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A FUZZIFIED RELEVANCE TREE APPROACH FOR SOLVING THE COMPLEX PLANNING

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A new type of relevance tree approach, the fuzzified method, is developed by substituting reductionism concept for the fuzzy set one. Some properties of this method are clarified by comparing it with PATTERN method, one of the well known relevance tree approach. Regarding the results, several propositions and theorems are induced. This new method will be usable for solving complex problems or plannings.

Key words; Fuzzified relevance tree, PATTERN method, Fuzzy integral, Complex Planning, Random Digit Experimentation, Rank Correlation.

1. INTRODUCTION

The relevance tree method has been used as the most flexible principle available not only for normative forcasting, but also for decision making analysis. The PATTERN method (Planning Assistance through Technical Evaluation of Relevance Numbers), one of the well known relevance tree methods, has been applied to the NASA Air Space Project, development of medical care system, etc.[1)] This method is based on the reductionism [3] and has many merits. However, difficulties occasionaly occur in dealing with complex problems. To eliminate the defects of the PATTERN method, we have developed a new type of relevance tree approach, "the Fuzzified Relevance Tree Method" by substituting reductionism concept for the fuzzy set one. This new method is clarified and evaluated by comparing it with the PATTERN method.

2. CHARACTERISTICS OF PATTERN METHOD

2.1 Relevance Tree

The PATTERN method, recognized as the technique to normative forcasting or decision making, is

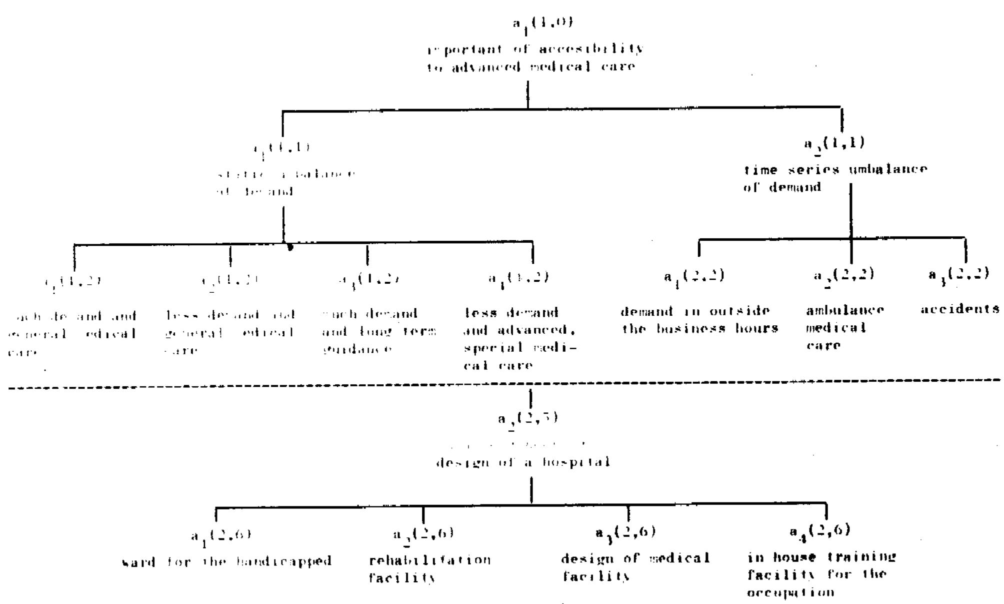

Fig. 2.1 An Example of the Relevance Tree [10]

constructed to reflect the objects in forcasting or decision making. The tree is expressed by a hierarchy including subobjects, strategies, policies, tasks, etc. The levels of the tree correspond to the levels in which the objects is reductioned. There are some issues on each level, and they are grouped on each level according to their relations with the issues on the upper level. We denote each issue in the i-th group on t-th level as $a_k(i,t)$. Figure 2.1 demonstates a representative case of the relevance tree [10]. Scenario writing is used in constructing the relevance tree.

