A study of reasoning rules of expert system of enterprise human resource competence appraisement based on fuzzy relation

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Abstract

This paper presents a new fuzzy expert system for enterprise human resource competence appraisement. In this system, fuzzy relation based rules are created in order to improve the reasoning efficiency.

Keywords: enterprise human resource competence appraisement, expert system, fuzzy reasoning

1. Introduction

Since Feigenbaum built the first knowledge based reasoning system in 1965, expert systems have been greatly developed in both theory and applications, especially in the fields of project design and clinical diagnosis. Researchers working in the field of human resource management also pay attention to this technique because there are a great number of reasoning rules formed according to human experience.

Since 1990s, human resource management (HRM) has become an important strategy in many industrial enterprises. However, in the course of HRM, there exist a great deal of uncertainty caused by spontaneous decisions or human interventions or changing environments. Therefore, developing an expert system in the field of HRM is more difficult and more complex than in physical systems. From the point of view of techniques, a traditional expert system is based on knowledge storehouse and has tended to be mature. However, many problems in expert systems, such as knowledge acquisition, advanced knowledge description, reasoning with uncertainty, system optimization and man-machine interface, have not been solved completely

As both the information technology (IT) and human society are developed so rapidly, searching for a reasonable realization of human resource value has become an important topic in HRM. In this background, human resource appraisement has become a basic work of HRM in a modern enterprise. It aims at taking actions for an optimal realization of human resource values and enterprise's goals. An expert system for enterprise human resource appraisement can effectively improve the whole management level of the concerned organization and help this organization to make appropriate strategic decisions. According to the professional development view (Schein, 1978) and the professional development oriented enterprise human resource appraisement theory, this paper gives reasoning rules of an expert system in this field. These rules are based on the principle of fuzzy reasoning in order to actualize the course of reasoning of this expert system. Also, in this paper we study knowledge description of fuzzy rules in this expert system using possibility theory.

2. A model of enterprise human resource competence appraisement

In 1973, McClelland (1973) provided the birth foundation of the competence theory. In a competence appraisement, we divide the appraisement criteria into two types, i.e. dominance criteria and recessive criteria. Dominance criteria include three main factors of the concept of human resource, i.e. physical conditions, ability and personal knowledge while recessive criteria include personal interest and personal psychology. Dominance criteria measure the value of human resource while and recessive criteria affects and determines the value of use of human resource. If the results of dominance criteria are given, the capacity of use of human resource (competence) is determined by the results of recessive criteria. This principle is quite different from traditional personnel measure and traditional appraisement model. In a traditional appraisement model, related factors (physical conditions, personal interest, knowledge, ability, and so on) are independent appraisement systems and the final result is obtained by calculating the weighted average of the criteria given by these independent systems.

The computing formula of the traditional appraisement is given as follows.

$$Q_i = (1-\lambda)\sum_{j=1}^{m} r_{ij} a_{ij} + \lambda \sum_{k=1}^{n} w_{ik} u_{ik} \tag{1}$$

In the Eq. (1) Q_i denotes the membership degree of appraising result related to the i appraisement comment. a_{ij} and u_{ik} are the membership degrees of the j -th dominance criterion and the k -th recessive criterion related to the i -th appraisement comment respectively. r_{ij}, w_{jk}, λ and $(1-\lambda)$ are the weights respectively, with $\lambda \in [0,1]$, $\sum_{j=1}^{m} r_{ij} = 1$, $\sum_{k=1}^{n} w_{ik} = 1$.

The final result generated by the traditional appraisement model is the biggest value of the membership degrees of the appraisement result related to all appraisement comments. It is shown in Eq. (2):

$$Q_k = \max\{Q_1, Q_2, ..., Q_r\} \tag{2}$$

According to Eq. (2), the general appraisement result corresponds to k-th appraisement comment.

