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Evaluation of Classified Information on Web Agent Using Fuzzy Theory

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Abstract

The rapid growth and spread of the World Wide Web has made it possible to easily access a variety of useful information. It is, however, very difficult to retrieve, manage, and use the desired information in web. Various kinds of systems such as Search engines, MetaSearch engines, Spiders, Softbots, Intelligent Agents or Web Agents have been developed by a large number of researchers and companies. Those systems as intelligent agent are employed to avoid the overload of information. To efficiently improve the Software Agents, it is necessary to represent and classify the retrieved data. And to improve performance of the Intelligent Agents to create the classification, it is offered how to evaluate the propriety with other information retrieved from the Web and to recommend to the user the most suitable information.

Key Words : fuzzy theory, Intelligent Software Agents, Multiagent Systems.

1. Introduction

The development of internet has brought enormous changes to our lives. All of the actions off-line happen immediately on-line through it. For example, many items such as information retrieval, education, shopping, and airline, train and bus reservation are being carried out on-line. And it is possible for user to inquire various questions of prices, timetables, etc. and finally to purchase commodities like tickets on-line. The development of the WWW(World Wide Web) has, therefore, made it possible for any user on internet to find any kind of useful information.

There are, however, serious problems in retrieving and using the information, because huge amount of information is stored in a large number of databases. Some of these problems are; the number of "sites" which offer a variety of useful information is increasing explosively; the number of founded documents (data) is countless; information provided by company can also be useless as time passes; different representations for the same kind of information are used[1,2].

A variety of approaches have been taken to solve these problems. One of the most popular is the Search Engines using software systems like "softbots", "spiders" or "worms" to recollect all the possible information stored in the Web. These systems build a complete, dynamic database that can provide the desired information to users who want it. The next one is the MetaSearch Engines; these systems with a set of search engines use different techniques to improve the retrieve task. Third, the Intelligent Software Agents are the approaching method to employ the concept of agent. These Agents are a new paradigm for developing software applications. Finally, the MultiAgent Systems are applications to deal with the interaction between groups of intelligent agents attempting to cooperate to solve the problems. MultiAgent Systems are successful since they are able to solve big problems, cooperate each other, and share skills and knowledge[3,4].

All of the past systems trying to manage the overload of information through the analysis and classification of it needed to retrieve, filter, represent and store the information obtained from the Web and to give this stored information to the user or to other agents in the system. Based on this, it is possible to develop systems that implement specialized agents that could retrieve the information from different sites in the Web. In general, a MultiAgent system that deals with information stored in the Web should comprise two different types of agents(WebAgent, MetaWebAgent). One of both agents is specialized in retrieve, filter and store information from a particular site in the Web. Another can reuse the knowledge WebAgent retrieve and reason form it (using classical techniques in Artificial Intelligence, like planning or learning) to solve a problem.

In this paper, based on fuzzy theory, actions of agents can be compared, evaluated and classified properly. Fuzzy knowledge-based Prototype is offered to evaluate the distance between actions of different agents.

2. Reasoning by Fuzzy Relation

In 1973, L. A. Zadeh employed fuzzy reasoning, that is, the fuzzy relation that make fuzzy linguistic implication model in order to employ CRI(Compositive Rule Interference) method that make compositive calculation of fuzzy relation. Many researches have been in progress for applying fuzzy reasoning mutual cooperation evaluation system on network, network-based intelligent examination and diagnosis system, etc. to field of education evaluation.[5,6].

Fuzzy reasoning is a successive procedure to reason new relation or fact from certain given fact or relation. And fuzzy implication is fuzzy proposition represented by fuzzy relation as a predicative like general logical system. Implication

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$A \rightarrow B$ is fuzzy relation from A to B, represented by R in CRI method. CRI method is represented as fuzzy transformation as follows[7].

$$B' \equiv A' \circ R$$
$$B'(y) \equiv (A' \circ R)(y) \tag{1}$$

In fuzzy implication $A \rightarrow B$, fuzzy relation R can effectively make fuzzy implication model.

