Mathematical Modeling of the Organization Performances by Improving a System Diagnostic

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Abstract

Lately, the deep transformations taking place into the structure of human society determines the conceptual reconsideration of the way of approaching the organization management , through increasing the performance level. If so far, we focussed especially on the material side of the organization, neglecting the human relations and the morality, at present, we pay a special attention to taking into consideration the information allowing a description of the functions fulfilled by the determinant components of the structure. Thus, the superficial observation of some apparent phenomena is replaced with a thorough study of the subtlety of the real [1]. To this end, a system S is studied using the triplet: component, function and membership degree of the function to component.

1. Introduction

The study of an eco-socio-economic system involves the determination, through a careful observation, of the functions of the components associated to its structure.

In this way, the premises of passing from the superficial analysis of the apparent state to the profound study of the subtle state specific to the system, are created.

To this end, the system S can be represented with the aid of a triplet (C_i, f_j, μ_{ij}^0), namely:

$$S_p = \left\{(C_i, f_j, \mu_{ij}^0),\ i=\overline{1,n};\ \ j=\overline{1,m}\ \right\} \tag{1}$$

where:

C_i = the i rank component of the system;

f_j = the j rank function of component i;

μ_{ij}^0 = the membership degree of component C_i related to the property of satisfying the function j, estimated by observer O; $\mu_{ij}^0 \in [0,1]$;

n = components number of system S;

m_i = functions number of component C_i;

S_p = primal representation of system S.

The duality system is further on applied. The system S can have a dual representation, if we use a triplet $(f_h, C_k \chi_{hk}^0)$, where the component is replaced with the function and the function with the component, namely:

$$S_d = \left\{(f_h, C_k, \chi_{hk}^0),\ \ h \in \overline{1,m},\ \ k \in \overline{1,n})\right\} \tag{2}$$

where: χ_{hk}^0 = the estimated membership degree of function f_h related to the property of satisfying the component C_k, evaluated by observer O.

$\chi_{hk}^0 \in [0,1]$; $\chi_{hk}^0 = \mu_{kh}^0$; $\chi_{ji}^0 = \mu_{ij}^0$; m_k = functions number of the component C_k;

S_d = dual representation of system S.

The primal system is under a matrix representation:

$$S_p = \begin{array}{c} \\ f_1 \\ f_2 \\ \cdot \\ f_j \\ \cdot \\ f_m \end{array} \begin{pmatrix} C_1, & C_2, & \dots, & C_i, & \dots, & C_n \\ \mu_{11}^0 & \mu_{21}^0, & \dots, & \mu_{i1}^0, & \dots, & \mu_{n1}^0 \\ \mu_{12}^0 & \mu_{22}^0, & \dots, & \mu_{i2}^0, & \dots, & \mu_{n2}^0 \\ \dots & \dots & \dots & \dots & \dots & \dots \\ \mu_{1j}^0 & \mu_{2j}^0, & \dots, & \mu_{ij}^0, & \dots, & \mu_{nj}^0 \\ \dots & \dots & \dots & \dots & \dots & \dots \\ \mu_{jm}^0 & \mu_{2m}^0, & \dots, & \mu_{im}^0, & \dots, & \mu_{nm}^0 \end{pmatrix} \tag{3}$$

and the dual system becomes:

$$S_d = \begin{array}{c} \\ C_1 \\ C_2 \\ \cdot \\ C_k \\ \cdot \\ C_n \end{array} \begin{pmatrix} f_1 & f_2, \ \cdots \ , \ f_j, \ \cdots \ , \ f_m \\ \chi^0_{11} & \chi^0_{21}, \ \cdots \ , \chi^0_{j1}, \ \cdots \ , \chi^0_{m1} \\ \chi^0_{12} & \chi^0_{22}, \ \cdots \ , \chi^0_{j2}, \ \cdots \ , \chi^0_{m2} \\ \ldots\ldots\ldots & \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ \chi^0_{1k} & \chi^0_{2k}, \ \cdots \ , \chi^0_{ji}, \ \cdots \ , \chi^0_{mj} \\ \ldots\ldots\ldots & \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ \chi^0_{1n} & \chi^0_{2n}, \ \cdots \ , \chi^0_{jm}, \ \cdots \ , \chi^0_{mn} \end{pmatrix} \qquad (4)$$

It is noticed that the dual system S_d is represented with the aid of the transposed matrix S^*_p of the matrix representing the primal system and conversely, namely:

$$S_d = S^*_p \quad \text{and} \quad S_p = S^*_d \qquad (5)$$

Besides the duality principle, we apply the principle of *antithesis* principle which was used, to a great extend, by Stefan Odobleja.

