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Simulation of The Initial Stages of Software Development

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Abstract: This study discusses the development and practical implementation of the simulation methods to support the process of initial stages of software development. We show applicability of this model on a number of experiments conducted. There are many special methods for such purpose. Most of them operate with black-box type models that do not give interpretation of actions during simulation process. In this study, we propose the use of cognitive modeling approach in the initial stages of software development. The key factors and their mutual influence have been highlighted as well as mathematical formalization has been described. In the calculation of system characteristics both the direct and indirect impact of disciplines has been taken into account.

Key words: Software development, cognitive approach, simulation, decision making support, initial stages

INTRODUCTION

Software development is a complex process that involves developers and customers as well as other staff of the company and the software development is influenced by many factors (Kravets *et al*., 2014). A large number of software development projects and the need to optimize this process suggest that it is necessary to develop a model that will increase the efficiency in decision-making at the authorized persons in part and there's a need to pay most attention to the work organization (Belov and Kravets, 2013).

To describe the diversity of factors and their interactions (Kravets *et al*., 2013, 2014) it is advisable to use cognitive modeling approaches. This type of modeling can fully describe the operation of the technical and economic systems (Bosenko *et al*., 2013) and also to make a further study of the constructed models (Avdeeva *et al*., 2007).

Cognitive modeling is based on the construction of a situation cognitive map which is a signed weighted graph. Due to this the construction of a cognitive map may use both quantitative and qualitative data (Avdeeva *et al*., 2007).

Cognitive modeling involves consistent structuring information about the system under study based on the following scheme:

- Any event that occurred in the system was due to certain reasons. The appearance of these reasons linked to the movement of material (resources, money, goods, etc.) and intangible streams (information interaction)
- Each highlighted stream can describe the appropriate set of factors. Union of all such sets is a set of system factors
- There are a relationships between the factors determined on the basis of consideration of the causal chains that describe the motion of streams

In the construction of a cognitive model for the initial stages of software design there are the following steps:

- Construction of a model that reflects the situation "as is"
- Target vector assignment
- Initial trends assignment
- Further there is the process of simulation based on the model created
- "Free" development of the situation

Modeling based on the values of control actions.

COGNITIVE APPROACH USE

To determine the groups of factors that affect the design of the initial stages of development, we should carry PEST-analysis. This method of analysis is a marketing tool that is designed to identify the political, economic, social and technological aspects of the environment that influence the development of the company.

Thus, we obtained four groups of factors which are the most important strategy for managing the initial stages in the design of technical systems. Now, we define the interference factors. In Table 1, there are groups and factors.

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Table 1: Groups and factors of system

Economic factors	Technical factors	Academic and professional factors	Management factors
1: Hardware cost	5: Hardware	10: Development relevance	13: The availability and quality of TK, TP
2: Total development cost	6: Availability of high-quality, licensed software	11: Professional skills in software development	14: Permanent requirements and constant objectives
3: Software cost	7: Capabilities and performance of the target platform (OS)	12: Development idea	15: Time resources
4: Workers' salary	8: Personal skills	26: Number of similar projects	16: Leadership in software development process
18: Extent of use	9: Availability of and compliance with coding standards	27: Employees skills sharpening	17: Source data quality
19: Ability to attract investors	22: Testing quality	28: Introduction of scientific developments	29: Work management from above
20: Duration of use	23: The timely repair and depreciation of equipment		30: Exchange of experience between developers
21: Promotion for special development and plan advancement	24: Accuracy of the software operation		
	25: Crash recovery time		

At the next stage of the cognitive model design we define direct connections that characterize the causal relationship between factors identified. Such connections will be called interference between factors. Interference can be positive or negative (Anoprienko, 1999; Kuleshov, 2008). Positive interference means that an increase (decrease) in the value of one factor leads to an increase (decrease) in the value of another factor. Negative interference means that an increase (decrease) in the value of one factor leads to a decrease (increase) in the value of another factor (Fig. 1).

To determine the strength of interference factors we will use linguistic variables such as "very strong", "strong", "significant", "moderate" and "very weak". To the given set of linguistic variables we compare some numerical scale so that each linguistic variable will correspond to the number on the scale. To the scale it is expedient to use [0, 1]. The scale designed is as follows:

- "Very weak" -0.1
- "Moderate" -0.3
- "Significant" -0.5
- "Strong" -0.7
- "Very strong" -1.0

Factors interference can be reflected using the cognitive map and using the matrix interferences. In a matrix of interferences rows and columns are compared to model factors and the value at the intersection of ith row and j-ro column indicates the weight and direction of the i-ro influence factor on the jth factor (Avdeeva *et al*., 2007).

Figure 2 shows a fragment of interferences matrix for cognitive model of the initial stages of the software development.

