A NEW TECHNIQUE OF FUZZY INFERENCE AND NEW GENERATION EXPERT SYSTEM *

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ABSTRACT: This is to mainly search for the problems of the application of fuzzy inferrence in the future generation expert system. Forthisreason, on architecture of new generation expert system disigned by our selves are introduced first (NGESM). And according to characteristics of NGESM (speedy current process of large-scaled knowledge), the new technique of fuzzy inference--LFSI is set up. The technique includes a more powerful knowledge represent model --limited fuzzy production relation and a high speed fuzzy semantic inference technique , in which relation composition and general mathematics operation are necessary. At last, the fuzzy inference algorithm of F-NGESM (Fuzzy-NGESM) is given.

KEYWORDS: Fuzzy Production Relation High Spped Inference
Fuzzy Semantic inference Fuzzy Expert System

NEW GENERATION EXPERT SYSTEM

1. MOTIVATION

The present AI system are almost based on production system (PS) (1) (2) . But in PS architecture,"inference" and "storage" are seperated, as a result a flask neck problem which is more profound and complex than "Von Neumann flask neck" comes into being--PS falsk neck (no uncertain problem solution in Von Neumann machine) . This makes the intrinsic concurreney contained in problem solving process unable to be effectively developed. Therefore we are designed a new type of system architecture (TUSA) to be the fundamental architecture of expert system (3) (see fig.1). NGESM is the concrate realization of TUSA. Theories thoroughly solved the "flask neck" problem of ES and can possibly become a new fundamental architecture of future generation intelligence commputer.

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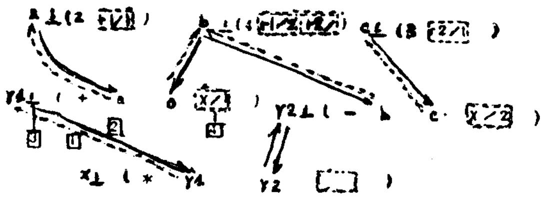
2. RELATIVE INFORMATION.

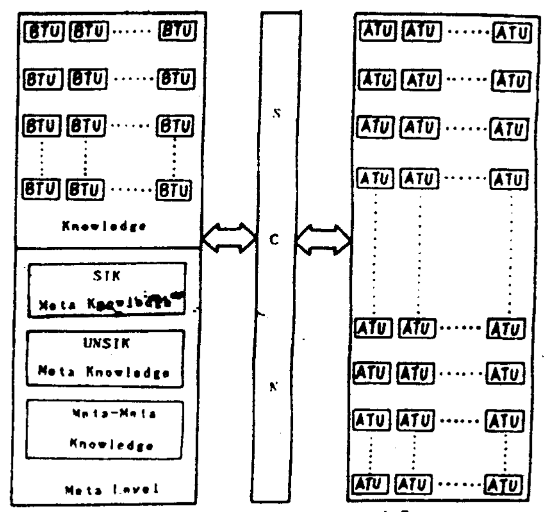
The frame of NGESM is the same as what fig.1 indicates. The following points, however, needs explaining.



1: Demand-driven 2, 3: Data-driven
4: Reference-address

Fig.1 The solution of x=(a+b)*(b-c) under multi-flow model with data flow as essential base

(1) The whole system consists of thinking units. BTU in AKM adopts nonodimensionalg, virtual, multitree array structure. ATU in blackboard AB adopts network structure. Every ATU, BTU processes simple function of inference and storage, e.g. basic match, act basic operation, receiving and sending token. But ATU can infer more complicatedly than BTU.



A K M (Active Knowledge Memory) A B (Active Blackboard)
ATU: A Thinking Units BTU: B Type Thinking Units
SCN: Synchronization Communication Net
Knowledge relying on the fields of Specific Issues
SIK: Knowledge relying on the fields of Specific Issues
UNSIK: Knowledge UNrelying on the fields of Specific Issues

Fig 2 Thinking units system architetures conceptual model

(2) NGESM adopts multiflow computing model with the combination of data driven, demand driven and necessary controldriven with data flow eing main (computing principles, see. fig. 2). Data driven maximally taps the concurrence of the procedure of problem solving, and overcomes the problems in complex assistant operation, required by demand driven. Demand driven solves the irregularity of data driven and the effective processing of high level data structure. Control flow driven make certain control more effective. Computing principles are shown in fig.2. By fig.2 we know: demand driven control, in fact, paves the way for data flow.

(3) In NGESM, knowledge is, by level, stored in AKM. Temporary data are fact are stored in AB. Thefact data in ATU are not authorized to send tokens to SCN·(the fact data here equal the factual knowledge in ES knowledge base and the temporary data users deposit). Through the control of the different positions of ATU by different-level meta knowledge, concurrency realize various ideas of hearistic control.

