VISUALIZATION OF CARTOGRAPHIC INFORMATION USING DTM

Claudia Robbi
National Institute for Space Research - INPE
Av. dos Astronautas, 1758
12227-010 São José dos Campos - SP, Brazil
e-mail: robbi@ltid.inpe.br

KEY WORDS: Cartography, DTM, Thematic, Mapping, Three-dimensional visualization, statistical information visualization

ABSTRACT

The representation of geographical phenomena by two-dimensional maps presents serious limitations that may be overcome by means of a three-dimensional (3D) model. The advent of powerfull enough computers, and, consequently, Geographical Information Systems (GIS) allows the creation of models which represent continuous spacial phenomena, and its visualization by Computer Graphics. Softwares that have been developed to represent the relief of the Earth's surface through digital terrain models (DTM's) could be used to visualize many other different data sets. In this work, 3D models are generated from population density data sets of Sao Paulo State, Brazil, which were obtained from Annual Report of Sao Paulo State (SEADE, 1992). Choropleth maps were produced through the classification of the DTM from data variation, called "DTM slicing". With "DTM slicing", analyses of data caracteristics are possible, such as "what are regions that have more than 500 inhabitants per km^2, or regions with reduction in population?

RÉSÙMÉ

La représentation de phénomènes géographiques au moyen de cartes bi-dimentionelles présentent de sérieuses difficultés qui peuvent être contournées au moyen de l'utilisation de modèles tridimentionels. L'apparition de calculateurs suffisamment puissants et, en conséquence, de Systèmes d'Information Géographiques (SIG), permet la création de modèles qui représentent des phénomènes spaciaux continus, et leur visualisation par infographie. Les logiciels qui ont été développés pour représenter le relief de la superficie terrestre, à travers des modèles numériques d'élévation (MNE), peuvent être utilisés pour visualiser bien d'autres ensembles de données. Dans ce travail, les modèles 3D ont été obtenus à partir d'ensembles de données sur la densité de population dans l'état de São Paulo, Brésil, qui ont été extraits du Rapport Annuel de l'État de São Paulo. Des cartes choropléthes ont été produites à travers une classification du MNE, appelé "découpe en tranche du MNE". Au moyen de cette "découpe", des analyses sur les caractéristiques des données sont possibles, telles que "quelles sont les régions qui ont plus de 500 habitants au km2, ou quelles sont les régions qui ont eu une diminution de population?"

1. INTRODUCTION

The statistical data sets aggregated by statistical or administrative areas can be represented through choropleth maps. The choropleth mapping may be thought of as a three-dimensional (3D) statistical surface. This surface is composed by prism. The height of each prism is proportional to the value it represents, and the bases are defined by the frontiers of statistical or administrative areas (DENT, 1986). The visualization of these data models sometimes are called prism maps.

The digital models, that represent surfaces, are obtained by interpolation techniques. If the geographical location and attribute Z, of the points set, are known, a regular rectangular grid can be generated. The 'Z' value of grid points are calculated by interpolation. The statistical information represented with choropleth maps have its geographical location known, and the statistical information is the attribute itself, or 'Z' value of the digital model. If a digital model represents appropriately these statistical surfaces, through a regular rectangular grid, the operations with these grids permit the user of GIS to acquire and to observe different information about the phenomena, like population distribution. One kind of operation is to classify data variation, with a procedure called "DTM slicing".

In this work, three-dimensional models are generated from population density sets of Sao Paulo State, Brazil (SEADE, 1992). The data sets are aggregated by government regions that encompasses municipalities. Sao Paulo State has 624 municipalities, 43 government regions and 15 administrative regions. The municipalities form the government regions, and the government constitute regions the administrative regions. Sao Paulo State is situated between latitudes 19°47'22"S and 25°18'35"S, and longitudes 44°09'46"W and 53°05'15"W. The state has approximately 31000000 inhabitants, according the 1991 census (SEADE, 1992).

