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A method of project feasibility assessment on creation of information-control systems for complex technical objects on the basis of fuzzy cognitive modeling

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Abstract : A realistic assessment of the practical feasibility of a project on creation of information-control systems (ICS) for complex technical objects (CTO) at the initial stage of its life cycle is the key to its subsequent successful implementation. Currently, project feasibility assessment is largely based on the analysis of the previous experience of realization of similar projects and, in particular, on building a project feasibility model. The process of model formation is weakly structured, because it is characterized by a lack of accurate quantitative input data about the project being developed (sometimes, the project parameters are not known precisely due to limited knowledge of the project leader and its executors) and its multifactorial nature.

In this paper, we propose one of the most effective approaches to the study of the weakly structured processes: the methodology of fuzzy cognitive modeling, which consists in the construction and analysis of the structure of a fuzzy cognitive model (FCM) under the fuzzy input data. To analyze the FCM structure, some system indicators of the FCM can be used, calculated on the basis of the processed fuzzy input data, as well as the categorical methods based on a homomorphic (structural equivalent) representation. The results obtained by calculating the FCM system indicators under fuzzy input data will enable, on the basis of the values, to select the control vertices with the greatest influence on the target vertices and to evaluate the extent of this influence. The results obtained using categorical methods allow preserving the integrity of the presentation of complex technical objects due to the invariant character of a poly-model object description and allow reducing the study of the problems of one kind to the problems of another kind.

Keywords : Fuzzy cognitive model, processing of fuzzy input data, categorical methods.

1. INTRODUCTION

Presently, the creation of ICS for CTO is a time-consuming process, because it is connected with significant expenditure of material, labor and financial resources in the risk conditions due to uncertainty of the factors of the internal and external project environment. This process also includes scientific research, development, design and experimental works, field tests and the documentation preparation.

A significant reduction of the development period and increasing complexity of the ICS result in the impossibility of applying the traditional design methods, overspending the budget and/or failure to meet the deadlines of the project on ICS creation or just its complete failure. Therefore, at the stage of pre-project research at the beginning of the ICS life cycle, there is a need to assess the feasibility of the project on ICS creation in the conditions of fuzzy input data, since there is a weak structuring of theoretical and factual knowledge about the project, it is not always

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possible to obtain an accurate mathematical description of the ICS creation process due to the lack of accurate quantitative initial data about the project being developed (Lipaev, 2006; McConnell, 2007).

Despite a large number of works by many domestic and foreign authors (E.O. Dmitrieva, A.P. Eremeeva, N.V. Kostereva, I. Attarzadeh, P. Kumar and others) dedicated to creating ICS for CTO, the problem of assessing the project realizability at the initial stage of its life cycle is still open. This is due to the fact that the studies do not provide detailed processing of the input data (Iiyasov, & Vasil'ev, 2009; Stylios, & Groumpos, 2000). As an assessment of the projects on ICS creation, they consider just an estimation of economic efficiency of the project. The above-mentioned works are devoted to the problems, arising during the stage of design and manufacture of ICS, because it is fairly easy to analyze them and to comprehend using the experience and the available statistical data. The project feasibility assessment on creation of ICS for CTO in the conditions of fuzzy initial data requires innovative approaches to analyzing and forecasting situations, which, as a result, brings enormous economic benefits for the project.

In this regard, to guarantee compliance with the customer requirements, to achieve the necessary technical and economic indicators, it is expedient to apply fuzzy cognitive modeling, which consists in the construction and analysis of the FCM structure, which in turn makes it necessary to have deep knowledge in the subject area and perform laborious research work (Bozhenyuk, & Ginis, 2013; Ginis, 2015; Kolodenkova, 2016; Kosko, 1986).

In this paper, a method of project feasibility assessment on creation of ICS for CTO using fuzzy cognitive modeling is considered. To analyze the FCM structure, it is proposed to undertake the calculation of system indicators based on the processed fuzzy initial data and the categorical methods based on a homomorphic representation.