Simple fuzzy implication is as formula(2)

$$\text{if } A \textit{ then } B \tag{2}$$

Formula (2) can be represented as formula (3) through fuzzy relation R

$$R = A \times B \tag{3}$$

Supposing R is fuzzy set for S, R is fuzzy relation on X×Y, and S is fuzzy relation on Y×Z, R ∘ S, composition of R and S, is relation on X×Z. In types of composition rule for fuzzy relation, there are Max- Product composition, Max-Max composition, Max-Min composition, Min-Max composition, and Min-Min composition.

The Membership function of Max-Production composition is as formula (4).

$$\mu_{R \circ S}(x, z) = \max_{y \in Y}\{\mu_R(x, y) \circ \mu_S(y, z)\} \tag{4}$$

The Membership function of Max-Max composition is as formula (5).

$$\begin{aligned} &\mu_{R \circ S}(x, z) \\ &= \max_{y \in Y} [\max\{\mu_R(x, y) \circ \mu_S(y, z)\}] \\ &= \max_{y \in Y} \{\mu_R(x, y) \vee \mu_S(y, z)\} \end{aligned} \tag{5}$$

The Membership function of Max-Min composition is as formula (6).

$$\begin{aligned} &\mu_{R \circ S}(x, z) \\ &= \max_{y \in Y} [\min\{\mu_R(x, y) \circ \mu_S(y, z)\}] \\ &= \max_{y \in Y} \{\mu_R(x, y) \wedge \mu_S(y, z)\} \end{aligned} \tag{6}$$

The Membership function of Min-Max composition is as formula (7).

$$\begin{aligned} &\mu_{R \circ S}(x, z) \\ &= \min_{y \in Y} [\max\{\mu_R(x, y) \circ \mu_S(y, z)\}] \\ &= \min_{y \in Y} \{\mu_R(x, y) \vee \mu_S(y, z)\} \end{aligned} \tag{7}$$

The Membership function of Min-Min composition is as formula (8).

$$\begin{aligned} &\mu_{R \circ S}(x, z) \\ &= \min_{y \in Y} [\min\{\mu_R(x, y) \circ \mu_S(y, z)\}] \\ &= \min_{y \in Y} \{\mu_R(x, y) \wedge \mu_S(y, z)\} \end{aligned} \tag{8}$$

3. Fuzzy Evaluation System for Information Classification by Web Agents

3.1 Structure of Fuzzy Evaluation System.

As information classification techniques, method to measure distance between two vectors is often employed and these vectors represent the information. For showing the degree of relation of a vector with other vectors, methods to measure the distances have been used. But if original information on the problem is inexact, the use of usual distance, like Euclidean distance, does not give successful results because such distances do not take into account all the semantic information that is known about the data. Therefore, the use of nontraditional method of distance measurement, like fuzzy distance, should improve the efficiency of the Web Agents as well as the results obtained from traditional techniques.

To develop a Software Agent using a fuzzy system that classifies its own retrieve knowledge, first it is necessary to obtain a representation that can be applied over the fuzzy algorithm. Once this information is retrieved and filtered, it is possible to construct a vector that characterizes the data. This vector represents a set of characteristics grouped in general features about availability of task. This information could be represented as $(F_1, F_2, \ldots, F_n)$, a set of values characterized a travel in the Web. In each $f_i \in F_i$, the range of possible numerical values of f_i become F_i.

3.2 Evaluation Result and Fuzzy Number

When agents select the information in consideration of outcome value of evaluation, there are occasions when the outcome of certain item can not meet user's need even though it is generally good outcome. In these cases, the results of selection may appear to be different. In general cases, information is classified by general outcome value of evaluation. But the method to meet the minimum condition of specific item and classify most similar information is important. Set comprising only outcome values including more than fixed possibility among the outcome values of evaluation included in fuzzy set can be made. And limited value for each item proper for user is represented as follows.

