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Data Mining vs. Mathematical Modelling: Nonlinear Dynamics and Chaos Theory

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Data Mining vs. Mathematical Modelling: Nonlinear Dynamics and Chaos Theory

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Temporal behavior of natural phenomena has been difficult to characterize and quantify [Boxian et al. 1994; Broomhead et al. 1986]. Complexity of a natural phenomenon does not depend on the number of causes that govern it but essentially on the number of their interconnections, on the magnitude of such linkages and on the feed-back processes [Drazing, 1992]. An extraordinary advance of the environmental sciences will take place in the next years as a result the new technologies used in data mining [Sivakumar, 2000; Sivakumar, 2004; Turcotte, 2003]. Specifically, nonlinear analysis it is known that the long-term behavior of the motion and states of the atmosphere can be described by the global attractor. Namely, starting with a given initial value, the solution will tend to the attractor as time goes to infinity. An attractor is a set to which a dynamical system evolves after a long enough time. That is, points that get close enough to the attractor remain close even if slightly disturbed. The fractal dimension of the atractor in the phase space provides very useful information about the nature of the processes that generated the sequence of values measured in time [Grassberger P. and I. Procaccia, 1983]. In a deterministic system, the present values of the measured properties are related to their previous values. The dimension of the attractor tells us the number of independent variables in this relationship [Eckman, J.P and D. Ruelle, 1992]. "The number of independent variables is the smallest integer that is greater than or equal to the fractal dimension of the attractor". For example, the fractal dimension of the attractor for the Lorenz system is equal to 2.03. Thus a set of 3 equations with 3 independent variables can generate the sequences of values in time of the Lorenz system.
We managed to develop a system combining the **MATLAB** language and the **TISEAN** routines in order to make comparisons between our system and evaluate the results obtained using the **VRA software** and also to a great extent eliminate the "black box" pertaining to this. However there is an advantage to presenting the environment, totally in graph form.

According to these results, we might conclude that the values calculated for the Correlation Dimension are correct and thus its interpretation; this will generally be achieved in the case of observed time series. The key was to use a theoretical time series in our analysis, which is the numerical solution for Lorenz's system, for the variable "z".

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