2.2 Quantitative Evaluation on the Relevance Tree

Using the relevance tree, each issue $a_k(i,t)$ $(k=1,2,\cdot\cdot,m(t))$ is evaluated, usually by specialists, from several points of views. Criteria, c_p $(p=1,2,\cdot\cdot,q)$, are used for this purpose, and weights, $e_p \in [0,1]$ $(p=1,2,\cdot\cdot,q)$, of significance are subjectively attached to the criteria by the evaluators themselves. At each level in the PATTERN formulation, a matrix (Fig.2.2) is

CRITERIA: ITEM	CRITERIA: WEIGHT	ISSUE IN (i,t): $a_1(i,t)\cdots a_k(i,t)\cdots a_n(i,t)$
c_1	e_1	s_{11} ···· s_{1k} ····· s_{1n}
.	.	. . .
.	.	. . .
c_p	e_p	s_{1k} ···· s_{pk} ····· s_{pn}
.	.	. . .
.	.	. . .
c_m	e_m	s_{m1} ···· s_{mk} ····· s_{mn}
RELEVANCE NUMBER $BR(a_k(i,t))$		$\sum_p s_{p1}\cdot e_p \cdots \sum_p s_{pk}\cdot e_p \cdots \sum_p s_{pn}\cdot e_p$

Fig. 2.2 Matrix of Significance Number

expressed for matching the issues against the criteria. Each entry in the matrix, called a "significance number", $s_{pk} \in [0,1]$, is calculated through the evaluation process based on the criteria c_p, and the weight e_p. The "relevance number" of an issue $a_k(i,t)$, $BR^*(a_k(i,t))$, is represented by $\sum_p s_{pk}\cdot e_p$ for an evaluator;

$$BR^*(a_k(i,t)) = \sum_p s_{pk}\, e_p \, . \qquad (2.1)$$

It should be noted that the PATTERN formulation requires the criteria weights be normed to unity, that is $\sum_p e_p=1$. Total relevance figures, $TDR^*(a_k(i,n))$, for any particular issue $a_k(i,n)$ are defined by multiplying individual relevance numbers upwards to the top of the tree as follows,

Definition 2.1

$$TDR^*(a_k(i,n)) = \prod_{t=1}^{n} BR^*(a_{k(t)}(i(t),t)). \qquad (2.2)$$

The priority of an issue at the lowest level can be determined by the value $TDR^*(a_k(i,t))$ of the issue.

Usually there are complex evaluators (f evaluators), and the relevance number, $BR(a_k(i,t))$ is obtained averaging $BR^*(a_k(i,t))$ through the evaluation process as follows,

$$BR(a_k(i,t)) = \sum_{j=1}^{f} BR_j^*(a_k(i,t))/f, \qquad (2.3)$$

where j means the j-th evaluator. And the total relevance figures $TDR(a_k(i,n))$ is represented as follows,

Definition 2.2

$$TDR(a_k(i,n)) = \prod_{t=1}^{n} BR(a_{k(t)}(i(t),t)). \qquad (2.4)$$

2.3 Merits and Demerits of PATTERN Method

Merits of the PATTERN method are as follows; a) The PATTERN method offers a consistent system through analysis of problems and evaluation. b) The three steps formed by scenario writing, reduction into issues and comparisons of issues, are similar to human thinking, and are familiar to us. c) In the process of scenario writing, details in the problem can be picked up. d) Policies as solving tools are explored logically by the relevance tree. e) Multi issues can be easily evaluated using the relevance tree. f) Evaluators themselves can clarify the evaluation of issues using the criteria and the significance number. g) Intuitive evaluation and the difference among them could be expressed quantitatively. h) The priority of policies can be ordered by TDR.

On the other hand, PATTERN method has the following defects. 1) Scenario writing procedures and construction methods of the relevance tree have not been completely clarified. 2) Methods of measuring the adequacy of the relevance tree have not been presented. 3) Too many issues are required to express details of subobjects (Jantsh [1] reported that there were more than 2300 issues related only to operational technical defects in the APOLLO planning in NASA). 4) Too much time is needed to construct and evaluate the relevance tree. Accordingly many specialists are required to apply this method for a long duration (it is said that six months was necessary for the technicians and OR specialists to construct the relevance tree related to space and military projects in Honeywell [1,2]). 5) An enormous cost is required to construct the relevance tree and to evaluate issues ($250,000 ~ 300,000 was spent in six months to construct the relevance tree in the Honeywell project). 6) There are no discussions about the mutual relation among criteria.

There is a belief that any complex problems (projects or systems) can be clarified by reductioning them in detail. Ironically, many of the above mentioned difficulties are attributable to reductionism on which the PATTERN method is based. This reductioning process is not identified uniquely in the PATTERN method. And too many level reduction of hierarchy makes it difficult to evaluate issues attentively. This complication becomes obvious by considering the following simple case of binary n level relevance tree. When the number of issues on the t-th level is 2^t, the total number of issues is $\sum_{t=1}^{n} 2^t$. If it takes three minutes to evaluate an issue (referring our experimentation with two criteria [9]), it necessitates about three hours in case of five hierarchy level and twelve full work days, for evaluation alone, in the case of ten level.

