Formalization of Indistinct Expert Representations about the Object of Research

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It is offered additional possibilities on increase of expert's estimations accuracy of by introduction in base model the factors considering a "pessimistic" or "optimistic" spirit of the expert and providing in next automated correction of the examination result.
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1 A problem condition

Objects of research are frequently characterized by the big complexity, multitude of interconnected factors influencing against each other in obvious or not the obvious form, external and internal, operated and casual influences [1]. To formalize such process so that everything, that influences an object state, has been considered - is difficult and often impossible problem.

The person on the basis of the experience and erudition, mental capacity, which cannot be modeled more or less precisely in present, can, on the basis of the supervision on a number of signs, estimate the process as a whole. Even if these estimations are made insufficiently precisely, all of them are very important for decision-making.

Therefore inclusion of the person (the expert, the making decision person, the executor etc.) in a contour of a certain information system (IS), under certain circumstances, will allow increasing substantially its efficiency.

However, the person, possessing the big abilities, has also the specific goals. As it is underlined in [2] persons wishes to operate, first, according to the interests; secondly, the person knows a coordination of the present and future interests; thirdly, it can arrive according to the knowledge.

2. Ways of problem solution.

In our opinion, it is possible to supply person actions, fourthly, with its propensities to an "optimistic" or "pessimistic" estimation of object state.

With that end in view in [2] function of possibility which characterizes internal potential suitability of object, in difference from the probability considering a consequence of actions of external factors on object of research is used. The person appoints to object degree of possibility (number from an interval [0,1]), their set is named possibility of distribution. With the help of possibility of distribution are allocated and estimated causal relationships of characteristics appearing, object factors in this or that environment.

Necessity of introduction of function "possibility" as authors [2] consider, and it is impossible to disagree with it, follow from this, that there are extreme cases when the likelihood information on an object state is absent or the object is in an abnormal condition i.e. when its condition can strongly differ from likelihood forecasts.

Let's consider a problem of an estimation of object state by the expert on the basis of possibility function. The problem description we will give according to [3].

1. The purpose - determining by expert doubtful data about control object for maintenance of the most effective organization of administrative influences.

2. Alternative variants of the decision - there are available ***n*** linguistic variables, each of which characterizes a certain state of research object. Then the choice of i^{th} linguistic variable characterizing the most true condition of a material stream, will be ***i*** th variant of the decision of the given problem.

3. External conditions - objectivity of the expert, the presence of traditional conditions at which the object usually shows the properties and co-operates with an environment.

4. Outcomes - in created model of the deci-

sion of the given problem as criterion the volume-quantitative characteristic of the shown properties of object during the considered period acts at concrete - the established influences on it.

5. A rule of a choice of decisions. It is necessary to establish a rule with help of which it is possible to choose a set of preferable decisions or the unique decision at a choice of the most suitable linguistic variable.

3. The Elements of the theory and base model

The term «a linguistic variable» is offered for the first time Lotfi Zadeh [4]. The basic assumption motivating the linguistic approach [5], consists that perception the person of dependence of function of an accessory $\mu_f(P)$ - object P to indistinct set F from $x_1, x_2, \ldots, x_n$ generally insufficiently precisely and is well formalized to make possible tabulation $\mu_f(P)$ as size function $x_1, x_2, \ldots, x_n$. For more rough and, hence, less exact description of this dependence it is supposed, that value tabulation $x_1, x_2, \ldots, x_n$ and $\mu_f(P)$ - linguistic (for example, use of terms is "more", "less", «within norm», etc.), instead of numerical, also linguistic methods for the interpolation of the table of relations R defining $\mu_f(P)$ on values absent in the table of sizes $x_1, x_2, \ldots, x_n$ are used. Linguistic value x_i, $i=1,2, \ldots, n$, in other words, is the answer to question Q_i: « What value of size x_i? »- also that corresponding value $\mu_f(P)$ is the answer to question Q:« If answers on $Q_1, Q_2, \ldots, Q_n$ an essence $r_1, r_2, \ldots, r_n$ accordingly, what size $\mu_f(P)$? The purpose of such interpretation of sizes $x_1, x_2, \ldots, x_n, \mu_f(P)$ is record of distinguishing algorithm R_{tr} in a kind ветвящегося the questionnaire consisting of questions which are set consistently, and a question set on a step j, depends on the answer to the previous questions.

