A control of a digital copy of an enterprise by a targets classifier as a task of control a dynamic system

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Abstract. The area of research includes control theory, dynamic systems, parameters of the external environment, mode, integral indicators, goal. A review of scientific works shows the absence of digital copies of economic objects. The main idea of the research is to show the activity of an economic object (enterprise) as a digital copy. The digital copy of the economic object (enterprise) in the research is formalized. The target function of control the digital copy of the enterprise is set. Evaluation of the operating mode of a digital copy of an enterprise using 1.2 million parameters by an integral indicator method. Evaluation of the operating mode of a digital copy with an embedded target classifier. Both modes of operation depend on the control decisions taken, taking into account the influence of unpredictable signals from the external environment.

1. Introduction

Formally, a target classifier first appeared in the United States after the adoption of the constitution in September 17, 1787 [1]. A commission began to work on the creation of documents with goals and their assessments: civil servants, military [2]. The form of these documents is preserved to this day. Also the Commission compared the system for creating and evaluating targets with similar systems operating in other countries: Great Britain, France, Germany, Italy and Canada [2]. The commission created a general document but it took into account more personal goals. The first who realized about the system of goals classifier was F. Taylor. The author realized that the future belongs to the system of goals of the enterprise but not the individual [3]. In 1954 P. Drucker gave the concept of "Management by Objectives" and the economic world accepted it with a standing ovation. After the Second World War the world needed a new control tool to respond to new global challenges in the development of the state and society [4]. P. Drucker proposed: a hierarchy of goals, goals are agreed, work is evaluated by criteria, employees understand goals and rewards, there is a goal-action feedback [4]. In 1981 P. Mayer formed more stringent criteria for goals: concreteness, measurability, attainability, relevance, timeliness [5]. In 1996 R. Kaplan and D. Norton expanded the direction of evaluating goals with a balanced scorecard: finance, customers, company business processes, personnel development [6]. Today there is an understanding of the "normality" that goals should be set ambitious (FAST goals) and they will not always be achievable. The
The activity of an economic object (enterprise) is usually modeled by: intersectoral balances, vector, parametric and neural network modeling, agent-based approach, etc. in this case, the control loop of the target classifier is not identified as a separate object for research. The problem is the parameters of characterize the classifier targets of the activities of the enterprise remain unaccounted for due to the large dimension of the data. The formalized approach to assessing the effectiveness of the implementation of the classifier of goals is no by framework of the research of an enterprise as a dynamic system. It is difficult to identify and interpret any stable judgments and patterns.

The control of economic systems was dealt with by: V. V. Leontiev and L. V. Kantorovich, A. G. Granberg, A. G. Aganbegyan, V. F. Krotov and others [8-10]. In 2009 proposed integral indicators to determine the financial crisis of 2008 based on the method of correlation adoptometry. In 2013 integral indicators were used as a separate method to characterize the activities of an enterprise in various working conditions and take into account the relationship of its elements.

A purpose of research is: to estimate the state of an economic object as a multidimensional dynamic system in the basic mode of operation and its control mode, through the targets classifier with unknown parameters of the external environment.

2. Method

It is enough to imagine the economic activity of the enterprise as $S = \{T, X\}$, where $T = \{t: t = 1, ..., T_{max}\}$ - a lot of time points with a selected interval for analysis; $X$ - set of system parameters; $x(t)=[x^1(t), x^2(t), ..., x^n(t)] \in \mathbb{R}^n$ - vector of indicators corresponding to the state of the system. Indicators of the vector $x(t)$ - the value of financial expenses and income of the enterprise. The dimension of the system $n$ is 1.2 million parameters. Based on the parameters $X$ and $T$, we consider our economic object a multidimensional dynamic system (hereinafter referred to as the system).

The analysis of the system at the moment $t$ is performed $x(t)$ on the basis of previous measures. The parameter $k$ is the length of the time series segment (accepted $k=6$ months in the work). Then we have a matrix

$$
X_k(t) = \begin{bmatrix}
x^T_{t-1} \\
x^T_{t-2} \\
\vdots \\
x^T_{t-k}
\end{bmatrix} = \begin{bmatrix}
x^1(t-k) & x^2(t-k) & \ldots & x^n(t-k) \\
x^1(t-k) & x^2(t-k) & \ldots & x^n(t-k) \\
\vdots & \vdots & \ddots & \vdots \\
x^1(t-k) & x^2(t-k) & \ldots & x^n(t-k)
\end{bmatrix}
$$

(1)

$$
R_{ij}^t(t) = \frac{1}{k-1} \sum_{l=1}^{k-1} x^i(t-l)x^j(t-l), \quad i,j=1, ..., n,
$$

(2)

$$
r_{ij}(t) = \frac{1}{k-1} \sum_{l=1}^{k-1} x^i(t-l)x^j(t-l)
$$

(3)

where $t$ are the time instants, $r_{ij}(t)$ are the correlation coefficients of the variables $x^i(t)$ and $x^j(t)$ at the time instant $t$.

