AN EXPERT SYSTEM WITH THINKING IN IMAGES

Zhang Hongmin

Department of Mechanical Engineering,
The Air Force College of Engineering,
Xian, China

Abstract

In this paper we present a new method of modelling human thinking in images, which had been applied to the expert systems for diagnosis of faults in aircraft and blood diseases. In this method, firstly, the knowledge and experience of experts are described by the theory of fall shadows random sets in the factors space. Secondly, to gain their knowledge and experience, we put them to the psychological test according to the theory of set-valued statistics. Thirdly, we consider thinking in images as a process of comparing, analysis and recognition. Finally, we apply consciousness-tree to modelling the complex process

Keywords: Expert systems, thinking in images, fall-shadows of random sets, set-valued statistics, consciousness-tree

1. INTRODUCTION

An expert system is an information processing system, which could store human knowledge and experience and model human thinking process for processing knowledge and information. So far, it has made great progress in modelling human logical thinking. Some logic-based programming languages, as LISP, PROLOG and so on, which are applied to artificial intelligence areas, have been offered.

According to professor Qian Xueshen's points of view, however, modes of human thinking may be divided into logical thinking, thinking in images and inspirational thinking. We consider that the main study direction of artificial intelligence would be thinking in images and inspirational thinking.

Logical thinking is a process of using concepts for judgment and inference. The inference process must abide by some rules and certain program. In the real world, human experts apply logical thinking as well as thinking in images. For instance, when an engineer with abundant experience makes a decision for some problem, his thinking process is that he recognizes a matter by making use of image according to his experience. His foundation of decision-making is not some concepts and rules, but some practical matters and impressions of imagery in human brains. This is what we mean by saying thinking in images. It is very much different from logical thinking.

Generally, human recognizes matters by thinking in images from an integral impression. Thinking in images has features, i.e., fuzziness and integrality. A doctor does not diagnose patient's illness according to a single symptom of temperature, blood pressure, or weight and pure reasoning rules, but according [illegible] all the symptoms of the patient's illness and his own [illegible] imagery. For this reason, we should apply the method of fuzzy mathematics for representing the process of thinking in images.

In this paper, we present a new idea and method of modelling human thinking in images, i.e., the basic theory of knowledge representation, knowledge acquisition and application of knowledge. We use the method to build up a STIM (Shell of Thinking in IMages) expert system, which has been applied to the expert systems for diagnosis of faults in aircraft and blood diseases, and gained satisfactory results.

2. KNOWLEDGE REPRESENTATION

In this section, we offer a new mathematical method, with which describes knowledge of thinking in images.

2.1 Factors space

Factors space would be useful for mathematically describing the real world [1]. In this paper we are going to use some theory on factors space.

DEFINITION 2.1 A factors space is a family of sets $\{X_f\}$ $(f \in F)$, where F is a complete Boolean algebra $F=(F, \vee, \wedge, c)$ satisfying

1) $X_0 = \{\emptyset\}$; (2.1)

2) if $\{f_t\}$ $(t \in T)$ are independent, i.e., for any $t_1, t_2 \in T$, $f_{t_1} \wedge f_{t_2} = 0$, then

$$X_{\bigvee_{t \in T} f_t} = \prod_{t \in T} X_{f_t} \tag{2.2}$$

where 0 and 1 are the smallest and the lagest element of F respectively, and $\prod_{t \in T}$ is Cartesian product, allows that

$$\{\emptyset\} \times A = A \tag{2.3}$$

We call the elements of F the factors, X_f the range of factor f and X_1 the whole rang or state space.

An image of object can be described as point in a finite or infinite dimensional factors space. In doctor's image, for instance, a patient's state may be described as a point in multidimensional factors space where the factors are sex, weight, temperature, blood pressure, etc.

For any $A \in X_f$, $g \leq f \leq h$ define

$$\uparrow^h A \triangleq A \times X_{(h \wedge f^c)} \tag{2.4}$$

and also

$$\downarrow_g A = \{x \mid x \in X_g \ \& \ (\exists y \in X_{(f \wedge g^c)})((x,y) \in A)\} \tag{2.5}$$

We call $\uparrow^h A$ the cylindric extension of A from f to h and $\downarrow_g A$ the projection of A from f to g.

