

Запропановано алгоритм, який базується на мірі можливості, для оцінки задоволення ступенем зайнятості в організації. Ефективні чинники задоволення роботою зібрані через інтерв'ю. У результаті аналізу інтерв'ю складено нечіткі правила. За допомогою отриманих правил, використовуючи нечіткий алгоритм виведення, заснований на мірі можливості, обчислена оцінка задоволення роботою. Основна перевага підходу – можливість працювати із недосконалою інформацією

Ключові слова: задоволення роботою, міра можливості, нечіткий алгоритм виведення, мінесотське анкетне опитування задоволення

Предложен алгоритм, базирующийся на мере возможности, для оценки удовлетворения степенью занятости в организации. Эффективные факторы удовлетворения работой собраны через интервью. В результате анализа интервью составлены нечёткие правила. При помощи полученных правил, используя нечёткий алгоритм вывода, основанный на мере возможности, вычислена оценка удовлетворения работой. Основное преимущество используемого подхода – способность работать с несовершенной информацией

Ключевые слова: удовлетворение работой, мера возможности, нечёткий алгоритм вывода, миннесотский анкетный опрос удовлетворения

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AN ALGORITHM BASED ON A POSSIBILITY MEASURE AND USED TO EVALUATE THE JOB SATISFACTION INDEX

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1. Introduction

Much work has been done in the area of evaluating job satisfaction. However, these methods are insufficient because they are based only on a statistical method. Therefore, perceptual information rather than numbers should be specified concerning the essentials and the basic factors of job satisfaction, including such parameters as activity, independence, variety, status, supervision-human resource, supervision-technical, moral values, security, social service, authority, ability, company policies and practices, compensation, advancement, responsibility, creativity, working conditions, co-workers, recognition, and achievement. Information determined by perception can be processed by a more adequate method, e. g., by using a fuzzy logic theory and a possibility measure. A fuzzy logic, introduced by Zadeh, provides us with a new mathematical expression to deal with uncertain information. From this viewpoint, we will represent the basic definition of the problem undertaken in this study.

2. Analysis of previous studies and statement of a problem

In the area of workplace psychology [1], job satisfaction is one of the most researched problems. For example, in [2], job satisfaction is associated with everything from leadership to job design. The study contemplates the key definitions concerning job satisfaction. The main theories related to explaining job satisfaction are given in [2], but it is also important to explore what factors precede and constitute job satisfaction.

In study [3], the definition of job satisfaction is given as follows: "Job satisfaction is the level of contentment a person feels regarding his or her job. This feeling is mainly based on an individual's perception of satisfaction. Job satisfaction can be influenced by a person's ability to complete required tasks, the level of communication in an organization, and the way management treats employees. Job satisfaction falls into two levels: affective job satisfaction and cognitive job satisfaction. Affective job satisfaction is a person's emotional feeling about the job as a whole. Cognitive job satisfaction is how satisfied employees feel concerning some aspects of their job, such as payment, hours or benefits".

In [2], many researchers and practitioners are cited as providing their own definitions of what job satisfaction is. However, the two most common definitions describe job satisfaction as: "the pleasurable emotional state resulting from the appraisal of one's job as achieving or facilitating the achievement of one's job values" [4], and "the extent to which people like (satisfaction) or dislike (dissatisfaction) their jobs" [2]. There are many theories about job satisfaction in real world literature. Job satisfaction theories have a strong overlap with theories explaining human motivation.

The most common and prominent theories in this area include: Maslow's needs hierarchy theory [5], Herzberg's motivator-hygiene theory [6], the job characteristics model [7], and the dispositional approach [8].

These theories are described and discussed in literature related to human motivation [9–12]. Some determinants of job satisfaction are analysed in [13–16]. In [17], an affective approach to job satisfaction is described. Job satisfaction indicators and their correlates are analysed in [18].

Job satisfaction does not only concern how much an employee enjoys work. Taber and Alliger [19] have analysed other exponents such as the level of concentration required for the job, the level of supervision, and task importance. This study demonstrates that the accumulating enjoyment of work tasks enhances overall job satisfaction.