$$C_\alpha = \{x \in U \mid \widetilde{f}_i(x) \geq \alpha\} \tag{9}$$

Where, C_α means user's limit degree. To show $\alpha-cut$ for outcome value of fuzzy evaluation is:

$$\widetilde{F}_i = \begin{cases} \widetilde{f}_i & \widetilde{f}_i \geq \alpha \\ 0 & \widetilde{f}_i < \alpha \end{cases} \tag{10}$$

To show the outcome value of fuzzy evaluation applying $\alpha-cut$ to each item is as follows:

$$U_{\widetilde{F}_i} = \{\widetilde{F}_1, \widetilde{F}_2, \ldots, \widetilde{F}_n\} \tag{11}$$

Where, $\widetilde{F}_1, \widetilde{F}_2, \ldots, \widetilde{F}_n$, applying $\alpha-cut$, is the outcome representing user's limit value. Sup and inf about standard value is defined as follows, each standard value is set up with intermediate value between 0 and 1, and intermediateness of sup and inf is shown as fuzzy interval value between 0 and 1. And if the value is more than sup, it is considered value out of boundary value and set up with 1, and if less than inf, 0.

$$INFs_i = \{b \mid \tilde{f}_i \geq b\} \tag{12}$$

$$I_{Lsize} = \frac{\tilde{f}_i - \inf f_i}{p} \tag{13}$$

$$I_{Usize} = \frac{supf_i - \tilde{f}_i}{p} \tag{14}$$

Where I_{Lsize} is the interval range which is less than standard value, I_{Usize} is the interval range which is more than standard value, and p means interval number.

Therefore each membership function is defined as follows.

$$I_i = \{0.0/I_0, \ldots, 0.5/I_5, \ldots, 1.0/I_{10}\} \tag{15}$$

Correspond to formula (15) the result value of evaluation of each item and show them as fuzzy number. And for weight $\widetilde{W}_i$, expert impose suitable weight according to importance of evaluation item.

To show as fuzzy number the above result value $\widetilde{F}_i$ and weight for each item is table 1.

Table 1. Weight and fuzzy number for each item

no.	item	system A	system B	…	system N
1	$\widetilde{W}_1$	$\widetilde{F}_{1A}$	$\widetilde{F}_{1B}$	…	$\widetilde{F}_{1N}$
2	$\widetilde{W}_2$	$\widetilde{F}_{2A}$	$\widetilde{F}_{2B}$	…	$\widetilde{F}_{2N}$
3	$\widetilde{W}_3$	$\widetilde{F}_{3A}$	$\widetilde{F}_{3B}$	…	$\widetilde{F}_{3B}$
⋮	⋮	⋮	⋮	…	⋮
n	$\widetilde{W}_n$	$\widetilde{F}_{nA}$	$\widetilde{F}_{nB}$	…	$\widetilde{F}_{nN}$

Entire fuzzy numbers of each system is shown as $S(\cdot)$.

$$S(A) = \widetilde{W}_1 \otimes \widetilde{F}_{1A} \oplus \cdots \oplus \widetilde{W}_n \otimes \widetilde{F}_{nA} \tag{16}$$

$$S(B) = \widetilde{W}_1 \otimes \widetilde{F}_{1B} \oplus \cdots \oplus \widetilde{W}_n \otimes \widetilde{F}_{nB} \tag{17}$$

$$\vdots$$

$$S(N) = \widetilde{W}_1 \otimes \widetilde{F}_{1N} \oplus \cdots \oplus \widetilde{W}_n \otimes \widetilde{F}_{nN} \tag{18}$$

Where $S(A)$, $S(B)$, …, $S(N)$ means triangular fuzzy number. The degree of propriety is represented as $D_\lambda(A)$, $D_\lambda(B)$ …, $D_\lambda(N)$ and λ means the degree of propriety of system. Low value of λ means that the degree of propriety is high.

