Proceedings of the 3rd Beijing International Conference on

SYSTEM SIMULATION AND SCIENTIFIC COMPUTING

October 17 - 19, 1995, Beijing, China

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PREFACE

As well known that system simulation techniques are very important in a great variety of scientific research areas and engineering practices. In response to these, the Third International Conference on System Simulation and Scientific Computing offers a forum for researchers and engineers in system simulation and scientific computing to discuss recent developments, to exchange new ideas and to analyse trends for further research, and also to provide them an opportunity to establish and maintain contacts with colleagues.

As a successor of the First International Conference on System Simulation and Scientific Computing, Beijing, October 23-26, 1989 and the Second International Conference on System Simulation and Scientific Computing, Beijing, October 20-23, 1992, the Third International Conference on System Simulation and Scientific Computing is to be held in Beijing on October 17-19, 1995. This Conference is sponsored by Chinese Association for System Simulation (CASS) and co-sponsored by Federation of European Simulation Societies (EUROSIM), International Association for Mathematics and Computers in Simulation (IMACS), Japan Society for Simulation Technology (JSST), Korean Simulation Society (KSS) and Society for Computer Simulation International (SCSI).

The Proceedings in your hand contains excellent plenary speeches and papers presented at the Conference and covers various branches in system simulation and scientific computing including System Simulation Theory and Methodology, Modeling and Algorithm, Simulation Software and Simulation Computer Systems, Application of Artificial Intelligence and Expert System to System Simulation, Real-Time Image Generation and Display Technique, Simulators and Simulation Equipment, The Application of Simulation Technology to Engineering and Nonengineering Areas, CAE/CAD/CAM/CIMS/CAS.

I believe that all the plenary speeches and papers will offer you plenty of valuable information and be of much benefit to simulation scientists and engineers all over the world.

Wen Chuanyuan

MODELING PROBLEMS OF HYBRID EVENT DYNAMIC SYSTEMS

Wen Chuanyuan
P.O.Box 85,
Beijing University of Aeronautics and Astronautics,
Beijing 100083, P.R.China

1. Abstract

This paper discusses the modeling problems of hybrid event dynamic systems consisting of continuous,discrete and inference-decision event dynamic systems.

2. Introduction

An event in a narrow sense would be regarded some times as information of certain event happened. In fact, the meaning of an event is more widespead and profound than the narrow sense explained above. It could represent human thought activity , behaviour process, and even the overall procedures or processes of an action. For example, it could include an idea, a project, management, performance, evaluation which are engaged in economic plan or complicated engineering systems.

3. Modeling Problems of Hybrid Event Dynamic Systems

(1)General Description of Hybrid Event Dynamic Systems

Hybrid event dynamic systems consist of continuous, discrete and inference-decision event dynamic systems. It is a universal conception of high generalization and abstraction for overall systems. Some scientific terms or definitions of hybrid event dynamic systems are illustrated as follows:

A.Event

An event is all the activities to perform a task throughout its whole life cycle. The process is a subunit of an event if a process belongs to one part of the event which is considered as a fundamental unit of a task.

Here, the event is represented as ${}^{x}_{z}\overset{S_k}{\underset{ij}{E}}{}^{y}_{t}$ [4]. The indexes of the symbol are: E— event, S_k— the classification of the event, x,y,z — space position and its variation or generalized space expressing various variables of the event, t— time of the event.

B.Hybrid Event Dynamic Systems(HEDS)

As well known, HEDS consists of continuous, discrete, inference-decision event dynamic systems. The principle for classification among the three kind systems could be specified with the internal characteristics of certain system. For example, the general flight control system could be treated as continuous event dynamic system without considering the external acting signal of discrete event mode.

a.Continuous Event Dynamic Systems(CEDS)

The CEDS could perform the specific requirements of certain event with predetermined static and dynamic quality when it is driven by the information of the event.

b.Discrete Event Dynamic Systems(DEDS)

Discrete events happen at discrete time and generally with randomness. DEDS could transit its states according to certain rules where it is driven by information of the event.

c.Inference-Decision Event Systems(IDES)

I think that IDES has the following three special features:

The first is that the external excitation and internal motive of human neural system always have the characteristics of discrete event.

The second is that signals are generally conducted with impulse mode and continuous electricity field propagation style via neural system.

The third is that thought activity and inference-decision are very complicated processes of multiple stage integration and high order comprehension mechanism of human brain.

In this paper, the thought activity and behaviour process system is regarded as one part of HEDS.

(2)The Relationship among CEDS,DEDS,IDES and HEDS

Some concepts of CEDS and DEDS could be given as follows:

DEDS could contain sub-event system, which belongs to CEDS. For example, a stochastic service system is a DEDS, which would be analysed with queuing theory. However, the dynamic processes of customer and servant belong to CEDS, and would be analysed with algorithm of CEDS. Sometimes CEDS would work under DEDS condition. For example, flight control system is generally a CEDS according to its inherent characteristics. But sometimes it works under DEDS condition when stochastic gusts act on the aircraft.