A NEW TECHNIQUE OF FUZZY INFERENCE --LFSI

1. KNOWLEDGE REPRESENTATION IN LFSI

The knowledge representation in our LFSI adopts a limited fuzzy production relation. As for information concerning the limitend fuzzy production relation, see reference (4). Our brief introduction follows below. The so-called limited fuzzy production relation is the production satisfies the following conditions.

1) The structure of the production is

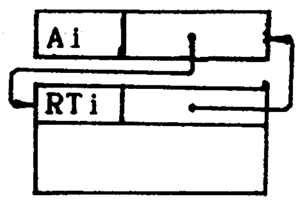
$\widetilde{\text{if}}$ <A1(RT1)>...<Ai(RTi)> $\widetilde{\text{then}}$ <B1>...<Bi>.

( ),< >: the contents in the brackets may appear 0 or 1 time.

Ai,Bi: is the main word.

RTi: is fuzzy implicated relation table, its structure and linkage to Ai are shown in fig. below.

RTi			
Ai	B1	Bi	Bn
ai1	b11	bi1	bn1
aii	b1i	bii	bni
ain	b1n	bin	bnn



2) There is only one consequent in "$\widetilde{\text{if}}$... $\widetilde{\text{then}}$" (i=1 for Bi).

3) There is only one fuzzy proposition in "$\widetilde{\text{if}}$... $\widetilde{\text{then}}$", and the others are all the binary logical.

4) The elements number fg of the ordered sets of fuzzy concepts of fuzzy language operator is limited for every proposition (max(fg) = 7).

5) The inexactness of probability could not be considered.

2. LIMITED FUZZY SEMANTIC INFERENCE (LFSI)

In our technic of limited fuzzy semantic inference, the backward inference model is adopted. As the limited fuzzy production relation is used for knowledge representation, inference mechanism of this technic is almost the same as general production systems. But modifications ar erequird, i.e. if a goal is a fuzzy proposition, then searching of the goal is done in two steps. First to match main-words, if successful, match fuzzy language oprator. This process is similar to the problem reduction of FRIL of Zhou Shanqiong and J.F. Baldwin." But these two are substantially different. They produce a reduction tree at first and then soive it.

But in our method, the reducing and solving are proceeded simultaneously. Besides, relation composition operations and general mathematical operations are not necessary. Nor are the concerning theories of L.A. Zadeh and bacic relation tablle of J. F. Baldwin (the possibility distribution of L.A.Zadeh in fact). And our efficiency is much high than that of J.F.Baldwin and S.Q.Zhou. Desides, our inference process is concurrency.

3. HIGH SPEED TECHNIQUE OF LFSI

To factually apply the limited fuzzy semantic technic to autonomous real time control expert system, we, by making referenc of ideas of Reta algorithm and ES/KERNEL algorithm (5) ,advanced three kinds of high speed fuzzy semantic inference tecnic --R*FSI.E*FSI (R* fuzzy semantic inference,E* fuzzy semantic inference) (6) and T*FSI (fuzzy smantic inference based on two-fold random search) . At the present, we are applying the three tecnics to the automated decision command expert system for the attack of submarine torped and to the autonomous real time expert system for accident idgnosis of neuclear power. We are now giving a brief introduction to the main idea of the high speed technic.

(i) The High Speed Technique of R*FSI

The factors causing the lowness of inference speed of production system are as follows:

(1) "large-Scalization" ie the augumentation of the scale of the rule number and elements of work memory.

(2) "complication" ie the following cases appear in rule condition: a) the augumentation of variables b) the augumentation of suject value comparation among various models c) the augumentation of "OR" coherence of subject value.

R*FSI particially solved th above stated two problems of fuzzy production system. The high speed of R*FSI includes two parts.

1) To popularize the intercovering part of the parttern of rules. As there is so large a part of intercovering, the times for matching are reduced substantially. (for narration covenience, we didn't give the examples of fuzziness.The same follows below)

2) When infering, it is unnecessary to match every time all rule condion part with all state elements in work memory,only changed variables as matching object. As, in

every cognitive cycle , state changing in work memory is limited, the times for matching are reduced substantially.

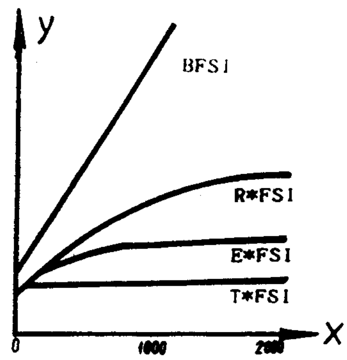
(ii) The high speed Technique of E*FSI

In R*FSI, if the more complex the rules are, the more conditions of logic "OR" are and if avriables are used in the rules, then the larger the net composition of R*FS is and therefore the superiority of R*FSI is greatly reduced.

