Towards a Comprehensive Multilayer Hybrid Display for GIS Data

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1. Introduction

As we naturally relate to our world in three or more dimensions, some data may be more readily visualized in 3D. However, direct 3D analogues to 2D GIS are not always ideal because they can suffer from several shortcomings. These issues include: hilly terrain occluding data, the self-occlusion of data and the simultaneous visualization of different types of data in 3D.

Studies have shown that 2D views are often used to establish precise relationships, while 3D views help in the acquisition of qualitative understanding (Springmeyer et al., 1992). It would be ideal if the benefits of both 2D and 3D could be incorporated into the same GIS. Our hybrid 2D/3D system attempts this by seamlessly integrating 2D and 3D views within the same window. Our system visualizes multiple layers of information that can be continuously transformed between 2D and 3D over the base-terrain. In the current work, we present a set of expanded capabilities for our GIS which include: hybrid landmark and chart layers, 3D point layers, the aggregate grouping of multiple hybrid layers, layer painting and unified controls for layer groups.

2. Related Work

In recent years, GIS has gradually moved into the third dimension such systems include ArcGIS (ESRI, 2006), Terrafly (Rishe et al., 1999) and GeoZui3D (Ware et al., 2001). However, a recent review (Stota and Zlatanova, 2003) of the status of 3D GIS postulated that 3D GIS is merely at a point where 2D GIS was several years ago. Often 3D is simply used for illustration or fly-bys and we argue that further research is needed to fully explore the possibilities and constraints of 3D GIS. Our work is also somewhat related to a small number of prototype systems proposed in the area of medical visualization that incorporate aspects of 2D and 3D in some fashion (Tory and Swindells, 2003).

3. Review of the Hybrid 2D/3D GIS

Our first prototype (Brooks and Whalley, 2005) allowed multiple layers of information to be continuously raised or lowered by the user, using control balls, directly over the base-terrain. During elevation, the layers maintain their geographical position relative to the base terrain and flatten (figure 1a-d). It is important that the user is able to mentally map a flattened 2D layer to the 3D terrain that it is residing over. To aid this, a ground level shadow of the layer system is provided which indicates the correlation between the data in the 2D/3D layers and the 3D base terrain.

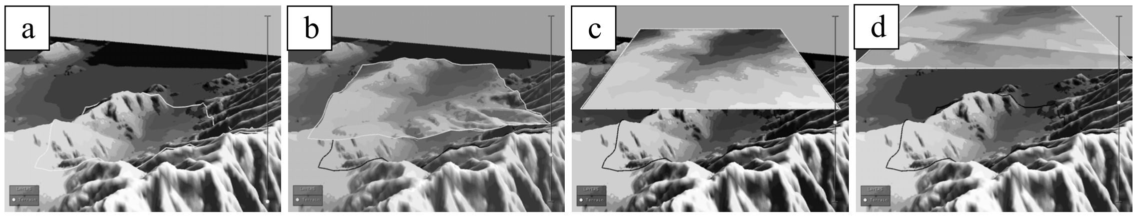

Figure 1: A layer is shown gradually rising from image *a* to image *d*.

4. New Hybrid GIS Facilities

This section discusses the new expanded capabilities of our hybrid GIS. In particular, we expand the range of possible hybrid layers that our system now offers and provide new interactive facilities for controlling how layers are visualized.

4.1 Layer Grouping

Our layering system offers a convenient means of handling multiple heterogeneous sets of aspatial data by separating the data content into layers, with each layer's height controllable via its own associated control ball. We now add the ability to group two or more layers into a single entity. The user can form a layer group simply by raising (or lowering) layer A's control ball onto the control ball of layer B. Layers can also be added to an existing group in the same fashion. An example of three grouped layers is shown in figure 2, left. The layers are: atlas, railroads and hypsography.

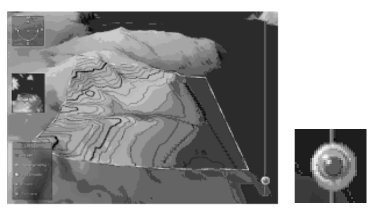

Figure 2: Left: Multiple thematic layers grouped into a single unit. Right: close-up of multiple control balls in an *onioned* state.

When multiple layers are grouped it is important to provide a visual indication of the grouping and of the individual member layers. We achieve this by modifying the edge trim that surrounds each layer in the grouped state. Each of the representative colors for each of the layers is incorporated into the new edge trim in an alternating dash pattern (figure 2, left). Secondly, (figure 2, right) we display the combined control balls as if they are each a layer of an onion that has been sliced in half. This onioning offers a further visual cue to the user and is also a practical means of control.

We also need to clarify exactly how layers are shown with respect to other layers in the same group. The case that poses difficulties is when using multiple raster layers in a single group, as they completely occlude each other. To overcome this issue, we introduce the notion of direct layer painting which allows the user to reveal the data contained in one raster layer at the expense of all other raster layers in the same group. This effect is localized to wherever the user 'paints'.

Let us consider an example layer group that contains 3 raster layers added in this order: A, B and C. Initially, the raster layer that is completely visible is the first layer, A, that was added to the group. Layers B and C are not initially visible. This default arrangement may not be sufficient as the user may wish to see certain portions of all three layers, A, B, and C, at the same time. To tailor visibility within the group, the user can perform layer painting. The user first clicks on the name of the layer (within the layer legend) that he or she wishes to reveal portions of. We will assume this is layer B. The user then paints with the mouse directly onto the rendered area of the layer group. The areas that the user paints over will then only show information contained within layer B, thereby hiding data from layers A and C. The user can therefore adjust the visibility of all layers in a given group in this fashion. Figure 3 shows an example of this where 3 disjoint regions are painted for 3 raster layers within the group. Note that the regions have been colour coded in this figure illustrate the concept; normally, the corresponding raster data from the 3 layers would be shown.