2. DEVELOPMENT OF A METHOD OF PROJECT FEASIBILITY ASSESSMENT WITH APPLICATION OF FUZZY COGNITIVE MODELING

The method of project feasibility assessment on creation of ICS with application of fuzzy cognitive modeling consists in processing fuzzy input data, the construction and analysis of the FCM structure. To realize this method, we proposed eight stages.

Stage 1. Identification of factors C_i, $i = 1,\dots, h$ and the connections w_{ij} between the factors ($i = 1,\dots, h$; $j = 1,\dots,h$), h is the number of factors.

Stage 2. Setting the current values of the factor parameters ${}^{x}C_i$ and the connections w_{ij} between them.

The values of the factor parameters can be represented in the form of :

1. Precise numbers (they differ by the units of measurement and orders of magnitude);
2. Trapezoidal fuzzy numbers ; $xCi = [{}^{x}C_i1, {}^{x}C_i2, {}^{x}C_i3, {}^{x}C_i4,]$
3. Linguistic descriptions.

The values w_{ij} of the connections between factors can be represented in the form of :

1. Fuzzy numbers from the interval [– 1; 1];
2. Trapezoidal fuzzy numbers ; $w_{ij} = [w_{ij1}, w_{ij2}, w_{ij3}, w_{ij4}]$;
3. Linguistic descriptions.

Here x_{C_i1}, x_{C_i4} ; w_{ij4} are the pessimistic and optimistic estimates of the factors and their connections, respectively; $xC_i = [x_{C_i2}, x_{C_i3},]$; $w_{ij} = [w_{ij2}, w_{ij},]$ are the intervals of most probable estimates of the factors and their connections, respectively. Let us note that, so far, we are not dealing with FCM as a mathematical apparatus; we are only operating with the notion of factors (C_i). As soon as we start working with FCM, we will operate with the notion of a vertex (v_i).

Stage 3. Processing of fuzzy initial data. The algorithm is presented in Section 3.

Stage 4. Construction of the adjacency matrix and a fuzzy cognitive model.

The element w_{ij} of the matrix W at the intersection of the i-th row and the j-th column characterizes the influence of the vertex v_i on the vertex v_j.

Stage 5. Analysis of the structure of the fuzzy cognitive model.

After the formation of the matrix W, we conduct an analysis of the FCM structure, *i.e.*, we calculate the system indicators of the FCM, allowing studying the forces of mutual influences between the vertices or between a vertex and the system. In what follows, a *system* is understood as a fuzzy cognitive model.

To determine the mutual influence of the vertices from the original fuzzy adjacency matrix W with the positive-negative fuzzy connections, it is necessary to move to a fuzzy matrix of positive connections $R = \|r_{ij}\|_{2h \times 2h}$ of the size $2h \times 2h$, the elements of which are determined from the matrix $W = \|w_{ij}\|_{h \times h}$ of the size $h \times h$ by the following substitutions (Borisov *et al.*, 2007; Korostelev *et al.*, 2009; Silov, 1995):

Then, a transitive closure of the matrix is carried out in the following manner:

$$\begin{cases} \text{if } w_{ij} > 0, \text{ TO } r_{2i-1,2j-1} = w_{ij},\ r_{2i,2j} = w_{ij}, \\ \text{if } w_{ij} < 0, \text{ TO } r_{2i-1,2j} = -w_{ij},\ r_{2i,2j-1} = -w_{ij}, \\ \text{the remaining elements take non-zero values.} \end{cases}$$

Then, a transitive closure of the matrix $\overline{R^{(m)}} : \overline{R^{(m)}} = R \vee R^2 \vee \ldots \vee R^{(m)}$ is carried out in the following manner:

$$\overline{R^{(m)}} = [r_{ij}^{(m)}];\ i,\ j = \overline{1;h};\ m = \overline{1;h};\ r_{ij}^{(m)} = \max(r_{ij}^{(m-1)};\ r_{im}^{(m-1)} \cdot r_{mj}^{(m-1)})$$

where h is the number of vertices;

if $m < h$, then the construction of the matrix $R^{(m)}$ is continued;

if $m = h$, then the construction of the matrix $R^{(m)}$ is finished.