Inference-decision event systems always possess the characteristics combineed with DEDS and CEDS. In this way it presents a hybrid event dynamic system, even a super-hybrid event dynamic system.

(3)The Specific Mathematical Description and Algorithm for CEDS, DEDS and HEDS

As well known, CEDS can be described with differential or partial differential equation. The appearance or transition of DEDS state can be described with logic level mathematical model without considering physical time factors(for example, definite automata, Petri net), dioids algebra and statistical level mathematical model(for example, queuing theory).

By studying the appearance and finish of events, state transition, event dynamic process and information relationship among CEDS, DEDS, IDES and HEDS, and information structure of HEDS, some description methods and mathematical models are presented as follows.

A.HEDS Information Structure Models

Here the keypoint is to take events as the core. Meanwhile the reference[4] had explained the building of mathematical models of hybrid event systems, mainly through the processing and expressing method of tree form, time chains, space chains, generalized space chains, concurrent processing, hierarchical structure. That paper had also discussed all the details about the symbols of time, space , sequence and classification of an event, parallel and serial decomposition and interconnection of events, description of states and characters of materials, environment, workflow, a dynamic reaction process and concurrent engineering.

B.The Mathematical Model of HEDS

We take the fire/flight control system as a simplified example of HEDS and discuss how its mathematical model is built.

The main feature of tactical decision, trajectory generation or override coupler would be discrete links. However, the task of trajectory generation link is to calculate the continuous trajectory according the command given by tactical decision link. We give the brief equations of HEDS which is combined with equation of DEDS and CEDS, boundary conditions in accordance with the specific requirements of HEDS.

The following is simplified equations of DEDS:

$$X_d(k+1) = A_d X_d(k) + B_d U_d(k+1) + G_{cd} X_c(k+j_{cd}) \quad (1)$$

or

$$F_{cd} : \tilde{X}_c(k) \rightarrow \tilde{X}_d(k+j_{cd}) \quad (2)$$

The following is simplified equations of CEDS:

$$X_c(k+1+j_{dc}) = A_c X_c(k+j_{dc}) + B_c U_c(k+1+j_{dc}) + G_{dc} X_d(k+1+j_{dc}) \quad (3)$$

or

$$F_{dc} : \tilde{X}_d(k) \rightarrow \{\tilde{X}_c(k+j_{dc}), \tilde{A}_c, \tilde{B}_d, \tilde{G}_{dc}, \tilde{U}_c(k+j_{dc})\} \quad (4)$$

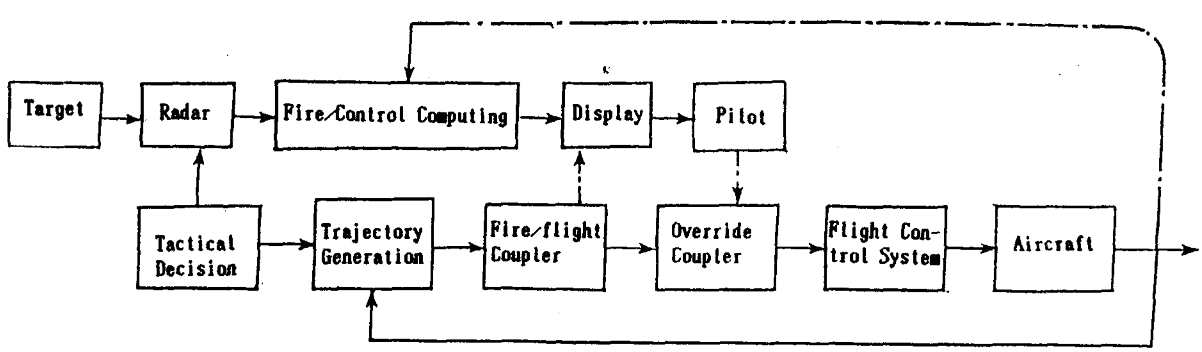

Fig.3.1 Simplified block diagram of a fire/flight control system

The example for boundary conditions of HEDS is as follows:

$$\{\sum_{i=1}^{n}[(T_{c_i d}-T_{c_i a})+\Delta T_{c_i}]-\sum_{j=1}^{m}[(T_{s_j f}-T_{s_j b})+\Delta T_{s_j}]\} \le 0 \quad (5)$$

$$G_{cd}X_c(k+1+j_{cd}) = \begin{cases} G'_{cd}X_c(k+1+j_{cd})\delta(k+1+j_{cd}-m_c) \\ G'_{cd}X_c(k+1+j_{cd})[I(m_{c_1})-I(m_{c_2})] \end{cases} \quad (6)$$

$$G_{dc}X_d(k+1+j_{dc}) = \begin{cases} G'_{dc}X_d(k+1+j_{dc})\delta(k+1+j_{dc}-m_d) \\ G'_{dc}X_d(k+1+j_{dc})[I(m_{d_1})-I(m_{d_2})] \end{cases} \quad (7)$$

