One approach for aggregation of fuzzy estimates of several groups of experts

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***Abstract*—**This paper introduces one approach to group decision-making, where experts' opinions are expressed by fuzzy sets. It is meant that there are several groups of experts and, therefore, several finite collections of fuzzy sets turn out. Then a quite simple approach for aggregation of obtained finite collections of fuzzy sets into resulting one is proposed and its algorithm is determined.

***Keywords*—**Group decision-making, Finite collection of fuzzy sets, Fuzzy aggregation operator, Regulation, Representative.

I. Introduction

An uncertainty assists at practically any situations in our life. One of the most effective ways to take account of this phenomenon is a using of group decision strategy. These processes by their nature represent a transformation from individual opinions of experts into the resulting one.

In the present paper we suppose that there are a several groups of experts and each expert expresses his subjective estimate by a fuzzy set [5] that represents the rating to an alternative under a given criterion. As a result for each group of experts a finite collection of fuzzy sets is obtained. It is understood that experts are specialists of the same level, but this does not mean that their estimates may not be essentially different. The essence of our proposed approach consists in the following. A degree of agreement between experts' estimates is measured by the general metric defined by means of the isotone valuation introduced in the paper and embracing the whole class of distances between of fuzzy sets.

Further, the concepts of regulation and representative of a finite collection of fuzzy sets are introduced. The motivation of their introduction is explained in [3]. A representative is defined as a fuzzy set such that the sum of distances between this set and all other members of the considered finite collection of fuzzy sets is minimal. Speaking in general, a representative may take an infinite number of values, but it can be defined uniquely by using a special fuzzy aggregation operator.Our task is to aggregate the obtained finite collections of fuzzy sets into the resulting one. Almost all the theoretical results represent, to one extent or the other, a generalization of the results obtained in [2], [3] including a terminology.

II. Essential Notions

$\Psi(X)=\{\mu \mid \mu: X \to [0;1] \subset \Re\}$ - lattice of all fuzzy sets in X.

$\varnothing$- minimal element of $\Psi(X)$: $\mu_{\varnothing}(x)=0 \quad \forall x \in X$.

U - maximal element of .

$A=B \Leftrightarrow \mu_A(x)=\mu_B(x) \;\; \forall x \in X, \;\; A,B \in \Psi(X)$.

$A \subseteq B \Leftrightarrow \mu_A(x) \le \mu_B(x) \;\; \forall x \in X, \;\; A,B \in \Psi(X)$.

Definition 1. The union and intersectionof fuzzy sets A and B are determined as follows:

$$\mu_{A\cup B}(x)=\max\{\mu_A(x),\mu_B(x)\} \; \forall x \in X \; ;$$
$$\mu_{A\cap B}(x)=\min\{\mu_A(x),\mu_B(x)\} \; \forall x \in X \; .$$

It is not difficult to verify that the distributivity of $\bigcap$ and $\bigcup$ holds in $\Psi(X)$:

$$\begin{aligned} &A\bigcap(B\bigcup C)=(A\bigcap B)\bigcup(A\bigcap C),\\ &A\bigcup(B\bigcap C)=(A\bigcup B)\bigcap(A\bigcup C). \end{aligned} \tag{1}$$

We say that the function v: $\Psi(X)\to\Re^+$ is *isotone estimation on* $\Psi(X)$ if [1]:

$$\begin{aligned} &v(A\bigcup B)+v(A\bigcap B)=v(A)+v(B)\\ \text{and}&\\ &A\subseteq B \Rightarrow v(A)\le v(B). \end{aligned} \tag{2}$$

We say that the isotone estimation v is *continuous* if for each $a\in[v(\varnothing);v(U)]$ there exists $A\in\Psi(X)$ such that $v(A)=a$.

Consider the following equation:

$$\rho(A,B)=v(A\bigcup B)-v(A\bigcap B). \tag{3}$$

Proposition 1. *Eq.* (3) *represents the metric on*$\Psi(X)$, *i.e. it meets the following requirements*:

1) $\rho(A,B)=0 \Leftrightarrow A=B$;

2) $\rho(A,B)=\rho(B,A)$;

3) $\rho(A,C)+\rho(C,B)\ge\rho(A,B) \;\; \forall C\in\Psi(X)$.

Proof. Let $\rho(A,B)=0 \Rightarrow v(A\bigcup B)=v(A\bigcap B)$. By Definition 1 and (2) we can conclude that $A\bigcup B=A\bigcap B \Rightarrow A=B$. Now let $A=B \Rightarrow A\bigcup B=A\bigcap B$ $\Rightarrow v(A\bigcup B)=v(A\bigcap B) \Rightarrow \rho(A,B)=0$ .So, 1) is true.