DEFINITION 2.2 For any $A \subseteq X_1$, define

$$\tau(A) \triangleq \wedge\{f \mid \uparrow^1(\downarrow_f A) = A\} \tag{2.6}$$

We call $\tau(A)$ the rank of A. If $f \geq \tau(A)$, we say that A is clear in

X_f otherwise we say that A is unclear in X. If $f \leq \tau(A)$, we offer a concepter of clear degree.

DEFINITION 2.3 Let δ be a function from σ-algebra to [0,1]. $\forall A \subseteq I$, δ is a clear degree satisfying the conditions:

1. $\delta_A(\emptyset)=0$; $\delta_A(f)=1$, $\quad f \geq \tau(A)$ $\quad$ (2.7)

2. If $h \wedge g=0$, then $\delta_A(h \vee g)=\delta_A(h)+\delta_A(g)+\lambda\delta_A(h)\delta_A(g)$ $\quad -1<\lambda$, $h, g<\tau(A)$; $\quad$ (2.8)

3. If $\forall \in N$, $f_i \in F$ and f_i is monotonic ($f_1 \leq f_2 \leq \cdots \leq f_n \leq \cdots$ or $f_1 \geq f_2 \geq \cdots \geq f_n \geq \cdots$), then $\lim_{i \to \infty} \delta_A(f_i)=\delta_A(\lim_{i \to \infty} f_i)$ $f_i<\tau(A)$ $\quad$ (2.9)

The clear degree is a λ-fuzzy measure. Environment of fuzziness can be described by the clear degree.

DEFINITION 2.4 We call $(X_f, \mathcal{B}_f, P_f)$ $(f \in F)$ a factors field if (X_f) $(f \in F)$ is a factors space; for every $f \neq 0$ $(X_f, \mathcal{B}_f, P_f)$ is a probability field; and $\{f_t\}$ $(t \in T)$ are independent then $(X_{\vee_{t \in T} f_t}, \mathcal{B}_{\vee_{t \in T} f_t}, P_{\vee_{t \in T} f_t})$ is the product probability field of $\{(X_{f_t}, \mathcal{B}_{f_t}, P_{f_t})\}$ $(t \in T)$.

For any $\mathcal{b} \subseteq P(X_f)$, if $f \leq h$, we define

$$\uparrow^h \mathcal{b} \triangleq \{\uparrow^h c \mid c \in \mathcal{b}\} \qquad (2.10)$$

If $g \leq f$, we define

$$\downarrow_g \mathcal{b} = \{\downarrow_g c \mid c \in \mathcal{b}\}. \qquad (2.11)$$

We can easily prove that.

2.2 Set-valued Statistics and Fall-shadows of Random Sets

Set-valued Statistics were proposed by Wang Peizhuang [2]. The classical statistical experiments, which are familiar to us, are mostly used to measure some physical quantities, and are rarely based upon the psychological reflections of human beings. The set-valued statistics is however closely connected with the psychological process. There is a knowledge problem here. A large number of experiments in physical psychology have proved that there exists very precisely a power function law between the changes in psychological reflection quantity which is obtained by various sense organs (such as vision organ, hearing organ, taste organ, touch organ) and the changes in various physical stimulation quantities in the outside world (such as bright degree, sound degree, sweet degree, fragrant degree). This shows that a scientific psychological measurement method may objectively reflect the real world. As to those objects which cannot be measured by physical or chemical or any other measurement means, the psychological measurement is really an important quantitating method. So we may say that bringing psychological measurement into set-valued statistics is not a fault but an advantage.