Since the dimension of the matrix of transitive closure may be large, we propose to represent this result in the form of a matrix of mutual influence. This matrix consists of positive-negative pairs $Z = \|(z_{ij}, \bar{z}_{ij})\|$, where z_{ij} characterizes the strength of the positive influence $\bar{z}_{ij}$, the strength of the negative influence of the i-th factor on the j-th one, formed according to the rule:

On the basis of the matrix Z, the system indicators of the FCM can be calculated, which allow distinguishing the control vertices with the greatest impact on the target vertices and assessing the extent of this influence.

This analysis allows identifying which of the vertices have the greatest impact on the entire system and vice versa, and also which are most influenced by the system.

Stage 6. Conducting impulse modeling on the fuzzy cognitive model and a scenario analysis (Gorelova, 2015; Gorelova *et al*., 2006; Kulba *et al*., 2002).

Stage 7. Analysis of the results.

Stage 8. Selecting a scenario of the system development.

A modification of the proposed method is the use of an algorithm of the fuzzy initial data processing.

3. ALGORITHM OF THE FUZZY INITIAL DATA PROCESSING

Next, we consider the developed algorithm of processing the fuzzy input data, consisting of twelve steps (Kolodenkova, 2016).

Step 1. Entering the values of the parameters of vertices and the connections between them.

Step 2. If the values of the vertex parameters are presented in the form of trapezoidal fuzzy numbers, then go to step 3; if the condition is not met, to the step 4.

Step 3. Normalization of the values of vertex parameters, presented in the form of trapezoidal fuzzy numbers.

For the normalization, we suggest the following transformation method :

$$x_{v_i}^{\text{norm}} = \left[\frac{x_{v_i 1}}{x_i^{\max}}, \frac{x_{v_i 2}}{x_i^{\max}}, \frac{x_{v_i 3}}{x_i^{\max}}, \frac{x_{v_i 4}}{x_i^{\max}} \right],\ x_i^{*\max} = \max_{1 \le i \le h^*} \{x_{v_i 4}\};$$

where $x_{v_i}^{\text{norm}}$ are the normalized interval values of the vertex parameters, $x_{v_i}^{\text{norm}} \in [0; 1]$, $v_i \in V$, $i = \overline{1, h}$; V is the set of vertices;

$x_i^{*\max}$ are the maximum values among the maximum values of the vertex parameters, presented in the form of trapezoidal fuzzy numbers;

h^* is the number of vertices, the parameter values of which are presented in the form of trapezoidal fuzzy numbers.

In order to obtain one normalized fuzzy value from the interval, it is recommended to use the following conversion method:

Step 4. If the values of the vertex parameters are presented in the form of linguistic descriptions, then go to step 5; if the condition is not satisfied, to step 6.

Step 5. Structuring the values of the vertex parameters. For the parameters of vertices, the values of which are presented in the form of linguistic descriptions, we propose to carry out structuring, where to each linguistic description of the vertex parameter, there is assigned one number from the interval [0; 1] (Table 1).

Table 1. Estimation of the value of the vertex parameter of the linguistic variable "The factor level"

Linguistic description (the level of factor)	*Numerical value*
Low	[0.1; 0.3]
Below average	[0.31; 0.5]
Average	[0.51; 0.7]
Above average	[0.71; 0.9]
High	[0.91; 1]

Step 6. If the values of the vertex parameters are presented in the form of precise numbers (they do not differ by the measurement units and the orders of magnitude), then go to step 8; if the condition is not satisfied, to step 7.

Step 7. Normalizing the values of the vertex parameters, presented in the form of precise numbers.

For the normalization, we propose the following way of transformation:

$$x_{v_i}^{*\text{norm}} = \frac{x_{v_i 1}^{\text{norm}} + x_{v_i 2}^{\text{norm}} + x_{v_i 3}^{\text{norm}} + x_{v_i 4}^{\text{norm}}}{4} \qquad (1)$$

where $x_{v_i \text{curr}}$ is the current value of the vertex parameter.

Note that the formula (1) for normalizing the values of the vertex parameters, presented in the form of trapezoidal fuzzy numbers, is not suitable as the interval values of the vertex parameters should not intersect, because only in this case the "maximum" or "minimum" relationships are established (Levin, 1998; Voshchinin, 2002).