Let U - universal set, $X = \{x_i\}$ - the approximate quantitative characteristic of object in i - m an interval of estimate of i-th a linguistic variable, where i - quantity of linguistic variables. Variable X receives value from universal set U. Let $u \in U$ an object state at which it is expected that it will receive concrete quantitative value. Then [2]

$$\Pi x_i(u) = Poss\{X = u\},\ i = 1,2,\ldots,n, \quad (1)$$

Where $\Pi x_i(u)$ - degree of possibility of an estimation i-th a linguistic variable.

$\Pi x_i(u)$ it is defined according to [6] as follows:

$$\Pi x_i(u) = \begin{cases} 0 & M_i \le \beta_i \\ \dfrac{M_i - \beta_i}{\alpha_i - \beta_i} & \beta_i < M_i < \alpha_i \\ 1 & M_i \ge \alpha_i, \end{cases} \quad (2)$$

where α_i, β_i - accordingly the top and bottom borders of quantitative values at a concrete state of object which can be characterized i^{th} a linguistic variable.

Values α_i and β_i are determined by the expert subjectively on the basis of the knowledge of a state of a material stream. M_i - quantitative values which are put in conformity to typical values by i^{th} linguistic variable.

4. An offered variant of specification of base model

Values of function of possibility are degrees of possibility for each linguistic variable. This function on an interval [0,1] is defined. However, the estimation of function of possibility, at top α and bottom β borders, established for the expert can be essentially specified, if possibility quantitatively to estimate some factor W characterizing its propensities to an "optimistic" or "pessimistic" estimation is represented. If to consider this factor expression (2) becomes:

$$\Pi x_i(u) = \begin{cases} 0 & M_i \le \beta_i(W) \\ \dfrac{M_i - \beta_i(W)}{\alpha_i(W) - \beta_i(W)} & {}_i(W) < M_i < \alpha_i(W) \\ 1 & M_i \ge \alpha_i(W), \end{cases} \quad (3)$$

As an example in table 1 are resulted dependences α, β, M from a corresponding linguistic variable about concrete quantitative values at a concrete state of object (assemblage of units for days on one of the enterprises).

Table 1

1.	Considerably above norm	1200	1250	1130	1210	1180
2.	Above norm	1150	1210	1050	1150	1110
3.	Norm	1100	1170	1005	1130	1035
4.	Below norm	1050	1105	950	1100	1010
5.	Considerably below norm	950	990	900	970	920

On fig. 1, on the basis of the data resulted in the table, corresponding functions of possibility are constructed.

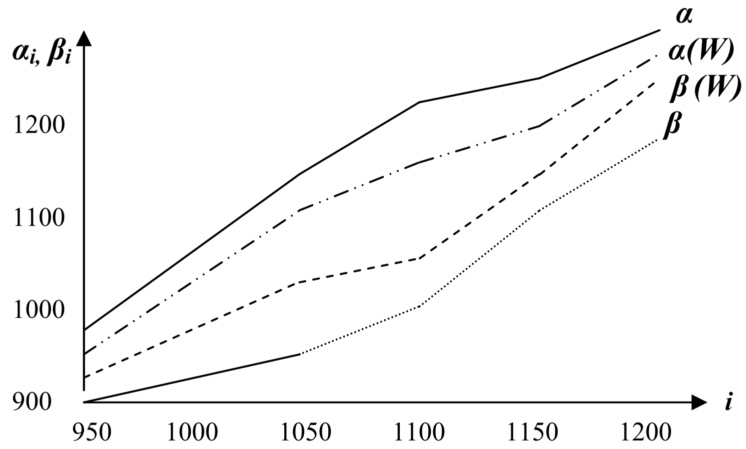

Fig.1. Construction of functions of possibility.