Image of a kind of object for experts can be described as a subset in the factors space. A large number of images of experts are random sets in the factors space. Now we define the measurable structure and "random variable" on $\mathcal{P}(U)$. Denote

$$\hat{u} \triangleq \{B \mid B \in \mathcal{P}(U),\ B \ni u\} \qquad (2.12)$$

$$\dot{U} = \{\dot{u} \mid u \in U\}. \qquad (2.13)$$

[illegible] σ-field $\check{\mathcal{B}}$ containing $\dot{U}$, $(\mathcal{P}(U), \check{\mathcal{B}})$ is a measurable space. A measurable mapping from some factors field $(X_f, \mathcal{B}_f, P_f)$ to $(\mathcal{P}(U), \check{\mathcal{B}})$

$$\xi : X_f \longrightarrow \mathcal{P}(U) \qquad (2.14)$$

$$\xi^{-1}(b) = \{\omega \mid \xi(\omega) \in b\} \in \mathcal{B}_f \quad \forall b \in \check{\mathcal{B}}$$

is called a random set on U, which is a random variable on $\mathcal{P}$ [illegible]. In what follows, we use $\mathcal{F}(X_f, \mathcal{B}_f; \mathcal{P}(U), \check{\mathcal{B}})$ to denote all such random sets.

DEFINITION 2.5 [illegible] $\mathcal{F}(X_f, \mathcal{B}_f; \mathcal{P}(U), \check{\mathcal{B}})$. Denote

$$\mu_\xi(u) \triangleq P\{\omega \mid \xi(\omega) \in \hat{u}\}, \qquad (u \in U) \qquad (2.15)$$

[illegible] called the fall-shadow of ξ. Knowledge representation may be used by the fall-shadows.

DEFINITION 2.6 For given random sets $\xi : X_f \rightarrow \mathcal{P}(X)$ and $\eta : X_f \rightarrow \mathcal{P}(Y)$ [illegible]

$$\mu_{(\xi,\eta)}(x, y) \triangleq P\{\omega \mid \xi(\omega) \ni x,\ \eta(\omega) \ni y\} \qquad (2.16)$$

is called the union fall-shadow of ξ and η. If $\mu_\xi(x) > 0$, then [illegible]

$$\mu_{\eta|\xi}(y \mid x) \triangleq P(\eta \ni y \mid \xi \ni x) \qquad (2.17)$$

is called the conditional fall-shadow of η when $\xi \ni x$.

PROPOSITION 2.1 The necessary condition for independence of ξ and η is

$$\mu_{(\xi,\eta)}(x, y) = \mu_\xi(x)\,\mu_\eta(y) \qquad (\forall x \in X, y \in Y) \qquad (2.18)$$

[illegible] probability measure on the measurable space $(U, \mathcal{B})$, and the fall-shadow μ_ξ of random set ξ on U is integrable, denote

$$\bar{m}(\xi) = \int \mu_\xi(u)\, m(du) \qquad (2.19)$$

We [illegible] such set-valued statistics in which each [illegible] subset [illegible] $\xi \in \mathcal{F}(X_f, \mathcal{B}_f; \mathcal{P}(U), \check{\mathcal{B}})$, make independent [illegible] [illegible]

$x_1, x_2, \ldots, x_n$ [illegible] $x_i \in \mathcal{P}(U)$ $(i=1,\ldots,n)$.

[illegible]

$$\bar{\chi}(u) = \frac{1}{n} \sum_{i=1}^{n} \chi_{x_i}(u) \qquad (2.20)$$

It [illegible] ξ [illegible] function of μ_ξ, concerning [illegible] a theorem.

THEOREM 2.1 The law of great numbers of fall-shadow [illegible]

$$\xi_i \in \mathcal{F}(X_f, \mathcal{B}_f; \mathcal{P}(U), \check{\mathcal{B}}) \qquad (i=1,2,\ldots)$$

[illegible] independent and have the same distribution $\mu_{\xi_i}(u) = \mu(u)$. Then [illegible]

$$\bar{\xi}_n(\omega)=\frac{1}{n}\sum_{i=1}^{n}\chi_{\xi_i(\omega)}(u) \qquad (2.21)$$

[illegible] hold:

$$\bar{\xi}_n(u) \xrightarrow{a.e.} \mu(u) \quad (n\to\infty) \qquad (2.22)$$

[illegible]

[illegible] proposed by De Luca and Termini [illegible] some conclusion [illegible]

Let [illegible] be a universe of discourse and $\widetilde{\mathcal{P}}(X)$ be the set of fuzzy subsets of X. A fuzzy entropy is a mapping D from $\widetilde{\mathcal{P}}(X)$ to $[0,\infty)$ satisfying the conditions:

1) [illegible] A is an ordinary subset of X;

2) D(A) is maximum iff $\mu_A(x)=1/2$ $\forall x\in X$.

