# INTERPRETING IMAGES WITH GEODMA

**Thales Sehn Korting, Leila Maria Garcia Fonseca, Gilberto Câmara**

National Institute for Space Research (INPE)
Image Processing Division
Av. dos Astronautas, 1758 – São José dos Campos, Brazil
{tkorting,leila,gilberto}@dpi.inpe.br

**ABSTRACT:**

Object oriented analysis offers effective tools to represent the knowledge in a scene. Knowledge-based interpretation arises as an effective way to interpret remote sensing imagery. In this approach, human's expertise is organized in a knowledge base to be used as input of automated interpretation processes, thus enhancing performance and accuracy, and reducing at the same time the subjectivity in the interpretation process. Some systems such as Definiens, ENVI-FX, and more recently, InterIMAGE, have incorporated useful tools to aid the object-oriented classification. In this context, this work presents a system for object image analysis, called Geographical Data Mining Analyst (GeoDMA), which implements several mechanisms for automatic image interpretation. It performs image segmentation, objects feature extraction, supervised and unsupervised classification with raster, shape and cellular data sets. GeoDMA has been used for intra-urban land cover classification of high spatial resolution images and also to detect deforestation patterns in the Brazilian Amazon. Such different applications warrant the generalist behavior of the system. In this article, we discuss each module implemented in the system, the integration of objects obtained by segmentation to extract texture features and landscape metrics. We also show the main tools for data preprocessing, sample selection and feature visualization. Finally, one application of automatic urban interpretation is shown.

## 1 INTRODUCTION

In this paper we describe a novel software for Remote Sensing (RS) image analysis based on data mining techniques, called Geographical Data Mining Analyst – GeoDMA. It has been developed by the Image Processing Division at INPE (Brazil's National Institute for Space Research).

Some other image interpretation systems such as Definiens (Definiens, 2009), ENVI-FX (ENVI, 2009), and more recently, InterIMAGE (Costa et al., 2009), have also incorporated useful tools to aid the object-oriented classification. Such tools are useful in many RS applications, like urban planning, or deforestation detection, for instance. The increasingly amount of RS data brings the urgent need of computational tools to deal with it.

GeoDMA is a novel data mining software applied to RS, designed to be as generic as possible. Its intent is to detect patterns in geographical information databases. Being a free software its source-code is available, written in TerraLib, a free C++ geographical and image processing library. The system provides a flexible and friendly graphical user interface (GUI), as shown in Figure 1. All steps included in the data mining process are available in GeoDMA. The system provides a simple interface for feature extraction, visualization and normalization, sample selection for supervised algorithms, and classification methods to complete the interpretation.

## 2 MINING GEOGRAPHICAL DATA

GeoDMA was built to work with different types of RS data, like images or cadastral data. When the user provides an image, it is segmented into a set of regions, and the classification is based on their spectral and spatial features. According to (Baatz and Schape, 2000), a necessary prerequisite for object oriented image processing is successful image segmentation. (Haralick and Shapiro, 1985) have established that a good segmentation should
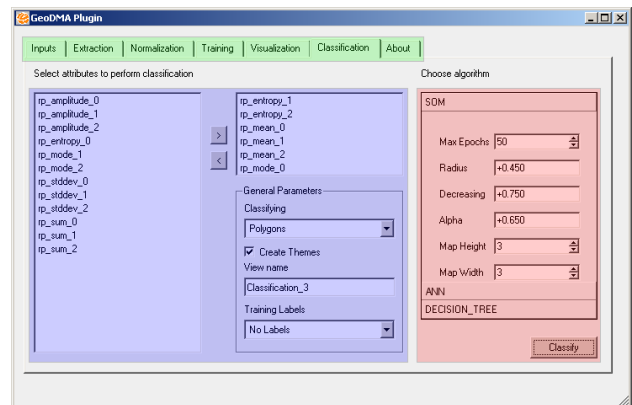


Figure 1: GeoDMA's GUI, Classification tab. Green area contains data mining steps, Blue area shows the available object features, and the Red area describes the functions to be applied into the data.

separate the image into simple regions with homogeneous behavior.