Step 8. If the values of the connections between vertices are represented in the form of intervals, then go to step 9; if the condition is not satisfied, *i.e.*, the values of connections between the vertices are represented as linguistic descriptions, then proceed to step 10.

Step 9. Normalization of the connection values between the vertices, presented in the form of intervals. The assessment of the nature and strength of connection between vertices, presented in the form of trapezoidal fuzzy numbers, on the five-grade scale, is given in Table 2.

Table 2. Assessment of the nature and strength of the connection between vertices

Numerical value	*Linguistic description*
0	Absent
[0.1; 0.3; 0.6; 1][-0.1; -0.3; -0.6; -1]	It strengthens very little It weakens very little
[1.1; 1.3; 1.6; 2][-1.1; -1.3; -1.6; -2]	It strengthens slightly It weakens slightly
[2.1; 2.3; 2.6; 3][-2.1; -2.3; -2.6; -3]	It strengthens moderatelyIt weakens moderately
[3.1; 3.3; 3.6; 4][-3.1; -3.3; -3.6; -4]	It strengthens stronglyIt weakens strongly
[4.1; 4.3; 4.6; 5][-4.1; -4.3; -4.6; -5]	It strengthens very stronglyIt weakens very strongly

For the normalization of the relation values, we suggest a similar way of transformation as for the values of the vertex parameters.

Step 10. If the values of connections between vertices are represented in the form of linguistic descriptions, then proceed to step 11; if the condition is not fulfilled, *i.e*., the values of relations between the vertices are represented by fuzzy numbers from the interval [- 1; 1], then go to step 12.

Step 11. Structuring the values of the connections between vertices. The structuring consists in the following: to each connection value, presented in the form of linguistic description, there is associated one fuzzy number from the interval [- 1; 1] (Table 3).

Table 3. Assessment of the nature and strength of the connection between vertices, presented in the form of linguistic descriptions

Linguistic description	*Numerical value*
Absent	0
It strengthens very little It weakens very little	[0.1; 0.3][-0.1; -0.3]
It strengthens slightly It weakens slightly	[0.31; 0.5][-0.31; -0.5]
It strengthens moderatelyIt weakens moderately	[0.51; 0.7][-0.51; -0.7]
It strengthens stronglyIt weakens strongly	[0.71; 0.9][-0.71; -0.9]
It strengthens very stronglyIt weakens very strongly	[0.91; 1][-0.91; -1]

Step 12. Construction of a fuzzy cognitive model.

End of the algorithm.

4. CATEGORICAL METHODS OF REPRESENTING AND STRUCTURING INFORMATION TO ANALYZE THE STRUCTURE OF THE INFORMATION-CONTROL SYSTEMS

Using the categorical methods of representing and structuring information for analyzing ICS, we have constructed a formal mathematical apparatus for presenting data, based on including the formed category of generalized computational models into the production systems of knowledge representation.

One of constructive ways to reduce uncertainty in the processes of preliminary preparation of these procedures of the decision-making support is a synthesis of deductive, inductive and abductive logical inference methods (Ohtilev *et al.*, 2006; Potapov, 2007). These methods are based on the scientific concepts such as the relationships between “the general” and “the particular”.

The structure and functioning of the analytical systems S depend on the following information entities: the object of the ICS analysis Q; the purposes of functioning of the analytical system G, determined by a specific decision-making task; the poly-model complex defining the structure of the system M; the environment defining the system parameters C, as well as the relations between these structures R = ($r_{Q, M}$, $r_{Q, C}$, $r_{Q, G}$, $r_{M, C}$, $r_{Q, M}$, $r_{Q, C}$).

Let $d = \left\langle n_i^d, C_d \right\rangle$ where n_i^d is the name of the parameter of the object of the ICS analysis; C_d is the value of the parameter . Generalizing the frame-based model of representation of the declarative knowledge, we represent the information sources as follows: D = (D^N, D^L, D^K), where D is a database; D^N is the data from the measuring tract of the system; D^L is the data collected during the operation of such class of systems in other regions; D^K is the data accumulated in the town planning documentation (Batishchev, & Gubanov, 2010).