Some factors of job satisfaction may rank as more important than others, depending on each worker’s needs and personal and professional goals. To create a benchmark for measuring and ultimately creating job satisfaction, managers in an organization can employ proven test methods such as the Job Descriptive Index (JDI) or the Minnesota Satisfaction Questionnaire (MSQ) [20]. These assessments help management define job satisfaction objectively.

In [21], the authors analyse the relationship between the psychological contract and facets of job satisfaction among non-profit sector employees, using the nascent non-hierarchical evidential c-means (ECM) clustering technique. To date, this technique has been theoretically discussed but not widely applied. Based on the Dempster-Shafer theory of evidence, the ECM is novel in facilitating the assignment of objects, not only to single clusters but to sets of clusters and no clusters (outliers). The study compares the theoretical underpinnings and findings from the ECM with those of three other well-known clustering techniques, namely (1) the hierarchical Ward’s method, (2) the non-hierarchical crisp k-means, and (3) the non-hierarchical fuzzy c-means approaches. The authors present and interpret cluster solutions from each clustering technique. They establish three clusters differentiated by the content of the employees’ psychological contracts. These clusters are validated by considering their relationship with facets of job satisfaction to ensure that the clusters are theoretically meaningful.

In [22], a fuzzy approach is suggested to measure the degree of satisfaction of graduates on the suitability of university education for working purposes. The designed fuzzy system is based on the Mamdani fuzzy inference. From Internet resources [23], it is known that the advantages of the Mamdani method are: (1) it is intuitive, (2) it has widespread acceptance, and (3) it is simple.

However, it is not a very effective method. The reasons are a need for precise input information and a loss of information in the defuzzification process. From this viewpoint, a possibility measure-based on Aliev’s fuzzy inference method is more effective [24].

3. The purpose and objectives of the study

The purpose of this study is to determine the level of employees’ job satisfaction by using the Minnesota Satisfaction Questionnaire (MSQ) and a possibility measure.

In accordance with the set purpose, the following research objectives have been identified:

- to analyse the basic facets of job satisfaction,
- to create a model of job satisfaction,
- to compute the job satisfaction index with real data under uncertainty.

4. Creation of the fuzzy job satisfaction index model

The basic definitions for creating the fuzzy job satisfaction index model are given below:

Definition 1 [25, 26]. A fuzzy set A defined on a universe X may be given as:

$$A = \{(x, \mu_A(x)) | x \in X\},$$

where $\mu_A : X \rightarrow [0,1]$ is the membership function. A membership value $\mu_A(x)$ describes the degree of belonging of $x \in X$ in A.

Definition 2 [25, 26]. A triangular fuzzy number \tilde{A} can be defined by a triplet (a_1, a_2, a_3) , where the membership can be determined by the following equation:

$$\mu_{\tilde{A}}(x) = \begin{cases} 0, & x \in [-\infty, a_1], \\ \frac{x - a_1}{a_2 - a_1}, & x \in [a_1, a_2], \\ \frac{a_3 - x}{a_3 - a_2}, & x \in [a_2, a_3], \\ 0, & x \in [a_3, +\infty]. \end{cases}$$

Definition 3 [27, 28]. A fuzzy aggregation operation, with an arithmetic mean. The arithmetic mean aggregation operator is defined by n trapezoidal fuzzy numbers (TrFNs):

The $\langle a_1, b_1, c_1, d_1 \rangle, \langle a_2, b_2, c_2, d_2 \rangle, \dots, \langle a_n, b_n, c_n, d_n \rangle$ produces the result $\langle \bar{a}, \bar{b}, \bar{c}, \bar{d} \rangle$, where

$$\bar{a} = \frac{1}{n} \sum_{i=1}^n a_i, \quad x_1, \quad x_2, \quad x_3.$$

Definition 4 [20, 29]. The Minnesota Satisfaction Questionnaire (MSQ) is designed to measure an employee’s satisfaction with his or her job. Three forms are available: two long forms (the 1977 version and the 1967 version) and a short form. The MSQ provides more specific information on the aspects of a job that an individual finds rewarding than do more general measures of job satisfaction. The MSQ is useful in exploring client vocational needs, in counselling follow-up studies, and in generating information about reinforcers in jobs.

