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Application the Dynamical System Theory (DST)

Применение теории динамических систем (ТДС)

Застосування теорії динамічних систем (ТДС)

Keywords: dynamical systems, linear equations, nonlinear dynamics, space condition.

Ключевые слова: динамические системы, линейные уравнения, нелинейная динамика, пространство состояния.

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The DST is a well established framework in the physical science. Broadly speaking, the DST is the study of the way a system changes over time (Devaney, 1992; Port and Van Gelder, 1995; Clark, 2001; Ward, 2002). The DST provides the mathematical tools for analyzing and describing systems that change over time. The DST can be used to explore a variety of systems. Cellular automata, finite state machines, and Turing machines are all examples of dynamical systems. In general, dynamics can be thought of as linear or non-linear. Linear dynamics are modeled by linear equations, in which continuous change in the input lead to a continuous change in the output. Linear equations are easy to solve, and fully understood (Port and Van Gelder, 1995). The problem with linear equations is that they cannot always describe the behavior of natural systems, for example, when continuous changes in a certain parameter lead to sudden jumps in behavior (Barton, 1994). Non-linear equations are, in contrast to linear equations, diffcult to solve and answers often involve patterns of solutions. A dynamical system can be expressed as a set of differential and difference equations that describe how a systems changes over time (Beer, 2000). Formally, a dynamical system can be modeled by

$$< T; S; \phi t >$$

With an ordered time set $T = \{t0, t1,\dots tn\}$, a state space $S = \{x0, x1,\dots xn\}$, and an evolution operator $\phi : S \rightarrow S$ that transforms an initial state $x0 \in S$ at time t0

Є T to another state x1 Є S at time t Є T. The time set T can be discrete or continuous. The state space S may be numerical or symbolic, continuous or discrete, and it may be finite- or infinite dimensional, depending on the number of variables required to describe the system's behavior (Port and Van Gelder, 1995; Beer, 2000). Modeling dynamical systems can also occur in calculus. A dynamical system is described by $x_{n+1} = F(x_n)$, in which the next state x_{n+1} is a transformation of the current state x_n by function F. When describing a dynamical system, we are interested in the long term behavior of a system. A dynamical system can be described by characteristics such as attractors, repellers, bifurcation, etc.

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The second North and East European Congress on Food NEEFood – 2013.

Факультетет АКС, кафедра інформаційних систем.