MODELLING OF URBAN ENVIRONMENTS

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ABSTRACT:

As a result of creation and handling of 3D digital map, approach to geographic environment has been revolutionized rendering possible an upgrade dynamic and objective analysis and making-decision. Our work is based on Cartography from stereophotogrammetry first where a 3D environment is created allowing an analysis and management on an own system providing a highest knowledge on environments is became a top necessary for environmental studies in real time and for a global analysis of urban areas. Thematic items and urban projects are created master using this technology. Based on the above mentioned work a prototype and a methodology have been created in order to develop a base modelling of several areas projects. So, multimedia products and maps edition on WEB servers will be improved.

1. INTRODUCTION

The level of optimization reached in the computation systems destined to manage graphic objects; the development of sensors of high resolution; the growing structure in anarchical urban environments and the interest in manipulating the information 3D obtained by photogrammetric methods in order to facilitate the integral studies and the taking of decisions with more degree of objectivity and dynamics allowed to develop the **Modulo3D** application on the **CartoSIG**[2] system providing an enhancing to the quantitative as well as qualitative knowledge of the environment.

The 3D models propitiate analysis on general situations with a better degree of comprehension and objectivity when recreating the complex study scenarios with an elevated degree of realism.

The present work describes the structure of the created application considering the harmonic integration of the 3D information with other sources of data so as to arrive to an integral management of the geographical scenarios, allowing the dynamic connection between the different applications that integrate the system, manage the objects and navigate on the scene.

2. GENERAL COMPOSITION OF THE SYSTEM

The Modulo3D application has been developed to work linking in real time with the model represented in 2D.

The system loads the information coming from different sources and locates them in layers, with the possibility of being published.

The visualization in 2D allows the work with a TOP view, where the datum keeps its height value, which is only manipulated by the 3D application.

The general design of the application is shown in the figure 1.
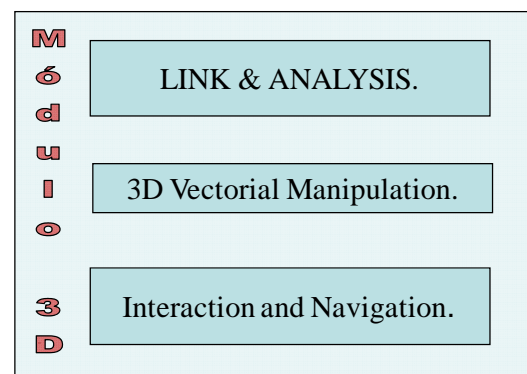

Figure 1. General design of the **Modulo3D** application.

The functions enunciated in figure 1 are carried out in the following way:

The **link** is carried out through exchanging the information of a list, distinguishing the elements by its layers and trying to those owing description in the field of height.

The consultations for the **analysis** are programmed on SQL, acting on the 3D and 2D environments.

The **three-dimensional vectorial manipulation** of the corresponding elements of the layers of the relief type is triangulated to conform the surface, specifying the ranges and variety of colors in order to differentiate the unevennesses. The surface can be shown in mesh or continuous shading.

The shape elements enter to the modeling process in charge of forming the structure of the objects on the scene starting from the vertexes that define its geometry to so as be transformed and simplified to primitive geometric forms.

Three are the main objects of the urban environment to represent in 3D: relief, sidewalks and buildings. The altimetry controls begin to validate the elements in an isolated way and latter in the geographical context in which they are located.

The **interaction and navigation** is carried out when the Modulo3D is activated, showing the work scene from different perspectives and amplifying degrees, with a pleasant **visualization** and a flexible displacement in the face of a realism that includes lights and shadowing of the objects.

Indistinctly, views 2D and 3D are activated. Only with this processing the observer's and he camera position change, by using the Zoom, Pan tools and by Drawing elements, without modifying the identification of the associated object.

It is in the view 3D where each object is three-dimensionally modeled transforming it into a solid, out of:
- Determination of the height of the objects on the terrain.
- Orthogonal Projection to the surface.
- "Blending the solids `objects with common faces.

3. GENERAL STRUCTURE OF THE MODULE

The general structure of the three-dimensional treatment module is represented in the figure 2, indicating the main parts that integrate it.
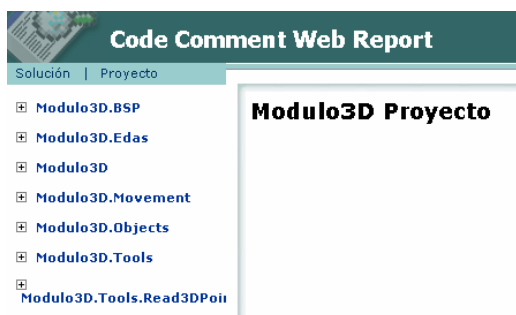
3.1 Classes structure

Figure 2. Structure of the **Modulo3D** application

Modulo3D offers a library of classes (DLL) on the platform **.Net** with the intention of facilitating the necessary functions for the visualization and three-dimensional interaction of the geographical information, thus being integrated to the **CartoSIG** system in an easy and robust manner.