The antithesis principle that is specific to *subtle sets* is relatively simple to be applied to functions. So, the antithetic function $\overline{f}_j$ can be attached to each function f_j, called, in medical practice, *dysfunction.*

2. System State Estimation

For each component C_i and function f_j, the observer *O* sets a series of criteria, namely, direct criteria K^0_p and antithetic ones, $\overline{K}^0_p$, for estimating the normality state of component C_i, respectively, direct criteria Γ^0_q and antithetical ones, $\overline{\Gamma}^0_q$, in order to estimate the normality state of function f^0_j. There are estimated:

- the membership degrees ν^0_{ip} of the component C_i related to the property of satisfying the criterion K^0_p, respectively $\overline{\nu}^0_{ip}$, of satisfying the antithetical criteria $\overline{K}_p$; $p = \overline{1, \nu^0_i}$, $\nu^0_i =$ number of criteria to estimating the state of component C_i;
- the membership degrees ν^0_{jq} of function f_j of satisfying the criterion Γ^0_q, respectively $\overline{\nu}^0_{gq}$ to satisfying the antithetical criterion $\overline{\Gamma}^0_q, q = \overline{1, q^0_j}$; $g^0_j =$, number of criteria for estimating the state of function fj.

We make corrections related to:

- the elimination of the criteria redundancy K_p and Γ_q;
- the elimination of the incompatibilities between criteria K_p and Γ_q;

We calculate the global membership degree g^0_i of the state of component C_i, estimated by observer *O*, by using an additive, multiplicative mixed operator:

$$g^0_i = \Psi_0(\nu^0_{i1}, \nu^0_{i2}, ..., \nu^0_{ip}, ..., \nu^0_{iv_i}) \qquad (6)$$

respectively, the antithetic global membership degree $\overline{g}^0_i$, namely:

$$\overline{g}^0_i = \Psi_0(\overline{\nu}^0_{i1}, \overline{\nu}^0_{i2}, ..., \overline{\nu}^0_{ip}, ..., \overline{\nu}^0_{iv_i}) \qquad (7)$$

Similarly, we estimate the global membership degree h^0_j of the state of function f_j evaluated by observer *O*, as well as, the antithetic global membership degree $\overline{h}^0_j$ of the antithetic state $\overline{f}_j (j \in \overline{1, m})$. It is obvious that the operating mode conceived by observer, will determine the aggregation operator Ψ_0 of the state of components, as well as, the aggregation operator Φ_0 of the operating state. Two global indicators of the system are obtained:

- the global membership degree G^0 of the system components related to the property of having a good state, namely:

$$G^0 = \Psi_0(g^0_1, g^0_2, ..., g^0_n) \qquad (8)$$

- the global membership degree H^0 of the system functions related to the property to have a good state:

$$H^0 = \Phi_0(h^0_1, h^0_2, ..., h^0_m) \qquad (9)$$

Similarly, we can calculate the global membership degrees of a bad state, both for the components and for the functions, namely:

$$\overline{G}^0 = \Psi_0(\overline{g}^0_1, \overline{g}^0_2, ..., \overline{g}^0_n) \in [0.1] \qquad (10)$$

respectively

$$\overline{H}^0 = \Phi_0(\overline{h}^0_1, \overline{h}^0_2, ..., \overline{h}^0_n) \in [0.1] \qquad (11)$$