3. A FUZZIFIED RELEVANCE TREE APPROACH

To avoid the difficulty of expressing complex problem (system) in detail by reductionism, we have applied the fuzzy set concept to the relevance tree and call this as the "fuzzified relevance tree". The intuitive judgement used in the evaluating process of the PATTERN method is somewhat similar to the fuzzy set concept, and so it can be replaced by the fuzzy concept. Furthermore, the fuzzy concept reduces the number of issues.

Denote the k-th issue in i-th group on the t-th level of relevance tree as $a_k(i,t)$ ($k=1,2,\cdots, m(i,t)$; m depends on i and t) which is the identified symbol used for the explanation of the PATTERN method. Let denote $A(i,t)=\{a_k(i,t)\}_k$, $A_t=\{A(i,t)\}_i$. The object on the t-th level is expressed by the fuzzy set $\underset{\sim}{A}_t$ on the set A_t. The fuzzy set $\underset{\sim}{A}_t$ of a universe of discourse $A_t=\{a_k(i,t)\}_{i,k}$ is defined as a mapping $\mu_{\underset{\sim}{A}_t}(a_k(i,t))$; $A_t \to [0,1]$, and is expressed by the following ordered pairs,

$$\underset{\sim}{A}_t=\{(a_k(i,t),\ \mu_{\underset{\sim}{A}_t}(a_k(i,t)))\},\ a_k(i,t)\in A_t,$$

where the value of membership function $\mu_{\underset{\sim}{A}_t}(a_k(i,t))$ is the grade that an issue $a_k(i,t)$ belongs to the fuzzy set $\underset{\sim}{A}_t$. Denote the conditional fuzzy relation proposed by an evaluator as $\mu_{\underset{\sim}{A}_t}(a_k(i,t)|a_{k'}(i',t-1))$, ($a_{k'}(i',t-1) \in A_{t-1}$, $a_k(i,t)\in A_t$) when the fuzzy set $\underset{\sim}{A}_t$ is conditioned by an issue $a_{k'}(i',t-1)$. (Fig.3.1).

Define the evaluation value of an issue $a_k(i,t)$ on t-th level as $FR^*(a_k(i,t))$. If $\mu^p_{\underset{\sim}{A}_t}(a_k(i,t)|a_{k'}(i',t-1))$ denote the grade of conditional importance by an evaluator from the p-th evaluation criteria, the next equation is defined.

Definition 3.1

$$FR^*(a_k(i,t))=\bigvee_p \mu^p_{\underset{\sim}{A}_t}(a_k(i,t)|a_{k'}(i',t-1)). \tag{3.1}$$

The $FR^*(a_k(i,t))$ expresses the maximum fuzzy relation between t-1-th and t-th levels by considering the evaluation criteria, and corresponds to the $BR^*(a_k(i,t))$ in the PATTERN method.