Definition 5 [30]. The trapezoid membership function is defined as:

$$\text{Tra}(x, \alpha, \beta, \gamma, \delta) = \begin{cases} 0, & x < \alpha, \\ \frac{x - \alpha}{\beta - \alpha}, & \alpha \leq x < \beta, \\ 1, & \beta \leq x < \gamma, \\ \frac{x - \delta}{\delta - \gamma}, & \gamma \leq x < \delta, \\ 0, & x \geq \delta. \end{cases}$$

Definition 6 [31]. The monotonically increasing linear membership function is defined as:

$$L(x, \alpha, \beta) = \begin{cases} 0, & x < \alpha, \\ \frac{x - \alpha}{\beta - \alpha}, & \alpha \leq x \leq \beta, \\ 1, & x > \beta. \end{cases}$$

The monotonically decreasing linear membership function is defined as:

$$L(x, \alpha, \beta) = \begin{cases} 1, & x < \alpha, \\ -\frac{x - \alpha}{\beta - \alpha}, & \alpha \leq x \leq \beta, \\ 0, & x > \beta. \end{cases}$$

Definition 7 [28]. The operation of fuzzy equality is widely used to calculate the truth-value of fuzzy rules in expert systems and fuzzy control systems:

$$a = b,$$

where **a** and **b** are linguistic values; = denotes the operation “is close to”. This operation is defined as a possibility measure for **a** to have the same value as **b**.

Calculation of the possibility (a/b) if a and b are trapezoidal fuzzy numbers (Fig. 1, a, b) corresponds to the following:

$$\mu_a(x) = \begin{cases} 1 - \frac{a_1 - x}{\alpha_1}, & \text{if } a_1 - \alpha_1 \leq x \leq a_1, \\ 1, & \text{if } a_1 \leq x \leq a_2, \\ 1 - \frac{x - a_2}{\alpha_r}, & \text{if } a_2 \leq x \leq a_2 + \alpha_r, \\ 0, & \text{otherwise,} \end{cases}$$

$$\mu_b(x) = \begin{cases} 1 - \frac{b_1 - x}{\beta_1}, & \text{if } b_1 - \beta_1 \leq x \leq b_1, \\ 1, & \text{if } b_1 \leq x \leq b_2, \\ 1 - \frac{x - b_2}{\beta_r}, & \text{if } b_2 \leq x \leq b_2 + \beta_r, \\ 0, & \text{otherwise,} \end{cases}$$

$$(a = b) = \text{Poss}(a / b) = \max \min(\mu_a(x), \mu_b(x)) =$$

$$= \begin{cases} 1 - \frac{a_1 - b_2}{\alpha_1 + \beta_r}, & \text{if } 0 < a_1 - b_2 < \alpha_1 + \beta_r, \\ 1, & \text{if } \max(a_1, b_1) \leq \min(a_2, b_2), \\ 1 - \frac{b_1 - a_2}{\beta_1 + \alpha_r}, & \text{if } 0 < b_1 - a_2 < \beta_1 + \alpha_r, \\ 0, & \text{otherwise.} \end{cases}$$

Concrete models of using fuzzy data are considered. The study is organized as follows. Section 2 analyses previous studies and states the problem. The research purpose and problems are presented in section 3. The algorithm of fuzzy inference is given in section 4. The research results are described in a conceptual form in section 5. The experimental results of calculations are described in section 6. The conclusion is presented in section 7.

Overall job satisfaction is a very important problem in real life. The basic problem of defining this notion is to evaluate overall satisfaction of the respondents by using job facets. To determine overall satisfaction by evaluating job facets, we use aggregation operators [27, 28]. To determine overall satisfaction of the respondents, the following Tables 1 and 2 are used [32].