Segmentation must represent commonly found targets in images, like roofs (Chesnel et al., 2007), streets (He et al., 2003) and trees in the urban context. In agricultural and forest applications (Perez et al., 2000, Silva et al., 2008), regions are related to crops and deforested areas, respectively. Two techniques for image segmentation are available in GeoDMA. The first one is the region growing algorithm, based on (Bins et al., 1996). The second algorithm is based on (Baatz and Schape, 2000), in which the average image objects size must be free adaptable to the scale of interest.

If only cadastral data is available, it is also possible to classify, however using different features. They include topological and contextual relations among regions. The system includes landscape metrics as well, gathering cellular spaces with raster or vec-
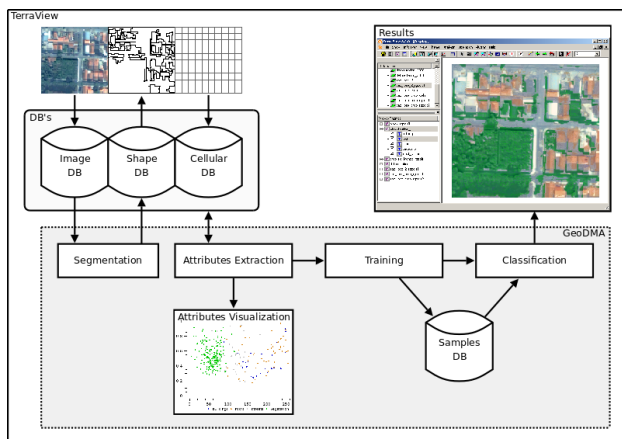
Figure 2: GeoDMA's framework.

tor information. Data storage and visualization in GeoDMA are provided by the free GIS called TerraView[1]. Figure 2 depicts the GeoDMA's framework.

Miller et al. related four main data mining steps, namely background, preprocessing, data mining itself and knowledge construction (Miller and Han, 2001). Such steps must be flexible and iterative, to improve the overall accuracy of every analysis. According to (Takatsuka, 2002) the lack of a single package to support and integrate these data mining steps over geographical information represents a noticeable bottleneck.

However, GeoDMA includes such steps. Preprocessing includes data selection, cleaning and reduction, outliers and redundant data detection. With feature space visualization, it is possible to explore data correlation and choose a subset of features for best classification. Visualization supports data preprocessing, selection of data mining tasks and techniques (Keim and Kriegel, 1994). Using the training tool, the domain-expert assigns representative data samples to each interest class.

Classification involves mapping data into specific categories whose cardinality is fewer than the number of data objects (Miller and Han, 2001). The algorithm called Self-Organizing Maps (Kohonen, 2001), available in GeoDMA, has the ability to group or typify automatically data according to different properties (Kalteh et al., 2008).

Supervised algorithms uses a priori knowledge created in the training step. It has been proved that experts often feel more at ease providing samples than developing rigid model-based preference rules (Greco et al., 2001). GeoDMA incorporates two supervised algorithms, the C4.5 classifier (Quinlan, 1993), which uses a decision tree to split data into different classes, and the Artificial Neural Networks, using the McCulloch-Pitts model (Haykin, 2008).

## 3 ONE EXPERIMENT IN GEODMA

Our system was applied in the urban environment (Pinho et al., 2008). Results were obtained using a Quickbird image from São José dos Campos, Brazil, composed by a panchromatic and a multispectral image with $0,60m$ and $2,4m$ spatial resolution, respectively. Part of the results are reproduced here. The input image (Figure 3) were segmented using the algorithm described

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Figure 3: Quickbird image.

in (Bins et al., 1996). Figure 4 depicts part of the resultant segmentation. Using the segmentation and the spectral information contained in the input image, automatic classification were performed.

Commonly found urban classes were defined and samples were selected in the training step. Classes include Ceramic and Metallic Roofs, Concrete, Asphalt Pavement, Swimming Pools, Shadows, Trees, and Grass. The system provides a friendly interface for sample selection, allowing the user to visualize the feature space. Training samples are highlighted on the scatterplots, giving an important tool for outliers and correlation detection. Figure 5 shows an example of feature space using two attributes extracted from the input data. The resultant classification using the C4.5 algorithm is shown in Figure 6.

