A Geographical Information System for Spatial Data Analysis Based on the Scalable Vector Graphics Standard.

Igor Pinheiro de Sales Cabral [1]
Jorge Henrique Fernandes[2]
Luiz Marcos Garcia Gonçalves[1]

[1] Universidade Federal do Rio Grande do Norte – UFRN
Caixa Postal 1524 – 59072-970 – Natal – RN, Brazil
{igor,lmarcos}@dca.ufrn.br

[2] Universidade de Brasília – UnB
Brasília – DF, Brazil
jorgehcfernandes@uol.com.br

Abstract. This paper presents two developed systems for analysis of geographical information, applied to specific regions in Rio Grande do Norte State, Brazil. The first implemented system uses conventional techniques (not for Internet use). We describe its internal structure, including the data base, mechanisms for extraction of information, and data treatment, which is done based on layers. We also discuss other implementation and maintenance aspects. Further, in the second system, we propose an improvement on the previous version, expanding it and developing functions for allowing its use on the Web. Implementation of this version was based on the use of Scalable Vector Graphics (SVG), a new standard for Web based GIS development. We discuss several aspects of this new Web system, in relation to the conventional one, also presenting a comparison between both approaches. Applications to industrialized and environmental areas are presented.

Keywords: GIAS, SVG, GIS, Spatial Analysis, environmental applications, Web.

1. Introduction

In this work we present two implemented versions, a conventional and a Web accessible one, of a system developed for analysis of geographical information, applied to a specific case study. The basis of the system corresponds to the association of micro-industries to a determined region of a map, to be actually kept correct with its approximated location.

The main characteristics of the proposed system are the used storage resources, management, manipulation and analysis of collected information. As example of analysis, from a sample of micro-industries on the region one can calculate the correlation of those with urban space reorganization in the city area. In the Web version, we use SVG for mapping and conversion of georreferenced geographical entities, and also for development of small systems using Oracle Data base. The adopted methodology was chosen after we applied similar concepts to geographical areas in Spain (Torremolinos, Málaga) and Germany (Zittau). In this way, this work basically proposes an enhancement in a software system, which makes it appropriated to several geographical analyses, being its use easy, with fast answer and low implementation and maintenance costs. Currently, the system is being applied to a pilot environmental protection area. This preliminary experiment shows its applicability to other environmental, in order to perform monitoring, currently being worked on at Federal University of Rio Grande do Norte.

2. The SVG standard

The SVG (Scalable Vector Graphics) is a standard for GIS development, recommended by the World Wide Web Consortium - W3C, to be used for creation of 2D graphics, elaboration of digital maps, and animation. Its language allows design of Web pages with high graphical resolution. Includes sophisticated elements as declivity, embedded fonts, transparency, animation, and filter effects, all using text commands. Graphics can be dynamically altered using scripts and a language based on the object oriented paradigm. It is possible to change any attribute of a graphical object and to treat events as for example mouse clicks. Any object of graphic type can be accessed by methods supported by the language, Neumann (2004).

There are some few products currently available based on SVG and other products that are in development process. Corel™ 9.0, Adobe™ Illustrator, and Sodipoli (Freeware) are examples of the first. SVG was partially developed by Microsoft, Adobe, Macromedia, IBM, Sun Microsystems, Apple, Xerox, Netscape, Corel, and Kodak. Currently, SVG files can be loaded into the browser by way of plugins. There are plans to, in short future, integrate it in the browser itself as for example in the Mozzila.

SVG uses a graphical file format, based on the Extendible Mark Language (XML). It is auto-defined as a Web development language provided to describe 2D graphics, allowing three types of graphic objects: vector, raster, and text. Any set of graphic objects can be grouped and transformed. Vector objects contain information about lines and curves of an image instead of information about its component pixels, Sampaio (2004). By using SVG, one can select, scale, index, and extract text. This allows high accessibility and internationalization. Based on texts, extern scripts, and links to the data base, SVG will be capable of following the current model, which is based on dynamical systems that use HTML language. Tools in the server and client sides have no problem working with text based contents of SVG files.