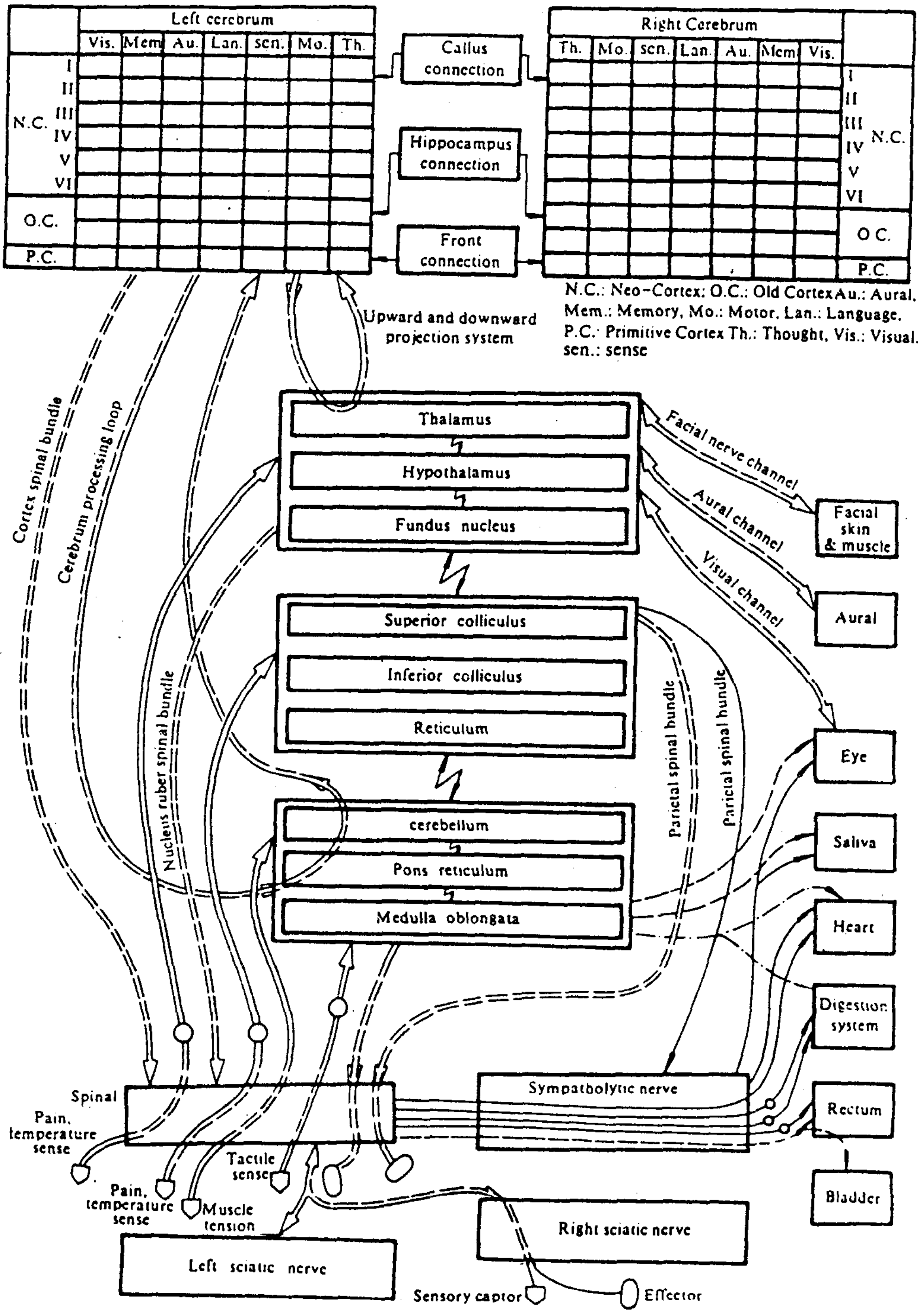

Fig.4.1 Simplified block diagram of neural signal flow

Here,

F_{cd}, F_{dc}— mapping relationship,

X_d,X_c — state variables or state transition of DEDS and CEDS, $X_d \in R^{n_d}$, $X_c \in R^{n_c}$,

A_d,B_d,G_{cd}— coefficient matrixes of DEDS and $A_d(n_d \times n_d)$, $B_d(n_d \times n_{ud})$, $G_{cd}(n_d \times n_c)$,

