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Fuzzy Knowledge Representation for Fuzzy Reasoning Systems

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Abstract—The fundamental aspect of fuzzy reasoning in Expert systems is knowledge representation. It is directly knowledge representation of fuzzy propositions in Expert Systems. It is easy through the intermediate represention of Fuzzy proposition with the Fuzzy Knowledge Representation. In this paper Fuzzy Knowledge Representation is proposed for fuzzy positions to Knowledge Representation in the system. The Fuzzy Agents are independent fuzzy reasoning components reasoning with fuzzy information in the system. These Fuzzy agents are to be co-operated and co-ordinated in distributed environment. The Automated Fuzzy Reasoning Systems (AFRS) and Distributed Automated Fuzzy Reasoning Systems(DAFRS) are studied using Fuzzy Knowledge Representation.

Index Terms— Fuzzy Knowledge Representation, Fuzzy Agents, Fuzzy reasoning and Distributed Fuzzy Reasoning

1 Introduction

The problem solving in the system may be viewed as a collection of intelligent agents and these agents are to be co-operated and co-ordinated in distributed environment. The fuzzy agent is the agent which deals with independent component in the Fuzzy system, each of which reasons based on the knowledge available [2]. If the information available to the system is uncertain information, it has to deal with Fuzzy logic[11].

In the following, Automated Fuzzy Reasoning Systems are studied with Fuzzy logic and Fuzzy reasoning using Fuzzy Knowledge Representation and Fuzzy agents. These Fuzzy Knowledge Representation and Fuzzy agents are are firther studied for the Distributed Automated Fuzzy Reasoning Systems (DAFRS).

2 FUZZY LOGIC AND FUZZY REASONING

Zadeh [13] has introduced Fuzzy set as model to deal with imprecise, inconsistent and inexact information. The Fuzzy set A of X is defined by its membership function μ_A take the values in the unit interval [0, 1]

μ_A: X →[0, 1], where X is Universe of discourse.

For example,

Consider the Fuzzy proposition "x is tall" and The Fuzzy set 'Tall" is defined as

μ_{Tall} (x) →[0, 1], x ∈ X

Tall= $\mu_{Tall}(x_1)/0.6+\mu_{Tall}(x_2)/0.75+...+ \mu_{Tall}(x_n)/0.67$

Fuzzy logic is defined as combination of Fuzzy sets using logical operators. Some of the logical operations are given below

Suppose A, B, C are Fuzzy sets, The operations on Fuzzy sets are given below

$A \vee B=\max(\mu_A(x), \mu_B(x))$ Disjunction

$A \wedge B=\min(\mu_A(x), \mu_B(x))$ Conjunction

$A^{-}=1-\mu_A(x)$ Negation

$A \rightarrow B=\min \{ 1, (1-\mu_A(x) +\mu_B(x)) \}$ Implication

$A \circ B=\min_x \{\mu_A(x), \mu_B(x)\}/x$ Composition

The Fuzzy propositions may contain quantifiers like "Very", "More or Less" ect. These Fuzzy quantifiers may be eliminated as

$\mu_{Very}(x) =\mu_A(x)^2$ Concentration

$\mu_{More\ or\ Less}(x) = \mu_A(x)^{1/2}$ Diffusion

Fuzzy reasoning[12] is drawing conclusions from Fuzzy propositions using fuzzy inference rules[10]. Some of the Fuzzy inference rules are given bellow

R1: x is A
x and y are B
———————
y is A∧B

R2: x is A
x or y is B
———————
y is A∨B

R3: x and y are A
y and z are B
———————
x and z are A∘ B

R4: x or y are A
y or z is B
———————
x or z are A ∨ B

R5: x is A
if x is A then y is B
———————
y is Ao (A→B)

3 FUZZY KNOWLEDGE REPRESENTATION

Considr the fuzzy proposition

Rama is Tall

The above proposition is represented in predicate logic

Is(Rama, Tall),

which is unable to convey the information.

The Fuzzy Knowledge Representation, an intermediate represention is nessasary for fuzzy proposition

Fuzzy Knowledge Representation is the intermediate representation to knowledge base in the systems. Fuzzy know-

ledge representation is the knowledge representation of the Fuzzy proposition.

