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Combining SP-Octrees and impostors for the visualisation of multiresolution models

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Abstract

Space-Partition Octree (SP-Octree) is a hierarchical representation scheme for solid modelling. It allows a multiresolution representation of polyhedral objects, and has been successfully used in progressive transmission. Moreover, this scheme allows visualising the model in an adaptive way. However, at intermediate levels of the SP-Octree, the obtained visualisation is a rough approximation of the object due to the fact that grey nodes are approximated by the face's planes belonging to the convex hull of the solid included in that node.

In this paper, we present an approach that improves the visualisation of these multiresolution SP-Octrees models by applying impostors over those planes that are not part of the solid boundary. This way, it is possible to obtain a more realistic visualisation of the object, although the maximum LOD is not used. At each moment, the impostor is selected depending on the observer's viewpoint. Each SP-Octree has associated a set of impostors that are views of the modelled complex solid.

Keywords: Computer graphics; Computational geometry; Object modelling; Image-based rendering; Adaptive visualisation; Octree

1. Introduction

The interactive visualisation of three-dimensional models is traditionally one of the most important applications of computer graphics. It is used in medicine, architecture, archaeology, etc. This interactive visualisation of complex models requires a great effort of the graphics hardware, due to the large number of polygons needed to represent the geometry at the expected level of detail and realism. This resource requirement may lead to a lack of interactivity.

The conflict between the rendered level of detail and the visualisation speed has motivated the development of several techniques to reach both goals. Under the generic name of level of detail (LOD), we gather techniques that represent a complex geometry in a simplified way when the observer is not close enough to the object.

1.1. Geometry-based LOD techniques

Geometry-based LOD techniques can be classified as *discrete* [1], i.e. the object is represented in several instances, each one at different LOD; *progressive* [2], i.e. the detail is extracted from an unique data structure during runtime; and *view dependent* [3,4], which is an extension of progressive techniques, in a way that the LOD is not uniform along the object, and it is *anisotropic*, depending on the point of view.

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Although the LOD concept is not restricted to a concrete area (images, solids, volumes), in three-dimensional computer graphics it is usually applied to the simplification of triangular meshes.

Another approach to represent volumes and solids with variable LOD is to represent them with schemes based on spatial decomposition, using hierarchical structures. Among these methods we can find the *Octree* [5,6] and several extensions to these (e.g., extended-Octrees [7]).

1.2. Image-based LOD techniques

Another approach to solve the conflict between realism and interactivity is the image-based techniques. The idea underlying this approach is to replace a complex three-dimensional geometry with a two-dimensional image that shows what should be represented by the removed geometry. This image is an *impostor*.

Many image-based techniques have been presented to represent solids [9–12,18], and all of them can be considered as view dependent. The complexity of the geometric model where impostors are applied, ranges from a single plane to triangular meshes.

2. SP-Octrees

Classical Octrees present an important drawback: the obtained representation of the object is approximate, so in order to obtain a better (but not exact) representation, it is necessary to increase the depth of the tree, and therefore to increase the storage cost.

To overcome this problem, several extensions to the classical Octrees scheme have been proposed, modifying the scheme in three different aspects of the representation:

- By changing the cutting planes used in the subdivision process [13].
- By modifying the information contained in the terminal nodes of the octal tree that represents the object, e.g., by adding information about the part of the object boundary that is included in each terminal node. By doing so, it is possible to exactly represent polyhedral objects. But, as a disadvantage, that information sometimes is repeated in neighbouring terminal nodes.
- By modifying the information stored in the internal nodes of the tree.

The proposed scheme, Space-Partition Octrees (SP-Octrees) [14], is based on the inclusion of boundary information in internal nodes, so the object is partially defined at each node of a level.

Thus, the information of boundary faces appears from the upper levels of the tree and it is not necessary to repeat that information in neighbouring nodes share a face.

This approach allows us to obtain information about the boundary of the solid in upper levels of the tree, which will accelerate certain operations over the model.

2.1. Node types

By using the same octal-tree structure as in classical and extended Octrees, we use a set of node types that allows one to include boundary information not only in the terminal nodes of the tree, but also in the internal ones.

Basically, the idea is to classify each node once depending on the characteristics (convexity or concavity) of the boundary planes that appear in it. Also, the internal nodes store those planes whose configuration does not change in the children nodes, so it is not necessary to repeat the information. This information allows delimiting the space where the solid is defined inside the node.

There are six different SP-Octree node types:

- *Black* and *White* nodes (Fig. 1), when the node is completely inside/outside the solid, as in classical Octrees.
- *Convex* node (Fig. 1), if the intersection between the solid and the node is convex. In this case, the node contains the set of planes from the boundary that

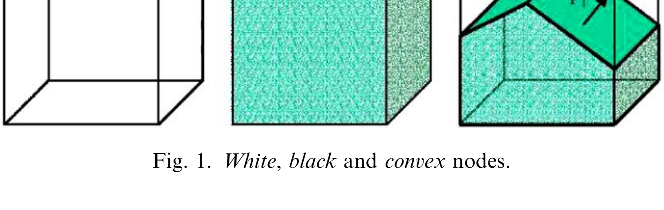

Fig. 1. *White*, *black* and *convex* nodes.