In the case of D^N, there holds the following condition $D^N = \left\langle X_k^{in} = X_k^{out}, F_j^{X_k^{in} \to X_k^{out}} = \varnothing \right\rangle$. D^L-data are a “black box”; the subject of monitoring is the set of input parameters and the set of output parameters, when, based on the input and output values, a model (mapping) of the input parameters into the output ones $D^L = \left\langle X_k^{in}, X_k^{out}, F_j^{X_k^{in} \to X_k^{out}} = \varnothing \right\rangle$ is recovered (selected); D^K is the data (knowledge), obtained as a result of research and design-experimental activity $D^K = \left\langle X_k^{in}, X_k^{out}, F_j^{X_k^{in} \to X_k^{out}} \right\rangle$. Taking into account that the system components are program objects and taking as a basis a system of products, we consider the following formal model $P_i = \left\langle M, M', R_i, O_i \right\rangle$. In this model, as a set of given literal M_i of the product system and the set of the formed literals $M_i^{'}$ of the product system, the generalized computational models are defined. R_i is the set of products of the i-th kind, O_i is the set of assigning procedures of the i-th kind. M = <A, F_M> 0, where A = {α_i, i = 1,…, n} is a finite set of the object state parameters, F_M is a finite set of relations on the set of parameters from A. F = <f_i, i = 1,…,k | $\alpha \in$ A> is a relation on the set of parameters f = <A, $gr(f)$> 0. We denote: the set of all mappings [omega] for all relations $f \in F_M$, the input parameters $in(\omega) = Z_A^{in}$ for the operator [omega], the output parameters $out(\omega) = Z_A^{out}$ for the operator [omega].

As the objects of the category M, there are defined the calculation models $Ob(M_i^k)$; for each pair of objects $Ob(M_j^k)$ and $Ob(M_j^k)$, there is defined the set of morphisms $Hom\ Ob(M_i^k)$; for each triple of objects there is defined composition of $Ob(M_i^k), Ob(M_j^k)$ and $Ob(M_l^k)$; for the morphisms $\varphi \in Hom(M_i^k, M_j^k)$ and $\psi \in Hom(M_j^k, M_l^k)$ there is defined composition $\varphi\psi \in Hom(M_i^k, M_l^k)$; for each object $Ob(M_i^k)$ there is defined a unit morphism $1_X \in Hom(M_i^k, M_i^k)$.

Based on the proposed formal apparatus, a methodology has been created for the purpose-oriented formation of a poly-model complex, which is characterized as a heterogeneous network structure with hierarchical elements. A method is created for automatic formation of a number of algorithms for calculating the target parameters based on the analysis of data pre-processing. The algorithms of implementation of the developed inductive inference methods have been created and investigated.

Taking as a basis the approach (Stefanyuk, & Zhozhikashvili, 2007) to building an order on the set of samples, we formulate the rules of structuring the obtained information: M_b^k if is a basis of the model, (M_0^k, ψ) is the initial situation, whereas (M_i^k, λ) is a derivative situation, $\lambda \in Hom(M_i^k, M_b^k)\ \&\ \exists\, \omega \in Hom(M_0^k, M_i^k)$ is the compatibility condition, then:

$$\exists\, (\mu \in Hom(M_i^k, M_j^k)) \to ((M_i^k, \phi) N (M_j^k, \upsilon))$$

where N is the sub-classing operation.

The condition of generalization of two models is expressed as follows:

$$(M_i^k, \phi); (M_j^k, \upsilon); \exists\, \eta : M_i^k \to M_m^k; \exists\, \mu : M_j^k \to M_m^k\ \&\ \exists \eta 1 : M_i^k \to M_{m1}^k,$$

$$\exists\, \mu 1 : M_j^k \to M_{m1}^k\ \exists\ \&\ \exists\, (\chi \in Hom(M_m^k \to M_{im1}^k)) \to (M_m^k, \beta).$$

The rule for determining a particular case:

$$(M_i^k, \phi); (M_j^k, \upsilon); \exists\, \eta : M_i^k \to M_m^k\ \&\ \exists\, \mu : M_j^k \to M_m^k\ \exists\, \eta 1 : M_i^k \to M_{m1}^k$$

$$\&\ \exists\, \mu 1 : M_j^k \to M_{m1}^k\ \&\ \exists\, (\vartheta \in Hom(M_n^k \to M_{n1}^k)) \to (M_n^k, \beta).$$

As a result, a structure is formed consisted of a plurality of model classes, each of which is represented by a hierarchical structure, the elements of which are connected by the “general-particular” relation.