Consequently, it follows a discrepancy Δ^0_c evaluated by means of the components state:

$$\Delta^0_c = G^0 - \overline{G}^0 \in [-1.1] \qquad (12)$$

and a discrepancy Δ^0_f evaluated by means of the functions state:

$$\Delta^0_f = H^0 - \overline{H}^0 \in [-1.1] \qquad (13)$$

To be close to 1, proves a normality state, towards a "good" state, and to be close to -1 proves an affection state, towards a "bad" state. At the same time, we can calculate an indicator of the discrepancies intensity within a system, estimated by components I_{ic} , respectively an indicator of the system discrepancies estimated by functions I_{ij}^{0}:

$$I_{dc}^{0} = \frac{1+\Delta_{c}^{0}}{2} \in [0.1] \tag{14}$$

respectively:

$$I_{df}^{0} = \frac{1+\Delta_{f}^{0}}{2} \in [0.1] \tag{15}$$

If this intensity tends to 1, it results a "good" state, and if it tends to 0, it results a "bad" state.

3. Defining the Affection State of the System

For a certain system S_u, we make several investigations, in order to estimate the state at a certain given moment *t*, and we calculate the indicators of synthesis , namely:

$\Delta_{uc}^{t0} =$ discrepancy of the global state of the system S_u, estimated by means of the components, at moment *t*, by observer *O*;

$\Delta_{uf}^{t0} =$ discrepancy of the global state of the system S_u, estimated by means of functions, at moment *t*, by observer *O*;

$I_{udc}^{t0} =$ indicator of the discrepancy intensity of the system S_u,estimated by means of components, at moment *t*, by observer *O*;

$I_{udf}^{t0} =$ indicator of the discrepancy intensity of the system S_u,estimated by means of functions at moment *t*, by observer *O*;

The analogies among the socio-economic systems and the biological, technical etc. systems are of great useful, as they allow to apply the principles of the interdisciplinarity.

A first classification of the diagnostic results:

- general diagnostic;
-diagnostic on system components (structure diagnostic);
- diagnostic on system functions;
- diagnostic specific to a certain accident.

In case of the general diagnostic of the system S_u, we take into consideration the discrepancies Δ_{uc}^{t0} and Δ_{uf}^{to} on a time horizon T . In case of the diagnostic on components/functions, we take into consideration the same discrepancies, calculated for the relevant element (component, function or combination).

The normality test is made:

$$\Delta_{\inf}^{c} \le \Delta_{uc}^{to} \le \Delta_{mp}^{c} \tag{16}$$

respectively:

$$\Delta_{\inf}^{f} \le \Delta_{ne}^{t0} \le \Delta_{\sup}^{f} \tag{17}$$

where: $\Delta_{\inf}^{c}, \Delta_{\sup}^{c} =$ the feasible upper and lower bounds of the studied component;

$\Delta_{\inf}^{f}, \Delta_{\sup}^{f} =$ the feasible upper and lower bounds of the studied function.

The Boolean variables δ_{cu}^{t0}, respectively δ_{fu}^{t0} are defined, which express the affection/normality state of the system S_u and which take value 1 if the state is good and 0 if the state is bad.

In case of an instantaneous diagnostic (accident, for instance) the system state expressing an acute state is considered on the basis of a single value. In case of a diagnostic with an historic of the system reflecting a chronic state, the mean $\overline{\delta}_{cu}^{0}$ (respectively, $\overline{\delta}_{fu}^{0}$) of the state which characterize the system is made, as well as the mean square deviations of this state σ_{cu}^{0}, respectively, σ_{fu}^{0} .

The normality test is:

$$\overline{\delta}_{cu}^{0} - k\sigma_{cu}^{0} \ge 0 \tag{18}$$

respectively,

$$\overline{\delta}_{fu}^{0} - k\sigma_{fu}^{0} \ge 0 \tag{19}$$

where: $k =$ likelihood coefficient providing the fact that the probability of the normality state exceeds $\left\{\left(1-\frac{1}{k^2}\right), k>1\right\}$.