3) [illegible] $\leq$ D(A), where A^* is any sharpened [illegible], i.e. $\mu_{A^*} \leq \mu_A$ [illegible] $\mu_A \leq 1/2$ and $\mu_{A^*}(x) \geq \mu_A(x)$ [illegible] $\mu_A \geq 1/2$;

4) D(A)=D($\bar{A}$) ($\bar{A}$ is as fuzzy as A).

[illegible], De Luca has proposed a general [illegible]

$$[\text{illegible}] \sum_{i=1}^{n} \big(\mu_A(x_i)\log\mu_A(x_i)+\mu_{\bar{A}}(x_i)\log\mu_{\bar{A}}(x_i)\big). \qquad (2.23)$$

[illegible] can be extended to evaluate a whole fuzzy partition [illegible] amount of ambiguity [illegible] deciding to which of $A_1,\ldots,A_m$ an element x belongs. [illegible]

$$\sum \mu_{A}[\text{illegible}]=1$$

[illegible] partition, the fuzzy entropy is

$$D(A_1,\ldots,A_m)=-\sum_{j=1}^{m}\sum_{i=1}^{n}\mu_{A_j}(x_i)\log\mu_{A_j}(x_i). \qquad (2.24)$$

[illegible] $(A_1,\ldots,A_m)$ is an ordinary partition of X, $D(A_1,\ldots,A_m)=0$. $D(A_1,\ldots,A_m)$ is maximum iff $\forall i$, $\forall j$, $\mu_{A_j}(x_i)=1/m$ (maximum ambiguity).

[illegible] X_f [illegible] $\in$ [illegible] be a factor space. μ_{A_j} [illegible]

[illegible] j [illegible] the factor space [illegible] $A^*_1,\ldots,A^*_m$ [illegible] partition satisfying the condition:

$$\mu_{A^*_j}(x)=\mu_{A_j}(x)\Big/\sum_{i=1}^{m}\mu_{A_i}(x) \qquad x\in X_f \qquad (2.25)$$

[illegible] fuzzy entropy of $(A_1,\ldots,A_m)$ [illegible]

$$D(A_1,\ldots,A_m)[\text{illegible}]\sum_{j\le 1}\sum \mu_{A^*_j}[\text{illegible}]\mu_{A^*_j} \qquad [\text{illegible}]$$

and the fuzzy information amount [illegible]

$$[\text{illegible}]_{max}(A_1,\ldots,A_m)-D(A_1,\ldots,A_m|f) \qquad [\text{illegible}]$$

[illegible] $D_{max}(A_1,\ldots,A_m)$ is maximum fuzzy entropy iff $\forall j$, μ_{A_j} [illegible] $D(A_1,\ldots,A_m|f)$ is the fuzzy entropy of $(A_1,\ldots,A_m)$ in the [illegible] X_f [illegible] $\in$ [illegible].

[illegible] of thinking in images may [illegible] the [illegible] degree, the [illegible] shadow, the entropy and information amount [illegible]

[illegible]

[illegible] is a process which [illegible] knowledge base, [illegible] learning [illegible] learning with teacher [illegible] In this section, [illegible]

[illegible] of paying [illegible] the theory of set-valued [illegible] stage.

[illegible] gives out the factor [illegible] f [illegible] $\in$ [illegible] give out a group of objects $(a_1, \ldots, a_m)$ [illegible] degree [illegible] the factor to be evaluated must rely upon [illegible] measurement then we invite some experienced experts [illegible] according to the basic rule of [illegible] following way.

[illegible] headache as an example [illegible] kind of disease, [illegible] number [illegible] "middling". Every participating [illegible] on the line, [illegible] about the degree [illegible] denote the first [illegible] and first point from right [illegible]. The interval [illegible] person, and $[a_i, \underline{a}_i]$ [illegible] calculating [illegible] according to [illegible] degree, and [illegible]

[illegible] calculate

$$\alpha = \frac{1}{n} \sum \quad i \quad i \qquad (3.1)$$

[illegible]

$$\bar{m} = \frac{1}{n} \sum^{n} \quad i \quad i$$

according to [illegible] we may represent the point estimation [illegible] degree [illegible] of α. $\bar{m}$ may be called the blindness of the [illegible] value of m, the more [illegible] about this estimation, and $\bar{m}=0$ means quite sure.