Fuzzy Knowledge Representation for the Fuzzy proposition " x is A" is defined as

[A]R(x)

Where Ä"is fuzzy set, R is a relation and "x" is individual in universe of discourse X.

For instance ,

The fuzzy proposition "Rama is Tall" is represented as

[Tall] Height(Rama)

Fuzzy Knowledge Representati shall be extended to

[A]R(x,y), where x X, y Y

For instance ,

The fuzzy proposition "Rama has Cough" is represented as

[Cough] symptom(Rama, Cough)

Fuzzy Knowledge Representation shall be extended to logical operators

[A lop B]R(x,y), where lop is ", V,¬, → "

The Fuzzy proposition "Elephant is Tall and Weight " is represented as

[Tall Weight]Big(Elephant)

4 AUTOMATED FUZZY REASONING SYSTEM

The AFRS(Automated Fuzzy Reasoning System) is Fuzzy Agent for Fuzzy reasoning with Fuzzy facts and rules. These Fuzzy facts and rules are modulated as Fuzzy Knowledge Representation. The Fuzzy agent is independent component which performs Fuzzy reasoning in AFRS.

The fuzzy agent is an intelligent agent which deals with uncertainty in the system.

Some of the Fuzzy Reasoning rules are

R1: [A]R(x)
[B](R(x) and R(y))
———————
[A B]R(y)

R2: [A]R(x)
[B](R(x) or R(y)
———————
[AVB]R(y)

R3: [A](R(x) and R(y))
[B](R(y) and R(z))
———————
[A B](R(x) and R(z))

R4: [A](R(x) or R(y))
[B](R(y) or R(z))
———————
[AV B](R(x) or R(z))

R5: [A]R(x)
if [A]R(x) then [B]R(y)
———————
[Ao (A→B)]R(y)

For instance

[Tall] hight(x)

[Approximayely_Equal(]height(x) andheight(y)_
———————
[Approximayely_Equal Tall]height(y)

Consider the following Fuzzy fact and rule for Fuzzy Reasoning in AFRS

Sita is young

If Sita is young then Gita is very young

Using the above Fuzzy fact and Fuzzy rule,it may be modulated as

[Young] Age (Sita)

If [Young] Age (Sita) then [Very Young] Age [Gita]

The Fuzzy reasoning using Fuzzy Knowledge Representation in AFRS is given using R5 as

[Young] [Young→ Very Young] Age(Gita)

5 DISTRIBUTED AUTOMATED FUZZY REASONING SYSTEM

DAFRS is a collection of AFRS in the distributed environment in which the Fuzzy agents are to be co-ordinated and co-operated in the Distributed environment[1,5. DAFRS performs reasoning with the Fuzzy agents and Fuzzy Knowledge Representation in the Fuzzy agents are to be co-ordinated and co-operated with the other agents in the Distributed environment. The co-operation is in three steps. In the First, the Fuzzy agent and Fuzzy Knowledge Representation are defined. In the Second, if the local Fuzzy agent has no sufficient information, it connects to other Fuzzy agent for required information. Third, the DAFRS is to co-operate and co-ordinate to get the final solution

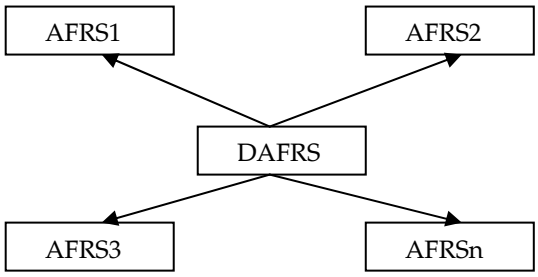

Fig.1.

Example 1

Consider two Automated Fuzzy Reasoning Systems AFRS1 and AFRS2 and each has the following Fuzzy Knowledge Representation.

AFRS1 consists of the following Fuzzy Knowledge Representation

Rama is Tall.

F1:[Tall] Height(Rama)

Rama and Krishna are approximately equal.

F2: [Approximately_equal] (Height (Rama) and Height (Krishna))

Gita is young.

F3: [Young] Age (Gita)

The AFRS2 consists of the following Fuzzy Knowledge Representation.

Krishna or Sita is tall.

F4: [Tall] (Height (Krishna) or Height (Sita))

Sita or Gita is small.

F5: [Small] (Height (Sita) or Height (Gita))

Sita and Gita are appriximateli equal.