$\rho(A,B)=v(A\cup B)-v(A\cap B)=v(B\cup A)-v(B\cap A)$
$=\rho(B,A)$. 2) is also true.

$\rho(A,B)=v(A\cup B)-v(A\cap B)\overset{(2)}{\le} v((A\cup C)\cup(C\cup B))$
$-v((A\cap C)\cap(C\cap B))\overset{(2.}{=} v(A\cup C)+v(C\cup B)$
$-v((A\cup C)\cap(C\cup B))-v(A\cap C)-v(C\cap B)$
$+v((A\cap C)\cup(C\cap B))\overset{(1),(2)}{=}\rho(A,C)+\rho(C,B)$
$+v(C\cap(A\cup B))-v(C\cup(A\cap B))\overset{(2)}{\le}\rho(A,C)+\rho(C,B)$.

3) is proved and the proof is completed. □

$\Psi(X)$ with isotone estimation v (2) and metric (3) is called *the metric lattice* of fuzzy set.

Definition 2[3],[.In the metric lattice the fuzzy set A^* is the representativeof the finite collection of fuzzy sets $\{A_j\},\ j=\overline{1,m},\ m=2,3,...$ if

$$\sum_{j=1}^{m}\rho(A^*,A_j)\le\sum_{j=1}^{m}\rho(B,A_j),\quad \forall B\in\Psi(X). \qquad (4)$$

Definition 3[3]**.** The finite collection of fuzzy sets $\{A_j^{'}\}$ is a regulation of the finite collection of fuzzy sets $\{A_j\}$ if for each $x\in X$the finite sets $\{\mu_{A_j}(x)\}$ and $\{\{\mu_{A_j^{'}}(x)\}\}$ are equal and $\mu_{A_1^{'}}(x)\le\mu_{A_2^{'}}(x)\le\ldots\le\mu_{A_m^{'}}(x),\ j=\overline{1,m},m=2,3,\ldots$.

Thus, a regulation presents a finite collection of *nested* fuzzy sets. The equality

$$\sum_{j=1}^{m}\rho(B,A_j)=\sum_{j=1}^{m}\rho(B,A_j^{'}) \qquad (5)$$

holds in the metric lattice for any $B\in\Psi(X)$ and the finite collection offuzzy sets $\{A_j\},\ j=\overline{1,m},\ m=2,3,\ldots$.

Theorem 1[2]**.***In the metric lattice of fuzzy sets the representative A^* of the finite collection of fuzzy sets $\{A_j\},\ j=\overline{1,m},\ m=2,3,\ldots$ is determined in the following way:*

$A_{m/2}^{'}\subseteq A^*\subseteq A_{m/2+1}^{'}$ *if m is even;*
$A^*=A_{(m+1)/2}^{'}$ *if m is odd*

We say that the finite collection offuzzy sets is *symmetrical* if in its regulation the first $[(2m+1)/4]$[1] sets are equal to $\varnothing$ and the last$[(2m+1)/4]$ sets are equal to U, m=2,3,… [2].

[1] Here and further on symbol [ ] denotes an integer part of a number.

Let us give an example of symmetrical finite collections of fuzzy sets. Let $\Psi(X)=\{\mu\mid\mu:X\to[0;1]\}$, $X=\{x_1, x_2, x_3\}$ and we have the two finite collections of fuzzy sets with even m = 4 ([(2m+1)/4] = 2) and odd m = 7 ([(2m+1)/4] = 3) numbers of members respectively, $\alpha,\beta,\gamma\in[0;1]$:

	x_1	x_2	x_3
A_1	1	1	0
A_2	1	0	1
A_3	0	0	0
A_4	0	1	1

and

	x_1	x_2	x_3
B_1	α	0	1
B_2	1	1	γ
B_3	1	0	0
B_4	0	β	1
B_5	0	1	0
B_6	1	0	1
B_7	0	1	0

By Definition 3 the regulations of these two finite collections of fuzzy sets are respectively:

	x_1,	x_2	x_3
$A_1^{'}$	0	0	0
$A_2^{'}$	0	0	0
$A_3^{'}$	1	1	1
$A_4^{'}$	1	1	1

and

	x_1	x_2	x_3
$B_1^{'}$	0	0	0
$B_2^{'}$	0	0	0
$B_3^{'}$	0	0	0
$B_4^{'}$	α	β	γ
$B_5^{'}$	1	1	1
$B_6^{'}$	1	1	1
$B_7^{'}$	1	1	1

It is obvious that the finite collections of fuzzy sets $\{A_j\}$ and $\{B_j\}$ are symmetrical.

