Research and development of decision-making methods for creating 3d objects in mechanical engineering

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Absract. The analysis of the criterion of integral proximity of a clear / fuzzy truth value to the value of absolute truth is carried out in this work. Confirmation of the possibility of using algorithms to create three-dimensional objects in engineering.

1 Formulation of the problem

To facilitate the work of the user and reduce the degree of his influence on the calculation process in solving the problem, let us consider the possibility of applying decision methods using odd truth.

2 The problem of alternatives ranking

Let us consider the problem of alternatives ranking [1,3,5] from set Z with respect to criteria k. The result of alternative $z \in Z$ can be estimated by the indicated quality criterion. The evaluation of the alternative can be represented in the form of a conjunctive form and fuzzy analysis will be denoted as $G_i(a)$:

$$W: < W_1 \cup \ldots \cup W_i \cup \ldots \cup W_n > \equiv$$

$$Z_1(z) = G_1(a) \cup \ldots \cup Z_i(z) = G_i(a) \cup \ldots \cup Z_n(z) = G_n(a) \quad (1)$$

The following necessary step is ranking. Let us apply an approach that is based on using the theoretically possible ideal alternative z_0.

Expression (3) takes the following form:

$$E: < E_1 \cup \ldots \cup E_i \cup \ldots \cup E_n > \equiv$$

$$Z_1(z_0) = F_1(z_0) \cup \ldots \cup Z_i(z_0) = F_i(z_0) \cup \ldots \cup Z_n(z_0) = F_n(z_0). \quad (2)$$

In order to evaluate the truth of the correspondence between the expressed alternative of the introduced ideal one, let us check the probability of truth (3) to (4):

$$T(W, E) = T(W_i \cup \ldots \cup W_i), T(E_i \cup \ldots \cup E_i). \quad (3)$$

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Let us establish the rule for ranking; $q(z)$ stands for the index of the integral adjacency of the membership function of the fuzzy truth evaluation and also the values *absolute* and *true*:

$$z_p > z_q <=> q(z_p) \leq q(z_q). \tag{4}$$

To exclude the exponential complexity of the algorithm for calculating expressions, we apply the following property:

$$T(W, E) = \check{T}\,(T(W_i, E_i)). \tag{5}$$

We denote by T the extended T-norm by means of the generalization principle. $T(W_i, E_i)$ is evaluation of the truth of the alternative according to the chosen criterion.

Figure 1 shows the interpretation of the criterion of integral adjacency of the fuzzy truth value to the value of absolute truth.

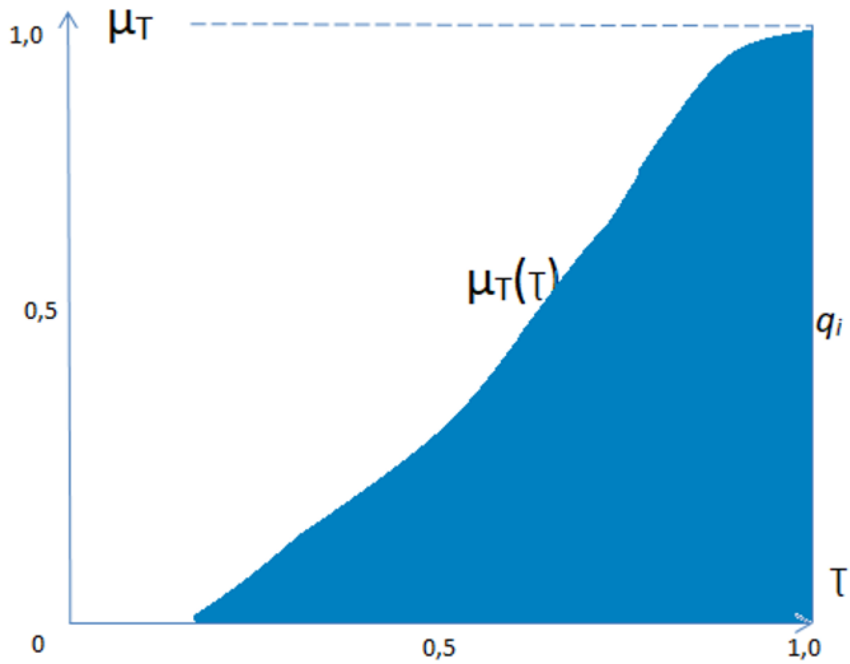

Fig. 1. Interpretation of the criterion of integral adjacency of the fuzzy truth value to the value of absolute truth.

It is obvious from Fig. 1 that (5) allows us to apply the method both for a small and for a large number of criteria.

With increasing number of criteria, it is effective to use calculation paralleling.

However, in this case, there is a need to harmonize solutions, both on the tiers inside the branch, and on neighboring branches. Besides it is necessary to coordinate all areas of the decision-making system.

To facilitate the work of users and simplify the matching procedure, there are methods [6] of finding the best compromise.

3 The fuzzy truth to the value of the absolute truth

Let a group of several objects is involved in the decision making process. Let us consider the process of harmonizing the evaluation of an object by the members of this group. In this case, let's assume that each object evaluates and makes a decision on a certain criterion, let us also assume that between the members of the process the criteria groups and rating scales are distributed.