Next we form one of the four integral indicators – the sum of the absolute indicators of the correlation coefficients. It is indicator for express estimation of the correlation of system parameters $G(t)$:

$$
R_i(t) = G_i(t) = \sum_{j=1}^{n} |r_{ij}(t)|.
$$

(4)

The state of the entire system is calculated as:
\[ G = \sum_{i=1}^{T_{\text{max}}} \sum_{i=1}^{n} G_i(t). \]  

(5)

The targets classifier \( V \) is a set of system purposes of enterprise function (business-process), which can be represented \( V_i^k \) as a set of target classifier:

\[ V = \sum_{i=1}^{T_{\text{max}}} \sum_{i=1}^{n} V_i^k(t). \]  

(6)

We will carry out the identification of the performed functions of the system with the targets for the function (business-process). Each targets classifier \( V_i^k \) is characterized by the business-process of the enterprise:

\[ V_i^k = \sum_{i=1}^{n} v_i^j(x'_i) \rightarrow \min, \]  

(7)

where \( v_i^j \) is name of target (compliance \( x'_i \) is \( v_i^j \) set as 1-yes, 0-no); \( x'_i \) - the costs of the \( i \)-target for the function (business-process) \( j \). Control method is \( V \). It is target \( v_i^j \) so have a vector of target classifier \( v(t) = [v_i^1(t), v_i^2(t), \ldots, v_i^n(t)]^T \in V \cdot n \cdot \text{dimension.} \) Then \( V = \sum_{i=1}^{T_{\text{max}}} \sum_{i=1}^{n} V_i^k(t). \)

Payment of the functional duties of employees of the economic system is limited by resources \( C \), then \( C(X) \leq C \). This restriction applies to all subsystems of the researched system.

The implementation of the method is performed in the author's complex of programs.

3. Characteristics of the research objects

The object of research is an economic object (enterprise). The enterprise harvests 800 thousand cubic meters’ wood in the Severo-Yenisei region. The procured raw materials are delivered on barges along the Yenisei River to Krasnoyarsk during the shipping period from June to September. The harvested round timber is used to produce deep wood processing products: floorboards, glued beams, eurolining, etc. In 1.5 years, it is planned to double production at the expense of bank loans, taking into account tax benefits under certain scenarios of market development and enterprise strategy.

At this enterprise, a management loop is being introduced through the classifier of targets: product goals, corporate goals, operational goals, management goals, resource goals, etc. [6]

4. Experiment result

The dimension of the dynamic system is \( S=1.2 \) million values. The control loop is \( V \) - targets classifier. Resource consumption in normal mode - 5,641,442 thousand rubles. From the 7th period incentive payments are added to specialists in each department to track the achievement of goals. The simulation algorithm execution time is 432 minutes.

A table 1 shows the experiment result of estimating the control mode \( V_i^j(t) \) through the classifier of targets.

| \( t \) | \( V_{\text{basic mode}} \) | \( V_{\text{class targets}} \) | \( \Delta V \) | \( t \) | \( V_{\text{basic mode}} \) | \( V_{\text{class targets}} \) | \( \Delta V \) |
|------|------------------|-----------------|--------|------|------------------|-----------------|--------|
|  1   | 87.3361          | 86.3361         | -1.0000|  30  | 96.3218          | 95.3223         | -0.9995|
|  2   | 70.9440          | 69.9439         | -1.0001|  31  | 105.1011         | 104.1018        | -0.9993|
|  3   | 51.4324          | 47.4321         | -4.0003|  32  | 98.6620          | 97.6627         | -0.9992|
|  4   | 56.3529          | 52.3535         | -3.9994|  33  | 82.1931          | 81.1937         | -0.9994|
|  5   | 59.2634          | 58.2645         | -0.9989|  34  | 76.2280          | 75.2268         | -1.0012|
|  6   | 73.3888          | 73.3896         | 0.0007 |  35  | 68.5178          | 68.5172         | -0.0006|
A figure 1 shows the experiment result of estimating the control mode $V_i(t)$ through the classifier of targets.

Figure 1. Indicator dynamics $V_i(t)$. 
5. The discussion of the results

The enterprise incurs additional consumption of resources (wages, business trips, taxes, office, communications) for the implementation of a dynamic control system by the method of classifying targets. The cost from the install (the targets classifier) will be 13,784 thousand rubles. The total costs of the enterprise for five years will amount to 5,655,226 thousand rubles.

6. Conclusion

The method of integral indicators was used to assess the operating modes of an economic object (digital copy of the enterprise) as a dynamic system: the first mode \( V_{\text{basic mode}} \) – 5,069.93 units and the second mode after the implementation of the targets classifier \( V_{\text{class targets}} \) – 5,089.93. Therefore, the assessment of the transition to object control through the targets classifier is estimated as \( \Delta V = V^k_{\text{class targets}} - V^k_{\text{basic mode}} = 19.99 \). The purpose of the research has been achieved.

References

[1] Grote C G 2002 The Performance Appraisal Question and Answer A Survival Guide for Managers (AMACOM press) p 253
[2] 1976 History of Civil Service Merit Systems of the United States and Select Foreign Countries together with Executive Reorganization Studies and Personal Recommendations compiled by the Library of Congress (Washington D C: USA U S Government printing office Wasington Press) p 500
[3] Taylor F W 1911 The Principles of Scientific Management (New York: Harper&Brothers)
[4] Drucker P F 1954 The Practice of Management: A Study of the Most Important Function in American Society (New York: Harper&Brothers) p 404
[5] Doran G T 1981 There's a SMART way to write management’s goals and objectives Management Review 70(11) 35-6
[6] Kaplan R S and Norton D P 1996 The Balanced Scorecard: Translating Strategy into Action (Harvard Business Press)
[7] Sull D and Sull C 2018 With Goals FAST Beats SMART MIT Sloan Management Review
[8] Kantorovich L V 2011 Mathematical and economic work (Novosibirsk: Russia, Nauka Press) p 760
[9] Krotov V F 1990 The Basics of Optimal Control (Moscow: Russia, Vysshaya shkola Press) p 430
[10] Slyusarenko V V, Dorrer M G, Masaev S N and Wingert V V 2008 Information support for assessing the effectiveness of the marketing activities of the enterprise 6 interregional scientific and practical conference of graduate students and young scientists «Actual problems of the development of the consumer market» (Krasnoyarsk: Russia, Krasnoyarsk Trade and Economic Institute Press)