Definition 4[2]**.** In the metric lattice of fuzzy sets fuzzy set the functional

$$S:\ \underbrace{\Psi(X)\times\ldots\times\Psi(X)}_{m\ times}\to\Re^+$$

is the coordination index of the finite collection offuzzy sets $\{A_j\},\ j=\overline{1,m},\ m=2,3,\ldots$ if it satisfies the following postulates*:*

P1. $S\{A_j\}=0$ if and only if the finite collection offuzzy sets $\left\{A_j\right\}$ is symmetrical;

P2. $S\{A_j\}$ reaches the maximal value if and only if all the fuzzy sets of the finite collection are equal to one another;

P3. $S\{A_j\}\geq S\{B_j\}$ if $\sum_{j=1}^{m}\rho(A^*,A_j)\leq\sum_{j=1}^{m}\rho(B^*,B_j)$; in addition $S\{A_j\}=S\{B_j\}$ if and only if $\sum_{j=1}^{m}\rho(A^*,A_j)$ $=\sum_{j=1}^{m}\rho(B^*,B_j)$

P4. $S\{A_j\cup B_j\}+S\{A_j\cap B_j\}=S\{A_j\}+S\{B_j\}$.

Theorem 2[2].*In the metric lattice of fuzzy sets the functional $S\{A_j\}$ is a coordination index of the finite collection of fuzzy sets $\left\{A_j\right\}$, $j=\overline{1,m}$, $m=2,3,\ldots$ if*

$$S\{A_j\}=q(\rho(\varnothing,U)-[(2m+1)/4]^{-1}\times\sum_{j=1}^{m}\rho(A^*,A_j)),\quad q>0\,. \tag{6}$$

Moreover, if the isotone estimation v is continuous, this representation is unique.

It is obvious that

$$S_{\max}=q\rho(\varnothing,U)\,,\quad q>0. \tag{7}$$

Example 1[2]. Let $\Psi(X)=\{\mu|\mu: X\to[0;1]\}$, $X=\{x_1, x_2,\ldots,x_N\}$, $N=1,2,\ldots$. We determine the isotone estimation of fuzzy set A in the following way:

$$v(A)=\sum_{i=1}^{N}\mu_A(x_i),\ \ x_i\in X,\quad A\in\Psi(X).$$

By (4) the isotone estimation v determines the following metric:

$$\rho(A,B)=\sum_{i=1}^{N}|\,\mu_A(x_i)-\mu_B(x_i)\,|\ x_i\in X, A,B\in\Psi(X)\,.$$

Note that in this case the isotone estimation$v$ is the ∑Count, while the metric coincides with the Hamming distance. From (6) we obtain that the coordination index of FC $\{A_j\}$ yields the following expression:

$$S\{A_j\}=q\left(N-[(2m+1)/4]^{-1}\sum_{j=1}^{m}\sum_{i=1}^{N}|\,\mu_{A^*}(x_i)-\mu_{A_j}(x_i)\,|\right),\ \ q>0 \tag{8}$$

It is easy to show that the coordination index of finite collection of fuzzy sets determined in the finite universe is equal to the sum of coordination indices in each element of the given universe.

$$S\left\{A_j\right\}=\sum_{i=1}^{N}S_{\{x_i)\}}\left\{A_j\right\} \tag{9}$$

III. Theoretical background

Now we introduce a significant concept of the similarity for finite collections offuzzy sets, which is based on the metric approach.

Definition 5[3]. In the metric lattice offuzzy sets the finite collection of fuzzy sets $\{A_j\}$ is similar to the finite collection of fuzzy sets $\{B_j\}$ if for each $x\in X$ $\rho(A_i^{'},A_{i-1}^{'})=k\rho(B_i^{'},B_{i-1}^{'}),\quad i=\overline{2,m},\quad j=\overline{1,m},\quad m=2,3,\ldots,$ where $k>0$ is the coefficient of similarity, $\{A_j^{'}\}$, $\{B_j^{'}\}$ are the regulations of $\{A_j\}$ and $\{B_j\}$ respectively.