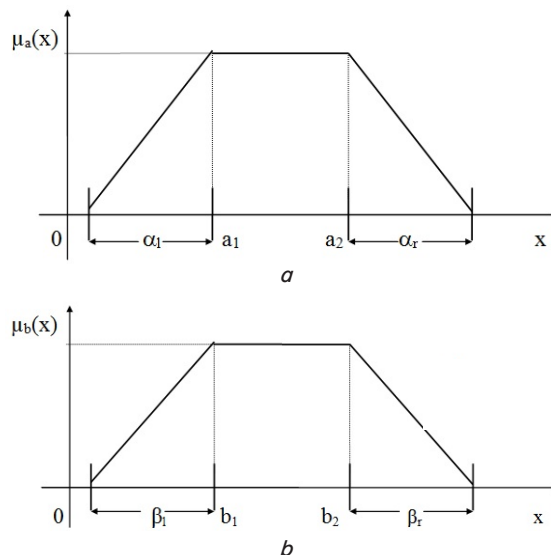


Fig. 1. Fuzzy numbers: a and b

Table 1

Minnesota Satisfaction Questionnaire (MSQ): Short Version

Item	JOB ASPECT/FACET	Scale				
		1	2	3	4	5
1	Being able to stay busy all the time (ACTIVITY)	1	2	3	4	5
2	An opportunity to work alone (INDEPENDENCE)	1	2	3	4	5
3	A chance to do different things from time to time (VARIETY)	1	2	3	4	5
4	A possibility to be “somebody” in the community (STATUS)	1	2	3	4	5
5	The way my boss handles his/her workers (SUPERVISION-PERSONNEL)	1	2	3	4	5
6	The competence of my supervisor in decision making (SUPERVISION-TECHNICAL)	1	2	3	4	5
7	Being able to do things that do not contradict my conscience (MORAL VALUES)	1	2	3	4	5
8	A way my job provides for steady employment (SECURITY)	1	2	3	4	5
9	A chance to do things for other people (SOCIAL SERVICE)	1	2	3	4	5
10	An opportunity to tell people what to do (AUTHORITY)	1	2	3	4	5
11	A chance to do something that makes use of my abilities (ABILITY)	1	2	3	4	5
12	The way the company policies are put into practice (COMPANY POLICIES AND PRACTICES)	1	2	3	4	5
13	My salary and the amount of work I do (COMPENSATION)	1	2	3	4	5
14	A chance for advancement in this job (ADVANCEMENT)	1	2	3	4	5
15	Freedom to use my own judgment (RESPONSIBILITY)	1	2	3	4	5
16	An opportunity to try my own methods of doing the work (for advancement in this job) (CREATIVITY)	1	2	3	4	5
17	The working conditions (WORKING CONDITION)	1	2	3	4	5
18	The way my co-workers get along with one another (CO-WORKERS)	1	2	3	4	5
19	The praise I get for doing a good job (RECOGNITION)	1	2	3	4	5
20	A feeling of accomplishment I get from the job (ACHIEVEMENT)	1	2	3	4	5

These survey items were taken from the Minnesota satisfaction questionnaire (short version) [20]. The answers received from 15 respondents (Fig. 1) have been processed on the basis of the aggregation method [27].

The important factors that have an impact on job satisfaction are: activity, independence, variety, status, supervision-human resource, supervision-technical, moral values, security, social service, authority, ability, company policies and practices, compensation, advancement, responsibility, creativity, working conditions, co-workers, recognition, and achievement.

Therefore, in this study, the twenty evaluated facets are chosen for determining overall job satisfaction [20]. The purpose is to specify the level of employees' job satisfaction by using the Minnesota Satisfaction Questionnaire (MSQ) and a fuzzy measure. By analysing the table and applying the aggregation operation, we have obtained the outputs provided below (Table 3).

The aggregated satisfaction per respondent is as follows: x_4 .

The structure of a production rule can be formally stated as follows. Before presenting the technique for knowledge representation by product systems, we define the term knowledge, which is widely used in this study.

The model of the following type is offered on the basis of the accepted data:

IF U_1 is A_{i1} and U_2 is A_{i2} and U_r is A_{ir} , THEN V is D_i and $CF_i \in [0;100]$, where CF_i is the confidence degree of the rule that is defined by an expert. It expresses the belief degree of the expert to the truth degree of the rule. A_{i1} , A_{i2} , A_{ir} , and D_i are linguistic values of the linguistic variables U_1 , U_2 , U_r , and V . The linguistic terms of the facets' grades are accepted as trapezoid, triangular, linear decreasing, and linear increasing membership functions [27, 30, 31].

