ISSN 1392-2785 ENGINEERING ECONOMICS. 2006. No 5 (50)
ECONOMICS OF ENGINEERING DECISIONS

Dynamic SWOT Analysis as a Tool for System Experts

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The entities analyzed within multi-purpose and multi-disciplinary areas are too complicated to be strictly quantitatively described. In such cases it is impossible to avoid verbal expert estimates. For the evaluation of system's behaviour the mechanism of SWOT analysis, which enables to cope with the problems static, is frequently employed. A detailed modelling, monitoring and prediction require a certain level of dynamics. To achieve optimal system parameters, strengths and weaknesses should be under the influence of dynamics. In order the experts could affect them professionally, additional fuzzy situations and factors need to be analyzed. The most convenient tool to solve such a task today is to use the mechanism of fuzzy cognitive maps FCM. The article suggests combining the mechanisms of SWOT (strengths, weaknesses, opportunities and threats) analysis and FCM (fuzzy cognitive maps) and indicates that such hybridization provides experts with a new tool of system analysis. The monitoring was modelled using FCM modelling package, developed in the Faculty of Computer Engineering in Kaunas University of Technology. The illustrated dynamic monitoring was carried out using various approaches. Experts select FCM elements of monitoring structure, their dependency on the total values of opportunities and threats, their impact on strengths and weaknesses of the system for the nodes being modelled. Thus, the experts complete a gradual evaluation of dynamics' modelling and results.

Keywords: *SWOT analysis, fuzzy cognitive maps, management.*

Introduction

While designing and analysing complicated systems, it is impossible to avoid fuzzy situations: systems are subjectively described (using words), the features of the elements are described with stochastic probability and mutual element interaction is not precisely known as well. In such cases for the analysis and the evaluation of the designed situations so called SWOT (Hillson, 2004) is used. SWOT is the acronym of the English words: Strengths / Weaknesses / Opportunities / Threats. In order to fill in SWOT analysis tables, the descriptions of all fuzzy situations should be normalized, which means that characteristics of features should become quantitatively measured and compared (Kosko, 1997). SWOT table would provide each specified case with a static estimate of the analyzed system, presenting the weight of its opportunities and threats.

The problem of the article. To achieve optimal system parameters, strengths and weaknesses should be under the influence of dynamics. In order the experts could affect them professionally, additional fuzzy situations and factors need to be analyzed. The most convenient tool to solve such a task today is to use the mechanism of fuzzy cognitive maps FCM (examples Jasinevicius, Petrauskas, 2003; Kosko, 1997).

The aim of the article is to combine the mechanisms of SWOT analysis and FCM into one solid complex for the purpose of dynamic system analysis.

Standardization of situation descriptions

Let the expert characterize the situation S by a set of feature estimates

$$\{C_1,...,C_i,...,C_M\} \quad (1)$$

Here C_i could be: numeric (for example, *14*), verbal (*small, medium, large*), or even insignificant (such as *brown, blue; hen or horse*), to which the expert is indifferent.

To measure and compare the estimates in between, normalization needs to be included:

$$\begin{cases} C_{i\min}=0, \quad C_{i\max}=C \quad \forall_i \\ Correspondence \quad C_i \leftrightarrow B_i \\ \qquad B_i \in [0,C] \end{cases} \quad (2)$$

In case of insignificant estimates numbers are randomly assigned from the same range.

Then the estimate set of situation's S features is presented as

$$\{B_1,...,B_i,...,B_M\} \quad (3)$$

Experts, frequently using personal experience, formulate additional features that are achieved as the extensions of the set (3):

$$\{A_1,...,A_j,...,A_N\} \quad (4)$$

Here $j=\{1,2,...,N\} \quad N>M$ and

$$\begin{cases} if \quad j=\{1,2,...,M\} \quad then \quad A_j=B_j \\ if \quad j=\{M+1,...,N\} \quad then \quad A_j=\Psi(B_i,...,B_k) \end{cases}$$
$$i,k=\{1,2,...,M\}$$

For the extensions the continuous logical function $\Psi(.)$ is used. For example:

$$\Psi(B_i,...,B_k)=\min(B_i,...,B_k)$$
$$\Psi(B_i,...,B_k)=\max(B_i,...,B_k)$$
$$\Psi(B_i,...,B_k)=exor(B_i,...,B_k)=\max(B_i,...,B_k)-\min(B_i,...,B_k) \quad (5)$$
$$\Psi(B_i,B_k)=B_i\to B_k=\max((1-B_i),B_k)$$

The estimates, prepared in such a way, are employed in the SWOT analysis and FCM mechanisms.

