Visual Access for 3D Data

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ABSTRACT

We describe a novel solution to the problem of occlusion in viewing three-dimensional data. A distortion function is used to clear a line of sight to previously obscured interior elements.

Keywords

Distortion viewing, 3D interaction

INTRODUCTION

There is accumulating evidence [1] supporting the idea that three-dimensional representations of data are advantageous. Unlike 2D techniques, 3D viewing encounters a fundamental problem in the display of information in that it is possible for an object of interest to be partially or wholly occluded by other objects. Current solutions provide access to such internal details through the use of cutting planes, layer removal, fly-through, and transparency. However, such techniques result in the loss of contextual information.

The recent desire to integrate knowledge and experience from the field of cognitive science into the design of user interfaces and new interaction paradigms has led to an appreciation of the importance of presenting data within its context [3, 4]. Our goal is to allow interactive access to 3D information spaces while maintaining context. This is achieved by providing a viewer aligned visual access distortion which clears a line of sight to the object of interest, permitting examination from all angles.

VISUAL ACCESS DISTORTION

The problem of occlusion arises when objects lie on or near the line of sight, between the viewpoint and the focus. The solution is to move data objects away from the line of sight where necessary, clearing a path to the focus. A distortion is applied radially about the line of sight, displacing data items in gradually decreasing amounts as their distance from the line of sight increases (Figure 1). Here the scale and hue of the focal node have been adjusted to distinguish it from the field.

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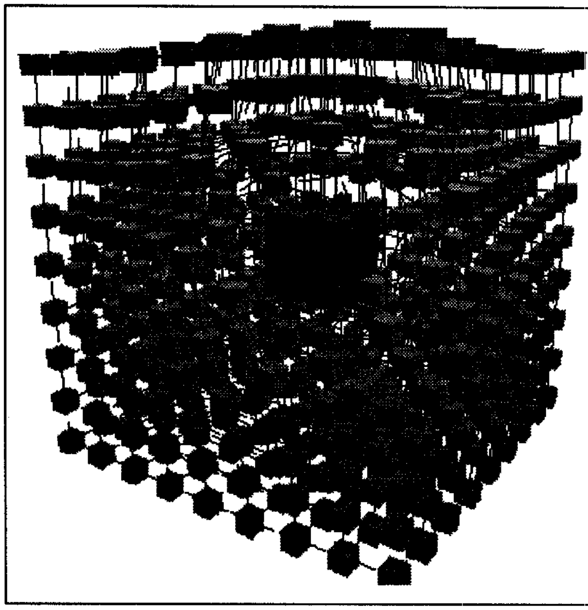

Figure 1: 3D Lattice with central focus made visible

This method extends the ideas and techniques used to deal with occlusion in 3DPS [2], namely a viewer-aligned distortion of an information space. Our algorithm proceeds as follows. Let L be a line segment extending from the focal object or region to the viewpoint (the line of sight), and a vector $\vec{v}$ be the shortest vector from any other object O at position P to a point N on the line L (used to establish the direction of the displacement). A gaussian distribution is used to calculate the magnitude of the displacement based on the length of v.

For a given value of $|\vec{v}|$ we determine the height h of the gaussian. The characteristic bell-curve of the gaussian means that for points near the line of sight (when $|\vec{v}|$ is small) h, will be greatest. Points further from the line of sight will have progressively smaller displacement values (Figure 2). The distribution of the distortion can be controlled by adjusting the height and standard deviation of the curve. Since the viewing direction is along the line of sight the resulting distortions will appear to be radially symmetrical about the focus. Furthermore, the visibility of the focus will be maintained under rotation of the data or motion of the viewpoint, smoothly deflecting potentially occluding nodes away from the line of

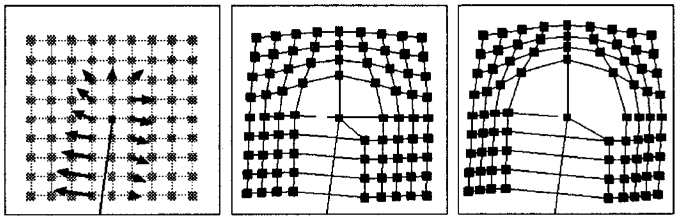

Figure 2: Cross section of expanding access distortion

sight as they approach it and returning them smoothly to their original positions as they move away (Figure 3).