Table 3

Results of the aggregation operation for 15 respondents

Notation of outputs	\bar{a}	\bar{b}	\bar{c}	\bar{d}
y1=	(2.4	3.2	3.59	3.875)
y2=	(2.4	3.12	3.55	3.775)
y3=	(2.45	3.17	3.63	3.9)
y4=	(2.15	2.75	3.31	3.55)
y5=	(3.4	4.2	4.52	4.7)
y6=	(2.6	3.4	3.8	4.1)
y7=	(2.7	3.5	3.89	4.175)
y8=	(3.05	3.85	4.24	4.525)
y9=	(3.15	3.95	4.32	4.575)
y10=	(2.95	3.71	4.06	4.225)
y11=	(2.35	2.99	3.54	3.825)
y12=	(2.55	3.23	3.72	3.975)
y13=	(3.05	3.77	4.15	4.3)
y14=	(1.9	2.58	3.08	3.35)
y15=	(2.85	3.61	4.02	4.275)

Let us take into account the aggregation of information, which is a very important problem for decision-making analysis. Information aggregation depends upon the nature of information.

Table 2

A sample of responses from 15 respondents [32]:

RESPONDENT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Job aspect/facet															
Activity (act)	4	2	3	1	4	4	4	4	4	4	4	4	5	3	4
Independence (ind)	4	4	4	4	4	2	4	4	4	2	4	4	3	2	4
Variety (var)	2	5	4	1	5	4	4	4	4	5	1	3	5	4	4
Status (stat)	4	5	5	3	5	2	4	4	4	5	4	4	5	4	5
Supervision-human resource (shr)	4	3	3	3	4	4	4	4	4	4	1	5	5	1	4
Supervision-technical (svt)	4	3	4	3	4	4	4	4	4	4	1	5	4	2	4
Moral values (mv)	4	4	4	5	5	4	4	4	4	5	4	4	5	3	4
Security (sct)	2	1	1	1	5	2	2	4	4	5	4	1	3	4	4
Social service (ss)	2	4	4	4	4	4	5	4	4	5	4	4	5	5	4
Authority (ath)	3	3	3	4	5	4	4	4	4	5	4	4	5	3	3
Ability (abl)	4	5	4	5	4	4	4	4	4	3	5	4	4	5	5
Company policies and practices (cpap)	2	2	1	1	4	3	3	4	4	3	1	1	1	1	1
Compensation (comp)	2	3	2	1	5	4	2	4	4	4	2	1	1	2	3
Advancement (adv)	2	1	3	4	4	4	4	4	4	5	4	2	3	1	4
Responsibility (resp)	4	3	4	3	5	3	2	4	5	5	4	4	5	2	4
Creativity (creat)	4	4	4	5	5	4	4	4	5	5	4	4	5	4	4
Working conditions (wk)	4	2	3	3	4	4	4	4	4	2	4	4	4	2	4
Co-workers (cow)	5	5	4	3	4	4	4	5	5	4	4	5	4	4	3
Recognition (rec)	4	4	5	4	4	4	4	4	4	1	4	4	4	2	4
Achievement (achv)	4	5	4	5	4	4	4	4	4	3	4	4	5	4	5

A sample knowledge base obtained by using initial data and aggregation operation results is shown below:

Rule 1: IF act = “satisfied” AND ind = “satisfied” AND var = “dissatisfied” AND stat = “satisfied” AND shr = “satisfied” AND svt = “satisfied” AND mv = “satisfied” AND sct = “dissatisfied” AND ss = “dissatisfied” AND ath = “neutral” AND abl = “satisfied” AND cpap = “dissatisfied” AND comp = “dissatisfied” AND adv = “dissatisfied” AND resp = “satisfied” AND creat = “satisfied” AND wk = “satisfied” AND cow = “very satisfied” AND rec = “satisfied”, AND achv = “satisfied”, THEN sd = “neutral”;

Rule 2: IF act = “dissatisfied” AND ind = “satisfied” AND var = “very satisfied” AND stat = “very satisfied” AND shr = “neutral” AND svt = “neutral” AND mv = “satisfied” AND sct = “very dissatisfied” AND ss = “satisfied” AND ath = “neutral” AND abl = “very satisfied” AND cpap = “dissatisfied” AND comp = “neutral” AND adv = “very dissatisfied” AND resp = “neutral” AND creat = “satisfied” AND wk = “dissatisfied” AND cow = “very satisfied” AND rec = “satisfied”, AND achv = “very satisfied”, THEN sd = neutral;