SWOT and FCM combination

From (Hillson, 2004) and (Kosko, 1997) it is obvious that the calculations completed in SWOT analysis tables could be carried out using adequate FCM. For example, FCM structure in figure 1 could match SWOT analysis table. This structure is obtained by FCM modelling package, described in (Jasinevicius, Petrauskas, 2003). The comparison of table and figure 1 indicates that the first step of FCM analysis coincide with the situation, describing SWOT statics.

Table

Static SWOT analysis

		Membership value	Impact	Strengths				Weaknesses			Σ
				ST1	ST2	ST3	ST4	WK1	WK2	WK3	
Opportunities	OP1	0.7	0.1	0.67				-0.5			0.087
	OP2	0.6	0.2		0.17	0.27	0.37			-0.5	0.182
	OP3	0.5	0.3	0.57				-0.5	-0.5		0.021
										Total:	0.29
Threats	TH1	0.7	0.15			-0.2	-0.6	0.2		0.43	0.079
	TH2	0.7	0.25	-0.3			-0.4		0.3		0.075
										Total:	0.15

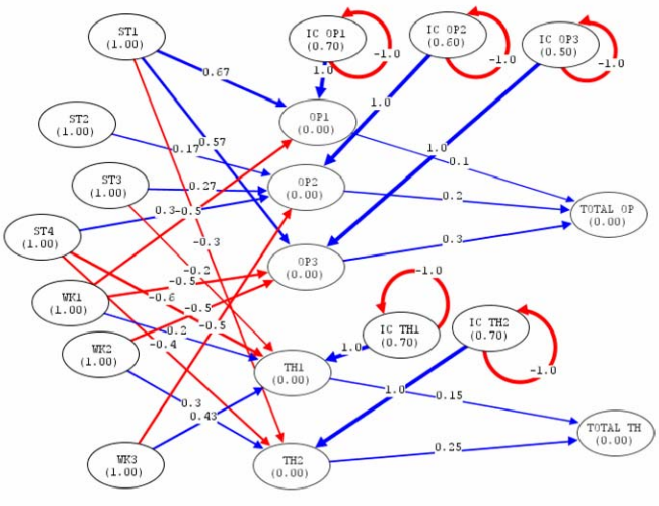

Figure 1. The structure of SWOT statics and FC

Monitoring of SWOT analysis dynamics

In order to obtain optimum system parameters, nodes, matching up strengths and weaknesses of SWOT table, should be dynamically affected within static FCM structure (Figure 1). Experts professionally analyze a magnitude of additional fuzzy situations and factors, and change the weight of influence on strengths and weaknesses on the basis of opportunities and threats' total results. General scheme of such situation monitoring is shown in figure 2.

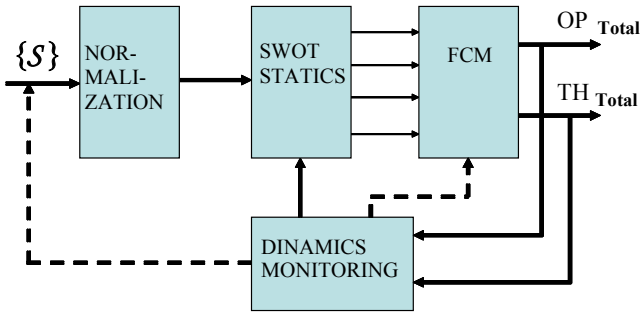

Figure 2. Scheme of dynamic monitoring organization

A detailed illustration of a simplified structure, presented in figure 2 is shown in figure 3, while the results of threats' decrease modelling are indicated in figure 4.