A_c,B_c,G_{dc}— coefficient matrixes of CEDS and $A_c(n_c \times n_c)$, $B_c(n_c \times n_{uc})$, $G_{dc}(n_c \times n_d)$,

U_d,U_c — input of DEDS and CEDS,

T_{c_id}, T_{c_ia}, ΔT_{c_i} — departmart, arrival time and time interval without input of the ith customer,

T_{s_jf}, T_{s_jb}, ΔT_{s_j} — finished, initial time of service and free time interval of the jth service desk,

k — the number of sampling period of DEDS, surely k could be selected as a number of sampling period of HEDS,

j_{dc} — the response time of CEDS delayed in respect to input from DEDS according to time unit of sampling periods.

j_{cd} — the response time of DEDS delayed in respect to input from CEDS according to time unit of sampling periods.

4. The Exploration of Modeling Problems of IDES Associated with Thought Activity

(1)General Description

Thought activity and inference-decision is a very complicated problem. Most of them are not so clear and have been limitedly known based on the work of physiologists, psychologists and biologists. We have analysed, induced and infered the related knowlodge via system science. The inference-decision event system associated with thought activity will be discussed briefly as follows.

(2)Some Ideas and Conclusions on the Function of Human Brain and Neural System Concerning the Modeling

A.Human Brain and Neural System are the Rhythmic Organism.

Under the effect of biologic clock rhythm, external stimulation and internal motives, human body acts adaptively and rhythmically at all times. Every system in human body, especially human brain and neural system act under the effect of biologic maternal clock, even at rest or in a deep sleep. The biologic maternal clock of most mammals lies on the center of inferior colliculus. Pineal is also an important composed part of the biologic clock of human body. It periodically grows hormone at night and changes its conditions in a hour, a day, a month, a season or a year.

B.The Neurons and Neural Fibers are Generally in a Growing State According to Needs

Because of the direction, speciality, propagation and reconstruction of the neurons and neural fibers, the neural system can deal with complicated information and events. Especial neurons and neural fibers would grow up due to the action of NGF(Nerve Grouth Factor), NSF(Neuronal Survival Factor), NEF(Neurite Extension Factor), NPF(Neurite Promoting Factor), NCAM(Neural Cell Adhension Molecule), which could be produced in case of the activity of external stimulation or internal motives.

C.The Main Information Bundles, Loops, Channels, upward and downward Projection System and Connections of Neural System and Human Brain.

Fig.4.1 [3] briefly indicates the main information transfer paths of the overall human brain and neural system.

D.The Memorizing Loop of Brain Cortex and Neural System

Fig.4.2 illustrates the memorizing loop of brain cortex and neural system.

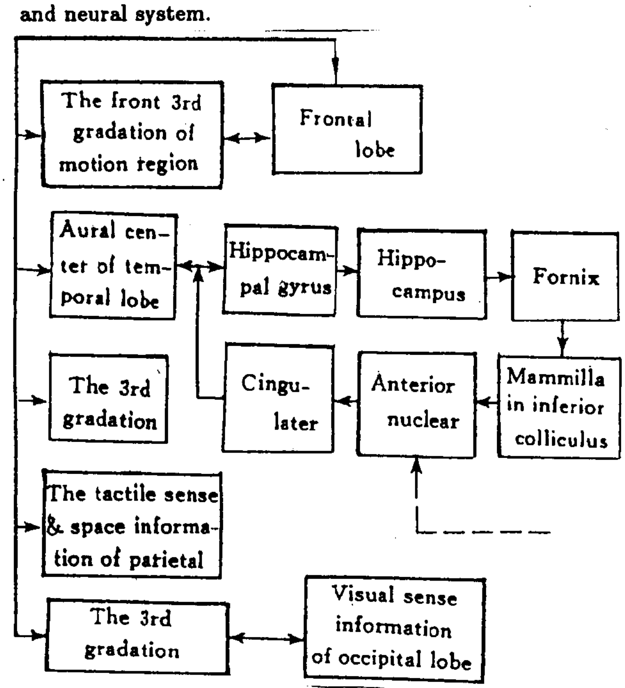

Fig.4.2 The memorizing loop of brain cortex and neural system.

E.The Function Columns of Brain Cortex

A cortex function column is a general structure framework of brain cortex, in which the cortex cells with same functions are arranged in regular space structure. Each function column includes many different kinds of neurons. The specially afferent impulses magnify, modulate and integrate in the column by various connections of neurons in the column. Each function column transmits information to other parts of central nervous through delivering impulses by pyramidal cells. At the same time, it also can inhibit the action of other neighbouring function column.