In real conditions to estimate quantitative values characterizing a state of object of research on homogeneous linguistic variables not always it is obviously possible. For example, in the absence of the sufficient information on concrete event or the incompetent answer to a concrete question given by the expert. Here "homogeneous" linguistic variables are meant by the term the variables characterizing the same event, for example only volume of output or only supply by power resources etc. At the same time, using of indirect data on concrete process would allow to reduce in some cases considerably uncertainty of a state of object.

5. A composite rule of a conclusion Lotfi Zadeh

In this connection Lotfi Zadeh [4] has developed a composite rule of a conclusion. We will consider, in what the essence of the named rule consists.

Let there are two statements ***A*** and ***B***. For estimation of ***B*** on the validity of the statement ***A***, are used a rule ***modus ponens*** from the traditional logic. However, in some cases, it is necessary to use this rule not in exact, and in the approached form. In this case L.Zadeh suggests [4] to use instead of a rule ***modus ponens*** a composite rule of a conclusion and proves in [4], that ***modus ponens*** there is a special case of a composite rule. Its essence consists in the following.

Let ***A*** - an indistinct subset of an axis ***OX***, and ***F*** - the indistinct relation in ***OX * OY.*** Forming cylindrical indistinct set $\overline{A}$, with the basis ***A*** and its crossing with indistinct relation ***F***, turns out indistinct set $\overline{A}\cap F$ (see fig. 2).

Projecting then this set on axis ***OY***, turns out value in the form of an indistinct subset of axis ***OY***. As $y = f(x)$ and $x = A$ - indistinct set of an axis ***OX***, receive value ***y*** in the form of an indistinct subset $\overline{A}$, ***A***, ***F*** and ***B*** accordingly. Then by definition of set ***A***

$$\mu_{\overline{A}}(x,y) = \mu_A(x) \qquad (4)$$

and, hence,

$$\mu_{\overline{A}\cap F}(x,y) = \mu_{\overline{A}}(x,y) \cap \mu_F(x,y) = \mu_A(x) \cap \mu_F(x,y). \qquad (5)$$

Projecting set $\overline{A}\cap F$ on axis ***OY,*** receive

$$\mu_B(y) = U_x \mu_A(x)\ ) \cap \mu_F(x,y), \qquad (6)$$

i.e. expression for function of an accessory of a projection (shade) $\overline{A}\cap F$ on axis ***OY.***

According to composition definition in [4] ***B*** it is suggest to present in a following mode:

$$B = A°F, \qquad (7)$$

where ° - a composition sign. If ***A*** and ***F*** have final carriers composition operation is reduced to максиминному to reduction of matrixes.