The populational density data sets were visualized and manipulated with the software SGI, developed at the National Institute for Space Research - INPE (Brazil), to verify the viability and efficiency of this kind of Cartographic Information representation. The SGI was developed to run in IBM-PC or compatibles, with operation system DOS. Data input in SGI is possible by digitizing or importing files with DXF or ASCII formats. In this software, the DTM is represented by a rectangular grid or triangular irregular grid (TIN).

2. GENERATING DIGITAL MODEL FOR CHOROPLETH MAPPING

In generating digital models for choropleth mapping, the value in the enumeration unit must be considered uniformly spread throughout the unit. The top of each prism in the digital model is horizontal and unchanging. Therefore, in the rectangular grid, all points that correspond a specific area must have the same value Z. In SGI, the first step to obtain this grid, is to store the polygons that correspond the enumeration units. The available data, to develop this work, were:

- Sao Paulo State Map with municipalities boundary (IGC, 1984);
- population densities by government regions about 1980, 1985 and 1991 (SEADE,1992).

Firstly, the boundary regions were digitilized and stored with vector structure. In this case, each polygon represents a government region. Afterwards, this vector structure was transformed in a raster structure, and the software did generate a rectangular grid making the correspondence between each pixel and population density value of government regions. This rectangular grid represents the 3D surface of choropleth mapping.

In the SGI, a DTM can be represented either by a set of contour lines, by a gray level map, or by means of a 3D visualization, among other possibilities. The 3D visualization can be defined in perspective or parallel projection. To population density values about 1980, 1985 and 1991, 3 grids were obtained. In the figure 1, the digital model of 1991 may be observed in a 3D visualization, using parallel projection.