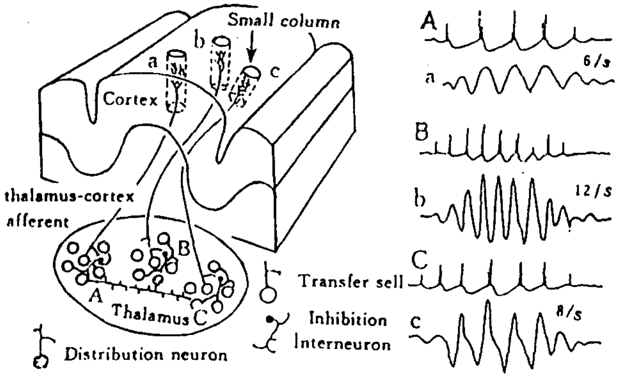

Fig.4.3 Brain bioelectric activities and the function column of brain cortex.[2]

A,B and C illustrate neuron of thalamus with their axon projecting to columns a,b,c. in different regions respectively.

A,B and C, the curves in the right side are the electric activities recorded in thalamus neuron.

a,b and c are the electric activities recorded on the surface of cortex column.

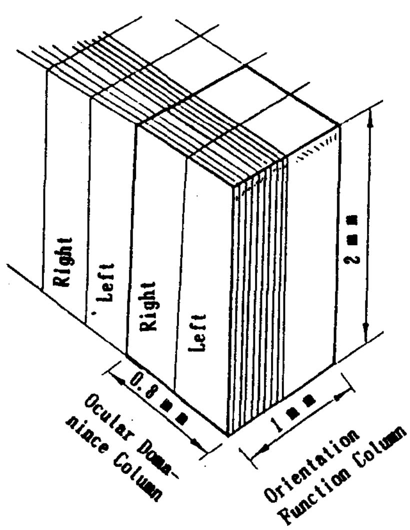

Fig.4.4 principle diagram of the hyper function column of visual cortex.[2]

Fig.4.5 briefly illustrates the main parts of visual blocks of monkey cerebrum.

The indexes in Fig.4.6 are shown as follows: V1, V2, V3, V4 -17th, 18th, 19th and 20th blocks of cortex; MT - Middle Temporal Cortex; MST - Medial Superior Temporal Cortex; VIP - Ventral Intraparietal Cortex; LIP - Lateral Intraparietal Cortex; PIT - Posterior Intratempo-

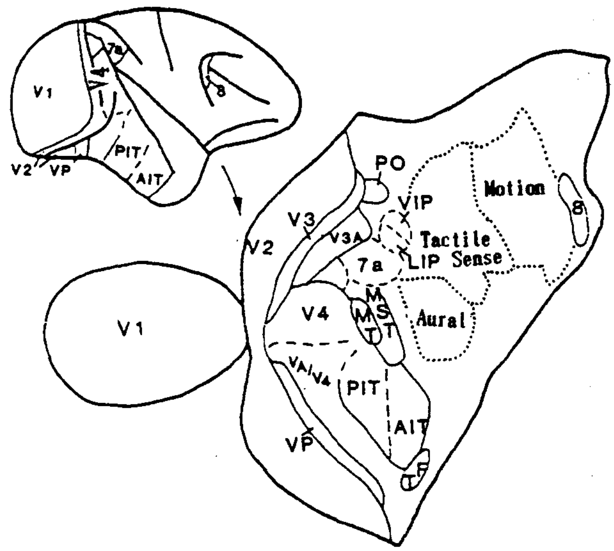

Fig.4.5 The distributed cortex blocks of monkey visual system.[2]

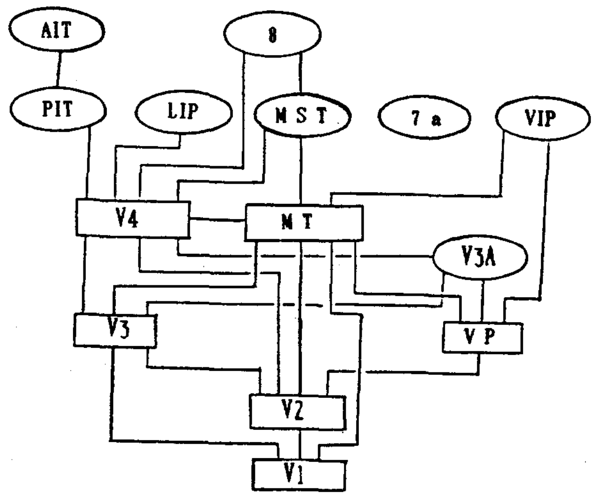

Fig.4.6 The gradation relationship of monkey higher visual cortex.[2]

ral Cortex; AIT - Anterior Intratemporal Cortex; 7a - A sub-block of 7th cortex block; 8 - 8th cortex block; PO - Parietal Occipital Cortex; VP - Ventral Posterior.

Fig.4.6 shows that twelve blocks of monkey vision cortex are classified into six gradations in accordance with anatomy. However its credibility waits validation by the matching effect according to cortex function.

The visual signal flows are projected mutually among the different visual cortexes.