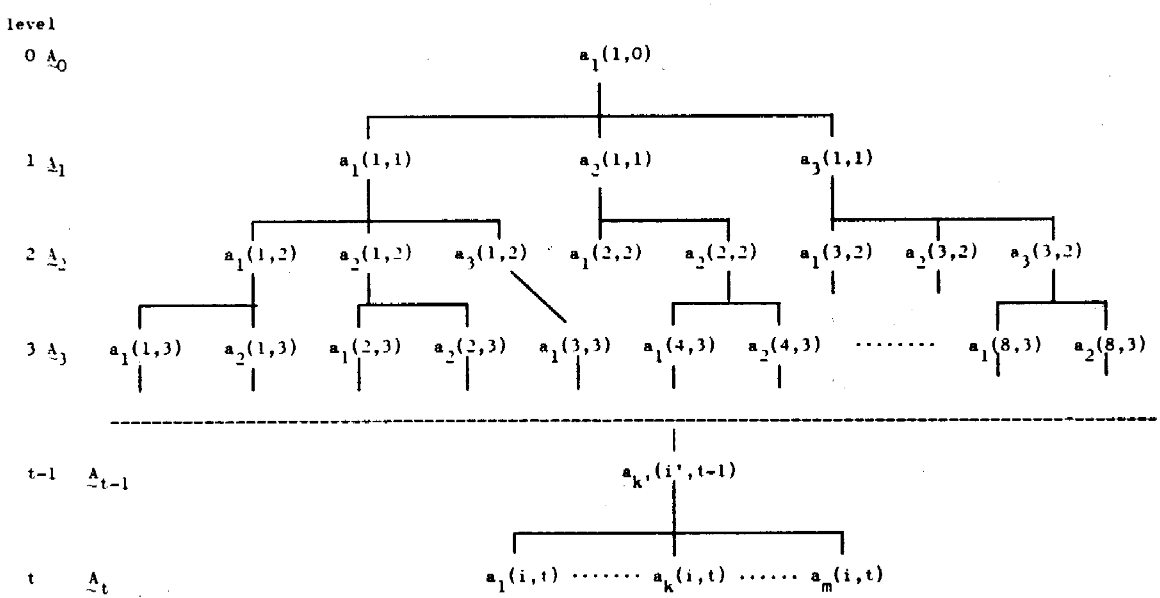

Fig. 3.1 Fuzzified Relevance Tree

Define the accumulated evaluation value $TFR^*(a_k(i,t))$ which corresponds to $TDR^*(a_k(i,t))$ in the PATTERN method as follows;

Definition 3.2

$$TFR^*(a_k(i,t))=FR^*(a_k(i,t))\wedge TFR^*(a_{k'}(i',t-1)). \quad (3.2)$$

Proposition 3.1

$$TFR^*(a_k(i,n))=\bigvee_{p(t),t}^{n}[\mu_{A_{t-1}}^{p(t-1)}(a_{k(t-1)}(i(t-1),t-1)|a_{k(t-2)}(i(t-2),t-2))\wedge \mu_{A_t}^{p(t)}(a_{k(t)}(i(t),t))|a_{k(t-1)}(i(t-1),t-1))] \quad (3.3)$$

where $\mu_{A_0}^{p(0)}(a_{k(0)}(i(0),0)|a_{k(-1)}(i(-1),-1)) = \mu_{A_0}^{p(0)}(a_1(1,0))$.

Proof: By the def.3.1 and def.3.2,

$$\begin{aligned} TFR^*(a_{k(n)}(i(n),n)) &= TFR^*(a_{k(n-1)}(i(n-1),n-1))\wedge FR^*(a_{k(n)}(i(n),n)) \\ &= \bigwedge_t FR^*(a_{k(t)}(i(t),t)) \\ &= \bigwedge_t(\bigvee_{p(t)} \mu_{A_t}^{p(t)}(a_{k(t)}(i(t),t)|a_{k(t-1)}(i(t-1),t-1))) \\ &= \bigvee_{p(t),t}[\mu_{A_{t-1}}^{p(t-1)}(a_{k(t-1)}(i(t-1),t-1)|a_{k(t-2)}(i(t-2),t-2))\wedge\mu_{A_t}^{p(t)}(a_{k(t)}(i(t),t)|a_{k(t-1)}(i(t-1), t-1))] . \end{aligned}$$

Equation 3.3 demonstrates the necessity of accumulated evaluation based on the max-min criteria using the conditional membership grades through levels.

When dealing with group decision value of $FR^*(a_k(i,t))$, the following $FR(a_k(i,t))$ can be defined using the group fuzzy measure $\bar{g}(\cdot)$ and fuzzy integral [4,6].

Definition 3.3

$$FR(a_k(i,t)) = \bigvee_{s=1}^{f}[FR_s^*(a_k(i,t))\wedge \bar{g}(\cdot)] = \bigvee_{s=1}^{f}[\tfrac{s}{f}\wedge\sum_{j=1}^{s}FR_j^*(a_k(i,t))/j], \quad (3.4)$$

for $FR_{s-1}^*(a_k(i,t))\geq FR_s(a_k(i,t))$, $(s=2,3,\cdots,f)$, where s is the number of members in the group.

Definition 3.4

$$TFR(a_k(i,n))=TFR(a_{k'}(i',n-1)\wedge FR(a_k(i,n)). \quad (3.5)$$

Proposition 3.2

$$TFR(a_{k(n)}(i(n),n))=\bigwedge_{t=1}^{n}FR(a_{k(t)}(i(t),t)). \quad (3.6)$$

4. COMPARISON OF PROPERTY BETWEEN THE TWO METHODS

In order to compare $BR^*(a_k(i,t))$ and $FR^*(a_k(i,t))$, consider the case that $s_{pk}=\mu_{A_t}^{p}(a_k(i,t)|a_{k'}(i',t-1))$ for any p.