3. A case study in implementations of a GIS: Caicó, RN, Brazil.

The objective of this case study is to develop a geographical information system, called GIAS (Geographical Information Analysis System), that aids in the analysis of the urban space reorganization, in Caicó-RN. The system users are mainly researchers of the Geography Department of Federal University of Rio Grande do Norte. In the initial application, our users wanted a software capable of importing a city map, that could allow them to accomplish several analyses involving cap, hat, and outfit industries, through graphic tools. Low cost is the main issue that we considered.

3.1. Description of GIAS 1.0

The first system version, GIAS 1.0, was developed using the software Borland Delphi 6.0 with the purpose of being self-sufficient in the requirements and requisitions for analysis in the case study. It is composed of 14 forms that are linked in order to generate the final executable file, totaling 5.246 lines of code.

3.1.1. Using layers

Most of existing GIS allow separation of map information in logical categories called map layers. Each layer usually contains information from only one characteristic type or a small group of related attributes. Data is separated in layers, thus they can be manipulated and spatially analyzed alone or combined with other layers. The ability of separating information in layers and the combination with other layers of information are some reasons for which GIS offers great research potential. Layers can be used to create composed maps showing a variety of data, each one incrementing information about the region in study. Logically, when we separate data in layers, we make easier handling and using the database and its products. The **Figure 3** shows examples of layers.

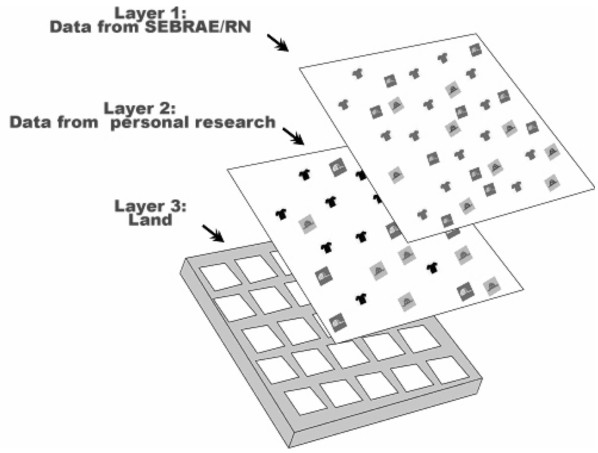

Figure 3. System with layers.

The system GIAS 1.0 has the ability of treating searches to be accomplished in different information plans, where each plan has its own caption to specify the cap, hat, and outfit industries. Sample data collected from some researches that were made by Brazilian Federal Institutes (SEBRAE, IDEMA, FIERN and others) was used by GIAS 1.0 to compare the industries growing and the reliability of the data collected. By treating these samples by software, a visual analysis of the thematic map can be carried out in several ways, according to the layer showed in each moment. For example, one can try the simultaneous visualization of SEBRAE and FIERN data; or only the FIERN data; or only the city map, letting the industries hidden; etc. Creation, edition and exclusion of each layer can be accomplished dynamically through a menu (using button options) presented in a form and the visualization, or not, can be done through the checkbox located in the corresponding layer (see **Figure 4**). Each information plan possesses a caption (see **Figure 5**) representing the service type of certain industry.

Figure 4. Layers management

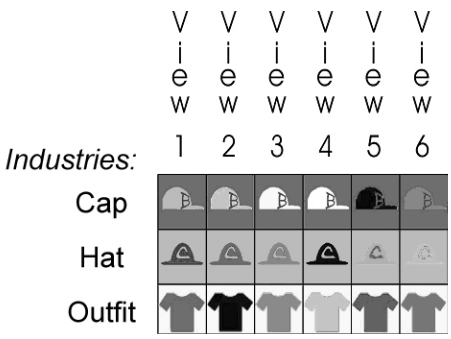

Figure 5. Layers caption

3.1.2. Output

A GIS software has as main purpose displaying, in several and qualitative ways, the data which was feed in the database. The effectiveness of a GIS is related to the way such information is extracted. We implemented in GIAS 1.0 four mechanisms for extraction of information: through graphics, sampling statistics, dynamical SQL (Structure Query Language), and thematic maps. These four components make GIAS 1.0 a versatile software with several possibilities of spatial analysis.

