the area an aspect that is well-differentiated from
that of the previous areas.

The delineating of homogeneously-texture
residential areas is a task that depends on the
photointerpreter's capacity for discriminating
between determined simpler textures and, by means of
more developed cognitive processes, discriminating
between more complex textures. The execution of this
task requires not only the study of
photointerpretation techniques, but also specific
knowledge of architecture and urbanism.

3 VALIDATION OF THE METHOD

This validation consists of verifying if the residential sectors of different textures also includes groups of inhabitants different with respect to given socioeconomic variables.

Such activity was carried out within determined restrictions due to the impossibility of executing another flight over the test area, of redefining the homogeneous town-areas using new photographic products, as well as of executing a specifically planned field survey, in order to obtain the validation.

In view of the impossibility, dictated by budgetary restrictions, aerial photographs, taken in 1977 of the urban area of São José dos Campos, were used, as well as the residential sectors of the same texture then defined (Oliveira et al., 1978), and the field survey effectuated for a research by DalBianco and Netto Jr (1979), based upon the division of the town into sectors.

In order to adjust the available material to the current interests, some residential sectors were eliminated from the study. This was done because, in some cases, the number of sample elements (residences) typifiying it was very small, or because there was no demonstrative difference between its texture and the texture of the neighboring sector, although the division had appeared to be coherent when it was proposed.

While the data collecting was done sector by sector, in the data analysis the sectors were compared by pairs.

Two sets of pairs of sectors of homogeneous texture were constructed: a) the first contained pairs of neighboring sectors, the comparison of which aimed at validating the process by which such geographic units were delineated. In this case 46 pairs of sectors were analysed; b) the second contained some pairs of sectors, defined by the photointerpretation, nonneighboring, and of a markedly differentiated texture. In this case the objective was the validation of the differentiation in texture as a standard for the differentiation of the residential population segments, as far as their position in the social structure of the city has concerned.

The processes used to analyse each of the sets of residences contained in each pair of sectors studied were the following:

Using the K MEANS algorithm implemented by Cappelletti (1982), in an adaptation of the algorithm introduced by Hartigan (1975), the residences of both sectors were reassembled according to field data referring to variables used as indicators of the social position: habitation standard, main householder's income and his schooling.

Hence for each set of two residential sectors, a data matrix was used with dimensions N x M, where N stood for the number of residences researched and M for the number of variables considered.

The algorithm aims at minimizing the sum of the squares of the Euclidean distances between units of a "cluster" and its center.

To the variables of habitation standard and schooling were associated the numbers 1, 2, 3 and 4, from the worst to the best habitation as well as from the lowest to the highest schooling.

The results of the utilization of the K MEANS algorithm determined the number of residences of each of the two sectors classified in each of the two clusters. The referring proportions being determined subsequently, according to the model presented in table 1, in which p. ij. stands for a proportion of elements of the sector i (defined through the photograph texture), assembled into cluster j (through the use of the algorithm).

Table 1. Data analysis model.

	1st Cluster	2nd Cluster
Sector 1	p. 11	p. 12
Sector 2	p. 21	p. 22

Based upon this table, a statistical test was carried out to verify if there was an expressive difference between the proportions of elements in each of the sectors classified in one of the clusters. This difference would mean that the populations of the sectors, where samples came from, were different with regard to their social position in the structure of the local urban society.

4 RESULTS

The differences between the proportions of elements in both clusters were examined in 46 pairs of neighboring sectors. The results showed an expressive difference among 29 of these neighboring sectors, at a significance level of $\alpha = 0.20$ and among 33 at a significance level of $\alpha = 0.30$.

During a new examination of the aerial photographs, it was discovered that those pairs of sectors, in which this difference did not prove to be expressive, were generally related to the pairs of sectors with less evident visual discrimination of the texture. There was only one exception that occurred in the case of one of those pairs.

In relation to the tests carried out with nonneighboring sectors having an outstandingly differentiated photograph texture, it was found that all of the 8 pairs compared showed a statistically expressive difference at a level of $\alpha = 0.01$ among the proportions of their elements classified in both clusters defined by the K MEANS algorithm. Six of them were expressively different at a level of $\alpha = 0.0007$.

Such results lead to the acceptance of the photograph texture differentiation of the residential areas as an appropriate standard for discriminating the different segments of the urban population according to their socioeconomic level.

Furthermore, it is to be emphasized that the sucess of this method will depend on the screening of only clearly differentiated textures.

5 CONCLUSIONS

The results in this study demonstrate that the visual photograph texture discrimination is an appropriate process for delineating residential town-sectors so as to become geographic references suitable to the purposes of urban planners.

Once, by means of the definition of these sectors, a set of geographic units sensitive not only to the physical differentiation of the residential environment, but also to the socioeconomic differentiation of the inhabitants, is obtained. These sectors may become a useful planning instrument. This may be possible specially if we take into account that the method involves a relatively simple process that can be carried out by a photointerpreter qualified for this task.

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