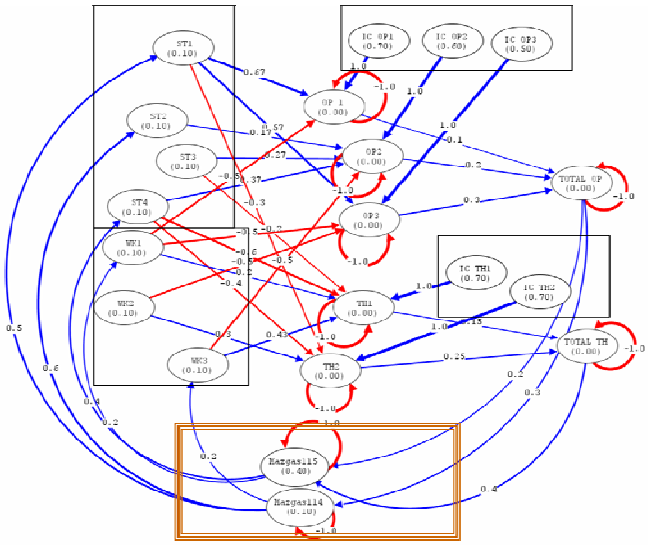

Figure 3. Specifications of monitoring structure

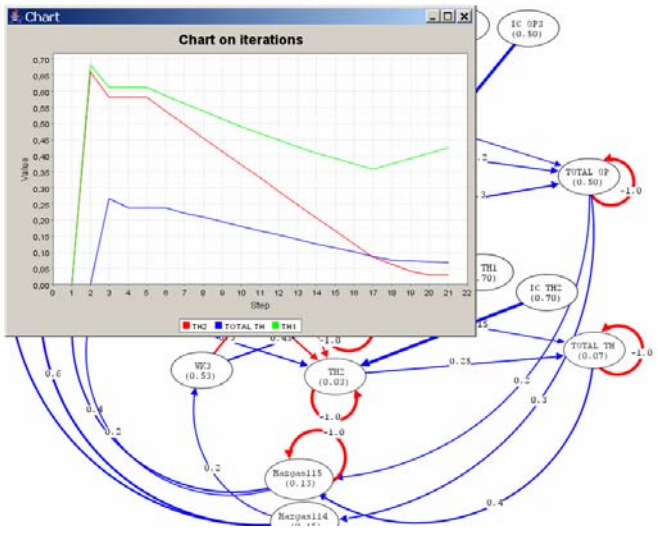

Figure 4. The results of threats decrease modelling

The bottom part of the picture above shows an extremely simplified FCM structure, indicated by a thick line, which matches up the block of dynamic monitoring of figure 2. The monitoring was modelled using FCM modelling package, developed in the Faculty of Computer Engineering in Kaunas University of Technology (Jasinevicius, Petrauskas, 2003). The illustrated dynamic monitoring was carried out using various approaches, however, the article presents just the example of the results of threat decrease.

Experts select FCM elements of monitoring structure (Node 115, Node 114), their dependency on the total values of opportunities and threats, their impact on strengths and weaknesses of the system for the nodes being modelled. Thus, the experts complete a gradual evaluation of dynamics' modelling and results.

Conclusions

1. SWOT analysis is frequently used for the static evaluation of the designed system.
2. Situation descriptions within SWOT analysis tables need to be standardized.
3. The influence of verbal factors for strengths and weaknesses is evaluated using FCM.
4. The combination of SWOT analysis and FCM methods enables experts to carry out dynamic monitoring of system's opportunities and threats.

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Dinaminės SSGG analizės priemonės sistemų ekspertams

Santrauka

Dažnai daugiafunkcinėse ir tarpdisciplininėse srityse nagrinėjamos esybės pernelyg sudėtingos, kad jas būtų galima aprašyti vien tiktai kiekybiškai. Tais atvejais neapseinama be verbalinių ekspertinių įvertčių. Šiuo metu sistemų elgsenai įvertinti paprastai naudojamas SSGG analizės mechanizmas, kuris leidžia susidoroti tik su problemų statika. Išsamus modeliavimas, monitoringas ir prognozavimas reikalauja tam tikro dinaminio lygmens. Šiame straipsnyje siūloma sujungti SSGG analizės ir miglotųjų pažintinių planų (MPP) mechanizmus. Parodoma, kad tokia hibridizacija praturtina ekspertus nauju sistemų analizės įrankiu.

SSGG analizė dažnai naudojama projektuojamoms sistemoms vertinti. Šioje analizėje situacijų apibrėžimai turi būti standartizuojami. MPP naudojama vertinant verbalinių veiksnių įtaką stiprių ir silpnų aspektų srityse. SSGG sistemos ir MPP metodų derinimas įgalina ekspertus vertinti dinaminį sistemų galimybių ir pavojų monitoringą. Monitoringas buvo sumodeliuotas naudojant MPP modeliavimo paketą, kuris buvo sukurtas Kauno technologijos universiteto Informatikos fakultete.

Kompiuterinės inžinerijos fakultete. Dinaminio monitoringo kūrime panaudoti įvairūs požiūriai į šią problemą. Ekspertai parinko MPP monitoringo struktūros elementus, nustatė jų priklausomybę nuo bendrų vertybių, galimybių ir pavojų. MPP sistema yra labai svarbus ir patogus įrankis sprendžiant sudėtingas problemas, o SSGG analizės ir MPP sistemos sujungimas į vieną bendrą kompleksą išplečia dinaminių sistemų analizės galimybes.

Raktažodžiai: *SSGG analizė, miglotieji pažintiniai planai, vadyba.*

The article has been reviewed.

Received in September, 2006; accepted in December, 2006.