So, it is necessary to obtain an agreed evaluation of the object in accordance with the priorities of the decision-making objects.

$$W:< W_{j1} \cup \ldots \cup W_{ji} \cup \ldots \cup W_{jn} >\equiv$$

$$Z_1 = G_{j1} \cup \ldots \cup Z_i = G_{ji} \cup \ldots \cup Z_n = G_{jn} \quad (6)$$

Depending on the importance of the criterion, each object in the decision-making group can set the criterion for the absence of artefacts as 18 and greater, and the file size cannot be more than the current one by 56%. Each object forms an ideal rating of the criterion in accordance with (9):

$$E:< E_{j1} \cup \ldots \cup E_{ji} \cup \ldots \cup E_{jn} >\equiv$$

$$Z_1 = F_{j1} \cup \ldots \cup Z_i = F_{ji} \cup \ldots \cup Z_n = F_{jn}. \quad (7)$$

Here by F_{ji}, we denote an ideal estimate of the i^{th} criterion, which was expressed by the j^{th} object of decision-making.

For example, an object can claim that the presence of artefacts is not critical and can reach 99%; therefore, the likelihood of their absence is below the threshold; it can also be assumed that the quality of the file is not essential and can be equal to the source file.

$$E:< E_1 \cup \ldots \cup E_i \cup \ldots \cup E_n >\equiv$$

$$Z_1 = F_1 \cup \ldots \cup Z_i = F_i \cup \ldots \cup Z_n = F_n \quad (8)$$

where $F_i = F_{1i}$ or F_{2i} etc.

In order to evaluate the truth of the statement of the j^{th} object according to the ideal estimate formed by it, it is necessary to verify the truth of (8) and (6):

$$T(W,E) = T(W_i \cup \ldots \cup W_i), T(E_k \cup \ldots \cup E_u) \quad (9)$$

As is known, when analyzing fuzzy values for each fuzzy truth evaluation, a criterion of correspondence is required as an absolutely true one. A variant of the solution and achievement of this criterion is the introduction of the index of integral adjacency of the membership function of the fuzzy truth evaluation of the prime statement *Wj* and the absolute truth value.

$$q_i = \int_0^1 [1 - \omega_T^{-1}(\omega_T(\tau))] d\omega_T(\tau), \quad (10)$$

and in the case of a discrete representation of membership functions:

$$q_i = \frac{1}{n} \sum_{k=0}^{n} [1 - \omega_T^{-1}(\omega_T(\tau)_k)] d\omega_T(\tau)_k \quad (11)$$

where ω_T^{-1} must satisfy the monotonicity condition and max $\omega_T(\tau) = 1$.

The introduced index q_t is numerically equal to the area of the shaded part in Fig. 1.

Thus, the system of binary preference relations on the set of fuzzy truth values takes the following form:

$$T_i > T_j <=> \omega_{T_i} > \omega_{T_j} <=> q_i \leq q_j \tag{12}$$

With the help of (4.20) it is possible to establish an order on fuzzy truth values:

$$T_1 > \cdots > T_j > \cdots > T_N <=> q_1 \leq \cdots \leq q_i \leq \cdots \leq q_N. \tag{13}$$

The evaluation, which was made by the first decision-making object, will be the result of the approval procedure.

To exclude the exponential complexity of the expression calculating algorithm, let us apply the following property:

$$T\left(W, E_j\right) = \check{T}_{i=1,n}\,(T\left(W_i, E_{ji}\right). \tag{14}$$

We denote by $\check{T}$ the extended T-norm by means of the generalization principle. $T\left(W_i, E_{ji}\right)$ is an assessed truth value of the alternative according to the chosen criterion.

To provide greater flexibility to this method, it is desirable to use criterion weights; let us write (16) as:

$$T\left(W, E_j\right) = \check{T}_{i=1,n}^{w_i}\,(T\left(W_i, E_{ji}\right) \tag{15}$$

4 Conclusion

Summarizing the above, it can be noted that we have studied the procedure for agreeing object evaluations on the basis of the formation of a hypothetical ideal criterion evaluation, using fuzzy truth evaluation to identify an agreed evaluation. This method is optimal for the stated task.

References

1. V. Zhukov, E. Masyutkin, B. Avdeyev, *The application of mathematical modeling for the development of devices as an example of viscous fluid purification from magnetic impurity*, IOP Conference Series: Materials Science and Engineering, № **177**, Pp. 012015. (2017) DOI: 10.1088/1757-899X/177/1/012015.
2. B. Avdeyev, E. Masyutkin, S. Golikov, S. Sokolov and V. Gavrilov, *Calculation of efficiency curve of magnetic hydrocyclone*, 2017 IEEE Conference of Russian Young Researchers in Electrical and Electronic Engineering (EIConRus), St. Petersburg, Pp. 1225–1228 (2017) DOI: 10.1109/EIConRus.2017.7910783.
3. B. Avdeyev, *Development of criteria for a magnetic hydrocyclones*, MATEC Web Conf. International Conference on Modern Trends in Manufacturing Technologies and Equipment (ICMTMTE 2017), Vol. **129**, P. 06012. (2017) DOI: https://doi.org/10.1051/matecconf/2017129060121.
4. Sokolova, E.A., Aslanov, G.A., Sokolov, A.A., *A modern approach to storing of 3D geometry of objects in machine engineering industry*, IOP Conference Series: Materials Science and Engineering, **177**, 6 (2017)
5. Sokolova, E., *The study of the possibility of using innovative technologies for saving engineering 3d objects*, MATEC Web of Conferences , **129**, 5 (2017)

6. Sokolova, E.A., Dzhioev, G.A, *Development of an algorithm for automated enhancement of digital prototypes in machine engineering* , IOP Conference Series: aterials Science and Engineering, **177**, 5 (2017)
7. Zhi-liang Zhu, Wei Zhang, Kwok-wo Wong and Hai Yu ,Nonlinear Sci. Numer. Simul, Inf. Sci., 3, **16** (2013)