This method scales well to multiple focal points. Here the displacement D of any point P relative to a set of n line segments L_i, where each segment L_i begins at an object of interest O_i and terminates at the viewpoint V, may be summarized as follows:

$$D = \frac{\sum_{i=1}^{n}(P - N_i) \times g(|P - N_i|)}{n}$$

where N_i is the point on the i^{th} line segment nearest the point P and $g()$ is the function that returns the height of a gaussian given the distance from the point P to the line L_i. The resulting displacement is the average of several independant distortions, each in a radial direction away from a line segment L_i. Thus it is possible to clear lines of sight to several objects simultaneously. For example in Figure 4 the upper left object is one layer deep into the 9x9x9 cube and the lower right one is 8 layers deep, but still visible.

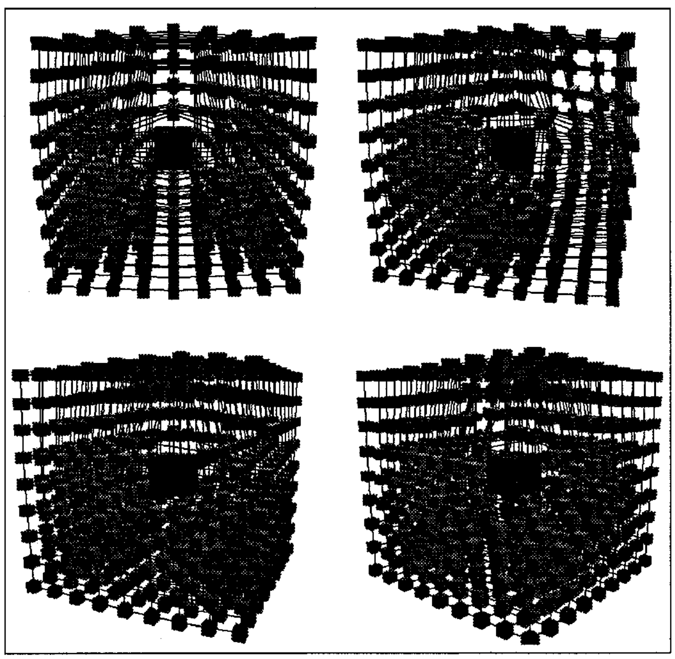

Figure 3: The distortion remains aligned to the viewer as the data set is rotated

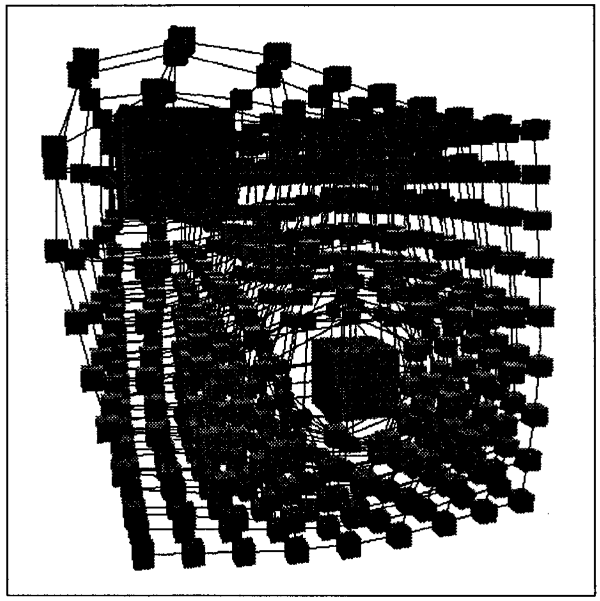

Figure 4: The access function may be applied simultaneously to more than one focus

CONCLUSIONS

The viewer aligned visual access distortion provides a clear line of sight to the internal structures of 3D data sets while maintaining smooth integration within its context. It is view rather than data dependant and provides control over the degree and extent of the distortion.

Future research includes the application of this method to both general 3D graph structures and solid 3D data, as well as a study of the potential use of perceptual cues to reveal the nature of the distortions.

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