Scientific Visualization of Occupation Data for Spatial Analysis of Animal Behavior Using OpenGL

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Abstract — The overriding goal of this work is to present the implementation of a tool for spatial analysis of georeferenced information as a means of gaining insights into animal behavior from scientific visualization. The spatial occupation data of monkeys from the species *Callicebus nigrifrons*, located in “Santuário do Caraça”, in the state of Minas Gerais, Brazil, has been collected by researchers of the Graduate Program on Vertebrate’s Zoology of Pontifical Catholic University of Minas Gerais (PUC Minas). The registers include information regarding gender, age, activity being performed in the moment of the observation and the height occupied in the trees of the forest. The project assumes a multidisciplinary characteristic, with several knowledge areas, such as Geography, Computer Science and engineering, connected together into providing Zoology’s scientists with a new comprehension of their problem.

Keywords: Scientific Visualization, Layer's Visualization, Spatial Analysis, OpenGL, Graphics Computation, Graphics Computation, Multidisciplinarity.

I. INTRODUCTION

The Scientific Visualization is an area which evolved from Computer Graphics. It studies algorithms and software to generate images that assist the user interpretation of data. It’s also an area that has been growing in recent times due to the increasing computer technology. It’s being used not only in Computing, but also in Biology, Geography, Medicine, Electrical Engineering, among others, to meet the need to visualize data sets of high level of complexity and size.

The graphic library chosen to be used for interaction between tool and user was the OpenGL, selected for being easy to implement and offers a wide variety of resources. Its use allowed the application of filters chosen accordingly to the researchers’ needs, which were implemented using the concept of geoprocessing layers. From this analysis, it was realized the importance of the information treatment for a better interpretation of the monkeys’ spatial occupation raw data collected through the survey conducted by zoology’s researchers.
II. OPENGL

The development of high performance graphics applications used to be exclusively of research institutions or companies that owned specialized graphics hardware and skilled programmers. A few years ago, this situation has changed with the appearance of graphics cards for personal computers and the development of graphics libraries which did not require extensive programming knowledge or hardware. One of such libraries widely used is OpenGL [1].

OpenGL can be defined as an open and multiprocessor specification of graphics routines and modeling libraries, used for the development of computer graphics applications, such as games and visualization systems. It allows developing interactive applications and generation of 3D images with a high level of realism. Its biggest advantage is the speed, since it incorporates several optimized algorithms, including the graphical primitives draw, texture mapping and other special effects [1].

Its operation is similar to a library of C programming language. However, when is said that a program is OpenGL based, means that it was written in some programming language and uses one or more OpenGL library.

The main OpenGL tools used in this project are:
- Geometrical primitives (points, lines and cubes);
- Geometrical transformations (rotation, translation and scale);
- Texture mapping;
- Rendering;

III. COMPUTER GRAPHICS

Computer Graphics refers to the generation of images which allows the visualization of real and imaginary objects represented in a computer model. It involves the creation, representation, processing, manipulation or evaluation of graphical computer objects, as well as the association of graphical objects with non-graphical data available for access [3]. It’s a method applied in many areas, from computers (through the development of graphical interfaces), operational systems and websites, to the development of games and animations.

In the context of data visualization, the Computer Graphics’ importance is in developing a human-machine interaction, in order to facilitate data interpretation [4].

Under the area of Computer Graphics, the techniques that allows the generation of images can be divided as:
- Process object modeling.
- The representation, in different forms, of collected data.
- Generation of images with variable degree of realism.

In this research, the following Computer Graphics software were used: Adobe Photoshop, CorelDraw and Blender.

IV. THE VISUALIZATION TOOL

This tool, developed by undergraduation and graduation engineering students, was the result of a research project that consisted initially in the analysis of a great amount of data about the spatial occupation of monkeys from the species Callicebus nigrifrons. The research was focused on the search for ways of visualization that would allow the study of animal behavior by Zoology researchers, interested in the observation of several animal groups and in the pattern identification of the male and female behavior.

The programming environment and language used for the development of the visualization tool was the Dev C++ and the C/C++ programming language. The research, which culminated in the tool presentation, was developed by Engineering and Information Systems graduating students. Its process was divided in 2 steps.

1st step:
- Identify, along with the Zoology researchers, the goals to be achieved by their studies, using the visualization tool;
- Identify the spatial occupation raw data available;
- Study the general concepts of Computer Graphics and its applications in the proposed problem;
- Study the OpenGL library and how it could be applied in the image’s generation;
- Deepen the knowledge in the C/C++ programming language, chosen to be used in the implementation of this visualization tool;
- Pursue the spatial analysis concept used by Geoprocessing, which consists in the visualization by layers of a raw georeferenced data, searching for patterns identification;
- Implement filters that allows the user to analyze the spatial occupation raw data, by the layering visualization.

2nd step:
- Study the ArcView software (part of ArcGis software, which is a Geographic Information System for working with maps and geographic information), whose Analyst 3D tool was used to build the profile of the region’s topography, from a topography map;
- Choose 3D models to be used to visualize the spatial occupation data, collected by graduation program in Vertebrate’s Zoology researchers of PUC-MG, with the help of OpenGL libraries.
- Apply textures that enrich the viewing, and differentiate the animals by gender;
- Model the studied region’s terrain, seeking to carry the Zoology researcher to an environment closest from the real one;

Next we will be describing the tool developing process mentioned in the steps 1 and 2.