In the formation of multi-model complexes, the following strategy of operating the computational models is used: either the model is an object of deductive inference and forms a more detailed result, or the model is an object of inductive inference for the structures of higher hierarchy.

Thus, setting the purpose of analysis leads to activation of several competing computing schemes $\varepsilon = (\Gamma_1, \Gamma_{2,\dots,} \Gamma_n)$, the formation of which is based on a set of game situations $I(\varepsilon, \gamma_j^k)$.

5. EXAMPLE OF PROJECT FEASIBILITY ASSESSMENT ON CREATION OF INFORMATION-CONTROL SYSTEMS

Assume that the connection forces between the vertices are estimated according to a five-grade scale and presented in the form of trapezoidal fuzzy numbers. As a result of normalizing and structuring, an adjacency matrix is obtained, where the values of connections between the vertices are represented by the numbers w_{ij} from the interval [- 1; 1] and are reflected in the constructed FCM of project feasibility assessment on creation of ICS for the nuclear power plants (Figure 1).

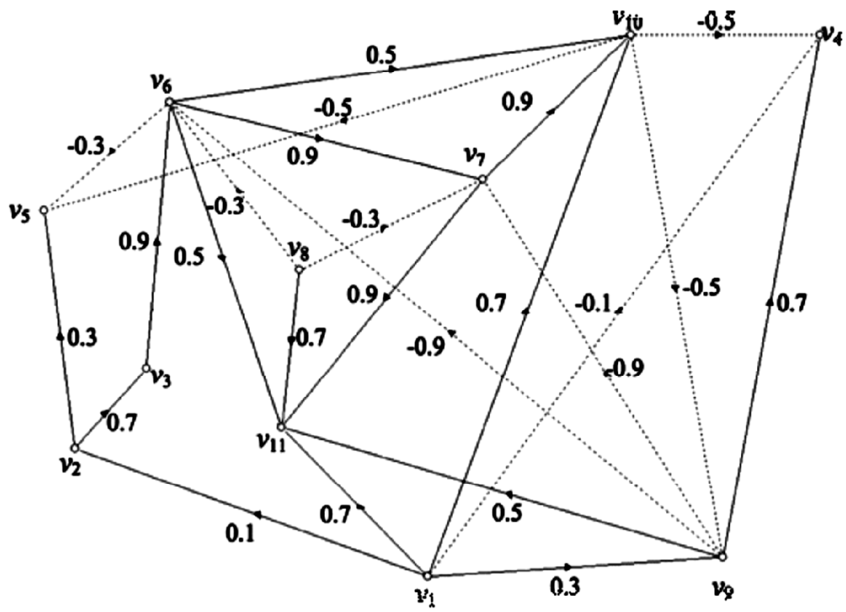

Fig. 1. Fuzzy cognitive model for project feasibility assessment on creation of ICS for the nuclear power plants.

Here the vertex v_1 is the number of tasks; v_2 is the productivity of executors (work execution speed); v_3 is the number of estimates of the ICS project (the estimates can be obtained using different approaches and methods, they can be presented in a format allowing making decisions on the ICS realization methods); v_4 is project completion (unsuccessful project completion, i.e. work schedule delay, project failure); v_5 is economic efficiency (carrying out the works at the lowest cost); v_6 is the ICS reliability (ICS is in an operable state during a certain time interval); v_7 is security and protection of ICS (the property of ICS to function properly without causing various negative consequences for people and the environment); v_8 are the external factors (the external factors influencing the nuclear power plant (seismicity, climate, floods)); v_9 is the number of errors committed by the executors; v_{10} is the time spent on the creation of the system; v_{11} is the financial resources spent on the creation of ICS.