[illegible] method

[illegible] expert puts only one point on the line, but [illegible] $0 \le k \le 10$), to be attached to it. This [illegible] degree to the point put.

[illegible] obtained from confidence method is (a_i, α_i) [illegible]

$$\alpha \quad \sum \alpha_i \quad i \quad \sum \alpha_i$$

[illegible] the point estimation to the degree discussed.

The [illegible] and confidence method may be transformed [illegible]. The more concentrated the points are, [illegible] participants [illegible]. We can find a functional [illegible] δ [illegible] θ between the concentration degree of the points [illegible] degree when putting [illegible], where θ [illegible] the confidence degree and the radius of the estimation [illegible] (x_i, θ_i) [illegible] result from the confidence [illegible], we can transform it into $[x_i - f(\theta), x_i + f(\theta)] \cap$ [illegible] which can be regarded as a result in the interval [illegible]

[illegible] $[x_i, x_i]$ [illegible] $\frac{x_i + x_i}{2}$ [illegible]

[illegible] the set of problems.

[illegible] μ_{A_j} [illegible]

[illegible] the information amount [illegible] i [illegible] space $\{f_i \mid f_i \in F\}$, $f_i \wedge f_j = 0$, $i \neq j$, [illegible]

[illegible] degree of the objects A [illegible] for the [illegible] (2.3), where we have

$$\delta_{A_j}(f_i) = \frac{I(f_i)}{\sum\limits_{f_t \leq \tau(A_j)} I(f_t)} \qquad (3.4)$$

where $\tau(A_j)$ is the rank of A_j.

[illegible]

[illegible] Modifying

[illegible] the system will give out a wrong conclusion [illegible] may modify automatically the knowledge-base [illegible] instance, [illegible] image x_0 [illegible] the computer, [illegible] give out a wrong conclusion A_j, but the [illegible] A_j [illegible]

$$\mu_{A_j}(x_0) = \mu_{A_j}(x_0) \cap N(x_0) \qquad (3.5)$$

and

$$\mu_{A_j}(x_0) = \mu_{A_k}(x_0) \cup Y(x_0) \qquad (3.6)$$

[illegible] x_0 [illegible] $\alpha|x - x_0|^2$ [illegible], $N(x_0) = 1 - Y(x_0)$, α [illegible] the expert given

[illegible] APPLICATION

[illegible] section, [illegible] divide the thinking in images [illegible] thinking: comparing, [illegible] and apply [illegible] to modify [illegible] thinking process.

[illegible] Process of Thinking in Images

[illegible] the thinking in images is a process of using [illegible] analysis and recognition. For instance, when [illegible] diagnose [illegible], his thinking process is as follows: he gets a tentative image by examining the total symptoms of the patient's [illegible], then compares the tentative image with the typical image of kinds of disease according to their [illegible] experience, makes a [illegible] by means of analysis and recognition. [illegible] is the mathematical description of comparing, [illegible] recognition.

[illegible] Comparing

Comparing is a kind of divergent thinking. [illegible] factors space [illegible] f_0 ($f_0 \in$ [illegible]), the computer gets an image u_0 ($u_0 \in$ [illegible] f) [illegible] by tentative examination patient's symptoms, then compares the image with the typical experience of kinds of disease A_j ($j=1, \ldots, m$). The process of comparing is usually divided into two steps: First, the computer project sets A_j ($j=1, \ldots, m$) of kinds of disease to tentative factors space (X_{f_0}) ($f_0 \in$ [illegible]), [illegible]

[illegible] kinds of disease. [illegible] process is [illegible] of experience. Secondly, the [illegible] by means of tentative image has one-sidedness, [illegible] comparing from integrality aspect, i.e., calculate the [illegible] degree $\delta_{A_j}(f_0)$ of kinds of disease A_j in tentative factors space X_{f_0} ($f_0 \in$ [illegible]) [illegible] method as follows.