We denote the similarity of two finite collections offuzzy sets in the metric lattice of fuzzy sets as $\{A_j\}\overset{k}{\cong}\{B_j\}\Leftrightarrow\{B_j\}\overset{1/k}{\cong}\{A_j\}$ or simply $\{A_j\}\cong\{B_j\}$.

In [3] one way of constructing such a finite collection of fuzzy sets $\{C_j\}$, which is similar to the given $\{B_j\}$ is considered in the metric lattice with continuous isotone estimation v, $j=\overline{1,m}$, $m=2,3,\ldots$:

$$\mu_{C_j}(x)=k\rho(B_1^{'},B_j^{'})+\mu_{C_1}(x),\ j=\overline{1,m},\ m=2,3,\ldots,\forall x\in X. \tag{10}$$

Theorem 1[3]. *If $\{A_j\}\overset{k}{\cong}\{B_j\}$ then for the coordination indices of these two finite collections of fuzzy sets the equality $S\{A_j\}=kS\{B_j\}+(1-k)S_{\max}$, $j=\overline{1,m}$ $m=2,3,\ldots$ holds.*

It is obvious that the following corollary of Theorem 1 is true.

Corollary.
$\{A_j\}\overset{1}{\cong}\{B_j\}\Rightarrow S\{A_j\}=S\{B_j\},\quad j=\overline{1,m},\quad m=2,3\ldots$.

Theorem 2[3]. *In the metric lattice of fuzzy sets with continuous isotone estimation for any two finite collection of fuzzy sets $\{A_j\}$ and $\{B_j\}$ such that $S\{A_j\}$, $S\{B_j\}<S_{\max}$ there exists the finite collection of fuzzy sets $\{C_j\}$ such that $\{C_j\}\cong\{B_j\}$ and $S\{C_j\}=S\{A_j\}$, $j=\overline{1,m}$, $m=2,3,\ldots$.*

It is clear that in the metric lattice of fuzzy sets for each finite collection offuzzy sets there exists an infinite set of similar finite collections offuzzy sets. This statement is correct even for the given coefficient of similarity. Let us determine some specific conditions for uniqueness of finite collection offuzzy sets, which is similar to the given one.

Theorem 3[3].*In the metric lattice of fuzzy sets with continuous isotone estimation for any two finite collections of fuzzy sets such as $\left\{C_j\right\}\overset{k}{\cong}\left\{B_j\right\}$ and $S\{C_j\}>S\{B_j\}$, for each k there exists the only finite collection of fuzzy sets $\{A_j\}$ such as $\left\{A_j\right\}\overset{1}{\cong}\left\{C_j\right\}$ and $A_l=B_l^{'}$, $j=\overline{1,m}$, $l\in\{1,2,\ldots,m\}$, $m=2,3\ldots$.*

When proving this theorem the following formula was obtained:

$$\mu_{A_{lj}}(x)=\mu_{B_l^{'}}(x)+k(v(B_j^{'})-v(B_l^{'})),\ j=\overline{1,m},\ l\in\{1,2,...,m\},\forall x\in X\ . \quad (11)$$

In the sequel we need one specific modification of (11). Under the conditions of Theorem 3 let us consider the finite collection offuzzy sets $\{\overline{A}_j\}$ whose membership functions represent the arithmetic mean of the respective membership functions (3.11):

$$\left\{\overline{A}_j\right\}=\left\{\mu_{\overline{A}_1}(x)=v\left(\overline{A}_1\right)=\left(\sum_{l=1}^{m}\mu_{A_{l1}}(x)\right)\Big/m,\right.$$
$$\mu_{\overline{A}_2}(x)=v\left(\overline{A}_2\right)=\left(\sum_{l=1}^{m}\mu_{A_{l2}}(x)\right)\Big/m,$$
$$\left.\ldots,\ \mu_{\overline{A}_m}(x)=v\left(\overline{A}_m\right)=\sum_{l=1}^{m}\mu_{A_{lm}}(x)\Big/m\right\}$$
$$=\left\{\sum_{l=1}^{m}\mu_{A_{lj}}(x)\Big/m\right\},\ \ j=\overline{1,m},\ \ m=2,3,...,\ \ \forall x\in X. \qquad (12)$$

From the last expression by (11) $\left\{\overline{A}_j\right\}=\left\{\sum_{l=1}^{m}(\mu_{B_l^{'}}(x)-kv(B_l^{'}))\Big/m+kv(B_j^{'})\right\}$ and using the notation

$$c=\sum_{l=1}^{m}(\mu_{B_l^{'}}(x)-kv(B_l^{'}))\Big/m, \qquad (13)$$

we obtain that

$$\left\{\overline{A}_j\right\}=\left\{c+kv(B_j^{'})\right\},\ j=\overline{1,m},\ \ l\in\{1,2,...,m\},m=2,3,...,\forall x\in X\ . \quad (14)$$