Figure 1 - Digital model of population density of 1991

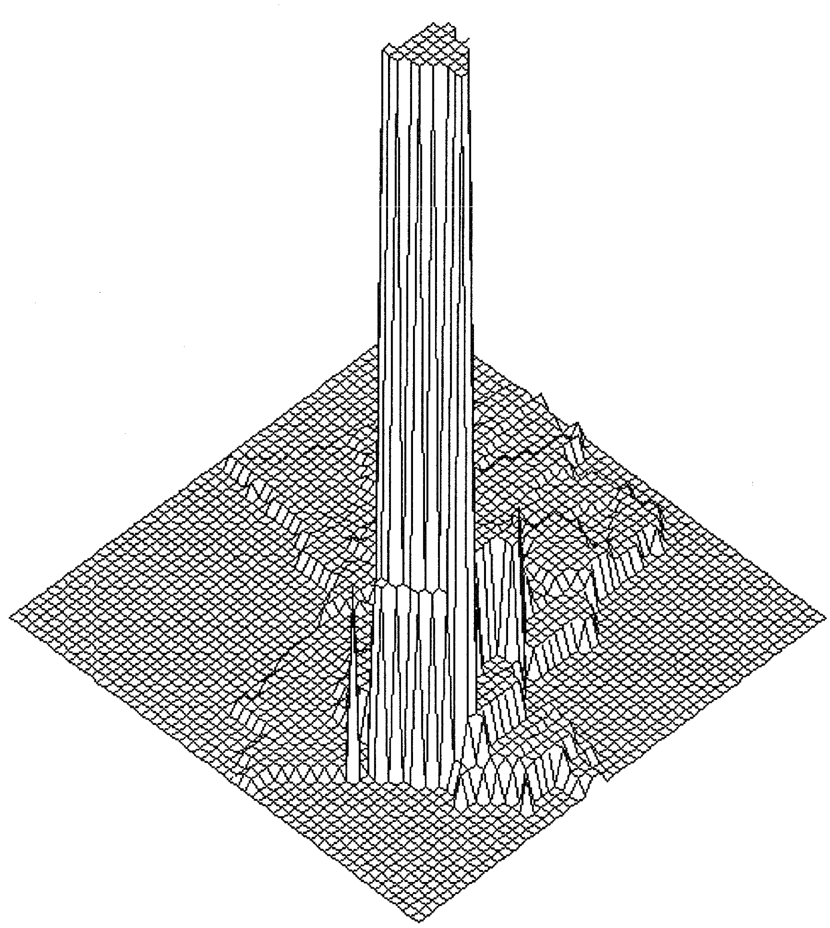
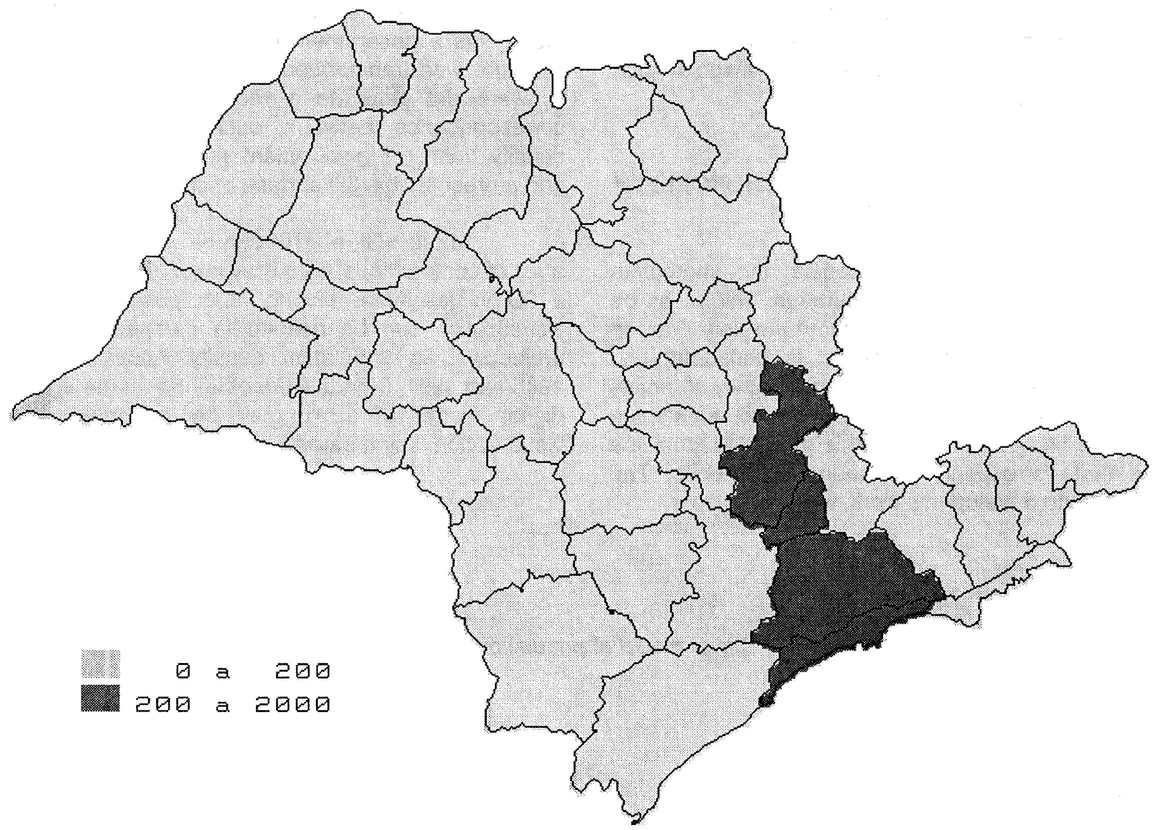


Figure 2 - Regions that have more 200 inhabitants per km^2



3. GENERATING MAPS WITH DISTINCTION CLASSIFICATION

In producing DTM's from population density data sets, the user can retrieve information about a specific geographic position for the study region. Moreover, the user can visualize any classification that he/she wants, or specific geographic analyses, through DTM slicing. Each DTM slicing operation generates a thematic layer that represents a population density map.