Charts are linked to information queries inserted in database, that give answers in a way that users have a better perspective of the spatial analysis (**Figure 6**). In this case study, we found eight possibilities for the types of graphics according to the application data used:

a) employment in a region;
b) formal, informal and mixed employment in a region;
c) value of production in a region;
d) modernization indicators;
e) the origin of the product buyers and the raw material;

Information can also be extracted from a relational database through procedures (SQL instructions), in which the user defines appropriate relationships for the query. Then, a control program uses relational algebra methods to build new tables. The main advantage, according with Burrough (1989), is that the queries can be formulated using rules based on boolean logic and mathematical operations. They allow different types of data to be searched, combined and compared. Among disadvantages, the operations involve sequential searches in the files in order to find the right data that satisfy the specified relationships, spending substantial time when data volume is huge.

The system has a practical way for information extraction using SQL. Form "consult" disposes several buttons with their functions in the respective labels, making more agile, dynamic, and easy to construct query instructions, addition, alteration and removal of data. Such form is very complete and overcomes the similar tools of most famous GIS that treat input SQL instruction in a manual way. An exception is the software Arcview that has a similar system, however with lower number of functions and without the possibility of data treatment through alteration, removal and addition. The **Figure 7** illustrates an example where the user wants to know how many cap industries are installed in the neighborhood of Caicó city. This example is based on sample data collected in loco (CodView = 1).

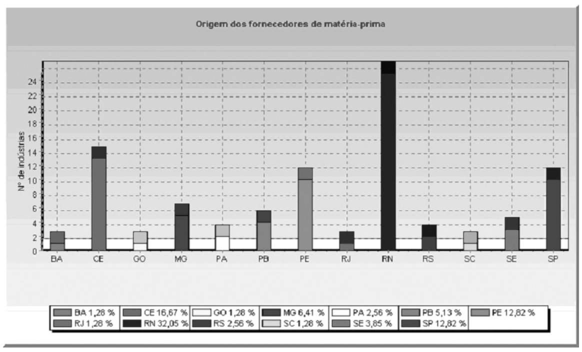

Figure 6. Graphic

Figure 7. SQL Instruction

Use of statistical sampling makes possible extraction of several information types as amount of industries, used labor, industries installed in certain time periods, family employment, industry type, classification. It also makes possible to calculate the total value of production from certain area previously selected in the map. Such functionality becomes quite useful when the user needs information from a specific city, neighborhood, block, etc. Properties of a selected area can be easily returned (see **Figure 8**).

Figure 8. Statistics

The use of thematic maps as an output mechanism is common in most GIS and denotes the elements that are in study with their respective positions, visually represented in the virtual world. For example, starting from information contained in the database, the system can generate images corresponding to the industries in a map that initially contains only city blocks. The images are associated to a specific location in the map. We can have thematic maps with different representations just changing among the visible and hidden layers that are available (see **Figure 9**).

