

*SIGGRAPH 1991
18th International Conference
On Computer Graphics and
Interactive Techniques*

*Las Vegas Convention Center
28 July - 2 August*

COURSE NOTES

C13

INTRODUCTION TO
FRACTALS

Chair

Dietmar Saupe
Universität Bremen

Lecturers

Heinz-Otto Peitgen
Universität Bremen
Przemysław Prusinkiewicz
University of Regina
Richard Voss
IBM T J Watson Research Center

Introduction to Fractals

SIGGRAPH 1991, Las Vegas

Abstract of Course

The course covers basic principles and applications of fractals, supported by video animations and live demonstrations. Its goal is to present the theoretical foundations of fractals from the computer graphics point of view, their algorithmic generation and their uses in modeling with emphasis on the basics. Topics include:

Random fractals

Visual introduction to fractals: coastlines, mountains and clouds, a survey of fractals in Nature, fractal dimension, statistical vs. exact self-similarity, fractional Brownian motion, representations in the spectral and time-domain, construction by random successive additions, lacunarity, rescale-and-add method for multi-variable fractals allowing variation of dimension and crossover scale.

Dynamical systems and fractals

Fast algorithms for Mandelbrot and Julia sets and their 3D-rendering, relation between fractals and chaos, and iterated function systems with applications in image compression, a film with interviews with Benoit Mandelbrot and Ed Lorenz.

Modeling

L-systems and biologically based modeling, developmental plant models with animation, fractals properties of plants, models of plant organs. computer demonstrations.

Speaker Biographies

Dietmar Saupe (Course chair). *1954 in Bremen, Germany. Dr. rer. nat. in Mathematics, 1982 at the University of Bremen. Visiting Assistant Professor of Mathematics at the University of California, Santa Cruz, 1985-87 and since 1987 Assistant Professor of Mathematics at the University of Bremen. There he is a researcher at the Dynamical Systems Graphics Laboratory with main interests in mathematical computer graphics and experimental mathematics. He has been involved in several past SIGGRAPH courses on fractals, as the course chair in 1988 and 89 and as the coauthor/coeditor of "The Science of Fractal Images," 1988, and "Fractals for the Classroom," 1990, both from Springer-Verlag. He is one of the contributors to the exhibit "Frontiers of Chaos" which is being shown worldwide under the auspices of the Goethe-Institute. Dr. Saupe is a member of the ACM and SIGGRAPH.

Heinz-Otto Peitgen. *1945 in Bruch, Germany. Dr. rer. nat. in Mathematics 1973, Habilitation 1976, both from the University of Bonn. 1977, Professor of Mathematics at the University of Bremen and since 1985 also at the University of California, Santa Cruz. Research in nonlinear analysis and dynamical systems. He has been a lecturer at the last five SIGGRAPH courses on fractals. He is coauthor (coeditor) of the books "The Beauty of Fractals," 1986, from which the exhibit "Frontiers of Chaos" of the Goethe-Institute evolved, of "The Science of Fractal Images," 1988, and of "Fractals for the Classroom," 1990, all from Springer-Verlag. Dr. Peitgen is a member of the AMS

Przemyslaw Prusinkiewicz. Dr. Prusinkiewicz is Associate Professor of Computer Science at the University of Regina, Canada, where he is leading the Computer Graphics Group. Born and raised in Poland, he received his M. Sc. and Ph. D. degrees, both from the Technical University of Warsaw, Poland, in 1974 and 1978. Before moving to Canada in 1982, he was Assistant Professor of Mathematics at the University of Science and Technology in Algiers. In 1988 he was Visiting Assistant Professor of Mathematics and Computer Science at the Yale University. The focus of his research is in the area of fractals and the modeling of plants. He is author (with coauthor Aristid Lindenmayer) of the book "The Algorithmic Beauty of Plants" (Springer-Verlag, 1990). Dr. Prusinkiewicz is a member of the ACM, SIGGRAPH, and the IEEE Computer Society.

Richard Voss. *1948 in St. Paul, Minnesota, 1970 B.S. in Physics from M.I.T. 1975 Ph.D in Physics from U.C. Berkeley where, from a condensed matter physics background, he became interested in fluctuation phenomena, $1/f$ noise (and its relation to shapes and music melodies), and the early work of Benoit Mandelbrot. 1975-present Research Staff Member at the IBM Thomas J. Watson Research Laboratory in Yorktown Heights, NY. He continues to work closely with Benoit Mandelbrot. He is a Fellow of the American Physical Society and a member of the Materials Research Society. His research in condensed matter physics includes low temperature macroscopic quantum phenomena in Josephson junction devices, $1/f$ noise, and the fractal characteristics of random media and growth processes. He has had sabbatical assignments at U.C. Santa Barbara and Harvard. He has been named Siefert Memorial Lecturer at the University of Montana in Bozeman and a Distinguished Lecturer at Trinity University in Texas.

Schedule of Course¹

Introduction to Fractals SIGGRAPH 1991, Las Vegas

1. **Visual Introduction to Fractals**..... 8.00 a.m.
R. Voss
2. **Basic Algorithms for Random Fractals**..... 9.45 a.m.
D. Saupe
3. **L-Systems and Fractals I**..... 11.30 a.m.
P. Prusinkiewicz
- Lunch break..... 12.00 a.m.
4. **L-Systems and Fractals II**..... 1.00 p.m.
P. Prusinkiewicz
5. **Deterministic Fractals**..... 2.15 p.m.
H.-O. Peitgen
6. **Fractals: An Animated Discussion (film)**..... 4.00 p.m.
H.-O. Peitgen, H. Jürgens, D. Saupe, C. Zahlten
- Summary and Closing.....5.00 p.m.

¹Times are only approximate and may change according to break schedule and other circumstances

Contents of Course Notes

Part 1 Random fractals

1. Fractals in Nature: From Characterization to Simulation..... 0-1 to 0-50
Richard Voss
2. Random Fractals in Image Synthesis.....1-1 to 1-29
Dietmar Saupe
3. Point Evaluation of Multi-Variable Random Fractals..... 2-1 to 2-13
Dietmar Saupe
4. The Synthesis and Rendering of Eroded Fractal Terrain.....4-1 to 4-10
F. Kenton Musgrave, Craig E. Kolb and Robert S. Mace
5. Transparencies..... 5-1 to 5-42
Dietmar Saupe

Part 2 Deterministic Fractals and Iterated Function Systems

6. Fractal Basin Boundaries: Julia Sets and the Mandelbrot Set..... A-1 to A-52
Heinz-Otto Peitgen, Hartmut Jurgens, Dietmar Saupe
7. Julia Sets and The Mandelbrot Set : Algorithms 6-1 to 6-33
Heinz-Otto Peitgen
8. The Beauty of Fractals Game, User Manual..... 7-1 to 7-8
Hartmut Jürgens, Heinz-Otto Peitgen, Dietmar Saupe, Marc Parment and Thomas Eberhard
9. Fractals: An Animated Discussion (film)..... 8-1 to 8-1
Heinz-Otto Peitgen, Hartmut Jurgens, Dietmar Saupe and Cornelia Zahlten
10. Introduction to Iterated Function Systems: Encoding Images by Simple Transformations..... B-1 to B-41
Heinz-Otto Peitgen, Hartmut Jurgens, Dietmar Saupe

Part 3 L-Systems and Fractals

11. The Algorithmic Beauty of Plants...(under separate cover)
Przemyslaw Prusinkiewicz and Aristid Lindenmayer