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| 13. ABSTRACT (Maximum 200 words) During this period substantial progress has been made in a number of areas, including the question of the reason for the existence of period doubling cascades; other areas include predictability and fractal basin boundaries; a new scaling effect concerning the way strange attractors are destroyed; and work in which quasiperiodic motions are to be expected in nature. This report summarizes the progress made and lists reports and papers resulting from the research performed during this period. | | | | |
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Interim report on grant AFOSR-81-0217
for the period ending 30 September 1983.

I am pleased to report that substantial progress has been made in a number of areas, including the question of the reason for the existence of period doubling cascades. A long paper on this topic is almost complete. A short paper giving sketches of proofs has been accepted for publication.

Title: Cascades of Period-Doubling Bifurcations: A Prerequisite for Horseshoes

Authors: J. A. Yorke and K. T. Alligood

Description: Since Smale (6) described the complicated dynamical behavior of horseshoe maps, many dynamical systems depending on a parameter have been shown to develop horseshoes. In the horseshoe, there are 2^k fixed points for the k^{th} iterate of the map. Numerical studies of parameterized maps and the investigations of Newhouse (5) indicate there is a rich structure of attractors for parameters preceding the existence of the horseshoe. Once the horseshoe is formed, however, all periodic points are unstable and almost any trajectory starting in the horseshoe eventually leaves it. Assuming that cross-sectional areas are contracting, we prove that infinitely many cascades of period doublings must occur in the process of forming a horseshoe. Each such cascade need not evolve regularly or monotonically, but it must contain attracting periodic points of all the periods k , $2k$, $4k$, $8k$, ..., for some k .

During the period under review we started and completed a paper which connects predictability and fractal basin boundaries.

Title: Final State Sensitivity: An Obstruction to Predictability

Authors: C. Grebogi, S. W. McDonald, E. Ott, J. Yorke

Description: In situations where nonlinear dynamical systems possess more than one time-asymptotic final state, very accurate specification of the initial conditions may sometimes be necessary for the reliable prediction of the final state that is eventually reached. A notion of final state sensitivity is introduced in terms of the scaling of the final-state-uncertain

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phase space volume with uncertainty in initial conditions. The relation of final state sensitivity to the existence of basin boundaries with noninteger (fractal) dimension is discussed, and the implications for prediction are illustrated by a numerical experiment and by suitable interpretation of previous theoretical and experimental work.

A paper has been completed describing a new scaling effect concerning the way strange attractors are destroyed,

Title: Truncated Development of Chaotic Attractors when The Jacobian is not Small

Authors: T. Short and J. Yorke

Reference: This is to be included in the Springer Verlag (or is it Academic Press) Proceedings of the Kyoto Japan conference "Chaos and Statistical Mechanics"

We also completed work on which quasiperiodic motions are to be expected in nature.

Title: Are Three-Frequency Quasiperiodic Orbits to Be Expected in Typical Nonlinear Dynamical Systems?

Authors: C. Grebogi, E. Ott, J. Yorke

Description: The current state of theoretical understanding related to the question posed in the title is incomplete. This paper presents results of numerical experiments which are consistent with a positive answer. These results also bear on the problem of characterizing possible routes to chaos in nonlinear dynamical systems.

Reference: Physical Review Letters, 1 August 1983, Vol. 51 #5, pp. 339-342.

The paper on Nowhere Differentiable Attracting Tori has been greatly extended (Revised August 1983) and gives much stronger evidence in favor of the Dimension Conjecture of Kaplan and Yorke.



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Title: The Lyapunov Dimension of a Nowhere Differentiable Attracting Torus

Authors: J. L. Kaplan, J. Mallet-Paret, J. A. Yorke

Reference: Accepted for publication in Ergodic Theory and Dynamical Systems.

Title: Fractal Basin Boundaries, Long-Lived Chaotic Transients, and Unstable-Unstable Pair Bifurcation

Authors: C. Grebogi, E. Ott, J. Yorke

Reference: Physical Review Letters, 28 March 1983, Vol. 50, pp. 935-939.

Description: A new type of bifurcation to chaos is pointed out and discussed. In this bifurcation two unstable fixed points or periodic orbits are created simultaneously with a strange attractor which has a fractal basin boundary. Chaotic transients associated with the coalescence of the unstable-unstable pair are shown to be extraordinarily long-lived.

In this paper we consider a new type of bifurcation to chaotic motion. This bifurcation is characterized by the simultaneous appearance of a pair of unstable fixed points or periodic orbits, a fractal (i.e., nondifferentiable) basin boundary, and a chaotic attractor (also commonly called a strange attractor). Just prior to this type of bifurcation, transient behavior with a chaotic character can take place, and these chaotic transients can be extremely long. The existence of such remarkably long-lived chaotic transients may have important implications for experiments on chaotic systems.

The papers with Alligood and the three with Grebogi are short papers for which much longer versions are in preparation.