Proposition 4.1

$$FR^*(a_k(i,t))\geq BR^*(a_k(i,t)). \quad (4.1)$$

Proof: It can be induced that $\min_p(s_{pk}) \leq \sum_p s_{pk}\cdot e_p \leq \max_p(s_{pk})$.

Then $$FR^*(a_k(i,t))=\bigvee_p\mu_{A_t}^{p}(a_k(i,t)|a_{k'}(i',t-1)) =\max_p(s_{pk}) \geq\sum_p s_{pk}\cdot e_p =BR^*(a_k(i,t)).$$

Theorem 4.1

$$FR(a_k(i,t)) \geq BR(a_k(i,t)). \quad (4.2)$$

Proof: Using the def. 3.3 and def. 2.1, it is said that

$$\bigvee_{s=1}^{f}[\tfrac{s}{f}\wedge\sum_{j=1}^{s}FR_j^*(a_k(i,t))/j] \geq \sum_{s=1}^{m}FR_s^*(a_k(i,t))/f$$

Then $FR(a_k(i,t)) \geq BR(a_k(i,t))$.

Lemma 4.1 $\sup_{\{x_t\}}(\min_t x_t-\prod_{t=1}^{n}x_t)=k_n^{1/n}-k_n$

subject to $\prod_{t=1}^{n}x_t=k_n$, $x_t\in[0,1]$ for every t.

Proof: In the case n=2, $0 \leq\min(x_1,x_2)-k_2 \leq k_2^{1/2}-k_2$. Then $\sup_{\{x_t\}}(\min x_t-\prod_{t=1}^{n}x_t)=k_2^{1/2}-k_2$ is induced ~~under~~ the condition $x_1=x_2$. Suppose $\sup_{\{x_t\}}(\min_t x_t - \prod_{t=1}^{n} x_t)=k_{n-1}^{1/(n-1)}-k_{n-1}$ when $x_t=x_{t+1}$ $(t=1,2,\cdots, n-2)$, then $\sup_{\{x_t\}}(\min_t x_t - \prod_{t=1}^{n} x_t)$

$=\sup_{\{x_t\}}(\min(\min_{t=1,2,\cdots,n-1}(x_t), \quad x_n)$.

This is obtained under the condition that $\min_{t=1,2,\cdots,n-1}(x_t) \quad =x_n$. Thus, $\sup_{\{x_t\}t=1,2,\cdots,h}(\min x_t - \prod_{t=1}^{n} x_t)$

$=\sup_{\{x_t\}t=1,2,\cdots,n-1}(\min(x_t) \quad -k_n) =k_n^{1/n}-k_n$, when $x_1=x_2=\cdots=x_n$.

Theorem 4.2

$$TDR(a_k(i,n)) \le TFR(a_k(i,n)) \le k^{1/n}-k,$$

where $\prod_{t=1}^{n} BR(a_{k(t)}(i(t),t)) = k$ (const).

Proof: By the proposition 3.2 and theorem 4.1, $TFR(a_k(i,n)) \ge \bigwedge_t BR(a_{k(t)}(i(t),t) \ge \prod_{t=1}^{n} BR(a_{k(t)}(i(t),t))$ because of $BR(a_{k(t)}(i(t),t))\in[0,1]$. Using the lemma 4.1, $TFR(a_k(i,n))-TDR(a_k(i,n)) \le k^{1/n}-k$.

Theorem 4.3 $TFR(a_k(i,n))-TDR(a_k(i,n)) \le n^{1/(1-n)}(1-1/n)$ for any $\prod_{t=1}^{n} BR(a_{k(t)}(i(t),t))$.

Proof: Denote $f(k)=k^{1/n}-k$. Then $f'(k)=1/n\cdot k^{1/n-1}-1$, $f''(k)=1/n\cdot(1/n-1)\cdot k^{1/n-2}<0$ for the nonnegative integer n. Thus the function f of k is unimodal concave, and $\sup_k(k^{1/n}-k)=n^{1/(1-n)}(1-1/n)$.

Theorem 4.4

It is difficult to use $TFR(a_k(i,n))$ for identifying the importance of the issues on the final level if $BR(a_k(i,t))$ has a property of approximately a random sample from the distribution on each level. The difficulty becomes magnified with the addition of more evaluators. On the other hand, $TFR(a_k(i,n))$ does not fall in this trap.