Classes:
- Library of Structures of data (**Edas and BSP**): Encapsulates the classes representing the structures of data: Lists, Edges, Balanced Tree (AVL), and Binary tree of Partition of the Space (BSP), dedicated to improve the temporary costs of the algorithms due to their high search and storage costs.

- Library Módulo 3D (**Modulo 3D**): Allows the exchange through the functions:

  - **Selection**: Activation of selection and consultation mode.
  - **Pan:** To travel on the scene.
  - **ZoomIn and ZoomOut**: Magnifying and Diminishing

  - **Textures** : Defines the association patron of textures.
  - **Mesh**: To visualize in wire mode.
  - **CreateWindow**: Creates the window OPENGL 3D, knowing the beginning width and height coordinates.
  - **LoadTextures**: Loads the textures specified in the textures.xml file.
  - **CreateWorld**: Creates the world or scene to visualize, to which the objects that conform it will be added.
  - **TerrainFromArray**: It creates a terrain taking the points from the list that conforms it.
  - **TerrainfromFile**: It creates a terrain from the information the " .SRG " file type contains the points that conform it.
  - **PoligonFromArray**: It creates a polygon out of the points stored in a list, with its own color, keeping its identification so as to interact with it in mode selection.
  - **CreateObserver**: The observer is created, with its window and world associated to carry out the visualization.
  - **DestroyWindows**: It closes the window created with OPENGL 3D.
  - **Colors**: Define the palette of colors when it is visualizing without textures.

- Movement Library: Contains the Camera, This class allows to carry out all the necessary functions of panning, zooming as well as moving in a specific direction for looking at a scene. The class Observer controls all the camera movements and show the scene (Render). These movements are defined by the user by means of the keyboard and the mouse.

- Objects Library: three dimensional hierarchy of objects with simple and compound objects (e.g., the world or scene that it will visualize). The objects are the components of the diverse layers in which the geographical information to visualize is organized, that is to say, terrain, the layer relief and polygons, of the layer areal with the information corresponding to the sidewalks and buildings of the map in question.

- Tools Library: Offers the common auxiliary tools for all the types of classes of the system.

  - **IOSourceFile**: Reads the information of the file with extension SRG (System of Graphic Representation) characteristic of the CartoSIG system;
  - **TexTureList**: It loads the objects` textures defined;
  - **ThreePoint**: It defines the points in three dimensions (x, y, z);
  - **WinApi**: It exports the functions of the libraries of Win32 to capture the mouse and its current position, and
  - **Utils**: it encapsulates the data common to the information visualizing 3D and it operates with the graphic functions of OpenGL.

4. IDENTIFICATION OF OBJECTS AND ALGORITHMS TO MODEL

CartoSIG manipulates the elements according to the classic distribution adopted in the SIG: points, lines and shapes; to this version the type of relief layers is added.

The modeling of the objects is divided in two groups attending to their topologies:

- Groups characterizing the morfometric structure of the terrain and they have a GLOBAL character, contained in the TERRAIN category. It contains the information of bench marks on the terrain, coast lines, reservoir lines, curved of level and pickets generated by published meshes.

- Groups that conform closed lines with topologies differentiated in areal layers to develop the defined three-dimensional objects as POLYGONS and they have a LOCATED nature. Other elements described in the structures such as sidewalks, blocks, parcels and buildings are including and are described from its TOP view in the Photogrammetric Stations and they have a hierarchical order in accordance with the function of their location on the terrain, evaluating the space characteristics which precedes it.

The defined color for the layer is assigned to the sidewalk elements as well as defined values to the buildings elements with defined values of texture defined by the user or they may be aleatory according to the selected palette of colors, allowing the differentiated visualization of each object, including the contiguous structures mediating in adjacent buildings.

The routes are defined by the lines of parallel sidewalk conforming closed spatial shapes

The hydrographic elements will be treated in their edges defining the line of maximum bench mark. In the case of the coast the line will be created by water line or the "bench mark zero" when it is not perceptible. This element in the modeling scene should have a closed conformation.

4.1 Modeling the terrain

The digital pattern of the land is created by implementing the algorithm of **triangulation Delaunay**, which generates equilateral triangles starting from the supplied data 3D.

The determined points using the photogrammetric technical define the surface of the ground, **CartoSIG** manages the data in structure 2D keeping the value of the height in the " Elevation " field.

The **Delaunay algorithm** has been applied under the variant of incremental triangulation [3], to eliminate redundant points on oneself position or erroneous, validating each one of the edges so that they fulfill the condition, being modified when the condition is not satisfied with in reference to the addition value of internal angles and its distribution. ccording to informatics terminology in computer terms this algorithm can diminish its temporary cost to O(nlogn) if logarithm cost data structures are used, the type of binary tree balanced of searching (AVL).

4.2 Polygons Modeling

A polygon is compound for a sequence of vertexes, ordered in counter-clockwise direction to guarantee a correct visualization of the object when establishing the normal vectors in the correct projection to assume the global effects of illumination, tone, texture and shadowing in the same sense.

