The Cage: Efficient Construction in 3D using a Cubic Adaptive Grid

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ABSTRACT

The Cage is an easy to use 3D grid. Built into a 3D modeler, it provides a visualized reference coordinate system that helps the user to orient himself in 3D space, and that supports efficient alignment and snapping methods. It can be adapted with a single mouse click to any new viewing situation and reference system. The Cage was implemented in C++ under Open Inventor on Silicon Graphics workstations. It was tested as a part of a 3D authoring tool for virtual TV studios.

KEYWORDS: Cage, grid, snapping, 3D modelling

INTRODUCTION

Direct manipulative 3D modelers allow the easy creation of sketches, but make it hard to get well–defined, precise results. Additional functions are needed to align objects, i.e. to make them exactly parallel, to scale them equally, to stack them, etc. Many alignment functions such as 'align left' need a reference coordinate system, which can be taken from the first selected object, the so–called reference object. If more than one object is to be aligned to the same reference object, then it is usually more efficient to select that object only once and to declare it as the reference for all subsequent alignment actions. If this is done, alignment can be substituted by a parameterless snapping method. The task of defining and visualizing such a reference system can be solved using a three dimensional grid. Eric A. Bier summarizes the advantages of grids claiming: "Grids are popular because they are easy to use (and easy to program)" [1, p.14]. In the following, we propose an adaptive grid mechanism that supports efficient construction in 3D.

THE CAGE

As suggested by its name, the Cage (Cubic Adaptive Grid) is a grid construction that encloses its contents. Since any of six enclosing planes can be turned on and off individually, the Cage can adapt its shape to different viewing situations as shown in figure 1. The appearance of the Cage can be customized using up to four components (figure 2).
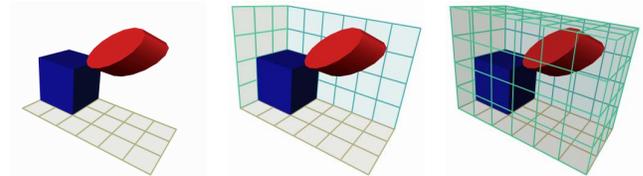

Figure 1: The Cage is made of up to six planes
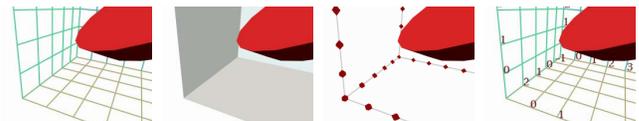
Figure 2: The Cage and its components: a) line grid b) translucent planes c) axis d) labels and grid

Line grids and translucent planes have special colors for bottom and back plane to visualize the Cage's position in 3D space. The labels along the axis always face the viewer.
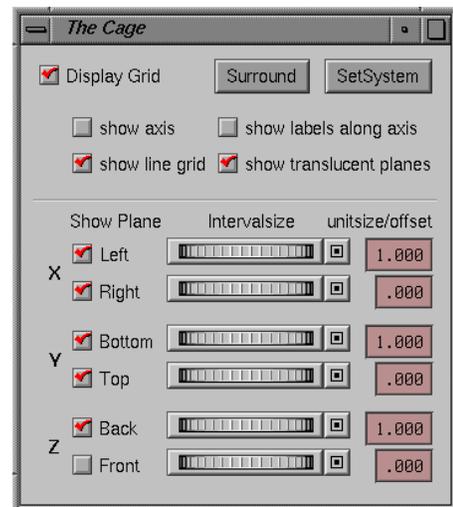
Figure 3: The user interface

Figure 3 shows the Cage's user interface that offers the functions to control the appearance as well as the main functions Surround and SetSytem and the fine positioning functions.

SURROUND

Surround allows the user to position the Cage by enclosing selected objects. There are three possible starting situations:

1. If one or more objects are currently selected, the selected objects are surrounded.

2. If no objects are selected, the whole scene is surrounded.
3. If the scene is empty, the Cage takes a default size and is centered around the origin of the current coordinate system.

When performing a Surround, the Cage is expanded if necessary, so that it always fits an integer number of units in all three dimensions. Since the Surround function does not need any parameters except the picked objects, it can be mapped to a single button on the user interface or to a hotkey or it can be executed automatically whenever a new object is picked.
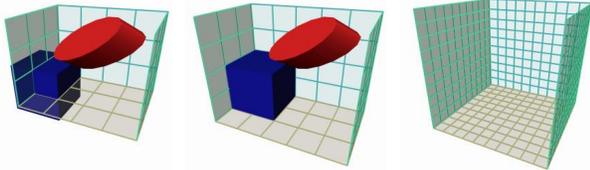

Figure 4: The effect of a Surround action on: a) a selected object b) the whole scene c) an empty scene.