Van Essen and others have presented some rules about the visual signal flow path:

First, the connections and visual signal flow projections exist mutually in two-way form among different vision cortex blocks.

Second, the feature of projection layer of cells and axons in the visual cortex of two-way connection is very different for each other. Most of the projection cells of forward and upward channels are positioned inside shallow layer of cortex. Only a few of them come from the deep layer of cortex. However, all of them stop at layer IV of visual cortex. Projection cells of backward or downward channels come from shallow and deep layers of visual cortexes and project to the layers except layer IV . They mainly come from layer I and IV

Third, in the view of the couple of connection of visual cortexes, it is possible to illustrate the gradation of overall cortexes.

VP in Fig.4.6 is limited by input of upper vision field, while V3 and V4 are limited by input of lower vision field.

V1→···→MT→MST is the motion information channel, V1, V2, V3, V4 → IT(PIT,AIT) is the visual information channel of colour and shape.

At last, in Fig.4.6, the rectangle means that its function is validated by experiments. And the ellipse shows that its function has not been proved.

(3)Some New Assumptions

A.Long Time (Permanent) Memory would Disperse in Different Areas.

It has been introduced in reference[2] that temporal lobe is the location of permanent memory, and the stimulation acting on vestibula nerve and olivary nucleus can inhibit the excitative effect of Purkinje's cells caused by single stimulation of vestibula nerve. And the inhibition effect can last more than one to three hours. Hence a new assumption would be given as follows: the location of permanent memory is not necessary to restrict its area to only one position, such as temporal lobe, the long time memory location would be especially existed inside the cerebellum. Therefore the permanent memory location would scatter in different lobes and different parts of human brain.

B.The Structure of Information Channels in Human Brain

There are a lot of information channels in human brain, which look like the bus structure of digital computer systems, and transfer signals perfectly coordinated with each other. The constructions of these information channels are surely a hierachical structure, and predominant gradation information channel is in the frontal lobe.

C.The Hypercube Structure of Neural Integration and Comprehension System in Especial.

The neural system of human brain consists of comprehension system for high gradation thought activity, integration mechanism of information processing, scattered and variable time interval memorizing systems, different gradation information channels, and even different hormone systems. The structure of neural comprehension system is non-uniformly and orderly composed of comprehensive organisms, hyper function columns and appropriate information channels. Moreover, it has a hypercube form. Therefore it facilitates complicated and multimode comprehension activities.

D.The Relationship among Thought Activity, Aided Inference and Computation Tools

Generally, the object of human thought activities is to make macro-decisions, quality analysis, rough or approximate computation. The micro-decision, precise or quantitative analysis and precise and complicated computation could be performed with the help of aided analysis, inference or computation tools, or with the help of brain trust.

E.The Improvement and Newborn of Hypercube Thought Organism

The human hypercube thought organism could be improved or have a newborn structure because of the interior motives or exterior stimulation based on new thought methods or inference rules invented by people.

(4)Thought Activities and Human Inference Methods.

Thought activities are the fundation of all human activities and are carried out by neural and hormone systems. Most of them are macro and orientational decisions and inferences. Here, we only briefly discuss the construction of simplified mathematical models for inference, pattern recognition, prediction and decision which would be performed via the hypercube function columns and its high gradation organisms and other neural systems acted by exterior stimulation and interior motives. Now, we will explain them with a few simplified formulas.

A.Simplified Reasoning

a.Deduction

M→ P	All M is P	(8)
S→ M	All S is M	(9)
S→ P	So all S is P	(10)

b.Induction

$$A, B, C \rightarrow a, b, c \quad (11)$$

$$B, C \rightarrow b, c \quad (12)$$

$$A \rightarrow a \quad (13)$$

c.Analogical Reasoning

$$A \rightarrow a, b, c, d \quad (14)$$

$$B \rightarrow a, b, c \quad (15)$$

$$B \rightarrow d \tag{16}$$

d.Nonmonotonic Reasoning

$$(\forall a)\{Bird(a) \wedge \sim Penguin(a) \wedge \sim Ostrich(a) \wedge \sim \cdots \Longrightarrow Fly(a)\} \tag{17}$$

The above formula means that most of birds can fly except Penguin, Ostrich and so on.

remark: '$\sim$' in the formula means Negation.

e.Fuzzy Reasoning

Under concept uncertainty condition, we let membership function $\mu_{F(u)}(u)$ describe fuzzy reasoning as follows:

Thirty years age is young $\rightarrow \mu_{young}(30)$

B.Pattern Recognition

a.The Principle of Statistical Pattern Recognition Method is Shown as the Following Formulas:

$U = [u_1, u_2, \cdots, u_n]^T$	characteristic vector	(18)
$\omega = [\omega_1, \omega_2, \cdots, \omega_n]^T$	pattern sorts	(19)
$U \approx \omega_i$	U is inside ω_i	(20)
$D_i(u) > D_j(u)$	$i, j = 1, 2, \cdots, m; i \neq j$	(21)

decision rule for U being inside ω_i sort.

b.Direct Fuzzy Recognition

$$\omega_i(u^*) = \max_{1 \leq j \leq n} \{\omega_j(u^*)\} \tag{22}$$

maximum membership decision rule for u^* being in sort ω_i

u – recognized object is an element in the universe of discourse U.