In E*FSI, through the adoption of the method of complementary nodes, the above-stated problems of R*FSI are solved effectively. By Rete emthod, under the condition of E*FSI, cohere subnet with internodes immediately. But here it is not done like this. Instead, in the subnet of the condition nodes whose indicating value is introduced(it is the subnet of element A, here), relative hypotheticol nodes are added. Internodes and complementary nodes are implicit. thus, logically the swell of network can be prevented.

(iii) The high Speed Technique of T*FSI

E*FSI is an efficient one to solve the problem of real time process of large scale knowledge. However E*FSI did not improve much the search efficiency. Therefore, we have proposed a two-fold random search method on the ground of E*FSI. The two-fold domly made in both depth and breadth directions. In order to implement this triditional knowledge represetation method need to be chenged.



x : the number of rules
y : the act time concerning rules
Fig. 3 The rule scale and the time of act in high speed LFSI

(iv) The Effectiveness of High Speed Technic of LFSI (See fig. 3.)

INFERENCE ALGORETHM OF F-NGESM

1) The ATU storing the goal is embedded with root tags.

2) Every stored goals in a demand state are embedded with the absolute address of ATU and all the slave idle ATU absolute address, and send this goals to SCN for every ATU storing goals. According to the number p of the tokens and

relavent regultions, SCN allocates p idle BTU (in the AKM) and ATU (in the AB) respectively to every BTU (in the AKM) belonging to "rules type" and to ATU embedded with fact data tags in AB, and then broadcast p goal tokens respectively into the allocated idle ATU and BTU mentioned above. (The number p of tokens has two values, token* as p*, token~ as p~.)

3) The parellel and independent going of every BTU and ATU matche sthe goals with kindling conditions of its own TU.

4) If the fact data (in blackboard AB) matched with goals comes into being, then (i) if fact data is an unfuzzy condition, then the unit ATU stored with fact data, according to the reference address in goal tokens, sends fact and absolute address of ATU pasing on goal tokens to corresponding ATU. Meanwhile according to the absolute address provided by goal token, locates the demand driven state to sending state, (ii) if fact is fuzzy condition, then ATU storing this fact data finishes the operation of (i) and checks the token if it has fuzzy language operator, if it has, then <a> locate Ai to "sending state" and Aij to "demand -driven state", <b> is registered at SCN .

If the rule matched with goal comes into being, then (i) if there is a fuzzy proposition in the rule-body matched successfully, then the ATU decomposes divides subgoals (fuzzy proposition) at the same time, as a result, Ai, Ai and Aij come into being, the ATU turns subgoals to be data driven state, Ai to be demand driven state, Aij to be "demand driven state"*, turns Ai and Ai to be the relation of "one" union, turns Aij to be or relation, and embed the number and absolute address to Ai, (ii) else the unit BTU of storing the rule according to the reference address in goal token, sends rule body and the absolute address of the unit passing on goal token to corresponding ATU, and embeds demand driven token to every subgoal in a rule body. And meanwhile according to the absolute address provided by goal token, locates the demand driven state of the goal token give to data driven state and illustrates the numbers of subgoal in the rulebody and their relationship: "AND" or "OR".

If that matched with storing goal is meta rule, then the unit BTU storing the rules, according to the absolute address provided by goal token giver, sends the rule body of the meta rules to the inner control articles of goal token giver so as to realize the search strategies of "Pseudo or Parellel", i.e. heuristic search of wide conditions.

If a rule or a fact data is matched by n goal(including meta rules) then it copies n rules or fact data and according to the methods stated above send respectively to ATU concerned.

If ATU provided with reference address by a goal token is already in "busy" state, then it is reallocated by SCN.

5) Recovers ATU embeded with fact data tags. BTU embeded with fact data tags releases, i.e. restores to "idle" state; if BTU embedded with "rule type" recovers, then the rule embedded with "meta level" recovers. 6)Every ATU check state of its own. (i) If it is "data driven" state, then (a) it checks the number of subgoal and the relationship ("AND" or "OR"). If it is "AND", then it is all; if it is "OR", then it cuts off according to the systematic wideth-step length of "OR" parellel (different systems may set up different width-step length) and its heuristic type in the control articles. (b) if it is in "waiting" state, then it checks the kindling conditions; if satisfied, then the following operations are performed "and" "or" and "one-unification" etc and turns "waiting state" to "sending state". (c) if it is in "sending" state, then it checks ATU to see if it is "root"; if it is, it reports: problem is already solvesd or it sends data to ATU nominated. (ii) If it is in "demand driven" state, then it regards the data inside as a new goal and starts to do from 2) And continues the above-stated procedure.

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