In our previous work on competence appraisement (Liu etc.), we construct a general model (Eq.(3)) improving the result of Eq.(1) by taking into account the influence of non-linearity in appraisement systems.

$$P_i = (1 - b_i \prod_{k=1}^{n} p_{ik}) = 1 - \left\{ \frac{1 - \sum_{j=1}^{m}(r_{ij} a_{ij}) \sum_{k=1}^{n}(w_{ik} u_{ik})}{[1 + \sum_{j=1}^{m}(r_{ij} a_{ij})]^s} \right\}^{\prod_{k=1}^{n} p_{ik}} \tag{3}$$

In the Eq. (3), P_i denotes the membership degree of the appraisement result related to the *i*-th appraisement comment. a_{ij} and u_{ik} are the membership degrees of the *j*-th dominance criterion and the *k*-th recessive criterion related to the *i*-th appraisement comment respectively. Sort u_{ik} 's according to the descending order of the *satisfactory degrees* of human resource relate to working environment for recessive indices, i.e., the *satisfactory degree* of $u_{(i-1)k}$ is better than that of u_{ik}, and stipulate $p_{ik} = \max\{u_{1k}, u_{2k}, ..., u_{ik}\}$. r_{ij} is the weight of the *j*-th dominance criterion, with $\sum_{j=1}^{m} r_{ij} = 1$. n is the coefficient of appraising working post with $n \geq 1$. The higher the coordination capacity of the working post, the bigger the value of *n*. For the posts of decision, management, techniques and production, n takes value of 5, 3, 2, and 1, respectively.

The expert system for an enterprise human resource appraisement is a decision support information processing system that helps the enterprise to select its human resource. As there exists a lot of fuzzy information in personal psychology, interest, knowledge, ability, performance and physical conditions, it is reasonable to apply the fuzzy reasoning to build the expert systems for enterprise human resource appraisement.

3. Reasoning network for enterprise human resource appraisement

An expert system for enterprise human resource appraisement aims at foreseeing (or reasoning) the value of human resource in the future and proposing an adjustment of working posts by exploiting existing computerized information. In the field of HRM of a modern enterprise, how to determine the value in the future is an important new research interest. As there exists a lot of uncertain information in the factors related to employee's appraisement, a fuzzy relations based reasoning method can be suitable for handling this uncertain information in order to increase the efficiency of enterprise human resource appraisement.

We build the reasoning network for enterprise human resource appraisement or employee performance. It is shown as Fig.1.

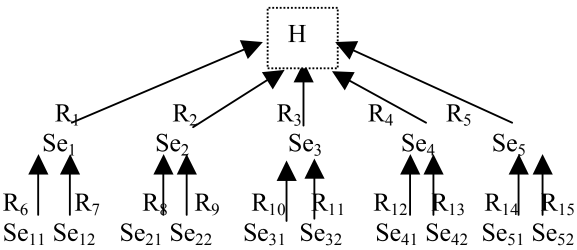

Fig.1 Reasoning network for enterprise human resource appraisement

The symbols in Fig.1 are explained as follows.

Se_1 denotes psychology, and composed by Se_{11}: personality, and Se_{12}: risk attitude.

Se_2 denotes interest, and composed by Se_{21}: interest type, and Se_{22}: interest intensity.

Se_3 denotes knowledge, and composed by Se_{31}: common sense, and Se_{32}: professional knowledge.

Se_4 denotes ability, and composed by Se_{41}: general ability, and Se_{42}: specialized ability.

Se_5 denotes physical conditions, and composed by Se_{51}: basic physical conditions, and Se_{52}: movement reaction.

H and R_i (i=1,2,,n) denote the performance of employee and the i-th rule of reasoning respectively.

4. Possibility distribution based on fuzzy reasoning

The reasoning method of *CRI* belongs to an approximate reasoning method, which is very close to human reasoning.

Let U and V be two domains of discourse, and $A \in F(U)$, $B \in F(V)$, $R \in F(U \times V)$ be a transform of fuzzy sets defined on U, V and $U \times V$. The corresponding formula (Zadeh, 1973) is given as follows:

$$B' = A' \circ (A \rightarrow B) \quad (4)$$

The Eq. (4) is called the reasoning synthetic rule, in which $\circ$ is the $\vee - \wedge$ synthetic operation, $A \rightarrow B \in F(U \times V)$ is a fuzzy relation relating A to B.

It is necessary to build fuzzy rules in the reasoning process of an expert system for enterprise human resource appraisement. For instance, according to the level of knowledge expressed by linguistic values such as *very high*, *high*, *middle*, *low* and *very low*, we wish to deduce a hypothesis that is either a result of appraisement or a possibility distribution of competence. In this section, we introduce fuzzy production rules to the expert system for enterprise human resource appraisement using possibility distribution.