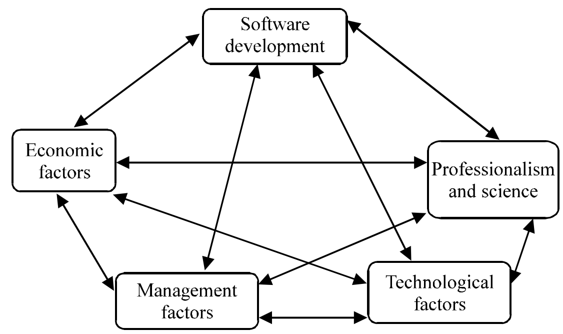

Fig. 1: PEST-analysis of factors

i/j	1	2	3	4	5	6	7	8	9	10
1		0.7	0.3		1					
2	0.7		0.7	1	0.5	0.7				
3	0.3	0.7		-0.1		0.7	0.5	0.1		
4		1								
5	1	0.7	0.5				1	0.5		
6		0.7	1	-0.1			0.5	0.7		
7	0.5	0.1	0.5		0.3	0.3		0.7		0.3
8						0.7	1		0.5	0.1
9		0.1				0.5	0.5			
10								0.5		

Fig. 2: Interferences matrix fragment

Initial trends, we define by the following linguistic variables such as "strong", "moderate", "weak" and the like, this set of linguistic variables and assign numeric values are in the range {0, 1}.

After setting the initial trends there is a need among all selected factors to determine the target and control factors.

TRENDS SIMULATION

Target factors: Factors, the dynamics of which must be brought closer to the desired values. The desired

Table 2: Target factors

Target factors	Their desired trends
Professional skills in software development	0.7
Result precision	0.9
Time resources	0.5
Extent of use	0.7

Table 3: Controlling factors

Controlling factors	Their desired trends
Staff salary	0.3
Organization of the experience exchange between developers	0.7
Attracting investors	0.6
Introduction of scientific developments	0.9

target factors dynamics achievement is a solution that is pursued in the cognitive model design. Desired target factor trends are specified using the same scale as that used for specifying the initial trends. Specified values of target factors are shown in Table 2.

Controlling factors: Factors that can help you manage the processes in the model, giving them certain control actions. Desired controlling factors trends are specified using the same scale as that used for specifying the initial trends. Specified values of controlling factors are shown in Table 3. First of all, we estimate the change in target factors in the free development of the system.

The dynamics of the free movement of model state x(t) is described by the equation: $X(j) = (A^0+A^1+A^2+...+A^n)\times x(0)$ (Sum of the corresponding column x initial value) (Maksimov and Kornoushenko, 1998).

In the case, the free development made on the basis of the following data: a matrix, the interferences matrix; x(0) vector describing the initial trend factors; t = 30 (approximately equal to the number of factors).

The simulation results for the free development of the system are presented in Table 4. We now carry out simulation of the system under the influence of her control actions.

System development dynamics under the influence of her control actions is described by the following equation (Maksimov and Kornoushenko, 1998):

$$x(t) = (I_N+A+A^2+...+A^t)x(0)+(I_N+A+A^k+...+A^{t-1})Bg(0)$$

A matrix = The interferences matrix
x(0) = Vector describing the initial trend factors
t = 30 = Approximately equal to the number of factors
Bg(0) = Vector of controllable actions from Table 3

Table 4: Target factors; desired trends; trends of free development, trends of controllable development

Factors	Desired trends	Trends of free development	Trends of controllable development
Professional skills in software development	0.7	-0.14	0.09
Software operation precision rate	0.9	0.39	0.54
Time resources	0.5	0.21	0.21
Extent of use	0.7	1.00	1.00

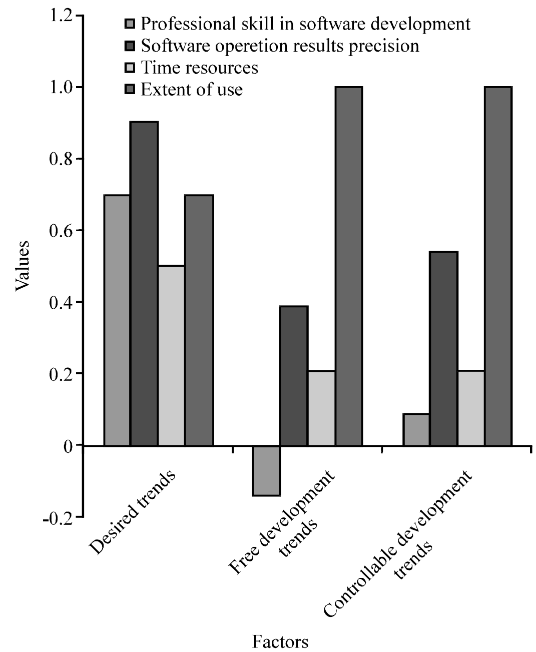

Fig. 3: Modeling results

RESULTS

The simulation results in the development of control actions are shown in Table 4. Figure 3 graphically depicts the work results. There are the trends of target factors identified skills in software development, the accuracy of the software operation results, time resources and extent of use.

CONCLUSION

The influence of subjects evaluated by experts and is expressed in weight coefficients. Proposed formalized procedure of development process integrity level and subject importance assessment is an apparatus that allows you to get the numerical values of these characteristics. The example of using the developed procedures on a simulation model is demonstrated.

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