Taking the same probability, we consider that the system is in an affection state, if:

$$\overline{\delta}_{cu}^{0} - k\sigma_{cu}^{0} \le 0\,, \tag{20}$$

respectively,

$$\overline{\delta}_{fu}^{0} - k\sigma_{fu}^{0} \le 0 \tag{21}$$

If conditions (18), (19) (20) and (21) are not met, the system is considered into a "suspected" state.

Usually, the diagnosis is stated for the situation given by relation (20), respectively (21), for chronic states, observed along a historical (for a long enough period *T* which to provide the necessary accuracy). In case of accidents or unexpected events of an acute state, one determines δ_{cu}^{t0}, respectively δ_{fu}^{t}, according to the evaluation at the moment t of the discrepancy Δ_{uc}^{t0} respectively Δ_{uf}^{t0} and one takes into consideration that the mean is equal to the instantaneous level $\overline{\delta}_{cu}^{0} = \delta_{cu}^{t0}$, respectively $\overline{\delta}_{fu}^{0} = \delta_{fu}^{t0}$, and for the mean square deviation, the following estimations are made: $\sigma^0_{cu} = 0.2\overline{\delta}^0_{cu}$, respectively $\sigma^0_{fu} = 0.2\overline{\delta}^0_{fu}$.

In case of using the intensity indicators of the discrepancy I'^0_{ude}, respectively I'^0_{udf}, the comparison 0 representing the center of the interval [-1.1] is replaced with comparison 0.5 representing the center of the existing field of the indicators placed on interval [0.1], into relations (18), (19), (20) and (21).

4.Diagnosing a Socio-economic System with Certain Dysfunctions.

In order to diagnose the affection , we use, besides the above synthetic indicators, the analytic knowledge to determining the symptoms, dependencies, risks etc.

To this end, we can construct a coupling between the set of causes:

C = $\{C_1, C_2, ..., C_n\}$ and of symptoms **S** =$\{s_1, s_2, ..., s_n\}$. A second coupling is constructed between symptoms **S** = $\{s_1,s_2,\ldots,s_m\}$ and anomalies („affections") **A** =$\{a_1, a_2, ..., a_p\}$, but also a third coupling between the anomalies **A** and treatments τ, as it is illustrated in figure 1.

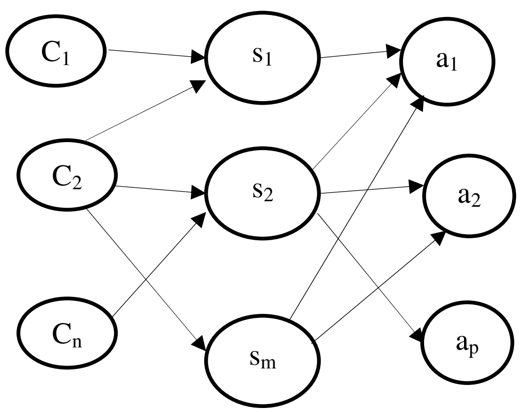

Figure 1
Diagnosing a Socio-economic System

In fact, the three couplings represent three applications, namely:

- Application $\mathbf{A_1} : \mathbf{P}(\mathbf{C}) \Rightarrow \mathbf{S}$;

$\mathbf{C} = \{C_1, C_2, ..., C_n\}$ $\boldsymbol{\tau} = \{T_1, T_2, ..., T_q\}$

- Application $\mathbf{A_2} : \mathbf{P}(\mathbf{S}) \Rightarrow \mathbf{A}$;

$\mathbf{S} = \{S_1, S_2, ..., S_m\}$

- Application $\mathbf{A_3} : \mathbf{P}(\mathbf{A}) \Rightarrow \tau$;

$\mathbf{A} = \{a_1, a_2, ..., a_p\}$

5. Conclusions.

The diagnostic problem is an interdisciplinary one but also a trandisciplinary one. The diagnostic must be specified for individual systems. Although, each system has particularities, yet, they can have common characteristics which allow generalizations (there is a unity in diversity). The experience gained in an informatic system of diagnosing and treating can be generalized.

The application of subtle sets permits to improve the methods of diagnosing. By confronting the results obtained through a diagnostic on the basis of components with the results obtained on the basis of functions, the confidence degree as regards the accuracy of the informatic system increases.

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