Rule 15: IF act = “satisfied” AND ind = “satisfied” AND var = “satisfied” AND stat = “very satisfied” AND shr = “satisfied” AND svt = “satisfied” AND mv = “satisfied” AND sct = “satisfied” AND ss = “satisfied” AND ath = “neutral” AND abl = “very satisfied” AND cpap = “very dissatisfied” AND comp = “neutral” AND adv = “satisfied” AND resp = “satisfied” AND creat = “satisfied” AND wk = “satisfied” AND cow = “neutral” AND rec = “satisfied”, AND achv = “very satisfied”, THEN sd = “satisfied”

It is required to determine the output of the above-mentioned rules by using the information described in Fig. 2.

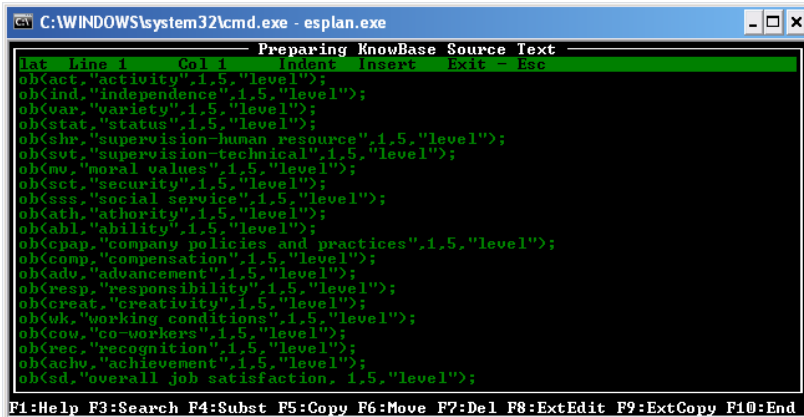


Fig. 2. Job facets

For every linguistic value, there exists its own universe set. For the object “independence”, a universe set is defined as the interval [20, 25]. The universe of a linguistic term is determined by using an interval that is represented by a figure.

5. The fuzzy inference algorithm description and analysis

Knowledge in production systems can be described in different ways. Some of the post-modern techniques for

representing knowledge include logical calculus, production systems, and a structured model. This work is devoted to the production system-based approaches of knowledge representation. The production system is the simplest one, consisting of three items: (1) a set of production rules, (2) a dynamic database called the working memory, and (3) a control structure or interpreter that interprets the database by using the set of production rules.

The production system has large applications in decision-making problems, in oil refinery problems, in psychology, in medicine, in business problems, in technical problems, and in social sciences [33–36].

The production description of knowledge in the knowledge base of overall job satisfaction is based on a fuzzy interpretation of antecedents and consequents in production rules [26].

$$R^k : \text{IF } x_1 \text{ is } \tilde{A}_{k1} \text{ and } x_2 \text{ is } \tilde{A}_{k2} \text{ and } \dots \text{ and } x_m \text{ is } \tilde{A}_{km} \text{ THEN } u_{k1} \text{ is } \tilde{B}_{k1} \text{ and } u_{k2} \text{ is } \tilde{B}_{k2} \text{ and } \dots \text{ and } u_{kl} \text{ is } \tilde{B}_{kl}, \quad k = \overline{1, K},$$

where $x_i, i = \overline{1, m}$ and $u_j, j = \overline{1, l}$ are total input and local output variables, $\tilde{A}_{ki}, \tilde{B}_{kj}$ are fuzzy sets, and k is the number of rules.

The basic steps of the fuzzy inference method are given below [26].

1. The truth degree of the rule is computed as [26]:

$$r_{jk} = \text{Poss}(\tilde{v}_k / \tilde{a}_{jk}) \cdot cf_k,$$

if the sign is “=” and

$$r_k = \left(1 - \text{Poss}(\tilde{v}_k | \tilde{a}_{jk})\right) cf_k,$$

if the sign is “≠”. Poss is defined as [26]:

$$\text{Poss}(\tilde{v} | \tilde{a}) = \max_u \min(\mu_{\tilde{v}}(u), \mu_{\tilde{a}}(u)) \in [0, 1],$$

$$r_j = \min(r_{jk}).$$

First, the objects are evaluated, i.e. every w_i object has appropriate linguistic value defined as (v_i, cf_i) . Where v_i is a linguistic value, $cf_i \in [0, 100]$ is a confidence degree of the value v_i . v_k is a linguistic value of the rule object, a_{jk} is a current linguistic value (j is the index of the rule, k is the index of relation) value (for example, A_ir).