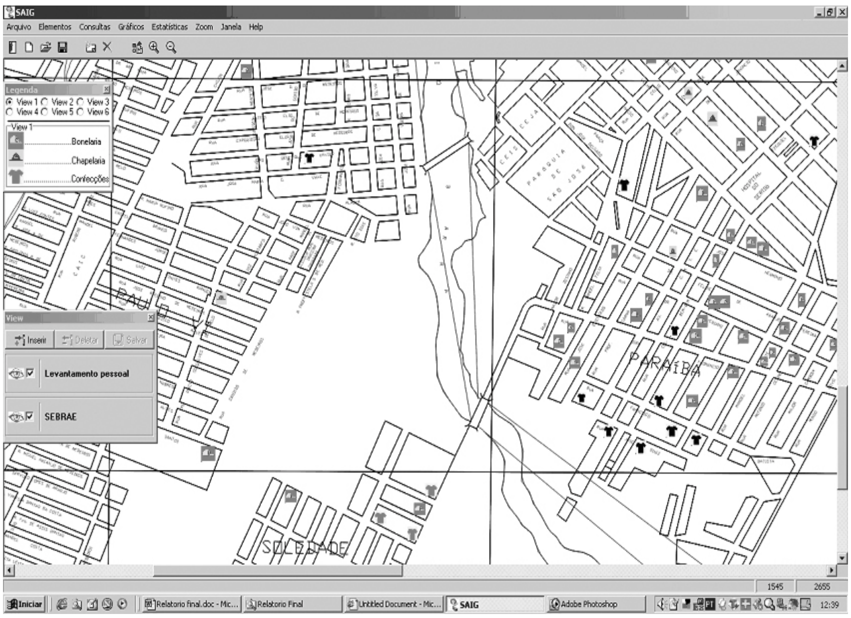

Figure 9. Thematic map

3.2. Description of GIAS Web

Once concluded the first version (GIAS 1.0), we noticed that the system would be able to reach users not just on local computers, but also on computers connected through the Internet.

Thus a new system called GIAS Web gave to the project higher accessibility making the study in the case study city more practical, without territorial limits. The main objectives behind the development of GIAS Web are:

a) supply a set of tools with which the user is able to work with data in long distance, independently if GIAS 1.0 is executed in the local machine;
b) supply functions to accomplish analyses with base in the generated thematic map. For example: the person responsible for data collection may store information in the database immediately after acquisition of answers from a questionnaire, and, almost in real time, other user in another place consulting such information using GIAS 1.0 or GIAS Web.

Spatial modeling was done by first converting an existing map to SVG format, then using Sodipodi for creation and manipulation of files with extension SVG and Macromedia Dreamweaver for creation of pages in PHP format. The result is an implemented software composed by 10 forms, totaling 67.618 code lines.

3.3. Connection between GIAS 1.0 and GIAS Web

During the implementation of GIAS Web, two important questions came up. First, how can the data contained in the database be reusable and how would data be converted to the Web system without distortion of its real places between layers? Second, how can a connection among these two systems be accomplished for making possible that any alteration made by the GIAS Web can have effect in the GIAS 1.0 and vice-versa? To answer these questions, we made a small modification in the systems, for using only one database. Therefore, in the implementation, only one database supplies relative information about the positioning and the industries data for GIAS 1.0 and GIAS Web, in a simultaneous manner.

3.4. Comparative analysis - GIAS 1.0 x GIAS Web

We first provide a discussion about what is the best method to work with GIS development, if SVG or Delphi. In SVG standard, maps are represented in vector format while in Borland Delphi they are in raster format. Graphics in vector format have a better structure of files, becoming possible to perform pan, zooming and other operations with better quality. **Figure 9** represents a screen shot of GIAS 1.0 while **Figure 10** represents a same region in GIAS Web. Comparing the two images, it can be visually observed that there is a larger accuracy in the details consequently better representation of the map in vector format (GIAS Web). This makes possible not only to work with industries but also with map information, such as: lake, blocks, streets, avenues and so on. Also, we are currently using this system to show environmental data sampled from a small portion of the Protected Area of Coral Reef of Rio Grande do Norte (APARC-RN) and it has proven to be useful (see **Figure 11**).

Another point that must be taken into account is about the relation to the pattern applied in the first version of the system that was maintained in the subsequent project phase: the icons for industry type representation continue with the same graphic appearance, the structure of the objects, etc., in SVG format.

Based on the above discussion, we present advantages and disadvantages of the two developed GIS platforms which were implemented using different platforms and languages. Several analyses were performed during implementation and system execution phases.