Proposition 2[3].*If under the conditions of Theorem 3 the finite collection of fuzzy sets* $\left\{\overline{A}_j\right\}$ *is determined by* (8) *then*

$\left\{\overline{A}_j\right\}\overset{1}{\cong}\left\{C_j\right\}$ *and consequently* $S\left\{\overline{A}_j\right\}=S\left\{C_j\right\}$, $j=\overline{1,m}$, $m=2,3,...,\ \ \forall x\in X$.

For the realization of the proposed approach we need a specific aggregation operator that meets certain requirements. Presently, in the fuzzy set theory there are several well known fuzzy aggregation operators (see e.g. [5]). The specific aggregation operator is discussed and formulated in [3]:

$$\mu_{A^*}=\begin{cases}(\mu_{A^{'}_{[m/2]}}+\mu_{A^{'}_{[(m+3)/2]}})/2 & if\ \sum\limits_{j=1}^{[(m+1)/2]}\rho(A_j^{'},A_{[m/2]}^{'})=\sum\limits_{j=[m/2]+1}^{m}\rho(A_j^{'},A_{[(m+3)/2]}^{'}),\\ \mu_{A^{'}_{[m/2]}}+\dfrac{\sum\limits_{j=1}^{[(m+1)/2]}\rho(A_j^{'},A_{[m/2]}^{'})}{\sum\limits_{j=1}^{[(m+1)/2]}\rho(A_j^{'},A_{[m/2]}^{'})+\sum\limits_{j=[m/2]+1}^{m}\rho(A_j^{'},A_{[(m+3)/2]}^{'})}(\mu_{A^{'}_{[(m+3)/2]}}-\mu_{A^{'}_{[m/2]}}) & otherwise.\end{cases} \qquad (15)$$

In [3] it is shown that (3.15) can be rewritten as follows

$$\mu_{\overline{A}_j^*}=\begin{cases}c+k\dfrac{v(B_{[m/2]}^{'})+v(B_{[(m+3)/2]}^{'})}{2} & if\ \sum\limits_{j=1}^{[(m+1)/2]}\rho(B_j^{'},B_{[m/2]}^{'})=\sum\limits_{j=[m/2]+1}^{m}\rho(B_j^{'},B_{[(m+3)/2]}^{'}),\\ c+k(v(B_{[m/2]}^{'})+\dfrac{\rho(B_{[m/2]}^{'},B_{[(m+3)/2]}^{'})\sum\limits_{j=1}^{[(m+1)/2]}\rho(B_j^{'},B_{[m/2]}^{'})}{\sum\limits_{j=1}^{[(m+1)/2]}\rho(B_j^{'},B_{[m/2]}^{'})+\sum\limits_{j=[m/2]+1}^{m}\rho(B_j^{'},B_{[(m+3)/2]}^{'}),}) & otherwise.\end{cases} \qquad (16)$$

Where c is determined by (3.13), k and v are coefficient of similarity and continuous isotone estimation respectively.

IV. An Approach for Fuzzy Aggregation and its Algorithm

Let p groups of experts be attracted to consider of a certain project and each of these groups consists of m persons. Each expert expresses his subjective estimate by a fuzzy set that is obtained. So, we have p finite collections of m fuzzy sets represents the rating to an alternative under a given criterion. As a result for each group of experts a finite collection of fuzzy sets. Let a universe be $X=\{x_1,x_2,...,x_n\}$. Our task is to aggregate the obtained fuzzy opinions.

We will arrive as follows. First of all determine the representatives of each finite collection of fuzzy sets with dimension ($n\times m$). Then form the finite collection of representatives with dimension($n\times p$) and determine its representative. In our opinion this representative is a quite adequate consensus of the considered group decision process

To realize our approach we modifyethe algorithm developed in[3].

Algorithm

Step 0: *Initialization: the finite collection of one-element fuzzy sets in the first finite collection of fuzzy sets* $\left\{B_{1j}\right\}$, *its regulation* $\left\{B_{1j}^{'}\right\}$, $j=\overline{1,m}$, $m=2,3,...$. *Denote theresult of the fuzzy aggregation in element* x_i, $i=\overline{1,n}$ *by* $\mu_1\left(x_i\right)$.