SETSYSTEM

SetSystem adapts the current coordinate system to the local coordinate system of a selected object and performs a Surround. Using this function, the Cage can take the shape of any coordinate System. If SetSystem is invoked while no objects are selected, the Cage returns to the global coordinate system.
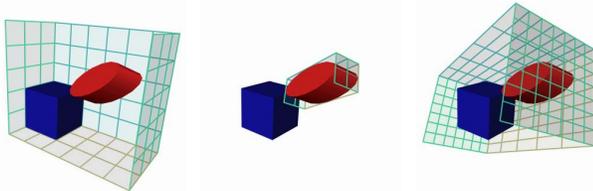

Figure 5: The same scene with different coordinate systems: a) The scene surrounded in the cube's system b) the deformed Cylinder is selected and SetSystem is performed c) A Surround on the whole Scene, now in the coordinate system of the deformed cylinder

SetSystem can be used to align objects with one another. The user picks the reference object and performs a SetSystem on it. Because the snapping method refers to the coordinate system currently defined and visualized by the Cage, all other objects can now be snapped easily into the resulting raster.

FINE POSITIONING FUNCTIONS

If the usual positioning using Surround does not lead to the desired shape, the Cage's dimensions can be adjusted explicitly. For each of the three dimensions, sliders allow the user to enlarge or to shrink the Cage. By giving an explicit unit size, the grid's meshes can be made wider or narrower. Offsets allow the Cage to be shifted in fractions of a unit.

AN EXAMPLE SNAPPING METHOD

Snapping can be done for different transformations like rotation, scaling and translation. To maintain specific degrees of freedom, snapping can be restricted using the dialog shown in figure 6. All coordinate axes named in the dialog refer to the Cage. Placing objects on a table, for example, requires the indicated settings with a SetSystem action on the table. Objects

will now snap easily onto the table's surface but can still be shifted on the table's surface or turned around the y–axis.
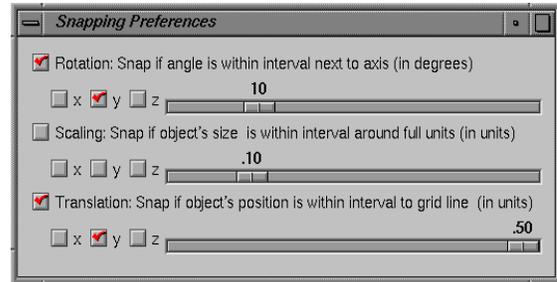
Figure 6: Restricting the effect of snapping

THE CAGE IN 2D

The Cage is applicable in two as well as in three dimensions as demanded by Bier [1,p.5]. The Surround function can be omitted, so that the grid always covers the whole screen (figure 7). Thus the Cage's functionality in 2D is essentially reduced to SetSystem.
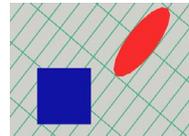

Figure 7: The Cage in two dimensions. A SetSystem operation was performed on the oval to adapt grid orientation and interval sizes to the oval's dimensions.

CONCLUSION

The Cage is a universal 3D grid which supplies a reference system for explicit alignment functions as well as for snapping mechanisms such as those described in [1], [2] and [3]. Its visualization and its simple interface help the user to orient himself in 3D space and to manage different coordinate systems.
1. It is easy and fast to use. Most of the work can be done using the two buttons Surround and SetSystem. All functions and options are accessible via single mouse clicks.
2. It is adaptive to new viewing situations. Surround and SetSystem adapt the Cage to any subset of objects.
3. It does not clutter the screen. Because it surrounds just the selected parts of the scene, the Cage is only as large as required. Options for the appearance help the user to reduce the visible information even further.

Due to its flexibility, the Cage allows a snap–to–grid method to be used in many situations where otherwise a more time demanding explicit alignment action would have to be applied.

EXTENSIONS

We are working on the integration of more elaborated snapping functions as suggested by Bier [1]. Using the Cage as a visible reference system, alignment functions for two objects (e.g. 'align left', a term that presupposes a reference system) like the ones available in Freehand [3] will be adapted to 3D.

REFERENCES

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