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Parallel ray tracing based upon a multilevel topological knowledge acquisition of the scene

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Abstract
Including the standard parallelization by grouping primary rays, this paper presents a new parallel ray-timing method based upon a topological knowledge acquisition of the scene. This topological knowledge focuses on relative positions between objects and processes and uses a new type of message. Indeed, instead of exchanging database pages or rays, processes exchange topological information. This information is used by each process to decrease its own list of objects to test against rays The acquisition of information about relative positions between objects and processes is obtained by a careful ordering of he pixel calculation. The processes are dispatched on a computer network including a parallel computer The organization of the processes on this network is a multilevel one leading to different levels of topological message exchanges This method is characterized by topological messages describing the scene, dynamic optimization of the database, easy parallelization on any network (no deadlock, fault tolerance, easily expandable and simple routing), and gives interesting results with true or simulated parallelism.

***Key* words** : Computer graphics. Ray tracing, Parallelism, Communications.

I. Introduction

Ray tracing is a powerful and widely used technique for realistic image synthesis. This method uses sophisticated illumination models [Wh80]. that can take into account complex effects. It simulates how a camera works by computing the inverted path of light rays falling onto it. From a special point in space (the eye), the algorithm computes the scene on the screen by determining the color of each pixel.

This method is simple in its principle but is time-consuming. Thus, most research currently focuses on sequential and parallel optimizations.

In the following. a *primary ray* is a ray extending from the observer through a pixel. All subsequent rays, recursively generated from this primary ray by reflection, transmission or shading, are called *secondary rays* and constitute the *calculation tree* of the pixel.

Three strategies have been considered for sequential optimization[G189]:

(1) Reduction of the total number of rays by adaptive tree depth control. statistical methods [Co86], [Pu86] or by using approximations based upon ray coherence [SSS74] [SDB86].
(2) Reduction of the average ray/object intersection time by :
* using bounding volumes [KK86] or optimizing the computing of some objects modeled by CSG [Ro82] ;
* using hierarchical bounding volumes [RW80] or spatial divisions like voxels [GI84] [FTI86]. Binary Space Partitioning trees [Ka85]. octrees [WKS86]. and divisions associated with CSG trees [APB87] :
* using directional techniques [HG86].
(3) Use of more general rays as in cone [Ain84], beam [HH84] and pencil [STN87] tracing methods.