The modeling of the polygons can be implemented by diverse algorithms, according to the characteristics of the elements to be processed:

4.2.1 Triangulation of monotonous polygons for holed polygons

A simple polygon can always break down in monotonous pieces carrying out a sweeping of the plane (algorithm plane-sweep). Once divided each piece is triangulated by the algorithm of monotonous triangulation.

4.2.2 Triangulation with Sweeping of points for the regular polygons

The sweeping of the elements that conform the polygon allows their decomposition, and at the same time diagonals are added to go conforming the pieces of minimum structure (triangular) considered as monotonous.

The lack of horizontal monotony only exists in the vertexes which interior angle is bigger than 180º and both edges are towards its left or its right.

The basic elements of the algorithm are:
- **Stopping points:** The ends of the segments of the polygon.
- **Sweeping state:** It is given by the list of edges intersecting the sweeping line.
- **Processing of the stopping points:** In the algorithm they are six types of stopping points, in dependence of the condition that fulfilled define aspects: .separation, union, beginning, ending, superior chain, inferior chain.

Once the polygon was triangulated, the SIG only provides the superior part of the object which was created using stereo photogrammetric methods. It presupposes the projection to the preceding object or in it hierarchical order or in its defect until the terrain. The polygon vertexes are manipulated in counter-clockwise, an calculating the perpendicular up to the terrain, an intersection point is created and the faces of the polygon will be drawn with the original and those projected vertexes.

5. ACHIEVED RESULTS

The Modulo3D application on the platform CartoSIG has been evaluated considering the information created by stereo photogrammetric method for mapping the plans to scale 1:500 of an urban environment. The evaluated region is divided by a river that ends in the sea in the Havana Coast. In Figure 3 different views of the system are represented with the modeling urban environment.

6. TECHNICAL REQUIREMENTS

The CartoSIG system with the module of integrated handling 3D needs the following requirements to work in an efficient way with an acceptable speed:
" 128 Mb of RAM as minimum,
" 1Ghz of speed (Ideal PIV with 2 GHz),
" Video card with more than 128 Mb.
" Framework 2.0.

7. CONCLUSIONS AND RECOMMENDATIONS.

After validating the structure of the application of Modulo3D and its integration to platform CartoSIG the objective of developing a tool inserted in a platform SIG that allows the interaction, handling and visualization of the environment and the objects that integrate it in a general and detailed mode, and representing them in their correct geographical location, magnitudes and geometry.

To arrive to the presentation of the present work as colophon of the results achieved demands a recognition to all the technicians and specialists that have supported in a permanent way the development of our specialty.
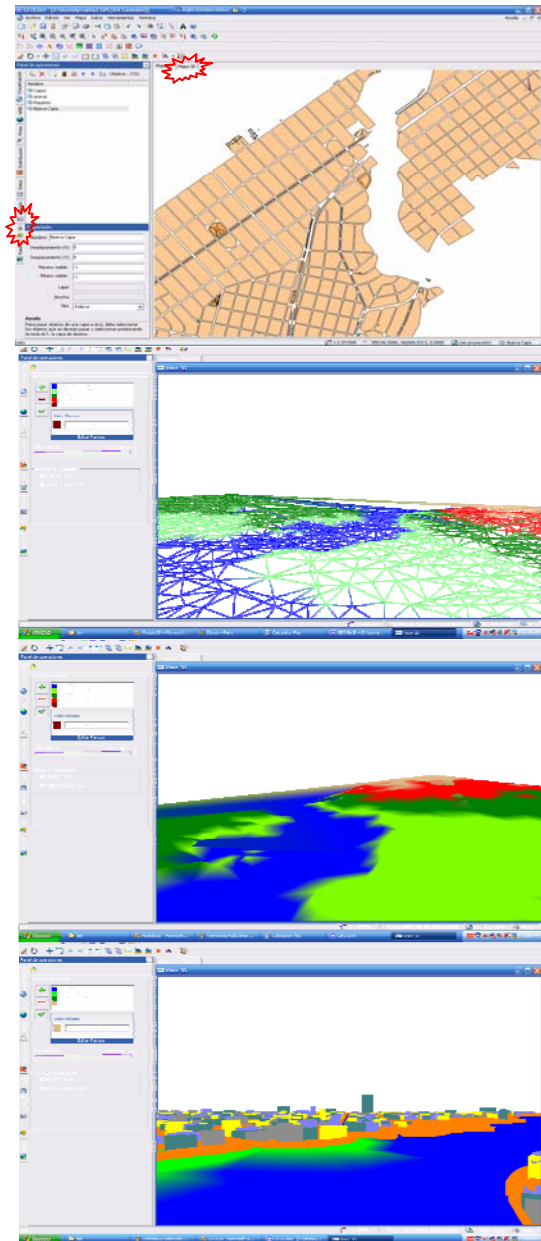

Figure 3. a) View 2D; b) Mesh, c) Terrain shadowed; d) View on Modulo3D of the scene.

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