Let X_{f_0} ($f_0 \in$ [illegible]) be a tentative factors space, u_0 ($u_0 \in X_{f_0}$) [illegible] image and sets A_j ($j=1, \ldots, m$) be kinds of disease [illegible] factors space of disease [illegible] X_{f_j} ($f_j \in$ [illegible], $f_j = \tau(A_j)$). If $f_0 < f_j$, then

$$\mu_{A_j}(u_0) = \mu_{(\downarrow_f A_j)}(u_0) \qquad (4.1)$$

where $\downarrow_f A_j$ is the projection from the factors space X_{f_j} [illegible]

If $f_0 > f_j$, then

$$\mu_{A_j}(u_0) = \mu_{(\uparrow A_j)}(u_0) \qquad (4.\,[illegible])$$

where $\uparrow f A_j$ is the cylindric extension from the factors space X_{f_j} [illegible] X_{f_0}). The clear degree of disease A_j [illegible]

$$\delta_{A_j}(f_0) = \sum_{f_t \in f_0} \delta_{A_j}(f_t) \qquad (4.\,[illegible])$$

[illegible]

[illegible] a kind of convergent thinking. [illegible] by the comparing calculation, we find out a disease [illegible] maximum possible as follows

$$\mu_{A_w}(u_0) = \max_{1 \le j \le m} \mu_{A_j}(u_0) \qquad (4.4)$$

[illegible] possible $\mu_{A_w}(u_0)$ and the clear degree $\delta_{A_w}(f_0)$

[illegible] values $\mu_{A_w}(u_0)$ and $\delta_{A_w}(f_0)$ are all very large, [illegible]

[illegible] result of diagnosis is disease A_w.

[illegible] the value $\mu_{A_w}(u_0)$ is very large and the $\delta_{A_w}(f_0)$ is [illegible]

[illegible] small, [illegible] extend the tentative factors space (X_{f_0}) to (X_{f_1}) where $f_0 < f_1$ and $\delta_{A_w}(f_0) < \delta_{A_w}(f_1)$.

Case ... If the value $|\mu_{Aw}(\ldots_0) - \mu_{Ah}(\ldots_0)|$ is very small, ... tentative factors space (X_{f_0}) to (X_{f_t}), where (X_{f_t}) ... factor space and $|\mu_{Aw}(\ldots_t) - \mu_{Ah}(\ldots_t)| = \max_{\leq i \leq} |\mu_{Aw}(\ldots_i) - \mu_{Ah}(\ldots_i)|$

... the values $\mu_{Aw}(\ldots_0)$ and $\delta_{Aw}(f_0)$ are all very small, ... tentative factors space (X_{f_0}) to (X_{f_1}), where ... $_0 \vee f_t$ and $I(f_t) = \max_{1 \leq i \leq} I(f_i)$, $f_t \wedge f_0$ ...

... the value ... is very small and $\delta_{Aw}(f_0)$ is very ... then the knowledgebase should be modified.

... gation

... synthesis decision making ... degree and the ... degree ...

$$\mu'_{A_j}(\ldots_0) = \mu_{A_j}(\ldots_0) \; \delta_{A_j}(\ldots_0)$$

$\mu'_{Aw}(\ldots_0) > \lambda$ ... w

... Consciousness Process

... thinking is conscious but the thinking process is ... In order to model human thinking process, ... expert system. ... described by a ... The ...consciousness-tree is ... decision tree ... such that each ... node ... decision function with variable weights $f_j(x)$ ... where ... factors of input ... i ... we have

$$\ldots_j(\ldots) = \sum \ldots_{ij} \ldots_i$$

$\ldots_{ij}$ ... weight coefficients (see [5]) ... human ... weights processing correspond ... thinking. Following are experience ... variable weight

