

Title: C4-IT 02-003 Fractal 2002

Author: Howard Marsh

Date: 8 May 2002

These reports summarize global activities of S&T Associate Directors of the Office of Naval Research International Field Offices (ONRIFO). The complete listing of newsletters and reports are available under the authors' by-line on the ONRIFO homepage: <http://www.ehis.navy.mil/onrnews.htm>, or by e-mail to respective authors.

TABLE OF CONTENTS

Keywords
Summary
Background
Discussion
Conclusion/Finding
Contacts

Keywords

Chaos
Complexity
Emergent Behavior
Fractal
Non-Gaussian
Nonlinear
Self-Similar

Summary

Fractal 2002 was an international multidisciplinary conference held in Granada, Spain on 17 to 20 March 2002. The purpose was to bring together practitioners in

various fields of science, engineering, medicine and economics to exchange views on complex spatial and temporal behavior. One of the products of the conference is the emerging insight into the complex nature of interacting systems. This is one of a series of conferences designed to maximize the development of collaboration across disciplines and to advance the state of the mathematical foundations for dealing with complex systems.

Information on this series of conferences can be found at the following web site.

<http://www.kingston.ac.uk/fractal/>

Background

One of the most important shortcomings in traditional mathematical approaches for classical physics and statistical analysis is an inability to deal with nonlinearities and interactions in a very effective way. The traditional approach of linearizing equations and then using perturbation theory to provide “vernier” adjustments to results is sufficient in many cases, but fails catastrophically in others. Treatment of seemingly random processes is one of the areas where these shortcomings are most significant.

The development of new techniques for dealing with these types of processes provides a mathematical basis for treating a wide variety of situations characterized by emergent behaviors, by statistical variations very different from standard Gaussian processes, and by strong degrees of self-similarity at multiple scale factors. These mathematical approaches are referred to by a variety of names such as chaos, complexity, and fractals.

Fractal 2002 was the seventh in a series of conferences, started in 1990, to bring together researchers in a wide range of disciplines to exchange views and share results related to fractal behavior in real-world systems. The presentations and discussions showed a great diversity in the application of fractal analyses to many different situations and a commonality of the underlying mathematics for dealing with realistic, non-Gaussian, stochastic processes.

Topics discussed at this conference included the following:

- Applications of fractals, including those in biology, medicine, engineering, economics and sociology
- Cellular automata
- Coherent structures
- Diffusion
- Disordered systems
- Fractal surfaces and volumes
- Fractals and chaos in signal processing

- Growth phenomena
- Iterated Function Systems
- Image analysis and synthesis
- Multifractal formalism
- Non-linear dynamical systems
- Pattern formation
- Phase transitions
- Self organization and cooperative phenomena
- Turbulence
- Visualization
- Waves and interactions

This conference was supported in part by a grant from the Office of Naval Research International Field Office.

Discussion

The research presented at this conference ranged from very simple correlation of observed patterns with fractal representations to more sophisticated analytical techniques for predicting and analyzing behaviors of complex systems. These mathematical techniques appear to have potential value for interpretation of information regarding measurements on real-world systems that exhibit history-dependent behavior.

The most significant presentations and discussions were from theoretical physicists who had moved into this field of research. Particularly strong participation was from Dr. Bruce West from the Army Research Office (ARO) and Professor V. V. Uchaikin from Moscow State University. Their presentations and discussions explored general mathematical formalisms for dealing with history-dependent statistical processes ranging from anti-persistence to persistence and that produce distributions with highly non-Gaussian characteristics. The significance of these presentations and discussions was that the researchers were not concerned simply with characterizing observations in terms of fractal behavior; they were concerned with developing mathematical tools to predict and analyze behavior based on fundamental principles.

One disappointment was the very limited U.S. participation in the conference. Aside from the ONRIFO participant (Howard Marsh), only two others were from the United States. One of these was Dr. Bruce West from ARO, and the Other was Dr. Susan Wearne from the Mount Sinai Medical School. In addition, there was no treatment of situations directly interesting to the U.S. Navy, although it would seem that this type of mathematical treatment could be very applicable to a number problems involving analysis of operational situation data.

Conclusion/Finding

This field of research appears to have potential value for a number of Navy and DoD interests. The most evident ones are for analyzing and predicting physical phenomena involving atmospheric and ocean behaviors. However, the value may also be in statistical analysis of situation data where history-dependent behaviors or strong interactions affect the processes. The movement of aircraft, ships, and vehicles could be within the first of these classes, and the behavior of forces could be in the second. In both cases, the change of state of the system is clearly non-Gaussian, and the ability to correlate observations with a model of the system will probably require mathematical tools to deal with the complexity and resultant emergent behavior that is generally observed.

The next Fractal conference will be held one-and-a-half to two years from now. The web site cited above will contain planning information, and ONR program officers and principal investigators involved with mathematical and statistical research should monitor that site and consider participating.

Contacts

Prof. Miroslav Novak, Kingston University, novak@kingston.ac.uk

Dr. Bruce West, U.S Army Research Office, westb@aro.arl.army.mil

The Office of Naval Research International Field Office is dedicated to providing current information on global science and technology developments. Our World Wide Web home page contains information about international activities, conferences, and newsletters. The opinions and assessments in this report are solely those of the authors and do not necessarily reflect official U.S. Government, U.S. Navy or ONRIFO positions.

[Return to ONRIFO Newsletters](#)