A fuzzy production rule is expressed as follows.

$$IF \ (X_1,...,X_n) \ then \ (Y_1,...,Y_m) \ with \ CF(R) \quad (5)$$

In the Eq. (5), $\widetilde{X}_i, (i = 1,2,...,n)$ and $\widetilde{Y}_j, (j = 1,2,...,m)$ denote the precondition and hypothesis of the fuzzy rule respectively, $CF(R)$ is the strength of rule, and $0 \le CF(R) \le 1$.

The deffuzzification of this production rule can be done by introducing the possibility distribution concept. In this case, the Eq. (5) can be expressed as follows.

$$IF \ (A(x_1),...,A(x_n)) \ then \ (B(y_1),...,B(y_m)) \ with \ CF(R) \quad (6)$$

In the Eq. (6), $A(x_i), (i = 1,2,...,n)$ and $B(y_j)$, $(j = 1,2,...,m)$ denote the possibility distribution of the precondition and the hypothesis of the fuzzy rule respectively, and $x_i \in X_i, y_j \in Y_j$.

In a specific case, we can use the degree of possibility or the degree of necessity to describe the result of the possibility distribution. In general, if the fuzzy set is regular, the degree of possibility does not be smaller than the degree of necessity. In the negative appraisement of human resource, it is more suitable to use the degree of necessity because the corresponding result is less risky. In the positive appraisement of human resource, it is more suitable to use the degree of possibility. The degree of possibility can be transformed into the degree of necessity. In practice, only the degree of possibility is used for data collection.

It is necessary to calculate the reliability of the rule conclusion. For a given rule:

$$IF \ [A(x), CF(A)] \ then \ B(y) \ with \ (CF, \lambda) \quad (7)$$

In the Eq. (7), $A(x)$ is the degree of possibility of the rule precondition, $CF(A)$ is the degree of reliability of satisfying this precondition, CF is the degree of rule strength when $CF(A) = 1$. It denotes the reliability of the conclusion when the rule prerequisite is satisfied by the evidence completely. λ is a threshold value of evidence matching rule's prerequisite. When $CF(A) \ge \lambda$, the evidence is matched with the rule's prerequisite matching and then strength of rule is:

$$CF[B(y)] = CF \times CF(A) \quad (8)$$

For multiple evidences given by multiple appraisement executives, if they meet D-S evidence theory (it can be seen in literatures), we can apply the composition formula of D-S evidence to calculate $CF(A)$. If the number of evidence is only one, $CF(A)$ can be obtained by calculating its weighted average.

For the rule whose prerequisite is composed of n preconditions:

$$IF \ [A(x_1), w_1, CF(A_1)] \ and... \ and \ [A(x_n), w_n, CF(A_n)] \ then \ B(y) \ with \ (CF, \lambda) \quad (9)$$

In the Eq. (9), $w_i, (i = 1,2,..., n)$ is the weight of the rule's precondition i, and $\sum_{i=1}^{n} w_i = 1$; When $CF(A_i) \ge \lambda$, for all $i \in \{1,2,..., n\}$, the evidence and rule's precondition are matched each other and the formula of calculating strength of rule is

$$CF[B(y)] = CF \times \sum_{i=1}^{n} (w_i \times CF(A_i)) \quad (10)$$

When more than two rules have the same conclusion, we can use the Eq.(8) or the Eq.(10) to calculate the rule strength.

Given $CF_1[B(y)]$, $\cdots CF_n[B(y)]$, the degree of reliability of the conclusion corresponds to the maximal value of them:

$$CF[B(y)] = \max\{CF_1[B(y)], CF_2[B(y)],..., CF_n[B(y)]\}$$

5. One application

Assuming that the appraisement comments are *very good (very high), good (high), general (normal), bad (low)* and *very bad (very low)*. They are denoted as $V = \{V_1, V_2, V_3, V_4, V_5\}$. If $1 \le i < j \le 5$, then $V_i \succ V_j$, in which $\succ$ denotes a partial order.The reasoning rules of the expert system for enterprise human resource competence appraisement are given as follows:

1) The reasoning rule of Se_1 that is determined by the possibility results of Se_{11} and Se_{12}:

$$IF \quad [A(Se_{11}) \ge 0.6(V_1), 0.5, CF(A_{11}) = 0.8]$$
$$and \quad [A(Se_{12}) \ge 0.6(V_1), 0.5, CF(A_{12}) = 0.8]$$

$$then \quad B(Se_1) = V_1 \qquad with \qquad (0.95,0.8)$$

$A(se_{11}) \geq 0.6(V_1)$ denotes the membership degree of the rule prerequisite related to V_1,which is not less than 0.6. It is calculated according to the principle of the biggest membership degree.