$$a_1^{(\alpha)} = \alpha(a_2 - a_1) + a_1 \tag{19}$$

$$a_3^{(\alpha)} = -\alpha(a_3 - a_2) + a_3 \tag{20}$$

$$b_1^{(\alpha)} = \alpha(b_2 - b_1) + b_1 \tag{21}$$

$$b_3^{(\alpha)} = -\alpha(b_3 - b_2) + b_3 \tag{22}$$

$$\vdots$$

$$n_1^{(\alpha)} = \alpha(n_2 - n_1) + n_1 \quad 23)$$

$$n_3^{(\alpha)} = -\alpha(n_3 - n_2) + n_3 \quad 24)$$

Where if $\alpha-cut$ is applied in order to get crisp value, $\alpha-cut$ of $S(A)$, $S(B)$, …, $S(N)$ can be shown as $[a_1^{(\alpha)}, a_3^{(\alpha)}]$, $[b_1^{(\alpha)}, b_3^{(\alpha)}]$, …, $[n_1^{(\alpha)}, n_3^{(\alpha)}]$, $\alpha \in [0, 1]$, and is as Figure 1. Result of evaluation by each evaluation item can be pessimistically evaluated about certain system or optimistically by user's subjective weight. That is to say, because evaluation result of each system may be drawn by subjective, qualitative weight of user, it may be considered that uncertainty can be contained. Hence, we can evaluate as making change of number of propriety $\lambda(\lambda \in [0, 1])$ according to score $D^\lambda_\alpha(A)$, $D^\lambda_\alpha(B)$ setting the value of $\alpha-cut$ for each item. Where, λ means a complex evaluation number. Small value of λ means to be high in the degree of 'optimism', high value of λ is to be low in the degree of 'optimism', therefore composition evaluation system considering both fac-

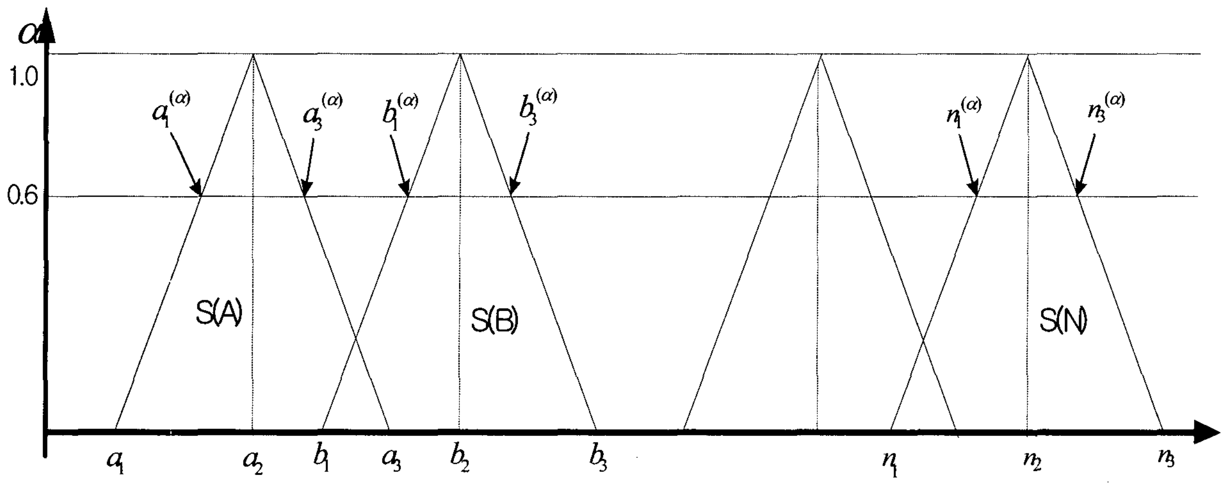

Figure 1. $S(\cdot)$ having performed $\alpha-cut$

tors can be shown. the value of propriety fuzzy number for each system can be defined as formula (25)~(27).

$$D^{\lambda}_{\alpha}(A) = \lambda a^{(\alpha)}_{1} + (1-\lambda)a^{(\alpha)}_{3} = P_A \quad (25)$$

$$D^{\lambda}_{\alpha}(B) = \lambda b^{(\alpha)}_{1} + (1-\lambda)b^{(\alpha)}_{3} = P_B \quad (26)$$

$$\vdots$$

$$D^{\lambda}_{\alpha}(N) = \lambda n^{(\alpha)}_{1} + (1-\lambda)n^{(\alpha)}_{3} = P_N \quad (27)$$