- Advantages of GIAS 1.0:
  a) Countless libraries coming from Delphi that can be used for map treatment and manipulation;
  b) Better tools for graphics use;
  c) Better information security.

- Disadvantages of GIAS 1.0:
  a) User is limited to use the system that is contained in a local machine;
  b) Unique programming language: PASCAL, limiting the accomplishment of necessary methods not supported by the language;
  c) Higher cost, once it depends on the software Delphi for development.
- Advantages of GIAS Web:
  a) Larger accessibility of the system; the whole world can access it through the internet;
  b) Interaction among several programming and script languages in the same form;
  c) Quality of the image is not affected if increased or reduced.
- Disadvantages of GIAS Web:
  a) Few available libraries;
  b) Data safety, due they are vulnerable to alterations by invasions or manipulation by users not authorized.

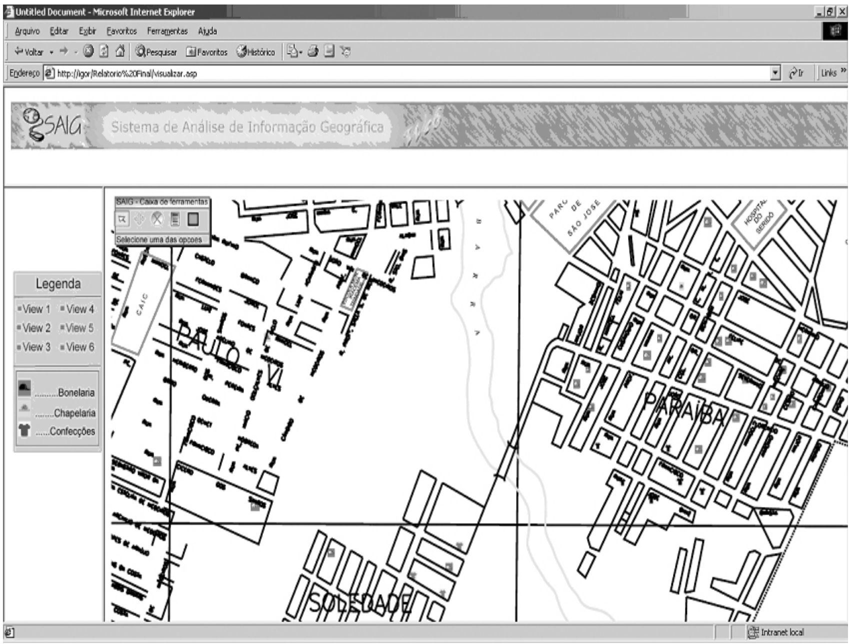

Figure 10. GIAS Web

4. Conclusion and perspectives

Use of SVG to develop geographical information allows easier access to data and with less cost. That is, the format SVG is based on XML, consequently free to be used by several users independent of platforms, software, and hardware. As it is a standard format, more and more applications will be able to give support to SVG, turning the choice more variable and cheaper.

We can not generalize that SVG format is better in any case, however we conclude that it could be better applied in the specific case of study, involving relational data of industries in Mossoró, RN, Brazil and also in a small portion of Maracajaú Coral Reef Protected Area. In the last case, GIAS Web was used to map underwater structures that were classified in a previous work, Farias (2004), in an area of about 300x400 meters (see **Figure 11**). We further intend to extend the developed GIAS Web system to all the Coral Reef region, which includes three regions of 6 x 3 kilometers, then allowing environmental official organisms to use it for analysis in these regions.