Proof: Denotes the p.d.f. of the distribution on t-th level as $f_t(x)$. It is induced that $BR(a_k(i,t))=\int_0^1 x\cdot f_t(x)dx=\mu_t$ for every $a_k(i,t)$. Then $TDR(a_k(i,n))=\prod_{t=1}^{n} BR(a_k(i,t))=\prod_{t=1}^{n} \mu_t$ for any k and i.

As the importance of issues on the final level affects the proposed purpose(zero level), the value of issues integrated on the lower level should reflect the evaluation on the upper level. We call the property which assures the connection of the lower level evaluation to the higher level one consistently as the "reversibility".

Theorem 4.5

The reversibility of evaluation between levels can be assured in our "Fuzzified Relevance Tree Method" under the condition that $TFR(a_{k'}(i',t-1)$ is smaller than the largest $FR(a_k(i,t))$ in $\{a_k(i,t)\}_k$, and the group can identify the fuzzy measures logically.

Proof: Let us consider the case that the issue $a_{k'}(i',t-1)$ is related to the issues $a_k(i,t)$ $(k=1,2\cdots, m(i,t))$ directly for each level. If the values $\{TFR(a_k(i,t))\}_k$ are integrated and the value becomes equal to $TFR(a_{k'}(i',t-1))$, we can say that the reversibility is assured between t-th level and t-1-th level. For this integration procedure, the fuzzy integral is applied. The fuzzy integral of $\{TFR(a_k(i,t))\}_k$ is written as $F(i,t)=\bigvee_k [TFR(a_k(i,t))\wedge g(A_t^k)]$, where g is a fuzzy measure, $TFR(a_k(i,t)) \le TFR(a_{k+1}(i,t))$ $(k=1,2,\cdots, m-1)$, and $A_t^k= \{a_k(i,t), a_{k+1}(i,t),\cdots, a_m(i,t)\}$. From the property of fuzzy measure, it is said that $g(A_t^k) = g(a_k(i,t)) + g(A_t^{k+1}) + \lambda\cdot g(a_k(i,t))\cdot g(A_t^{k+1})$, where $\lambda >-1$. If we assume $g(a_k(i,t))$ can be identified as $TFR(a_k(i,t))$, then $g(A_t^k)=TFR(a_k(i,t)) + g(A_t^{k+1}) + \lambda\cdot TFR(a_k(i,t))\cdot g(A_t^{k+1})$. Thus $g(A_t^k)-TFR(a_k(i,t))=\{1+\lambda\cdot TFR(a_k(i,t))\}\cdot g(A_t^k)\ge 0$. From this result, $F(i,t) = \bigvee_k TFR(a_k(i,t)) = \bigvee_k [FR(a_k(i,t))\wedge TFR(a_{k'}(i',t-1))] = (\bigvee_k FR(a_k(i,t)))\wedge TFR(a_{k'}(i',t-1))$. If $\bigvee_k FR(a_k(i,t)) \ge TFR(a_{k'}(i',t-1))$, then $F(i,t) = TFR(a_{k'}(i',t-1))$. For this reason, reversibility is assured under the condition that $TFR(a_{k'}(i',t-1))$ is smaller than the largest $FR(a_k(i,t))$ in the feasible set $\{a_k(i,t)\}_k$.

The more issues there are in the group of relevance tree, the more reversibility will be assured. It is not important to note that we are not recommending the construction of a complexed relevance tree composed of many issues in a group, but a simple relevance tree which satisfies the reversibility. By introducing a simple evaluating procedure, alternatives of relevance trees can be selected to assure reversibility. Thus this theorem contribute to clarify not only the calculation definition and procedure, but also to the construction method for suitable relevance tree.

5. NUMERICAL EXAMPLE OF RANDOM DIGIT EXPERIMENTATION FOR TWO METHODS

It may be difficult to compare the two methods because of the following reasons; 1) The concept of s_{pk} is different from $\mu^p_{\underset{\sim}{A}_t}(a_k(i,t)|a_{k'}(i',t-1))$ intrinsically. 2) The value attached to an issue is determined freely in the interval [0,1] at every level of hierarchy depending on the evaluators. 3) No criteria has been established to evaluate the relevance tree in the PATTERN method.

In spite of these difficulties, we will attempt to elucidate the similarities of the important order of issues on the final level between two methods. In order to avoid the special evaluation formula, a random digit experimentation is introduced. The number of issues and levels of relevance tree should not be too large because of the property of our fuzzified relevance tree.