In this work, some maps were obtained with DTM slicing, to exemplify this possibilities of choropleth mapping. In the first exemple (Fig.2) it is shown the map of regions that have more than 200 inhabitants per km^2, in 1991. This map was generate classifying the DTM with the following classes: 0 to 200, and 200 to 2000 inhab. per km^2. Other maps were obtained, with the DTM slicing operation, using the following methods for data classification (DENT, 1985): constant intervals, natural breaks and iterative method. The figures 3 and 4 present choropleth maps with constant intervals classification. In the first, we consider Sao Paulo population density, to observe its influency in the others data. The natural breaks classification, analized through the iterative method, was developed to generate the choropleth map of the figure 5.

Figure 3 - Population Density 1980 (inhab. per km^2) - Constant intervals classification without considering Sao Paulo population

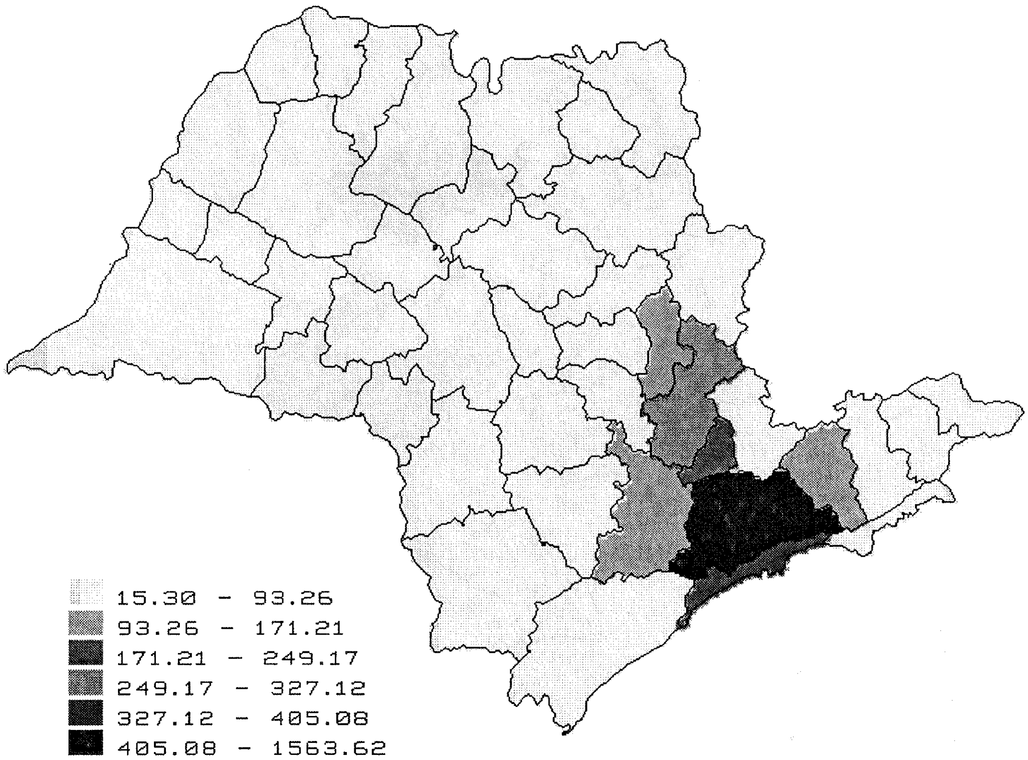


Figure 4 - Population Density 1980 (inhab. per km^2) - Constant intervals classification considering Sao Paulo population

