Revisiting Adaptively Sampled Distance Fields

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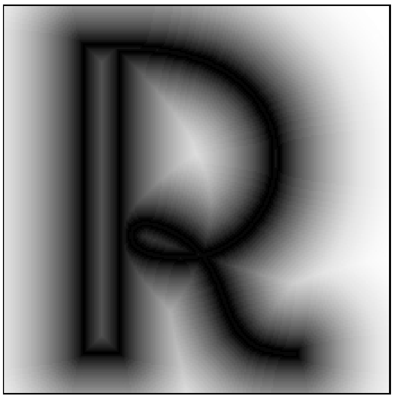
Implicit Shape Description. Implicit objects are a powerful shape description for many applications in computer graphics. An implicit objects is defined by a function $f\colon \mathbf{R}^n \to \mathbf{R}$ as the set of points $p \in \mathbf{R}^n$ satisfying $f(p) = 0$.

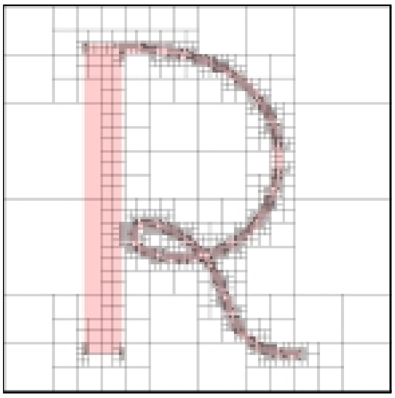
One simple implicit representation is the *characteristic function*, which is 0 inside the object and 1 outside it.



Distance functions. Implicit representations become more effective when f is a *signed distance function*, i.e., when $|f|$ gives the distance to the closest point on the objects and f is negative inside the object and positive outside the object bounded by the objects.

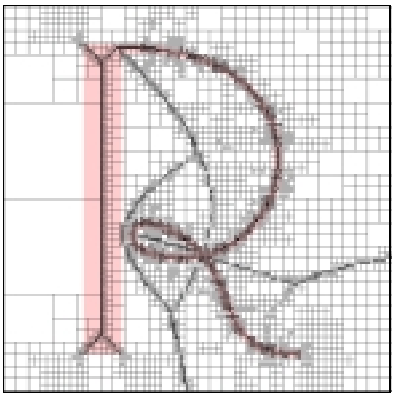
The distance function to an arbitrary objects does not have a simple analytic description, and we must resort to approximations. One simple solution is to use a volumetric representation, constructed by sampling f uniformly, but such models are very large and their resolution is limited by the sampling rate.

Frisken et al. [1] recently proposed *adaptively sampled distance fields* (ADFs) as a way to overcome these problems.



Boundary ADFs. The *boundary ADF* represents a shape with an octree that has three types of nodes: *interior*, *exterior*, and *boundary*. according to their relation with the solid object being represented. The cells that contain the boundary of the object are subdivided only when the distance function within a cell is not well approximated by trilinear interpolation of its corner values.

With boundary ADFs, the distance function f is only guaranteed to be reconstructed within a prescribed accuracy near the objects; interior and exterior cells may give very bad estimates of f. In other words, boundary ADFs only represent well the boundary of the shape.



Global ADFs. The boundary ADF is sufficient for applications that only need local boundary information, such as ray tracing. The boundary ADF is insufficient for applications that require accurate global information about f, such as offsetting, path planning, and volume rendering.

The *global ADF* which we propose is a variant of the ADF representation that is guaranteed to reconstruct f with the desired accuracy at any point of its domain. We simply apply the adaptation criteria to *all* cells of the octree instead of just to the boundary cells.

Note how the global ADF reveals all the characteristics of the distance function, capturing the skeleton very well.

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[1] Sarah F. Frisken, Ronald N. Perry, Alyn P. Rockwood, and Thouis R. Jones. Adaptively sampled distance fields: A general representation of shape for computer graphics. *Proceedings of SIGGRAPH 2000*, pages 249–254, July 2000.