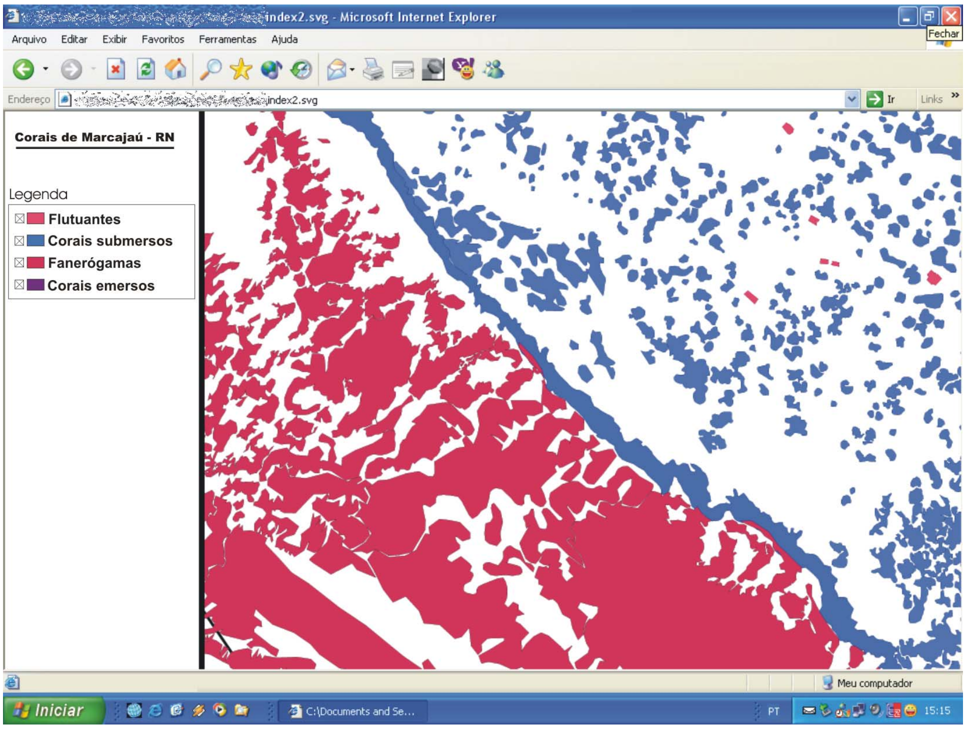

Figura 11. Map from Maracajaú Coral Reef region published in the Web using SVG

References

BARROS, S. Ademiro. **Sistemas de Informações Geo-referenciadas: conceitos e fundamentos.** Unicamp, 1999.

BORILLO, Ricardo. **SVG: gráficos e interactividad en la Web.** Available in: <http://www.mailxmail.com/curso/informatica/svg>. Accessed in: Out. 2004.

BURROUGH, P.A. **Matching spatial databases and quantitative models in land resource assessment.** Soil Use and Management, 5, 3-8.1999

CORNFORD, Dan. **Geographic Information Systems.** Londres, Aston University 2003.

COSTA, Maria de Fátima. **Cadeira de Sistemas Multimédia.** Available in: <http://student.dei.uc.pt/~mcosta/smm.html>. accessed in: Jan. 2004.

FARIA, Nuno. **Visualizador de Mapas para PDAs em SVG.** Available in: <http://bragatel.pt/ns000660/nasf/estagio.html#SVG>. Accessed in: Out. 2004.

FRITZE, Alexander. **Mozilla SVG Project.** Available in: <http://www.mozilla.org/projects/svg/>. Accessed in: Out. 2004.

NEA - Núcleo de Estudos Ambientais da UFRN. Available in: <http://www.natalnet.br/nea>. Accessed in: Out. 2004.

NEUMANN, Andreas; WINTER, Andréas M. **Vector-based Web Cartography: Enabler SVG.** Available in: <http://www.carto.net/papers/svg/index_e.shtml>. Accessed in: Out. 2004.

NEUMANN, Andreas; WINTER, Andréas M. **Vector-based Web Cartography: Enabler SVG.** Available in: <http://www.carto.net/papers/svg/index_e.shtml>. Accessed in: Out. 2004.

SAMPAIO, F. Nuno André. **Visualizador de Mapas para PDAs em SVG.** Available in: <http://bragatel.pt/ns000660/nasf/estagio.html#SVG>. Accessed in: Feb. 2004.