2) The reasoning rule of Se that is a determined by the possibility results of Se_1 and Se_2:

$$IF \quad [A(se_1) \geq 0.6(V_1), 0.5, CF(A_1) = 0.75]$$
$$and \quad [A(se_2) \geq 0.6(V_1), 0.5, CF(A_2) = 0.75]$$
$$then \quad B(Se) = V_1 \qquad with \qquad (0.95,0.75)$$

A rogatory table of the expert system rules for $Se_1$is shown in table 1.

Table1 the table of some reasoning rules

Rule	Se_{11}	Se_{12}	Se_1	Rule strength
1	⩾0.6(V_1)	⩾0.6(V_1)	V_1	0.76
2	⩾0.6(V_2)	⩾0.6(V_2)	V_2	0.76
3	⩾0.6(V_3)	⩾0.6(V_3)	V_3	0.76
4	⩾0.6(V_4)	⩾0.6(V_4)	V_4	0.76
5	⩾0.6(V_5)	⩾0.6(V_5)	V_5	0.76
6	⩾0.6(V_1)	⩾0.6(V_2)	V_2	0.81
7	⩾0.6(V_2)	⩾0.6(V_1)	V_2	0.81
8	⩾0.6(V_1)	⩾0.6(V_3)	V_3	0.86
9	⩾0.6(V_3)	⩾0.6(V_1)	V_3	0.86
10	⩾0.6(V_1)	⩾0.6(V_4)	V_4	0.90
11	⩾0.6(V_4)	⩾0.6(V_1)	V_4	0.90
11	⩾0.6(V_1)	⩾0.6(V_5)	V_5	0.95
12	⩾0.6(V_5)	⩾0.6(V_1)	V_5	0.95

The recessive index *psychology* (Se_1) includes *nature feature* (Se_{11}) and *risk attitude* (Se_{12}), the index *interest* (Se_2) includes *interest kind* (Se_{21}) and *interest strength* (Se_{22}), denoted as u_{i1}, u_{i2}, u_{i3} and u_{i4}. The recessive indices are also evaluated according to the following appraisement comments: *satisfy very much, satisfy, general, do not satisfy and do not satisfy very much*. Suppose the single factor appraisement matrix of recessive indices:

$$R = \begin{pmatrix} 0.3 & 0.6 & 0.2 & 0 & 0 \\ 0.9 & 0.1 & 0 & 0 & 0 \\ 0 & 0.3 & 0.6 & 0.2 & 0 \\ 0 & 0.2 & 0.6 & 0.3 & 0 \end{pmatrix} \quad \text{i.e.} \quad R = \begin{pmatrix} R_{Se_1} \\ R_{Se_2} \end{pmatrix}$$

We apply the fuzzy reasoning rules to calculate the result of appraisement.

The reasoning result of R_{Se_1} is related to V_2 according to the 7-th rule of table one according to the principle of the biggest membership degree for u_{i1} and u_{i2} respectively, and the corresponding believable level is 0.81.

The reasoning result of R_{Se_2} is related to V_3 according to the 3-th rule of table one, and the corresponding believable level is 0.76.

In the same way, we obtain the reasoning result of R is related to V_3, and the corresponding believable level is 0.76.

The result of human resource competence appraisement is related to V_3, and the corresponding believable level is 0.76.

6. Conclusion

Based on the theory of enterprise human resource competence appraisement, we study in this paper how to realize the related expert system using the fuzzy reasoning rules. This paper puts forward a reasoning network of the expert system for enterprise human resource appraisement based on the competence principles. It combines the professional development and the competence model and applies the *CRI* reasoning method for describing reasoning rules. However, it is a complex task to build a complete practical expert system on HRM because we have to solve a lot of problems affecting the expert system's validity, including knowledge acquisition, advanced description of knowledge, system optimization, man-machine interface and so on.

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