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SOFTWARE SELECTION ON BASE OF SUGENO INTEGRAL

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ABSTRACT

The article is devoted to the problem of software selection. As a rule, this tasks are formalized as models of multi-criteria decision making (MCDM). The peculiarity of this problem is in the fact that the evaluation criteria, is generally defined by linguistic expert. This requires the use of special methods, in particularly, the theory of fuzzy sets. To solve the problem, an approach based on the a fuzzy measure was used. In general, a fuzzy measure allows one to take into account the effect of the mutual influence of criteria. The main difficulty lies in identifying this measure. The fuzzy Sugeno measure and Sugeno integral were used. An example of solving the indicated problem is given.

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1. Introduction.

Software selection problem based on the formal methods is very actual [1-3]. As a rule, this tasks are formalized as models of multi-criteria decision making (MCDM). The peculiarity of this problem lies in the fact that the evaluation criteria, is generally defined by linguistic expert. This requires the use of special methods, in particular, the theory of fuzzy sets.

One of the problems MCDM − this is a problem taken as interrelation between criteria, i.e. the problem is non-additivity. Using these criteria such as the simple arithmetic mean, a weighted arithmetic mean, the geometric mean and a weighted geometric mean, median, mode, and others can lead to incorrect result. One of the approaches to solving this problem is the use of non-additive criteria, in particular, a fuzzy measure. The concept of fuzzy measure, based on the work of Choquet [4] in 1974 introduced by M. Sugeno [5]. In 1989, M. Sugeno [6] proposed the concept of λ fuzzy measure and a new method of aggregation is the Sugeno integral.

In general, a fuzzy measure allows one to take into account the effect of the mutual influence of criteria. The main difficulty lies in identifying this measure. There are several approaches to solving this problem [7 -9]. One of the approaches to solving this problem is the formalization of the expert's preferences based on the use of Shapley coefficients and maximization of entropy. Another approach to identifying a fuzzy measure [10] is an approach based on minimizing the squared differences between the Choquet integral and global estimates of alternatives.

In this paper, we will use the Sugeno aggregation function based on the fuzzy λ Sugeno measure.

2. Preliminaries.

Let's consider the basic concepts of the theory of fuzzy measure.

Fuzzy measure. Consider a variety of criteria $X = \{x_1, x_2, x_3 \ldots.\}$. $P(X)$. is a collection of all potential subsets that can be built on base of X

A fuzzy measure is a mapping $\mu(X): \rightarrow [0,1]$ that satisfies the following two conditions:

(i) $\mu(\emptyset) = 0 \; and \; \mu(X) = 1$

(ii) $if \; A \subseteq B \; then \; \mu(A) \leq) \mu(B)$

In general, a fuzzy measure is non-additive

A fuzzy measure $\mu(A)$ of a subset of criteria A has the meaning of a weighting coefficients and indicates the degree of importance of a given subset of criteria.

If $\mu(A \cup B) = \mu(A) + \mu(B)$ then the measure is additive

If $\mu(A \cup B) \geq \mu(A) + \mu(B)$ then the measure is super - additive

If $\mu(A \cup B) \leq \mu(A) + \mu(B)$ then the measure is sub - additive

Fuzzy λ- Sugeno measure: A set of criteria $X = \{x_1, x_2, x_3, \ldots x_n\}$ is given and consist of n criteria and a real number $\boldsymbol{\lambda} \in (-\mathbf{1}, \infty)$**. A fuzzy λ- Sugeno measure** is a function $g_\lambda(\mathrm{X}): \rightarrow [0,1]$ that satisfies the following two conditions:

$g_\lambda(\mathrm{X}) = 1$

If A, B ⊆T then $g_\lambda(A \cup B) = g_\lambda(A) + g_\lambda(B) + \lambda g_\lambda(A) g_\lambda(B)$

and $A \cap B = \emptyset$

The parameter **λ** can be determined from the equation

$\lambda + 1 = \prod_{i=1}^{n}(\lambda g_i + 1)$

If $-1 < \lambda < 0$ then $\sum_{i=1}^{n} g_i > g(X)$ – super-additive measure

If $\lambda = 0$ then $\sum_{i=1}^{n} g_i = g(X)$ - additive measure

If $\lambda > 0$ then $\sum_{i=1}^{n} g_i < g(X)$ - sub- additive measure

Sugeno Integral:

Suppose a g fuzzy measure is defined on a set X, then the Sugeno integral for the function $f: X \rightarrow [0, \infty]$ will have the form

$$\int f dg = \max_{1 \leq i \leq n}(\min(f(x_i), g(x_i)))$$

subject to the condition

$f(x_1) \leq f(x_2) \leq f(x_3) \ldots \ldots . f(x_n) \; f(x_0) = 0$

Consider software selection problem by 4 criteria $X = (x_1, x_2, x_3, x_4)$, which x_1-functionality, x_2- cost, x_3- reliability, x_4 - convenience