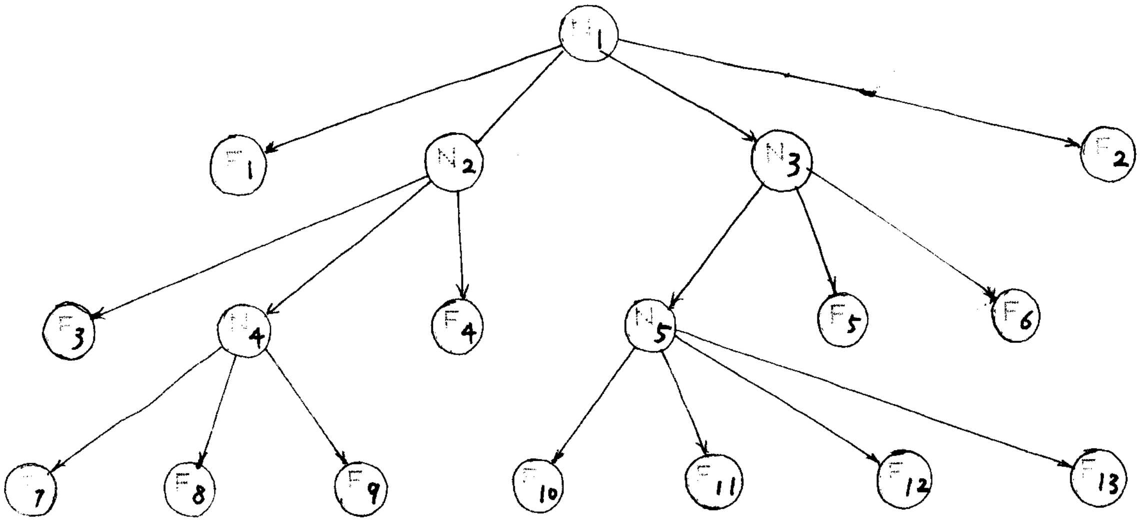
$\ldots_1, \ldots_2, \ldots_3$ ...

$\ldots_{11}(\ldots_1, \ldots_2, \ldots_3) = \dfrac{\ldots_{12}\ldots_2 + \ldots_{13}\ldots_3}{\ldots_{11}\ldots_1 + \ldots_{12}\ldots_2 + \ldots_{13}\ldots_3}$ ... $\ldots_{11}\ldots_1 + \ldots_{13}\ldots_3$

$\ldots_{12}(\ldots_1, \ldots_2, \ldots_3) = \dfrac{\ldots}{\ldots_{11}\ldots_1 + \ldots_{12}\ldots_2 + \ldots_{13}\ldots_3}$ ... $\ldots_{11}\ldots_1 + \ldots_{12}\ldots_2$

$\ldots_{13}(\ldots_1, \ldots_2, \ldots_3) = \dfrac{\ldots}{\ldots_{11}\ldots_1 + \ldots_{12}\ldots_2 + \ldots_{13}\ldots_3}$

... $\ldots_{11}, \ldots_{12}, \ldots_{13}$ ... the ... decision is F_w ... f_j ... $\leq j \leq$



N_i is a node and F_j is a leaf

Fig. 4.1 consciousness-tree

5 CONCLUSION

In the foregoing analysis, we have considered that human thinking process is complex. The complex thinking process contain three kinds of thinking modes, such as logical thinking, thinking in images and inspirational thinking. Every of them may be depicted by following three parts,

antecedents — contacting intermediary — consequents

The main difference one another is disparity in contacting intermediary, logical thinking by rules, thinking in images by experience (or imagery) and inspirational thinking by human [illegible], imagination, conjecture and insight and so on non-logical and super-images function. In this paper, use the method to build a STIM (Shell with Thinking in Images) expert system, which has been applied to the expert systems for diagnosis of faults in aircraft and blood diseases.

6 REFERENCES

[1] Wang Peizhuang, Sugeno M., The factors field and background structure for fuzzy subsets, Fuzzy Mathematics, No.2, 1982.

[2] Wang Peizhuang, Liu Xihui, Set-valued statistics, Journal of engineering mathematics, Vol.1 1984.

[3] De Luca, A., Termini, S., A defintion of a non-probabilistic entropy in the setting of fuzzy sets theory, Inf. Control 20, 301-312, 1972.

[4] Wang Peizhuang, Chuan Kai, Zhang Dazhi, Degree analysis and its application in plan choosing problem in the construction of hydropower stations, Soft optimization models using the fuzzy sets and possibility theory, 1984.

[5] [illegible], Zhang Fengming, Fuzzy decision-making in engineering, (to appear).

[6] Wang Peizhuang, Zhang Dazhi, Fuzzy decision-making, Beijing, 1985.