2. For each rule, we calculate

$$R_j = (\min_j r_{jk}) * CF_j / 100,$$

where CF is the confidence degree of the rule [26].

The user or the creator of the rule defines the firing level (π) and $R_j \geq \pi$ is checked. If the condition holds true, the consequent part of the rule is calculated.

3. The evaluated w_i objects have the S_i value [26]:

$$w_i, (v_i^1, cf_i^1), \dots, (v_i^{S_i}, cf_i^{S_i}),$$

where S_i is the number of the rules in the fuzzy inference process.

The average value is determined as follows [26]:

$$\bar{v}_i = \frac{\sum_{n=1}^{S_i} v_i^n \cdot cf_i^n}{\sum_{n=1}^{S_i} cf_i^n}.$$

IF $x_1 = \tilde{a}_1^j$ AND $x_2 = \tilde{a}_2^j$ AND ..., THEN $y_1 = \tilde{b}_1^j$ AND $y_2 = \tilde{b}_2^j$ AND ...
 IF ..., THEN $Y_1 = \text{AVRG}(y_1)$ AND $Y_2 = \text{AVRG}(y_2)$ AND ...

This model has a built-in function AVRG, which calculates the average value. This function simplifies the organization of compositional inference with possibility measures. As a possibility measure here, a confidence degree is used. The compositional relation is given as a set of production rules such as:

IF $x_1 = \tilde{A}_1^j$ AND $x_2 = \tilde{A}_2^j$ AND ..., THEN $y_1 = \tilde{B}_1^j$ AND $y_2 = \tilde{B}_2^j$ AND,

where j is the number of a rule. After all these rules have been implemented (with different truth degrees) the next rule (rules) ought to be implemented:

IF ..., THEN $Y_1 = \text{AVRG}(y_1)$ AND $Y_2 = \text{AVRG}(y_2)$ AND ...

By using this model, it is possible to construct hypotheses for generating and accounting systems. Such a system contains the rules:

IF <condition $_j$ >, THEN $X = \tilde{A}_j$ and the CONFIDENCE is cf_j .

Here " $X = \tilde{A}_j$ " is a hypothesis that the object X takes the value \tilde{A}_j . Using some preliminary information, this system generates the elements $X = (\tilde{A}_j, R_j)$, where R_j is a truth degree of a j th rule. In order to prove the hypothesis (i. e. to estimate the truth degree that X takes the value \tilde{A}_j), the recurrent Bayes-Shortliffe formula, generalized for the case of fuzzy hypotheses, is used [26]:

$$P_0 = 0,$$

$$P_j = P_{j-1} + cf_j \text{Poss}(\tilde{A}_0 / \tilde{A}) \left(1 - \frac{P_{j-1}}{100} \right).$$

This formula is realized as a built-in function BS:

IF END THEN $P = \text{BS}(X, \tilde{A}_0)$.

6. Research results

The applied method underlies information processing in the kernel of the expert system shell ESPLAN operation. Advantages of Aliev's method [24] are as follows: (1) it is intuitive, (2) it has widespread acceptance, (3) it is well-suited to human-like linguistic input information, (4) it allows modelling under second-order uncertainty by using the possibility-probability measure, and (5) it can be used as a basis of computing with words.

The research results are given below:

1. Determination of the term knowledge, which is widely used in this study.
2. Determination of the knowledge base structure by using initial data and an aggregation operation.
3. Representation of linguistic information by using fuzzy trapezoid numbers.
4. Calculation of the truth degree of the rules by using a possibility measure.
5. Calculation of the individual outputs by using a truth degree of the rules.
6. Calculation of the resulting value by using the fuzzy average value.

7. Discussion of the results

The above-described algorithm is realized by the ESPLAN expert system shell [24]. The shell of ESPLAN ensures:

- creation of expert systems for various applications,
- building of module-oriented structures and segmentation of knowledge bases,
- representation of fuzzy values,
- compositional inference with possibility measures,
- arithmetic operations with fuzzy numbers,
- realization of a simple question-ask dialogue by using special functions,
- setting of a confidence degree for any rule (in percentage),
- application of external programs, and
- data interchange by using a file system.

