Fast Fractal Growth

Department of Computer Science | University of North Carolina at Chapel Hill | March 2005

Background

Fractal structures are a common tool in visual effects. Whether it is L-Systems used to model plants, fractal Brownian motion used to generate a texture, or a recursively generated mountain range, the notion of self-similarity can be used to create convincing natural phenomena. Fractal growth algorithms, however, have not enjoyed the same popularity, because their central algorithm, such as the dielectric breakdown model (DBM), requires supercomputer scale resources to compute structures of practical size.

Highlights

- **A fast, memory-efficient fractal growth algorithm**
- **Simple implementation and simple user controls**
- **Over 3 orders of magnitude faster than previous methods**

The Challenge

In order to generate interesting fractal structures, the dielectric breakdown model requires an extremely computationally intensive numerical integration step where the electric potential throughout all space is obtained. Formally the problem is known as solving a Poisson problem over a regular grid. While this problem is very well studied, even the fastest methods take months to compute, and can consume several gigabytes of memory.

For visual effects, months of computation and gigabytes of memory are both unacceptable constraints on a production schedule. It can be shown that even if an optimal algorithm were devised for DBM, it would still take an unacceptable amount of computation time, and the memory requirements would remain the same. In order for fractal growth to be a useful visual effects tool, another approach is necessary.

The Approach

The central bottleneck in DBM is solving a massive Poisson problem over a regular grid to obtain values for the electric potential throughout space. In a general sense, this is known as the numerical integration of a boundary value problem. However, there are other ways to formulate this problem. In particular, there exist multipole formulations of the same problem. Instead of trying to integrate a difficult partial differential equation subject to certain boundary conditions, we assume that the system is composed of a set of point charges, each of which induce a potential of form 1/r. Integration then reduces to summing together several 1/r terms.

Using this approach, we can accomplish in seconds what would normally have taken hours, and in hours what would have taken months. Using this new algorithm, we can generate all types of natural structures, such as trees and lightning. By coloring in the potential field surrounding the fractal, we can also generate images reminiscent of Julia and Mandelbrot sets.

A lightning bolt generated with our new fast fractal growth algorithm.

Project Leaders

Ming Lin, professor

Graduate Research Assistants

Theodore Kim
Jason Sewall
Avneesh Sud

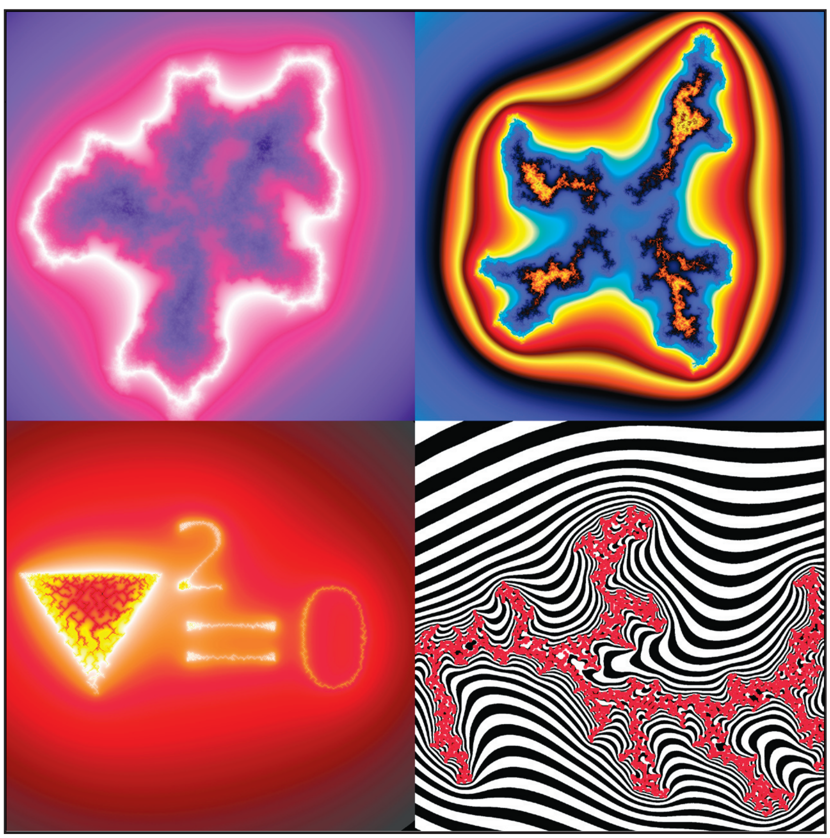
Research Sponsors

Intel Corporation, National Science Foundation, Army Research Office

Selected Publications

Kim, T., J. Sewall, A. Sud, and M. Lin. Green's Fractals: A Fast Fractal Growth Algorithm. 2005.

A tree generated with our new algorithm.



Fractal forms generated by algorithm reminiscent of Mandelbrot and Julia sets.