Figure 3: Disjoint regions shown painted for 3 separate raster layers in a layer group.

4.2 Point Layers

Point layers can be represented by a 3D sphere (figure 4) in our system. The size of the sphere can represent one aspatial aspect of the data points. Each sphere is embedded in a layer and as the layer flattens, the spheres also flatten to form a 2D view (figure 4, right). The spheres also become transparent with the layer if the layer is raised sufficiently high. Also, it is possible to form multiple point-layers for different data content where each point-layer is assigned its own color and meta-data legend entry.

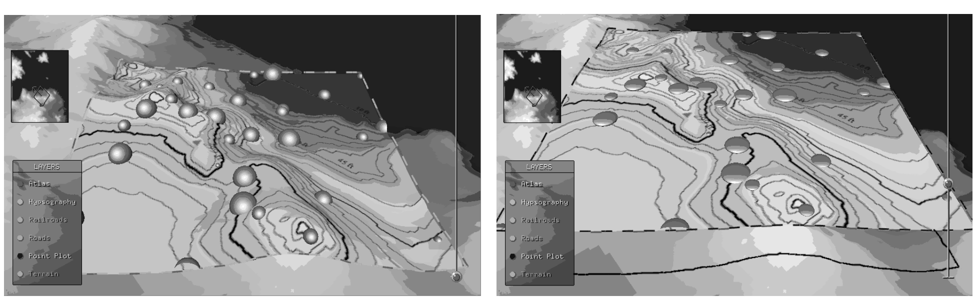

Figure 4: A partially transitioned point layer using sphere and disk symbols.

4.3 Landmark Layers

Our system now includes representations of major landmarks such as buildings in a cityscape (figure 5, left). As a cityscape is raised using the associated control ball, the buildings flatten gradually becoming 2D polygons.

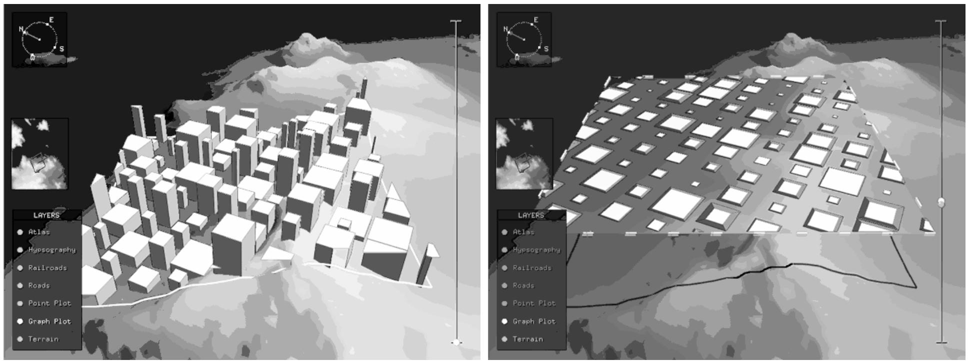

Figure 5: A landmark layer a ground-level (left) and at the flattening level (right).

During this flattening, the spatial information provided by the 3D view with respect to the building heights is lost. To overcome this a 2D scaled edge trim is implemented by scaling the top of the 3D building inwardly, proportional to the height of the building(figure 5, right). The taller the building, the more of an 'edge' there is around the building when flat. Additionally we shade a building as if it is 3D providing a further visual cue.

4.4 Chart Layers

Chart layers provide a way of visualizing aspatial data attributes using classifications. Our chart layers are also subject to 3D to 2D transitioning (see figure 6). Classifications include both pie-size and color. The semantics of the classifications are available in an auxiliary attribute-classification legend (figure 6 (right)). One might argue that when the chart layer is viewed in 3D, it offers an immediate impression of the overall data with respect to the 3D spatial terrain data. In the 2D mode it is more visually precise and eliminates potential occlusions.

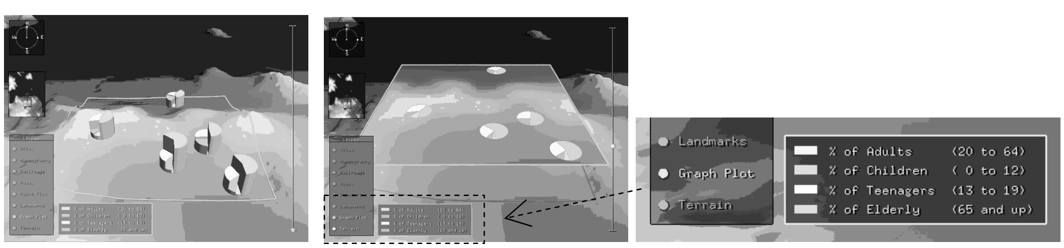

Figure 6: A transitioned chart layer employing a pie chart view. Right: Auxiliary legend for pie chart classifications.

5. Conclusions and Future Work

Our 2D/3D transitional layers can overcome both the self-occlusion and terrain-occlusion issues in 3D GIS. Our layering system also offers a convenient means of handling multiple heterogeneous sets of aspatial data and allows the user to temporally set aside data not in use. In the current work, we presented expanded capabilities for our system including: landmark layers, chart layers, 3D point layers, layer groupings and layer painting. There remain many opportunities for extending the system beyond its current form. One extension would involve the addition of advanced query facilities that could construct new query layers interactively. A user study would also provide insight into the practicality of the system.

6. Acknowledgements

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Biographies

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