Score evaluated from each item shows that high occupancy ratio of a system for whole evaluation score is relatively superior, and it is shown as formula (28)~(30).

$$N^{\alpha}_{\lambda}(A) = \frac{P_A}{P_A + P_B + \cdots + P_N} \quad (28)$$

$$N^{\alpha}_{\lambda}(B) = \frac{P_B}{P_A + P_B + \cdots + P_N} \quad (29)$$

$$\vdots$$

$$N^{\alpha}_{\lambda}(N) = \frac{P_N}{P_A + P_B + \cdots + P_N} \quad (30)$$

Values of $N^{\alpha}_{\lambda}(A)$, $N^{\alpha}_{\lambda}(B)$, ..., $N^{\alpha}_{\lambda}(N)$ means each score rate for all evaluated information, and biggest value means the most suitable system to user. Where $N^{\alpha}_{\lambda}(A)$, $N^{\alpha}_{\lambda}(B)$, ..., $N^{\alpha}_{\lambda}(N) \in [0, 1]$.

4. System Evaluation and Outcome Analysis

In order to select information suitable for user in evaluated information, fuzzy number of each information about measured outcome and weight according to each item are set up. In this, evaluated outcome value and weight is to be expressed as triangle fuzzy number. Weight of each item is set by fuzzy number and agent. And based on measured outcome value, value of each information setting value of $\alpha - cut$ as 0.7 is employed, and a complex evaluation number is set as 0.6. Outcome of fuzzy evaluation system from above condition is figure 2.

item no.	item	information A	information B	degree of sufficiency
1	CPU part	0.9	0.7	H
2	MEMORY part	0.9	0.8	VH
3	CASH MEMORY part	0.9	0.8	H
4	DISK part	0.9	0.7	M
5	BACK-UP part	0.8	0.7	M
6	SEVER part	0.8	0.8	H
7	Network part	0.8	0.7	L
8	Database part	0.9	0.8	VH
9	Stresstest part	0.7	0.7	VH
10	suitability part	0.6	0.7	VH
11	accuracy part	0.6	0.8	VH
13	interoperability part	0.7	0.8	M
14	security part	0.6	0.8	M
15	compliance	0.7	0.8	H
α-CUT				0.7
complex evaluation score				0.6

Suitable system is System B

Figure 2. Fussy evaluation system for information classification

Table 2 and 3 show degree of propriety and rate of propriety with $\alpha - cut$ applied according to each a complex evaluation number, table 4 and 5 represent degree of propriety and degree rate of propriety without $\alpha - cut$ applied according to each a complex evaluation number. When $\alpha - cut$ is applied and a complex evaluation number is set as 0.6, degree of propriety and evaluation is $D^{\lambda}_{\alpha}(A) = 6.8064$, $N^{\alpha}_{\lambda}(A) = 0.4970$, $D^{\lambda}_{\alpha}(B) = 6.8900$, $N^{\alpha}_{\lambda}(B) = 0.5031$. On the other hand, when $\alpha - cut$ is not applied, $D^{\lambda}_{\alpha}(A) = 6.9650$, $N^{\alpha}_{\lambda}(A) = 0.5027$, $D^{\lambda}_{\alpha}(B) = 6.8900$, $N^{\alpha}_{\lambda}(B) = 0.4973$. In this, when $\alpha - cut$ is applied as 0.7, it is evaluated that B is more suitable. but when $\alpha - cut$ is not applied, it is evaluated that A is more suitable. From this result, even though certain information generally prove to be proper, it can not be applied to all of user environment.

Figure 3 shows the degree rate of propriety according to a complex evaluation number with $\alpha - cut$ applied, and figure 4 shows the degree rate of propriety according to a complex evaluation number without $\alpha - cut$ applied. we can see that in figure 3, A is more adequate less than 0.4 in a complex-evaluation number, but B is more adequate more than 0.4 in a complex evaluation number.