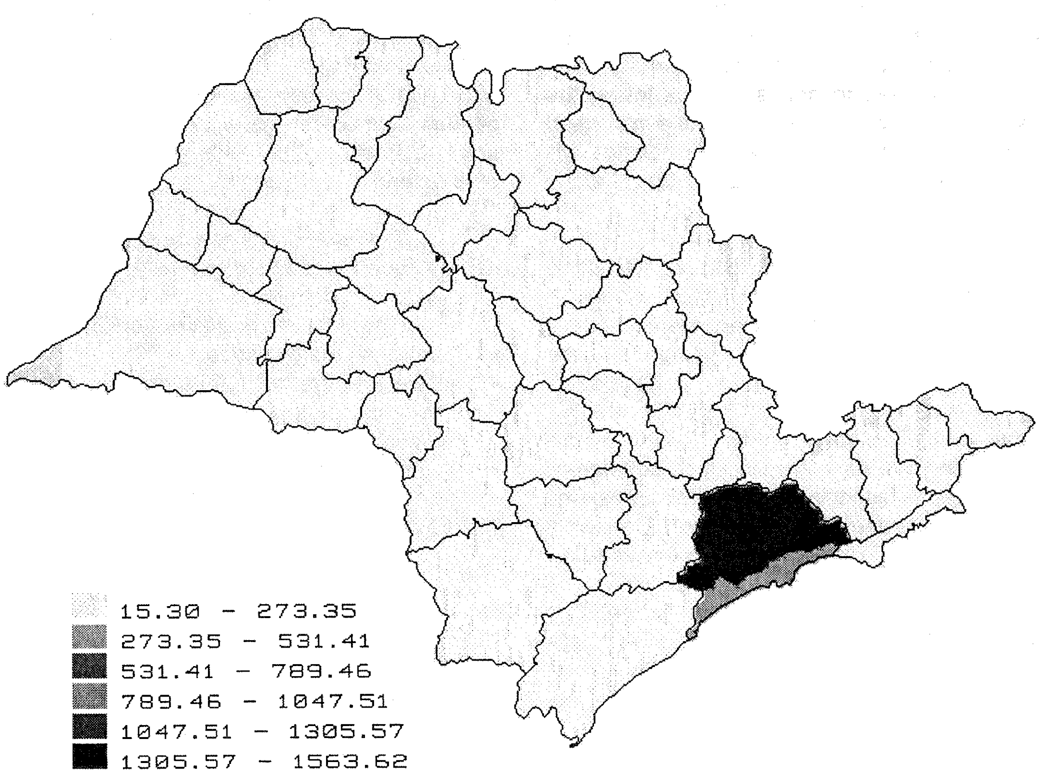
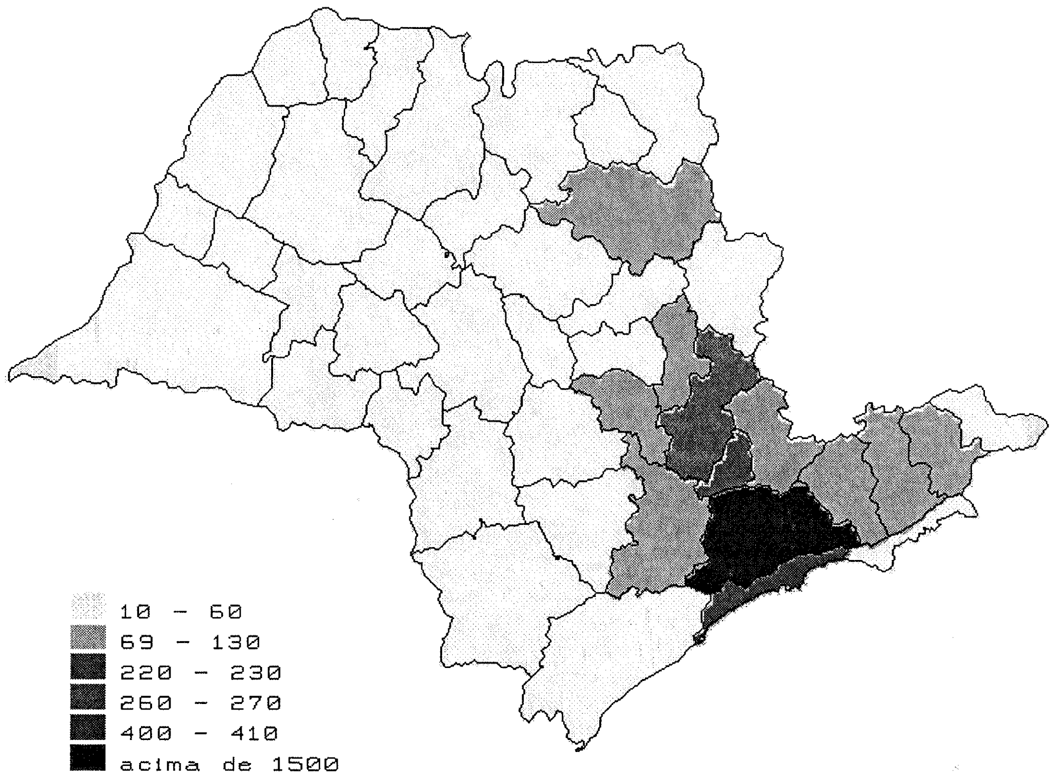