Let us assume the following conditions in our trial. 1) The binary relevance tree has three levels. 2) Only one evaluation criteria is used. 3) Random digit can be obtained from the two kinds of normal distribution. 4) Random digit experimentation is tried twenty five times in each case respectively. 5) There is only one evaluator, 6) The same value obtained through the examination is used for the calcuration of $TFR(a_k(i,3))$ and $TDR(a_k(i,3))$, that is, $s_{1k} = \mu^{1}_{\underset{\sim}{A}_t}(a_k(i,t)|a_{k'}(i',t-1))$. 7) The similarity of order of $TFR(a_k(i,3))$, $TDR(a_k(i,3))$ on final level is measured by the coefficient of rank correlation of Spearman, ρ, shown in the equation 5.1[2].

$$\rho = 1 - \frac{6\sum_i d_i^2}{N^3 - N} \tag{5.1}$$

N; number of issues on the final level (number of paires)

d_i; difference of order between the i-th pair.

Using the normal distribution $\cdot$ $N(\mu,\sigma^2)$, two cases A and B are considered as follows;

case A; $\mu = 0.5$, $\sigma = 1$

case B; $\mu = 0.7$, $\sigma = 1$.

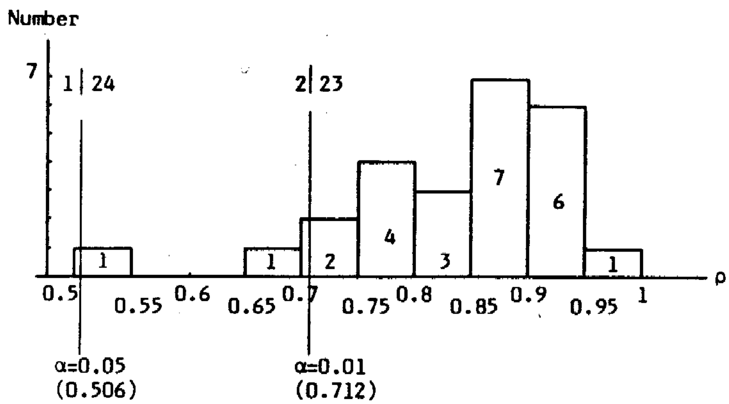

Fig. 5.1 Case A

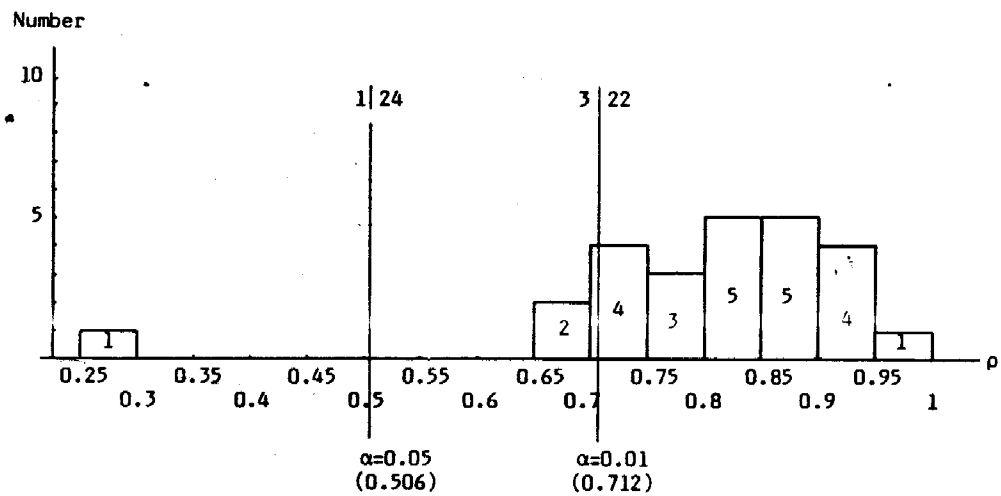

Fig. 5.2 Case B

Coefficient of rank correlation of Spearman

item value ··· normal random digits

case A ·· $\mu = 0.5$ $\sigma = 1.0$ $\sim N(0.5, 1)$

case B ·· $\mu = 0.7$ $\sigma = 1.0$ $\sim N(0.7\ 1)$

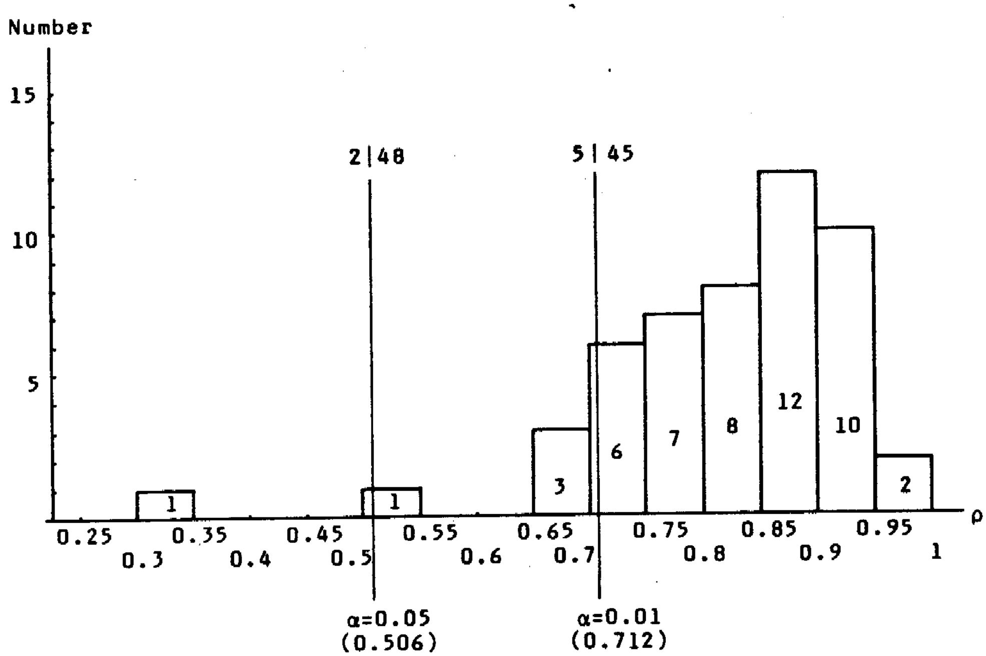

Fig. 5.3 case A∪B

Figure 5.1 ~Figure 5.3 show the histogram where the axis of spindle represents the number that the correlation values fall in the interval of horizontal axis in the cases of A, B, and A∪B, respectively. If we adopt the significant value $\alpha = 0.01$ or 0.05, then the outcome of the order on the final level in the fuzzified relevance tree is simillar to that of the PATTERN method from the statistical significance level.

6. CONCLUDING REMARKS

Although the relevance tree method can be useful for dealing with complex problems or plannings, difficulties sometimes arise in constructing a tree or evaluating issues, when there are too many issues and levels. In the strict application of reductionism, it may be difficult to reduce the issues and levels.