IV.1 – THE TOOL’S PRELIMINARY VERSION FOR THE ANALYSIS OF THE ANIMAL SPATIAL OCCUPATION DATA

The research first step culminated with a preliminary version of the software, which made use of simple.
geometrical primitives (points) to map the spatial coordinates of the data. Besides the “x” and “y” coordinates, the absolute height (measured in relation to the ground) is defined by the “z” axis. At this version, spatial analysis concepts were applied in order to identify behavior patterns.

The tool’s initial implementation was based on the reading of the raw data (not yet processed) retrieved from a “.txt” file. From this point forward, the organization of the data was made (name, gender, height in relation to the ground, geographic’s coordinates and living group) in specific vectors.

Initially, the monkey’s location was represented by points inserted inside a unitary edged cube, which represented the animal’s habitat. Following that, assuming the needs of the zoology researchers to study the animal’s behavior, the focus became the implementation of selectable layers to filter the displayed data.

Using Computer Graphics resources, we’ve implemented the first filter, which separated the monkeys between gender (male and female). It was attributed to the males the blue color and the females the red color as seen in Figure 1.

![Figure 1 – Points representing the animals inside the cube.](image)

To map the primitives (points) in the cube, the point of smallest coordinate value was determined among the raw data. After that, all the points were translated in the x, y and z axis, using the smallest coordinate value as reference in each axis. This way, the minimal value becomes part of the cube’s face. Afterwards, a correction was made by dividing the real coordinate of the points by the difference between the maximum and minimal amplitude of the spatial axis in question. This way, the (x,y,z) projection of occupation vectors becomes included between 0 and 1 and, consequently inside the cube.

To better navigate inside the virtual space of the cube, the tool also implemented operations that allows the user to define his degree of proximity to the date in question. Zoom, translations (both using the keyboard) and rotation (using the mouse).

Subsequently, the large data manipulation created the need to implement new filters on data visualization, organizing the content into layers of information [5].

The filters layers provided by the tool, allow to distinguish the monkeys in groups, heights, name and gender, which facilitates the spatial analysis to search for patterns of behavior. As the functions of handling menus with OpenGL are not intuitive, a side menu was created using functions related to the mouse positioning [Fig.2], that allows navigation between layers more practical.

![Figure 2 – Layers’ menu.](image)

**IV.2 – TOOL VERSION WITH IMPROVED VIRTUAL REALITY FOR SPATIAL ANALYSIS OF ANIMAL OCCUPATION DATA**

The Virtual Reality can be defined as an interface between user and machine, simulating a real environment and allowing the interaction with it [6].

The second step of the visualization tool development, still undergoing refinement, predicts the implementation of improved Virtual Reality. In this context, the implementation focus became the spatial occupation data refinement, through textures and 3D models. In addition, we performed a graphic mapping of the terrain where the data was collected, using the Analyst 3D tool from ArcGis software. This step was marked by its multidisciplinary characteristic, addressing Geoprocessing and graphics design knowledge.

The texture mapping in OpenGL, consists in loading the texture, defining the vertices in which it will be used and finally applying it.

The 3D modeling is a Computer Graphics’ area that acts on the creation of three dimensional entities, which can be statics (rendering) or moving images (animation), with or without interactivity. At this tool developing state, the modeling used has a static characteristic and without interactivity, because of its simplicity in visual data representation. Later studies and implementations will allow the dynamics modeling usage with interactivity, seeking seasonal behavior patterns in an improved Virtual Reality environment closest to the in loco animal visualization.

To the modeling, we opted for Blender software, which offers monkeys 3D models. With the model in the 3DS file format, a function was used to load it in the OpenGL environment. With the model inserted, was possible to apply...
textures and geometrical transformations, in order to suit it in the virtual space formerly occupied by simpler primitives, like points [Fig.3].

For the terrain graphic’s mapping was first used the ArcView software to make the geoprocessing of the topographic regions’ data. By the vectorization of contour lines, the program creates a Hypsometric map (representation of relieves through colors), which subdivides the relieves in greyscales where the limits are: white, representing the highest point of relief, and black, the lowest [Fig.4].

Afterwards, we used a C/C++ language algorithm (Height Mapping) that performs the reading of a heightmap in “.raw” file format, associating each value of the 256 shades of gray from the file to a corresponding height. The map is then scaled to the dimensions compatible with the cube [Fig. 5].

With the terrain inserted into the cube, the 3D monkey models were loaded in it. The Figure 6 illustrates a scene in which all the monkeys are displayed in different time periods.

The current work to improve the tool consists in introducing a dynamic model that allows seasonal visualization of the gross data (including temporal filters), while increasing the Virtual Reality sensation. Furthermore, we will apply texture over the relief, insert 3D models for the trees and also include new models to represent the monkeys’ activities, such as: feeding, foraging, getting around, sunbathing, and others.

V. CONCLUSION

To achieve the proposed objectives, it was necessary the use of computational resources such as 3D modeling, geoprocessing, graphical computing and high level programming. Thus was aggregated knowledge from several areas, transforming it into a multidisciplinary work.

As Scientific Visualization serves to assist in the interpretation of large amounts of data, it was necessary to generate images’ layers. Thus, we created an interface between data and user, allowing the observation and understanding of factors that might otherwise pass unnoticed by the raw analysis of the data. This fact supports the work of the masters in Vertebrates’ Zoology and other researchers in related areas.

The next research goal is to generate images related to spatial occupation density, using parallelism as a way to increase computing performance.
ACKNOWLEDGMENT

We would like to thank the PROBIC (Program of Undergraduate Research at Pontifical University of Minas Gerais - PUC Minas) and the FAPEMIG (Foundation for Supporting Research in the State of Minas Gerais, Brazil). Also, we would like to thank the Department of Geography at PUC Minas, in particular to Professor José Flávio Morais Castro, for his generous contribution in producing this work.

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