Then we calculate the basic system indicators. The results of calculation of the system parameters, reflecting the influence of vertices on the system and of the system on the vertices, are presented in Table 4.

It is obvious that the greatest positive impact on the system is exerted by the vertices v_2 (0.27) and v_3 (0.22), whereas they do not experience a strong influence on the part of the system. Slightly less positive impact on the system is exerted by v_1 (0.06), v_6 (0.16), v_7 (0.08), v_8 (0.01). Influencing the listed vertices, one can “turn” the entire system in a positive direction.

The vertices v_{10} (0.23) and v_{11} (0.32) are influenced the most by the system. It is highly probable that the impact of the system on these vertices is capable of cancelling out any negative impact from the outside, *i.e.*, if the project manager intentionally wants to exert some long-term influence on them, he/she should rely on the indirect influence, acting on the vertices v_1, v_2, v_3, v_6, v_7, v_8.

The vertices v_5 and v_9 are ambivalent but balanced, since the vertex v_5 weakens the system slightly (-0.03), but the latter weakens it rather strongly (-0.22); the vertex v_9 weakens the system rather strongly (-0.36), but the system weakens it insignificantly (-0.04). That is, the vertices v_5 and v_9 are with the negative two-sided influence (there are no negative cycles).

Table 4. The results of calculation of the system parameters, reflecting the influence of vertices on the system and of the system on the vertices.

Vertices	*Influence of the vertices on the system*	*Influence of the system on the vertices*	*Dissonance of influence*		*Consonance of influence*	
			of the vertex on the system	*of the system on the vertices*	*of the vertex on the system*	*of the syste on the vertices*
v_1	0.06	0	0.43	0	0.57	1.00
v_2	0.27	0.01	0.08	0	0.92	1.00
v_3	0.22	0.07	0.04	0	0.96	1.00
v_4	0	-0.14	0	0.14	1.00	0.86
v_5	-0.03	-0.22	0.04	0.46	0.96	0.54
v_6	0.16	0.01	0.04	0.15	0.96	0.85
v_7	0.08	0.07	0.04	0.15	0.96	0.85
v_8	0.01	0	0.09	0	0.91	1.00
v_9	-0.36	-0.04	0.53	0.15	0.47	0.85
v_{10}	-0.09	0.23	0.04	0.12	0.96	0.88
v_{11}	0	0.32	0	0.17	1.00	0.83

The consonance of the influence of the vertex v_9 on the system is low (0.47), whereas the dissonance of the influence of the vertex v_9 on the system is rather high (0.53). This suggests that the project manager should consider all kinds of connections of this vertex with other vertices.

Note that consonance determines how concordant the factors are in the simulated system. Moreover, the higher the consonance, the more convincing is the opinion on the sign of influence. Dissonance expresses a measure of distrust of the result and may occur for various reasons, for example because of a logical inconsistence or due to the inconsistency of the past experience with the present situation.

Thus, if the project manager counteracts the increasing resistance to changes (an increase in the number of external factors and the errors committed by the executors) and pays attention to the time and financial resources, then he/she is able to carry out and obtain reliable project feasibility estimates, as well as to accelerate the process of ICS creation.

6. CONCLUSION

The proposed method of project feasibility assessment on the basis of fuzzy cognitive modeling allows carrying out analysis of the FCM structure in the conditions of fuzzy initial data. The analysis of the FCM structure using calculation of the system indicators allows distinguishing the control vertices that have the greatest influence on the target vertices and assessing the extent of this influence and its reliability. The proposed algorithm of processing the fuzzy initial data allows normalizing and structuring the vertex parameter values and the connections between them so that the numerical values of the vertex parameters do not differ by the units of measurement or by the order of magnitude and belong to the interval [0; 1], whereas the connection values belong to the interval [- 1; 1] for the application of fuzzy cognitive modeling. The analysis of the FCM structure using a formal-mathematical apparatus based on the categorical approach allows a unified approach to the formalization of data and the processes at different stages of information processing.

A distinctive feature of the presented work is the fact that the proposed method for assessing the project feasibility can be used at the stage of pre-project studies for various branches of industry, economy and the prevention of emergency situations in the conditions of fuzzy initial data.

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