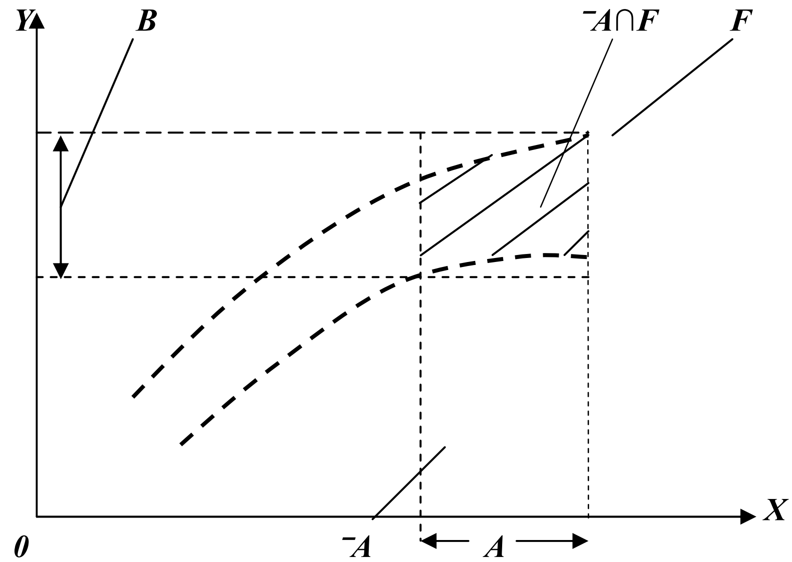

Fig.2. An illustration of a composite rule of a conclusion for indistinct variables

For interpretation of a composite rule of a conclusion Zadeh Lotfi offers the following.

Let ***U*** and ***V*** - two universal sets with base variables ***u*** and ***v*** accordingly. Let ***R (u), R (u, v)*** and ***R (v)*** designate restrictions on ***u, (u, v)*** and ***v***, and respectively, represent indistinct relations in ***U, U* V*** and ***V.*** Then, a composite rule of a conclusion asserts, that the decision of the equations of appointment

$$R(u) = A \text{ and } R(u,v) = F \qquad (8)$$

looks like

$$R(v) = A°F, \qquad (9)$$

where ***A°F*** - a composition ***A*** and ***F.*** In this case it does conclusion ***R (v) = A°F*** from this, that ***R (u) = A*** and ***R (u, v) = F.***

After carrying out of some object researches, the conclusion has been drawn, that at a choice of strictly certain statements characterizing its condition, a composite rule of a conclusion can be applied to an estimation of reliability of registered given (knowledge). In particular, indirect data on volume of consumed fuel, concentration of a smoke in an exhaust pipe, level of vibration and a specific rumble at engine work give the chance to judge reliability of data on quality of its repair and to compare to the data registered by the master of a repair repair truck in corresponding magazine.

6. Application of a composite rule

Let's consider application of a composite rule on a concrete example.

Let's assume, that work of the equipment of the enterprise is characterized by the linguistic variables, stating estimation ***U*** of its work (1 - worked smoothly, 2 - worked as times, 3 - worked with very big faults, did not work, 5 - there are no data) and volume of output ***V*** (1 - more than replaceable norm, 2 - within norm, 3 - there is less than norm, 4 - there is less than norm, 5 - there are no data).

$$U = V = 1 + 2 + 3 + 4 + 5.$$

Let

A = worked smoothly = 1/0 + 2/1 + 3/0 + 4/0 + 5/0

F = worked within norm = 1/0 + 2/0 + 3/1 + 4/0 + 5/0.

Then

$min\ (\mu_{AND}(0.9), \mu_F(0.5)) = 0.5,$

$min\ (\mu_{AND}(1), \mu_F(0.9)) = 0.9,$

$min\ (\mu_{AND}(0.2), \mu_F(1)) = 0.2,$

$min\ (\mu_{AND}(0), \mu_F(0.2)) = 0,$

$\min(\min(\mu_{AND}(1), \mu_F(0.9)) = 0.9, (0), \mu_F(0)) = 0$.

$\mu_{A \circ F}(u, v) = \max_u [\min_A(u), \min_F(u, v) = 0.9$.

However, during researches for the purpose of a choice of number of linguistic variables, there were difficulties according to efficiency of the control of data, on the basis of indistinct representations about an object state. In this connection it is necessary to enter some measure characterizing approximate error IS.

Let S be a set of conditions of object. We will enter concept of dim restriction $R(S^*V)$, where $V \in [1,0]$ - area of values of function of an accessory to a concrete condition of the object, defined by means of linguistic variables on the basis of value judgment of experts.

According to character of conditions of object, there are every possible linguistic variables $\{H_j\}_k$ which describe a stream, will name further their typical. However, it is necessary to notice, that a class $\{H_j\}_k$ much more already, than a class of every possible real situations. Therefore there is a problem of an establishment of a measure of distinction between a concrete situation and "nearest" the typical.

