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A NEW APPROACH TO CHAOS

Ray Brown[1] and Vivek Jain.[2]

[1]The EASI Academy
Falls Church, Virginia, USA

[2]George Washington University Medical School
The George Washington University, Washington D. C., USA

Abstract. It is well known that chaotic systems have unpredictable time series, exponentially sensitive dependence on initial conditions, a noisy spectrum, and various other properties of pseudo-random processes. These properties have made it difficult to analyze and understand chaotic systems using traditional approaches to the study of differential equations. In this paper we present a new approach to chaos. This approach is suggested by the most complex chaotic system known, the human EEG. We argue that chaotic systems, and complex systems generally, may be better approached by understanding their morphology as is done by physicians when inspecting the human EEG. From a morphological point-of-view, the complex, pseudo-random properties of chaotic time series are not an obstacle to understanding chaos or formulating applications of chaos. But to be mathematically and scientifically rigorous, this view requires that we formalize the concept of morphology and understand the source(s) of the morphology of chaotic systems. In this paper, we offer a formal definition of morphology and examine the sources of morphology for a class of ODE's with chaotic solutions. To support the development of a morphological approach, we turn to the concept of *Dynamical Synthesis* [6]. This is an approach that requires us to reverse engineer complex dynamics as opposed to deriving equations from the laws of science. Specifically, to achieve dynamical synthesis we must learn what are the building blocks of complex systems by first examining and dissecting many mathematical system that exhibit complex properties, and then derive the fundamental theorems that guide the use of the building blocks to construct models and carry out predictions. To initiate this program we first examine the source of complexity in chaotic systems and then derive three methods to generate this complexity; the third method derives almost periodic functions that have the properties of unstable manifolds.

Keywords. Chaos, EEG, EKG, morphology, complexity, dynamical synthesis.

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1 Introduction

The phenomena of chaos has been known since the work of Poincaré[13]. Without the aid of modern computers, Poincaré correctly analyzed the source of this complexity, illustrated with time-one maps in Fig.1, see [12] for details of how figures of unstable manifolds are derived.