Step 1: *Compute the values of coordination indices of the finite collection of one-element fuzzy sets* $\left\{B_{1j}^{'}\right\}$ *in each element* x_i, $i=\overline{1,n}$ *by* (6). *Denote these values by* $S_1\left(x_1\right)$, $S_1\left(x_2\right),...,S_1\left(x_n\right)$ *respectively. Compute the value of* $S_{1\max}$ *by* (7).

Step 2: *Choose out of the set* $\left\{S_1(x_i)\right\}$ *such element* S_1^* *which is greater than or equal to any other elements except* $S_{1\max}$.

Step 3: *Do* Step 4 *for* $i=\overline{1,n}$.

Step 4: Compute $\Delta=S_1^*-S_1\left(x_i\right)$:

- *If* $\Delta < 0$ *then* $\mu_1(x_i) = \mu_{B_{1j}}(x_i)$;
- *If* $\Delta = 0$ *then compute the value of* $\mu_1(x_i)$ *by* (15);
- *If* $\Delta > 0$ *then compute the value of* k_{1i} *from the equation* $S_1^* = k_{1i} S_1(x_i) + (1 - k_{1i}) S_{1\max}$ *andthe value of* $\mu_1(x_i)$ *by* (13) *and* (16).

Step 5: *Representation is* $\{\mu_1(x_1),\ \mu_1(x_2), \ldots, \mu_1(x_n)\}$.

We repeat these calculations for the second, third, and finally p^{th}finite collections of fuzzy sets As a result we obtain the following set

$$\{\mu_t(x_i)\}, \quad t = \overline{1,p},\ i = \overline{1,n} \tag{17}$$

and the resulting finite collection fuzzy sets:

$$\begin{matrix} \mu_1(x_1) & \mu_1(x_2) & \ldots & \mu_1(x_n) \\ \mu_2(x_1) & \mu_2(x_2) & \ldots & \mu_2(x_n) \\ \ldots & \ldots & \ldots & \ldots \\ \mu_p(x_1) & \mu_p(x_2) & \ldots & \mu_p(x_n) \end{matrix} \tag{18}$$

Now we determine the representative of fuzzy collection (18) by Algorithm 4.1 and obtain the consensus of the considered group decision process:

$$\{\mu_{\overline{A}^*}(x_i)\} = \mu_{\overline{A}^*}(x_1), \mu_{\overline{A}^*}(x_2), .., \mu_{\overline{A}^*}(x_n) \tag{19}$$

V. Conclusion

We consider the approach to making decisions for different problems in nonstandard situations with a lack of the previous experience and incomplete knowledge of the considered problem. In such cases we usually cannot do without expert evaluations which lead to the process of group decision-making, and it becomes necessary to solve a problem of alternatives aggregation. It is proposed to solve such problems by means of fuzzy sets. It is meant that there are several groups of experts. An approach is proposed for the processing of quantitative expert evaluations which are used in the group decision-making.

The approach is based on the coordination index and the similarity of finite collections of fuzzy sets and takes into account the specific character of the fuzzy aggregation operator. The approach is discussed and its algorithm is presented.

The method may also be helpful for a group of experts in the implementation of a project. Given a project with its vector of goals, the problem is to determine the coordination degree of evaluations made by contesters claiming to join the project group. The proposed approach enables one to calculate this degree and collect the most efficient project groupWe consider the approach to making decisions for different problems in nonstandard situations with a lack of the previous experience and incomplete knowledge of the considered problem. In such cases we usually cannot do without expert evaluations which lead to the process of group decision-making, and it becomes necessary to solve a problem of alternatives aggregation. It is proposed to solve such problems by means of fuzzy sets.

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References

[1] A. Averkin, I. Batirshin, A. Blishun. V. Silov, V. Tarasov, Fuzzy sets in the Models of Control and Artificial Intelligence (Nauka Press, Moscow, 1986) (in Russian).

[2] T. Tsabadze, The coordination index of a finite collection of fuzzy sets, Fuzzy Sets and Systems 107 (1999) 177-185.

[3] T. Tsabadze, A method for fuzzy aggregation based on grouped expert evaluations, Fuzzy Sets and Systems 157 (2006) 1346-1361

[4] J. Vaníček, I. Vrana and S. Aly, Fuzzy aggregation and averaging for group decision making: A generalization and survey. Knowledge-Based Systems 22 (2009) 79-84.

[5] L. A. Zadeh, Fuzzy sets, *Inform. Control* 8, No. 3 (1965), 338–353.