The approach based on minimax criterion of reference is offered. We will enter a set of dim restrictions $\{R_j(S^*V)\}_k$ which characterize a class $\{H_j\}_k$. Reference we will make by a rule:

$$H_j : \rho(S_j, R_j) = \inf, j = 1,2, \ldots, k \quad (10)$$

where $\rho(S_j, R_j)$ - a distance measure between real S_j and «the nearest typical» R_j which is set in a kind

$$\rho(S_j, R_j) = \sup_{s \in S}[\mu_{SjURj}(S) - \mu_{Sj \cap Rj}(S) \quad (11)$$

$$\mu_{SjURj}(S) = \max\{\mu_{Sj}(S), \mu_{Rj}(S)\} \quad (12)$$

$$\mu_{Sj \cap Rj}(S) = \min\{\mu_{Sj}(S), \mu_{Rj}(S)\}, s \in S \quad (13)$$

$\mu_{Sj}(S)$ - function of an accessory of the dim relation characterizing a real situation, $\mu_{Rj}(S)$ - set.

We define area of values ρ. According to definition of function of an accessory $\mu_{Sj}(S)$ and $\mu_{Rj}(S)$ belong to a piece $[0,1]$. Hence, according to formulas (12) and (13) $\mu_{SjURj}(S)$ and $\mu_{Sj \cap Rj}(S)$ also belong to a piece $[0,1]$. Substituting values $\mu_{SjURj}(S)$ and $\mu_{Sj \cap Rj}(S)$ in the formula (11), we find area of values of the entered measure of distance $0 \le \rho \le 1$. (14)

Can be constructed and other measures of distance, however, such measure most naturally follows from a combination of principles of "optimistic" and "pessimistic" approaches to estimations of concrete situations. In a case when typical and real situations coincide, the distance measure addresses in «*0*».

7. The formulas characterizing the account of an "optimistic" and "pessimistic" spirit of the expert.

Using formulas (12) and (13), and also (11), it is possible to deduce the formulas characterizing borders α and β taking into account an "optimistic" and "pessimistic" spirit of the expert:

$$\alpha_i(W) = \alpha_i(W)_{onm} - \alpha_i(W)_{necc}, \quad (15)$$

where $\alpha_i(W)_{onm} = \alpha_i + \alpha_i(1 - \mu_{SjURj}(S)) = \alpha_i[2 - \mu_{SjURj}(S)]$, (16)

$$\alpha_i(W)_{necc} = \alpha_i[2 - \mu_{Sj \cap Rj}(S)]; \quad (17)$$

$$\beta_i(W) = \beta_i(W)_{onm} - \beta_i(W)_{necc}, \quad (18)$$

where $\beta_i(W)_{onm} = \beta_i - \beta_i(1 - \mu_{SjURj}(S)) = \beta_i[2 - \mu_{SjURj}(S)]$, (19)

$$\beta_i(W)_{necc} = \beta_i[2 - \mu_{Sj \cap Rj}(S)]. \quad (20)$$

Amendments on a corresponding spirit of the expert are presented in the form of some size γ. For α $\gamma_{opt} = +\alpha(W)/2$, $\gamma_{pess} = -\alpha(W)/2$. For β $\gamma_{opt} = +\beta(W)/2$, $\gamma_{pess} = -\beta(W)/2$.

The size γ, can be used as the amendment to an estimation the concrete expert of a condition of object of research.

Conclusions

So, in the given work the size which gives the chance to enter amendments to estimation the concrete expert of a condition of object of research is received. The variant offered here for specification of base model of expert estimations intended for conducting the account of a "pessimistic" and "optimistic" component of the expert, can be used with success at creation and development of the systems intended for structurization of again registered data and knowledge, for example, such as «matrixes of elements of knowledge», described in [7] and other sources.

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