

# PORTRAY - AN IMAGE SYNTHESIS SYSTEM

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## ABSTRACT

PORTRAY is an image synthesis system which uses ray tracing to produce realistic images of three-dimensional scenes. Scenes are described to PORTRAY in a high-level description language. The basic geometric modelling technique is constructive solid geometry using primitive solids bounded by planes and quadrics. A variety of optical characteristics and phenomena may be specified. The scene description language allows the user to define object *classes* which may be used as if they were built-in primitives. PORTRAY uses a number of techniques, including a novel technique exploiting bounding volume coherence, to improve its ray tracing performance. PORTRAY is supported by an array of image manipulation tools which share a common image storage format.

KEYWORDS: bounding volume coherence, constructive solid geometry, illumination models, image synthesis, ray tracing.

## 1. Introduction

PORTRAY is an image synthesis system which generates realistic pictures of three-dimensional scenes. Scenes are described to PORTRAY using a high-level scene description language (SDL). The scene description is processed by a *scene compiler* called "PRCOMP". PRCOMP produces a file which describes the scene in a lower-level language. This intermediate file is read by the rendering program, simply called "PORTRAY", which uses ray tracing to produce an image of the scene. Figure 1 illustrates the structure of the system.

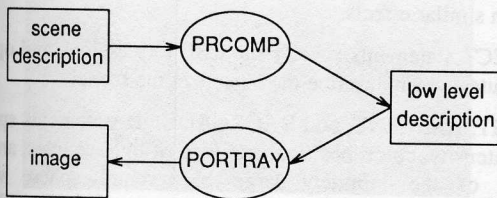


Figure 1

The PORTRAY image synthesis system is implemented in the C programming language, and runs under UNIX on VAX, Sun, and Pyramid computers.

This paper describes the geometric and optical modelling techniques used in PORTRAY, the scene description language, the processes of scene compilation and rendering, and the image format and image manipulation tools used with PORTRAY.

## 2. Scene Description Language

The SDL is a critical part of the PORTRAY system, since it determines the ease with which a user of the system can model the objects he wants in a given scene. With a particular SDL, some scenes may be impossible to describe, and many more scenes may be impractical to describe. The PORTRAY SDL incorporates a powerful geometric modelling technique and a variety of optical modelling techniques to give the user a large amount of descriptive power [1].

### 2.1 Geometric Modelling

The shapes of objects are described to PORTRAY by means of constructive solid geometry (CSG). CSG descriptions are expressions involving Boolean combinations of primitive solids. PORTRAY uses spheres, cones, cylinders, and cubes as primitive solids. These primitives have quadric and planar surfaces which make the problem of determining the intersection between a ray and the primitive quite simple. Primitives may be moved to arbitrary locations and rotated and scaled as desired. Unequal scaling may be used, for example, to turn a sphere into an ellipsoid, or a cube into an arbitrary rectangular block.

Primitive solids are combined using *regularized set operators* [2], namely union, intersection, and subtraction. The combination of two solids is guaranteed to be another well-defined solid. Any two CSG expressions can be combined using any of the three operators to obtain another CSG expression. Quite elaborate objects may easily be constructed in this way (see Figure 2).

The use of solid modelling instead of surface modelling entails some additional cost. To ray trace a solid consisting of a combination of primitive solids, we must first find the intersections between a given ray and each of the primitive solids. The resulting lists of intersections are then merged in a