All above-mentioned abilities are supported by ESPLAN knowledge representation of language based on production rules. The inference engine of the ESPLAN allows:

- establishing a forward-chaining width-first inference with truth degree calculation on the continuous scale [0,100],
- setting a truth threshold during the run-time in order to cut the rules with a current truth degree less than the threshold,
- tracing inference to the screen, and
- tracing inference to a disk to generate further explanation.

The shell of ESPLAN has its own WORDSTAR compatible text editor. The shell of ESPLAN is represented to a user as a multi-window interface.

An example:

We will use the following notations for representing the linguistic model: x_5 is Activity, x_6 is Independence, x_7 is Variety, x_8 is Status, x_9 is Supervision-human resource, x_{10} is Supervision-technical, x_{11} is Moral values, x_{12} is Security, x_{13} is Social service, x_{14} is Authority, x_{16} is Ability, x_{17} is Company policies and practices, x_{18} is Compensation, x_{19} is Advancement, x_{20} is Responsibility, y_1 is Creativity, x_{17} is Working conditions, x_{18} is Co-workers, x_{19} is Recognition, and x_{20} is Achievement.

Let us describe the model, taking into account the evaluated factors of an overall satisfaction by using the following rules:

Test 1: IF x_1 is very satisfied AND x_2 is very satisfied AND x_3 is satisfied AND x_4 is very satisfied AND x_5 is satisfied AND x_6 is satisfied AND x_7 is very satisfied AND x_8 is neutral AND x_9 is very satisfied AND x_{10} is satisfied AND x_{11} is satisfied AND x_{12} is neutral AND x_{13} is neutral AND x_{14} is satisfied AND x_{15} is very satisfied AND x_{16} is satisfied

AND x_{17} is very satisfied AND x_{18} is very satisfied AND x_{19} is satisfied, AND x_{20} is satisfied, THEN determine the value of the overall job satisfaction (SD-satisfaction degree).

Test 2: IF x_1 is very satisfied AND x_2 is satisfied AND x_3 is neutral AND x_4 is satisfied AND x_5 is very satisfied AND x_6 is satisfied AND x_7 is satisfied AND x_8 is neutral AND x_9 is neutral AND x_{10} is satisfied AND x_{11} is neutral AND x_{12} is neutral AND x_{13} is neutral AND x_{14} is neutral AND x_{15} is satisfied AND x_{16} is satisfied AND x_{17} is satisfied AND x_{18} is satisfied AND x_{19} is very satisfied, AND x_{20} is satisfied, THEN determine the value of the overall job satisfaction (SD-satisfaction degree).

It is required to determine the output of the above-mentioned data:

FOR TEST 1.

ANSWER:

SD = NEUTRAL; the truth degree of the rule = 13.0 %

SD = SATISFIED; the truth degree of the rule = 13.0 %

SD = SATISFIED; the truth degree of the rule = 50.0 %

SD = SATISFIED; the truth degree of the rule = 13.0 %

SD = SATISFIED; the truth degree of the rule = 13.0 %

The EXPERT system shell ESPLAN has determined that **the overall job satisfaction is SATISFIED, and the truth degree of the rule is 12.5 %.**

FOR TEST 2.

ANSWER:

SD = NEUTRAL; the truth degree of the rule = 38.0 %

SD = SATISFIED; the truth degree of the rule = 25.0 %

The EXPERT system shell ESPLAN has determined that **the overall job satisfaction is NEUTRAL, and truth degree of the rule is 25.0 %.**

The basic advantage of the used approach is being able to operate imperfect information for evaluating job satisfaction by using fuzzy logic.

8. Conclusion

The conducted research has resulted in the following:

1. The study has determined the basic facets of job satisfaction and defined the term “knowledge”.

2. The Minnesota Satisfaction Questionnaire (MSQ) and the basic determinants of respondents have made it possible to construct a fuzzy model for evaluating the job satisfaction index.

3. The described models were implemented by using the expert system shell ESPLAN, the language of technical computing Matlab, and various tests.

The obtained results have proved validity of the suggested approach.

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