ω_i – fuzzy sets within U.

c.Indirect Fuzzy Recognition

$\omega_1, \omega_2, \cdots, \omega_n$ are assumed to be n fuzzy sets within the universe of discourse U, and u is the fuzzy set waiting for recognition in U.

$$(u, \omega_j) = \max_{1 \leq i \leq n} \{(u, \omega_i)\} \tag{23}$$

The above decision formula shows that u extremely nestles up to ω_j

C.Prediction

Some prediction models would be introduced as follows:

a.Polynomial Trend Method

$$X = a_0 + a_1 t + \cdots + a_m t^m \tag{24}$$

b.Compound Grouth Method

$$\frac{dX}{dt} = bXR(X) \tag{25}$$

R(X) – environment resistance

or,

$$X(k+1) = bX(k)R(X_k)\Delta T \tag{26}$$

c.Monadic Regressivity model

$$X_i = \hat{\alpha} + \hat{\beta} Y_i + \varepsilon_i \tag{27}$$

$\hat{\alpha}, \hat{\beta}$ are estimation values with respect to samples (X_i, Y_i; i=1,2,$\cdots$,n) and statistical variables. Error item "ε_i" is Gaussian distribution stochastic variable with mean value "0" and variance σ^2.

D.Decision

a.Max Max Criterion

$$MaxW_{ij} = W_{i1}(A_i, Q_1) \vee W_{i2}(A_i, Q_2) \vee \cdots \vee W_{ik_i}(A_i, Q_{k_i}) \vee \cdots \vee W_{iJ}(A_i, Q_J) = W_{ik_i}(A_i, Q_{k_i}) \tag{28}$$

$$j = 1, 2, \cdots, J$$

$$MaxW_{ik_i} = W_{1k_1}(A_1, Q_{k_1}) \vee W_{2k_2}(A_2, Q_{k_2}) \vee \cdots \vee W_{mk_m}(A_m, Q_{k_m}) \vee \cdots \vee W_{Ik_I}(A_I, Q_{k_I}) = W_{mk_m}(A_m, Q_{k_m}) \tag{29}$$

$$W^{-1}_{mk_m}(A_m, Q_{k_m}) \rightarrow A_m \tag{30}$$

The indexes in the above formulas are shown as follows:

A_i – the ith decision, $A_i \in$ A set

Q_j – the environment condition can not be controlled, $Q_j \in$Q set

ω_{ij} – value function

$\vee$ – to pick max value

$W^{-1}_{mk_m}(A_m, Q_m)$ $\rightarrow$ to inversely pick A_m from $W_{mk_m}(A_m, Q_{k_m})$

A_m – the decision selected according to max max criterion.

b.Max Min Criterion

$$MinW_{ij} = W_{i1}(A_i, Q_1) \wedge W_{i2}(A_i, Q_2) \wedge \cdots \wedge W_{ik_i}(A_i, Q_{k'_i}) \wedge \cdots \wedge W_{iJ}(A_i, Q_J) = W_{ik'_i}(A_i, Q_{k'_i}) \tag{31}$$

$$MaxW_{ik'_i} = W_{1k'_1}(A_1, Q_{k'_1}) \vee W_{2k'_2}(A_2, Q_{k'_2}) \vee \cdots \vee W_{m'k'_m}(A'_m, Q_{k'_m}) \vee \cdots \vee W_{Ik'_I}(A_I, Q_{k'_I}) = W_{m'k'_m}(A'_m, Q_{k'_m}) \tag{32}$$

$$W^{-1}_{m'k'_m}(A'_m, Q_{k'_m}) \rightarrow A'_m \tag{33}$$

$\wedge$ – to pick minimum value

A'_m – the decision selected according to max min criterion

(5)Modeling for Thought Activities and Behaviour Processes

For simplicity we take buying apples as an example and utilize simplified graphic model to illustrate the information relationship of human thought activities and behaviour processes.(see Fig.4.7)

Fig.4.7 The principle diagram of thought activity and behaviour process events

Symbols in the figure:

S_{TA},S_{TAK},S_{TAK1},$\cdots$,S_{TAKL},S_{TAW},S_{TAW1},$\cdots$,S_{TAK_m},$\cdots$,S_{TAWM} stand for the events in thought activity respectively. X_{TA},Y_{TA},Z_{TA} and T_{TA} are the place (or generalized space) and time variables of S_{TA} which is the event of intending to buy apples. S_{TAK} means thought activity of considering what kind of apples being bought. X_{TAK}, Y_{TAK}, and Z_{TAK} express chemical and physical properties of apples and data address or other kinds of parameters(e.g. the memorizing address in temporal lobe).

