# The Stochastic Modelling of Trees

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*ABSTRACT*

We present here a fast method for the modelling of trees which brings together two interesting techniques. The trees are modelled as convex polyhedra for the description of the gross shape, and three-dimensional texture mapping is used for the detailed features.

The "essential" volume of the tree is represented as the convex intersection of half spaces. The advantage of this representation is that it allows an adaptive level of detail in the display. We use a special algorithm for the display of the convex intersection which computes it directly in the frame buffer. The algorithm also allows the computation of intersecting polyhedra.

To transform the convex polyhedra into a more realistic representation of trees, we use three-dimensional texture mapping to "modulate" the shape and the colour of the basic polyhedra. We then obtain an irregular non convex object, which is consistent in shape and general appearance regardless of the point of view and the size on screen. Three dimensional fractional Brownian motion is one of the procedural texture used.

KEYWORDS: tree modelling, half space intersection, stochastic modelling, frame buffer algorithms, adaptive modelling.

*RESUME*

Nous prèsentons ici une méthode rapide pour le modelage des arbres qui réunit deux techniques intèressantes. Les arbres sont modelés par des polyhèdres convexes pour la représentation de la forme globale, et une texture à trois dimension est utilisée pour modeler les détails.

La forme "essentielle" de l'arbre est réalisée par des polyhèdres convexes, résultats du calcul de l'intersection de demi-espaces. L'avantage de cette reprèsentation est qu'elle permet un niveau adaptif de détail. Nous avons développé un algorithme pour le calcul de l'intersection convexe directement dans la mémoire d'image. Avec une légère modification l'algorithme permet le calcul de polyhédres qui s'intersectent.

Nous transformons les polyhèdres en une reprèsentation plus réaliste des arbres en utilisant le "mapping" d'une texture à trois dimension pour moduler la forme et la couleur des polyhèdres de base. Nous obtenons ainsi un object non-convexe et irrégulier, dont la forme et l'apparence génèrale est consistante indépendemment du point de vue et de la taille de l'arbre sur l'écran. Le mouvement Brownien fractionel à trois dimensions est une des procédure de génèration de texture utilisées.

MOTS CLES: modelage d'arbres, modelage stochastique, intersection de demi-espaces, algorithmes de mémoire d'image, modelage adaptif.

## 1. Motivations

Trees are obviously very important in the modelling of natural scenes and landscapes. Problems are caused by the large number of trees needed and their considerable variety of shapes. The main criteria for a good model are to be realistic, easy to compute (both in terms of the basic operations needed and of the time complexity), flexible (capable of generating the intra- and inter-species variations in shape), adaptive (generating various level of details as needed) and compact. Of course, depending on the application, one or more of these criteria can be relaxed if not all can be met. The techniques used so far include grammar generation systems [AoKu84, Smit84], particle systems [ReBl85], polygonal description plus two-dimensional texture mapping [Bloo85] and simple volume primitives plus two-dimensional texture mapping [Gard84, Gard85]. The technique we will describe here, which is close in spirit to the ones used by Gardner, uses simple volume primitives (convex polyhedra) computed in the frame buffer associated with stochastic three-dimensional texture mapping. Table 1 gathers a subjective evaluation of these different techniques with regard to the above criteria. A scale of 0 (not at all) to 5 (best possible) is used.