Figure 5 - Population Density 1980 (inhab. per km^2) - Natural breaks classification



In the development of this work, it can observed that the utilization of DTM's to visualize and classify statistical information has some advantages. In the DTM the unclassed information are stored, and the user can access the data, without losing details that are generalized and simplified when the data are classified. The DTM is more useful to user, instead of a unclassed choropleth map, because the user can generate any classification map that he/she needs, without losing the original data. In this way, the user doesn't need interpreting the unclassed information, he/she will interpret the results of the classification that he/she automatically generated.

The result of the classification of statistical information, using DTM slicing in this digital model, is displayed in the screen, by a choropleth map, because the digital model stores constant values in the enumeration areas. When the DTM slicing is developed, the result contours of the classification DTM are the boundary areas itself. This fact permits to eliminate the necessary work when the data are classified separately, and then each class is associated with the correspond enumeration unit to generate the map. Even with automatic procedure, the DTM slicing avoids this search.

If the boundary enumeration units is stored in a vector structure, it is possible overlap the classified image with the boundary map. This permits the user to identify the units that correspond represented classed, as shown in figures 3, 4 and 5.

4. ARITHMETIC OPERATIONS WITH RECTANGULAR GRIDS

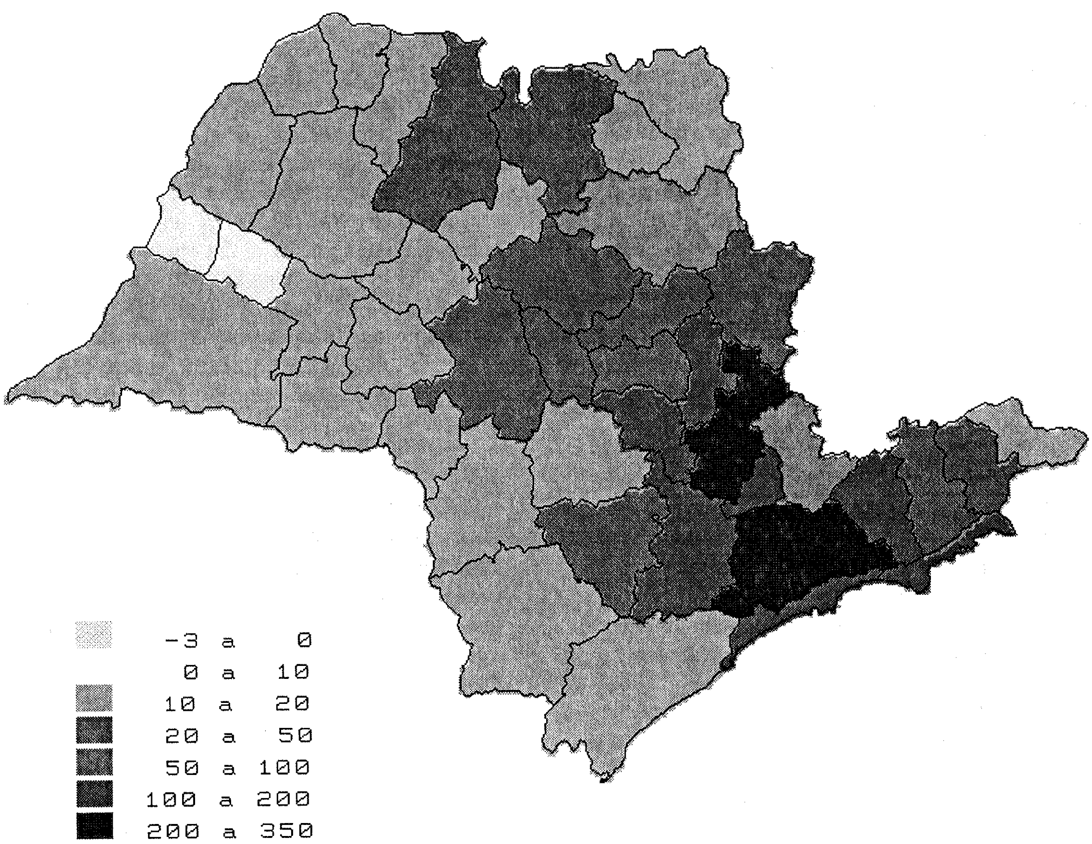
In the SGI, it is possible to realize arithmetic operations with two rectangular grids. Among this operations are: subtraction, addition, multiplication, division, mean. The subtraction operation between two grids is advantageous for representation of statistical data with DTM. If the user has statistical data of two different periods, he/she can generate two grids, for each period, and subtracting the grids, analyse the variation of phenomena in that period.