X_{TAW}, Y_{TAW}, Z_{TAW}, X_{TAWM}, Y_{TAWM}, and Z_{TAWM} are the event of the kth kind of apples being chosen and its generalized space variables. For example, X_{TAW} is place of an apple shop; Y_{TAW} is the kinds of apples which the shop sells; Z_{TAW} is qualities of apples in this shop. Among the above symbols S_{TA}, S_{TAK}, etc. , T(Thought) stands for thought activity, A means apple, and K means kind.

S_{BA} is used to show the behaviour process event of going to buy apples; B means behaviour. S_{BA} can be decomposed into a lot of serial or parallel sub-events.

5. Conclusions

Events generally include tasks, decisions, projects, implementations, processes and results. They involve the elements like people, materials, environment, etc. Hybrid event dynamic systems consist continuous, dicrete and inference and decision dynamic systems. In the view of basic principles and methods, this paper has briefly discussed the special features of HEDS, modeling problems of HEDS and IDES. However, there are a lot of medeling problems and other objects of hybrid event dynamic systems awaiting us to research.

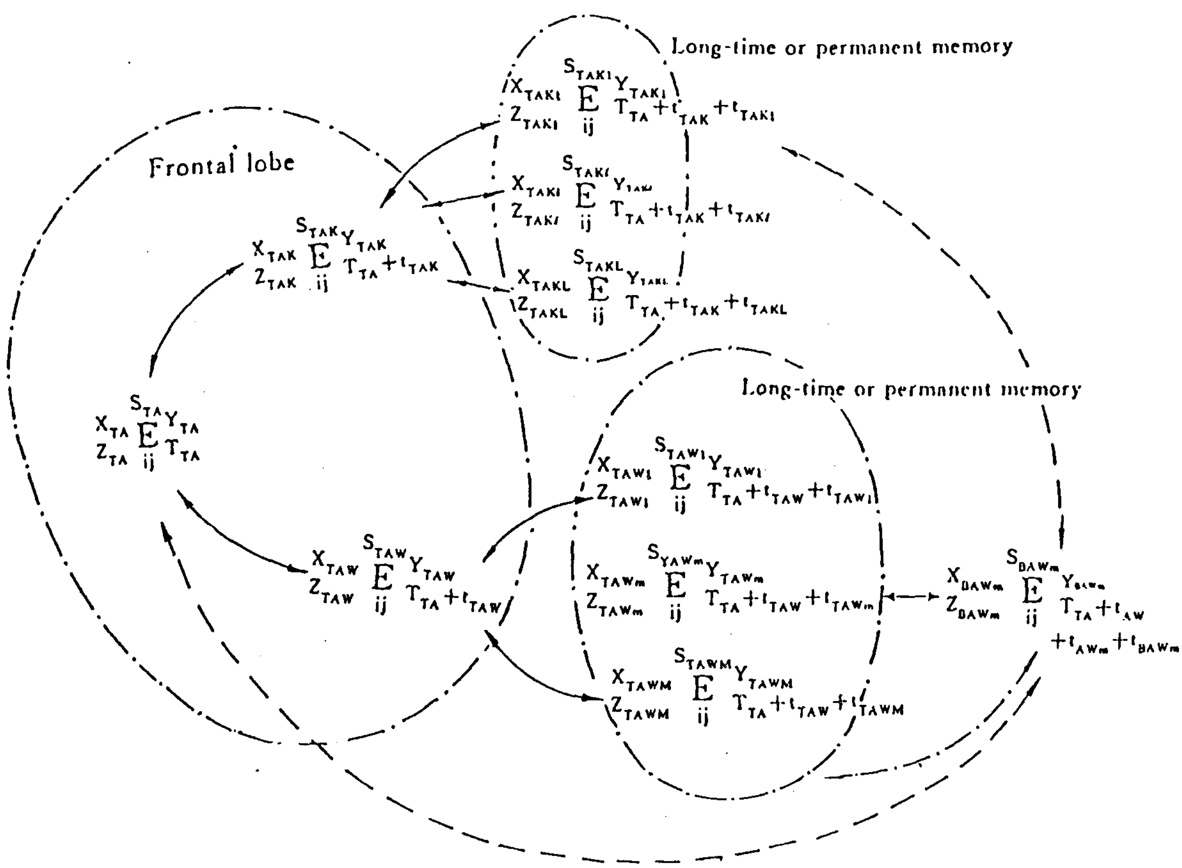

Fig.4.7 The principle diagram of thought activity and behaviour process events