METHODS FOR STOCHASTIC SPECTRAL SYNTHESIS

j.p. lewis

Computer Graphics Laboratory
New York Institute of Technology

ABSTRACT

A number of spectral modeling approaches in the engineering and estimation literature are potentially applicable to stochastic synthesis in computer graphics. Two specific approaches are developed. The orthogonality principle of estimation theory is used to derive a stochastic subdivision construction with specified autocorrelation and spectrum properties; this approach also provides an alternative theoretical basis for the popular fractal subdivision algorithms. A shaped Poisson point process is a second approach which conveniently separates the spectral and graphic modeling problems. Synthetic textures and terrains are presented as a means of visually evaluating the constructed noises.

KEYWORDS: stochastic models, texture synthesis, fractals, terrain modeling.

RESUME

Les méthodes de modèlisation spectrales empruntées aux sciences de l'ingénieur, ou dérivées de la theorie de l'estimation peuvent être appliquees à la synthèse stochastique dans le champ de l'informatique graphique. Deux points de vues sont présentés dans cette communication. A partir du principe d'orthogonalité de la theorie de l'estimation on peut dériver une méthode de subdivision stochastique possèdant certaines spécifications d'autocorrélation et propriétés spectrales; cette approche fournit aussi une base théorique nouvelle pour la construction d'algorithmes de subdivision fractale. Un processus utilisant un filtrage de l'impulsion de Poisson fournit une deuxieme approche, qui permet de déterminer une séparation claire des problemes de nature spectrale de ceux liés a la modèlisation graphique. Les textures synthétiques et les modèles de terrains présentés permettent d'évaluer visuellement les bruits ainsi générés.

MOTS CLEFS: Modèles stochastiques, Textures synthétiques, fractal, modèlisation de terrain.

1. Introduction

Stochastic techniques have assumed a prominent role in the synthesis of complex and naturalistic imagery, for example, [1][2][3][4][5][6][7]. This role has been termed *amplification* [5]: the image modeler specifies a pseudorandom procedure and its parameters; the procedure can then automatically generate the vast amount of detail necessary to create a realistically complex scene. The success of stochastic modeling depends both on its economy and on our ability to construct stochastic models to approximately emulate a variety of phenomena. The full power of stochastic modeling has not been achieved in existing techniques. For example, the widely-used stochastic fractal techniques model only spectra of the form f^{-d}, and thus cannot describe phenomena with scale-dependent detail or directional or oscillatory characteristics.

The problem of modeling a random process ("noise") with an arbitrary spectrum is well understood. Basically, the procedure is to filter an uncorrelated noise (as obtained from a random number generator) to obtain the desired spectrum. The spectrum of the filtered noise is simply the squared magnitude of the transfer function of the filter. Using this synthesis procedure, many of the filtering and spectral analysis approaches described in the literature are potentially applicable to the problem of stochastic modeling in computer graphics. This paper adopts two approaches, optimal mean-square estimation and a shaped point process model, to produce stochastic synthesis algorithms which are computationally suitable for computer graphics applications.

2. Generalized Stochastic Subdivision

The stochastic subdivision construction described by Fournier et. al. [1] may be generalized to synthesize a noise with an arbitrary prescribed spectrum (the generalized subdivision technique is described in more detail in [8]). The basis of the Fournier et. al. construction is a midpoint estimation problem: given two samples considered to be on the noise, a new sample midway between the two is estimated as the mean of the two