In our fuzzified relevance tree, the fuzzy concept substitutes for the reductionism, and suppresses the increase of issues and levels. To clarify the application of the fuzzy concept and to elucidate the property of fuzzified method, the well known PATTERN method was utilized as the object for the comparison. After developing several definitions for the fuzzified relevance tree method which relate to the PATTERN method, we are able to find some propositions and several theorems. That is, we could find the relation between $FR(a_k(i,t))$ and $BR(a_k(i,t))$, and $TFR(a_k(i,t))$ and $TDR(a_k(i,t))$, etc. The property of reversibility, assured in our method, will contribute not only to the foundation of our method, but also to give us criteria to construct an appropriate relevance tree. Random digit experimentation beyond the limitation of analytical approach was performed, and the order of issues on the final level between the two methods was compared using the coefficient of rank correlation of Spearman. Through the experimentation under several conditions, we could find the similarity of two methods from the statistical view point.

The most important thing remaining now is to apply our method in the practical field. The result will give us valuable materials and may contribute to modify our method.

FOOTNOTE

1) The PATTERN method has been applied to many field like follows; NASA Air Space Projects [1,2], Military Activities [2], Development of Medical Care System [10], Development of Medical Electronics [2], Development of Products [9], American Advertising [1,2], Decision Making in Governmental Organization [9].

2) If there are same orders, the following revised method is used here.

$$\Upsilon = 1 - \frac{6(S+U+V)}{N^3 - N}, \quad S = \sum_i d_i^2$$

$$U = \frac{1}{12}\Sigma(u^3 - u), \quad V = \frac{1}{12}\Sigma(v^3 - v),$$

where u, v is the number of same order on the level respectively.

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