To set the linguistic expert assessments, define following linguistic terms:

Very low -0.2, **Low** -0.4, **Medium -** 0.5, **High** -0.7, **Very high** -0.9

3. Problem solving.

Software alternatives and criterion values obtained from experts are presented in a matrix

Table 1. Criteria values for various software alternatives

	x_1	x_2	x_3	x_4
A_1	0.7	0.5	0.4	0.9
A_2	0.2	0.4	0.7	0.5
A_3	0.7	0.5	0.9	0.4
A_4	0.5	0.4	0.7	0.9
A_5	0.2	0.5	0.9	0.7

Given expert evaluation of fuzzy measures for the individual criteria

$g_\lambda(x_1) = 0.7$, $g_\lambda(x_2) = 0.5$, $g_\lambda(x_3) = 0.5$, $g_\lambda(x_4) = 0.7$

Sugeno equation for 4 criteria is

$$\lambda + 1 = \prod_{i=1}^{4} (\lambda g_i + 1)$$

We have:

$$\lambda + 1 = (0.7\lambda + 1)(0.5\lambda + 1)(0.5\lambda + 1)(0.7\lambda + 1)$$

After simplification, we obtain an algebraic equation

$0.122\lambda^4 + 0.84\lambda^3 + 2.14\lambda^2 + 1.4\lambda = 0$

After solving the equation in Matlab, we get the following roots:

$\lambda_1 = 0$

$\lambda_2 = -2.49 + 1.75i$

$\lambda_3 = -2.49 - 1.75i$

$\lambda_4 = -0.97$

We choose the root $\lambda \in (-1, \infty)$, we have $\lambda = -0.97$

The result shows the presence of a generally negative relationship between the criteria, i.e. sub-additivity takes place.

Let's calculate fuzzy measures for all subsets of criteria

$g_\lambda(\emptyset) = 0.$

$g_\lambda(x_1, x_2) = g_\lambda(x_1) + g_\lambda(x_2) + \lambda g_\lambda(x_1) g_\lambda(x_2) = 0.8605$

$g_\lambda(x_1, x_3) = g_\lambda(x_1) + g_\lambda(x_3) + \lambda g_\lambda(x_1) g_\lambda(x_3) = 0.8605$

$g_\lambda(x_1, x_4) = g_\lambda(x_1) + g_\lambda(x_4) + \lambda g_\lambda(x_1) g_\lambda(x_4) = 0.9247$

$g_\lambda(x_2, x_3) = g_\lambda(x_2) + g_\lambda(x_3) + \lambda g_\lambda(x_2) g_\lambda(x_3) = 0.7575$

$g_\lambda(x_2, x_4) = g_\lambda(x_2) + g_\lambda(x_4) + \lambda g_\lambda(x_2) g_\lambda(x_4) = 0.8605$

$g_\lambda(x_3, x_4) = g_\lambda(x_3) + g_\lambda(x_4) + \lambda g_\lambda(x_3) g_\lambda(x_4) = 0.8605$

$g_\lambda(x_1, x_2, x_3) = g_\lambda(x_1, x_2) + g_\lambda(x_3) + \lambda g_\lambda(x_1, x_2) g_\lambda(x_3) = 0.9432$

$g_\lambda(x_1, x_2, x_4) = g_\lambda(x_1, x_2) + g_\lambda(x_4) + \lambda g_\lambda(x_1, x_2) g_\lambda(x_4) = 0.9762$

$g_\lambda(x_1, x_3, x_4) = g_\lambda(x_1, x_3) + g_\lambda(x_4) + \lambda g_\lambda(x_1, x_3) g_\lambda(x_4) = 0.9762$

$g_\lambda(x_2, x_3, x_4) = g_\lambda(x_2, x_3) + g_\lambda(x_4) + \lambda g_\lambda(x_2, x_3) g_\lambda(x_4) = 0.9432$

$g_\lambda(x_1, x_2, x_3, x_4) = 1$

The results of calculation showed fuzzy measure of paired relationships among the greatest strength has relationship between x_1 *and* x_4 and the weakest among x_2 *and* x_3 the sets consisting of 3 criteria are the most interference criteria x_1, x_3, x_4 and the smallest x_2, x_3, x_4