Table 2. Propriety degree with $\alpha - cut$ according to each a complex evaluation number applied

λ	D(A)	D(B)
0	9.7357	9.5000
0.1	9.2475	9.0650
0.2	8.7593	8.6300
0.3	8.2711	8.1950
0.4	7.7829	7.7600
0.5	7.2946	7.3250
0.6	6.8064	6.8900
0.7	6.3182	6.4550
0.8	5.8300	6.0200
0.9	5.3418	5.5850
1.0	4.8536	5.1500

Table 3. Propriety degree rate with $\alpha - cut$ according to each a complex evaluation number applied.

λ	N(A)	N(B)
0	0.5061	0.4939
0.1	0.5050	0.4950
0.2	0.5037	0.4963
0.3	0.5023	0.4977
0.4	0.5007	0.4993
0.5	0.4990	0.5010
0.6	0.4970	0.5031
0.7	0.4947	0.5054
0.8	0.4920	0.5080
0.9	0.4888	0.5111
1	0.4852	0.5148

Table 4. Propriety degree without $\alpha - cut$ according to each a complex evaluation number applied.

λ	D(A)	D(B)
0	9.6500	9.5000
0.1	9.2025	9.0650
0.2	8.7550	8.6300
0.3	8.3075	8.1950
0.4	7.8600	7.7600
0.5	7.4125	7.3250
0.6	6.9650	6.8900
0.7	6.5175	6.4550
0.8	6.0700	6.0200
0.9	5.6225	5.5850
1.0	5.1750	5.1500

Table 5. Propriety degree rate without $\alpha - cut$ according to each a complex evaluation number applied.

λ	N(A)	N(B)
0	0.5039	0.4961
0.1	0.5038	0.4962
0.2	0.5036	0.4964
0.3	0.5034	0.4966
0.4	0.5032	0.4968
0.5	0.5030	0.4970
0.6	0.5027	0.4973
0.7	0.5024	0.4976
0.8	0.5021	0.4979
0.9	0.5017	0.4983
1	0.5012	0.4988

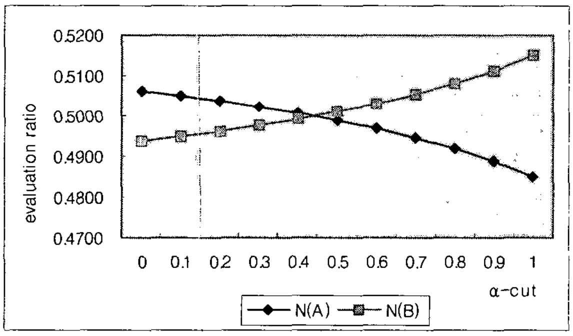

Figure 3. Propriety degree rate according to a complex evaluation number with $\alpha - cut$ applied.

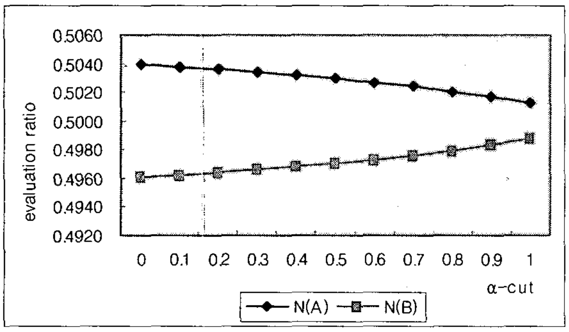

Figure 4. Propriety degree rate according to a complex evaluation number without $\alpha - cut$ applied.

5. Conclusion

This system is mainly used in comparison and evaluation among information. Web system with users' request for good quality of web service increasing is comprising a variety of information, and the degree of propriety between each information is evaluated in order to optimally classify information. For this, fuzzy theory is employed, and comparatively objective and more exact evaluation data to user can be provided. Also, agents can adjust weight between items to classify information and in consideration of searcher's minimum requirement, can classify.

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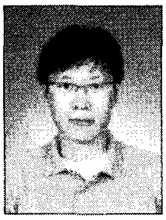

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