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V.F. GUBAREV
Space Research Institute under NAS of Ukraine and State Space Agency of Ukraine, Kyiv, Ukraine, e-mail: *v.f.gubarev@gmail.com*.
Yu.L. MILIAVSKYI
Educational and Research Institute for Applied System Analysis of the National Technical University of Ukraine “Igor Sikorsky Kyiv Polytechnic Institute”, Kyiv, Ukraine,
e-mail: *yuriy.milyavsky@gmail.com.*

FEATURES OF MODELING AND IDENTIFICATION OF COGNITIVE MAPS UNDER UNCERTAINTY

Abstract. A process of complex systems identification is examined in this paper. It was established that it is impossible to create a universal identification method. Only for a well-identifiable system with a high signal-to-noise ratio for each individual system mode, a high-quality model can be reconstructed. In other cases, if modes with sufficiently small signal-to-noise ratio exist, only a surrogate model can be obtained. For cognitive maps, theoretical foundations are developed, which may be used in approaches to find a surrogate model and then to improve the result using different tuning and learning algorithms. Numerical simulation was used to analyze the identification process.

Keywords: cognitive map, system identification, subspace method, complex system, ill-conditioning, regularization.

PROBLEM STATEMENT

Linear time-invariant (LTI) models are widely used for simulation of impulse processes in cognitive maps (CM). Many different ecological, social, economical, educational, financial and other systems can be modeled and analyzed based on a CM. Mathematically CM is an oriented graph with nodes representing complex systems coordinates (concepts) and edges describing cause–effect relations between the nodes. We consider weighted CM where edges are weighted depending on significance of corresponding relation. See, for example, Fig. 1 (CM of IT company) [1].

During complex system operation under different disturbances CM coordinates change in time. Each CM node R_i is set to values $z_i(t)$ in discrete times $t = 0, 1, 2, \dots$. The next value $z_i(t+1)$ is determined by current value $z_i(t)$ and coordinates increments of other nodes R_j connected to R_i at time *t*. Change of nodes R_j coordinates $P_j(t) = \Delta z_j(t) = z_j(t) - z_j(t-1)$, $t > 1$, is called an impulse. Propagation of impulses over CM nodes is called impulse process and according to [2] is described by the equation

$$z_i(t+1) = z_i(t) + \sum_{j=1}^{n} a_{ij} P_j(t), \quad i = 1, \dots, n, \tag{1}$$

where a_{ij} is a weight of edge from R_j to R_i.

Another way, CM nodes coordinates’ evolution rule (1) may be formulated as first-order difference equation in increments:

$$\Delta z_i(t+1) = \sum_{j=1}^{n} a_{ij} \Delta z_j(t), \quad i = 1, \dots, n. \tag{2}$$

Equation (2) may be written in a vector form:

$$\Delta z(t+1) = A \Delta z(t), \tag{3}$$

where A is a transposed CM adjacency matrix, Δz is a vector of coordinates