Calculate values of Sugeno integral for all alternatives:

$$C_1 = \int f dg = \max\Big(\min\big(x_3, g_\lambda(x_1, x_2, x_3, x_4)\big), \min\,(x_2, g_\lambda(x_1, x_2, x_4)\big),$$
$$\min\,(x_1, g_\lambda(x_1, x_4)), \min\,(x_4, g_\lambda(x_4))) = 0{,}7$$

$$C_2 = \int f dg = \max\Big(\min\big(x_1, g_\lambda(x_1, x_2, x_3, x_4)\big), \min\,(x_2, g_\lambda(x_2, x_3, x_4)\big),$$
$$\min\,(x_4, g_\lambda(x_3, x_4)), \min\,(x_3, g_\lambda(x_3))) = 0{,}6$$

$$C_3 = \int f dg = \max\Big(\min\big(x_4, g_\lambda(x_1, x_2, x_3, x_4)\big), \min\,(x_2, g_\lambda(x_1, x_2, x_3)\big),$$
$$\min\,(x_1, g_\lambda(x_1, x_3)), \min\,(x_3, g_\lambda(x_3))) = 0{,}4$$

$$C_4 = \int f dg = \max\Big(\min\big(x_1, g_\lambda(x_1, x_2, x_3, x_4)\big), \min\,(x_2, g_\lambda(x_2, x_3, x_4)\big),$$
$$\min\,(x_4, g_\lambda(x_3, x_4)), \min\,(x_3, g_\lambda(x_3))) = 0{,}7$$

$$C_5 = \int f dg = \max\Big(\min\big(x_1, g_\lambda(x_1, x_2, x_3, x_4)\big), \min\,(x_2, g_\lambda(x_2, x_3, x_4)\big),$$
$$\min\,(x_4, g_\lambda(x_3, x_4)), \min\,(x_3, g_\lambda(x_3))) = 0{,}6$$

We have:

C_1=0,7 C_2=0,6 C_3=0,4 C_4=0,7 C_5=0,6

Thus are best alternatives A_1 and A_4

4. Conclusions.

The article is devoted to the problem of modeling the software selection process. The main attention is paid to the problem of mutual influence of selection criteria. To solve this problem, was proposed an approach based on the use of Sugeno fuzzy measure and Sugeno integral. The problem of software selection with the 4 criteria was solved.

REFERENCES

1. Azadeh A. A robust decision-making methodology for evaluation and selection of simulation software package / A. Azadeh, SN Shirkouhi, K. Rezaie // International Journal of Advanced Manufacturing Technology. - 2010. - Vol. 47. - P. 381–393.
2. Karaarslan N. An application for modular capability-based ERP software selection using AHP method / N. Karaarslan, E. Gundogar // International Journal of Advanced Manufacturing Technology. –2009. - Vol. 42. - P. 1025-1033.
3. Smirlis YG Data envelopment analysis models to support the selection of vehicle routing software for city logistics operations / YG Smirlis, V. Zeimpekis, G. Kaimakamis // Operational Research. 2012. –Vol. 12. - P. 399-420.
4. Gustave Choquet "Theory of Capacities". Annales de l'Institut Fourier., 1953, 5: 131-295
5. Sugeno M. Theory of fuzzy integrals and its applications: Ph.D. Thesis. - Tokyo. - 1974. 237 p.
6. T Murofushi, M Sugeno, An interpretation of fuzzy measures and the Choquet integral as an integral with respect to a fuzzy measure Fuzzy Sets and Systems, 29 (1989), pp. 201-227
7. Tan C. Intuitionistic fuzzy Choquet integral operator for multi-criteria decision making / C. Tan, X. Chen // Expert Systems with Applications. - 2010. - Vol. 37. - P. 149-157.
8. Meyer P. On the use of the Choquet integral with fuzzy numbers in multiple criteria decision support / P. Meyer, M. Roubens // Fuzzy Sets and Systems. - 2006. - Vol. 157. - P. 927-938.
9. A Hybrid Algorithm to Extract Fuzzy Measures for Software Quality Assessment / X. Wang, M. Ceberio, S. Virani et al. // Journal of Uncertain Systems. - 2013. - Vol. 7, No. 3. - P. 219-237.
10. Pasrija V. Assessment of Software Quality: Choquet Integral Approach / V. Pasrija, S. Kumar, PR Srivastava // Procedia Technology. - 2012. - Vol. 6. - P. 153-162.
11. Yang H. Measuring Software Product Quality with ISO Standards Base on Fuzzy Logic Technique
12. M. Grabisch. The application of fuzzy integrals in multicriteria decision making. European J. of Operational Research 89: 445-456, 1996.
13. M. Grabisch, T. Murofushi, and M. Sugeno. Fuzzy Measures and Integrals. Theory and Applications (edited volume). Studies in Fuzziness. Physica Verlag, 2000.
14. M. Grabisch and Ch. Labreuche. The Choquet integral for 2-additive bicapacities. In 3d Int, Conf. of the European Soc. for Fuzzy Logic and Technology (EUSFLAT 2003), pages 300-303, Zittau, Germany, September 2003.