A exemple that presents the population growth, demonstrates this possibility to analyse statistical data. This exemple about the period between 1980 and 1991 is shown in figure 6. The procedure consists of:

- generating the two grids;
- subtrating from the 1991's grid the1980's grid values. The resultant grid represents the population growth in the period;
- visualizing this grids in 3D;
- slicing this DTM to observe the classes of population growth.

This classes can be used to specific analyses the user needs to develop. Figure 6 presents the choropleth map that represents the population growth in the periods mencioned above. This operation permit, for exemple, to observe that there was populational reduction in Adamantina region, between -3 to 0 inhab. per km^2, and high population growth in São Paulo and Campinas regions, between 200 to 350 inhab. per km^2.

Figure 6 - Population growth between 1980 and 1991 (inhab. per km^2)



5. CONCLUSIONS

With the produced DTM's, from populational density data sets, the user can retrieve information about a specific geographic position of the study area. Moreover, the user can visualize any classification he/she wants through DTM slicing. This fact shows that conventional Cartography is more limited than eletronic Cartography, for certain types of phenomena. Also it becomes clear that this representation is feasible, when digitally modeled. In conventional Cartography, population density is usually displayed with choropleth maps. On those maps, before the data are presented, the information is classified, and, therefore, it is generalized. So, the user can retrieve only processed information, and this information is restricted to only one classification.

In this work, populational density data are shown in some maps generated through DTM. But other kind of statistical information can be generating, classifing, analysing and operating with DTM techniques. In the same way that populational density was presented, analises using disease rate, infant mortality rate, crop yield per acre, and so on, can be performed.

REFERENCES

BURROUGH, P. A., 1986. Principles of Geographical Information Systems for Land Assessment. Clarendon Press, Oxford, 193p.

DENT, B.D., 1985. Principles of Thematic Map Desing. Addison-Wesley, Reading, Mass. 387p.

ICG - Instituto Geográfico e Cartográfico, Secretaria de Estado de Economia e Planejamento, Estado de São Paulo, 1984. Mapa de Divisão Municipal e Distrital do Estado de São Paulo.

SEADE - Fundação Sistema Estadual de Análise de Dados, 1992. Anuario Estatístico do Estado de São Paulo. pp 70-71.

SEADE - Fundação Sistema Estadual de Análise de Dados, 1994. Anuario Estatístico do Estado de São Paulo. pp 9-14.