The resultant classification, according to (Pinho et al., 2008), presented similar accuracy to the classification model built using a semantic network. The classification process in GeoDMA were
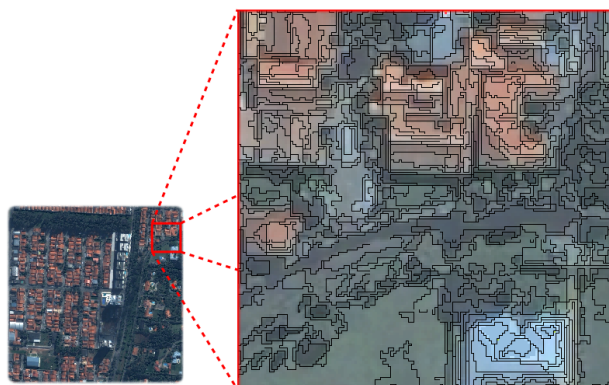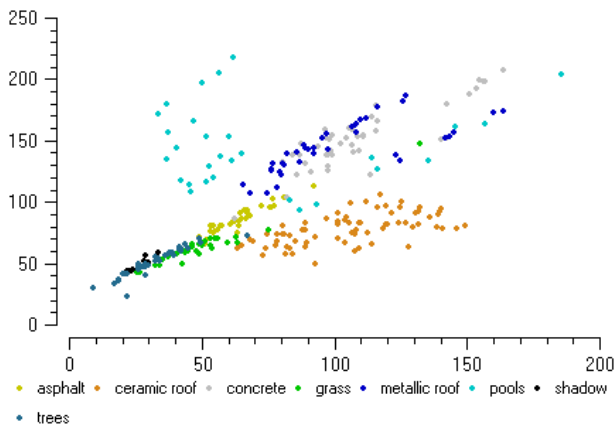


Figure 4: Resultant segmentation.

Figure 5: Features visualization using one scatterplot. $x$ and $y$ axis represents the average value for image bands 0 and 1.
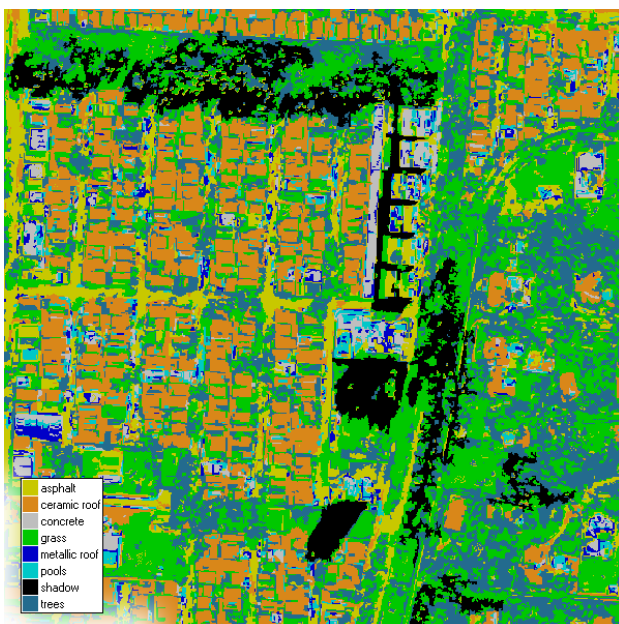


Figure 6: Resultant classification.

obtained more than 10 times faster than the construction of the model, which makes GeoDMA a good choice for image classification tasks.

## 4 CONCLUSIONS

(Openshaw, 1999) stated that the development of geographical data mining tools are a major research theme. In accord to (Han and Kamber, 2006), data mining and exploratory uses of information hold much promise. Exploratory tools should include novel methods for data visualization, and new techniques to describe the behavior of the different phenomena found in images. Research questions include if it is possible to apply the knowledge obtained from a certain region to similar imagery. In this scenario we presented GeoDMA, a free-software devoted to perform data mining analysis with geographical data.

Further research includes the implementation of multitemporal analysis, by integrating different periods in an image time series. By interpreting multitemporal imagery, we believe it is possible to infer automatically about changes occurred in the space. GeoDMA is freely available at `http://geodma.sf.net/`.

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