F6: [Approximately equal] (Height (Sita) and Height (Gita))

If Sits is is young Gita is very young

F7: if [Young] Age (Sita) then [very Young] Age (Gita)

The Fuzzy Agent in AFRS1 shall be reasoned as from F1, F2 usnig R1

F8: [Tall ▯ Approximately equal] Height (Krishna)

The Fuzzy Agent in AFRS2 shall be reasoning as from F4, F5 ising R2

F9:[Tall V Small]Height(Krishna) or Height(Gita)

The Fuzzy agents in AFRS1 and AFRS2 give the reasoning in the distributed environment from F8, F9 using R2

F10: [Tall ▯ Approximately_equal] V
[Tall V Small] Height(Gita)

From F3 and F6 using R1

F11: [Approximately equal ▯ Young] Age(Sita)

From F11, F7 using R5

F12: [Approximately equal ▯ Young] ▯
[Young →Very Young] Age(Gita)

The Fuzzy inference for " What about Gita's height and age" is given from F10 anf F12

[Tall ▯ Approximately equal] V [Tall V Small] Height(Gita) ▯
[Approximately equal ▯ Young] ▯
[Young->Very Young] Age(Gita)

Example 2

A Medical example is considered in the following to discuss DAFRS

AFRA1 has following facts and rules

Rama has Cold

If Rama has Cold Then Rama has Sneezing

If Rama has Cold Then Rama has Headache

The above Fuzzy facts may be modulated as

F1:[Cold] Symptom(Rama, Cold)

F2:If [Cold] Symptom(Rama, Cold) Then
[Sneezing] Symptom(Rama, Sneezing)

F3: If [Cold] Symptom(Rama, Cold) Then
[Headache] Symptom(Rama, Headache)

From F1 and F2 infer

F4:[Cold o (Cold → Sneezing] Symptom(Rama, Sneezing)

From F1 and F3 infer

F5:[Cold o (Cold → Headache] Symptom(Rama, Headache)

AFRS2 has following rules

If Rama has Sneezing Then Rama has Fever

If Rama has Headache Then Body pains

The above Fuzzy facts may be modulated as

F6:If [Sneezing] Symptom(Rama, Sneezing) Then
[Fever] Symptom(Rama, Fever)

F7:If [Headache] Symptom(Rama, Headache) Then
[Body_pains] Symptom(Rama, Body_pains)

From F4 and F6 infer " What is about Rama fever" as

F8:([Cold o (Cold → Sneezing] o
[Sneezing→Fever])Symptom(Rama, Fever)

From F5 and F7 infer" What is about Rama body_pains" as

F9: ([Cold o (Cold → Headache] o
[Headache →. Body_pains]) Symptom(Rama, Body_pains)

6 FUZZY KNOWLEDGE REPRESENTATION AND LOGIC PROGRAMMING

The Prolog is a Logic Programming language. It contains mainly predicates and Clauses[2]

A predicate is a relation with name of the relation and arguments . The arguments may be contain variables or constants.

for instance

father(x,y)

father(raama, dasaradha)

where father is name of the relation, x and y are variables, and raama and dasaradha are constants.

A clause is a rule with combination of AND/OR predicates for the rules.

For instance

grandfather(X, Z) :- father (X, Y) , father (Y, Z).

Suppose, we have following facts and rules

Raama is father of Lava

Raama is father of Kusha

Dasaradha is father of Raama

If X is father of Y and Y is father of Z then X is Grand father of Z

Suppose, we want to find grand children of Dasaradha

The Prolog programming may be written as

predicates

father(lava, raama).

father (kusa raama).

father (raama, dasaradha).

clauses

grandfather(X, Z) :- father (X, Y) , father (Y, Z).

Comple program for

grandfather(?, ?)

which give

lava

kusa

Consider the following Fuzzy fact and rule for Fuzzy Reasoning

Sita is young

If Sita is young then Gita is very young

The Fuzzy Knowledge Representation of the above Fuzzy fact and Fuzzy rule are given as

[Young] Age (Sita)

If [Young] Age (Sita) then [Very Young] Age [Gita]

In Prolog, it may be defined as

[Age (Sita, Young)

Age(Gita, Very young):- Age (Sita, Young)

It shell be programmed for Fuzzy reasoning

Age(Gita, (Young] ▯ (Young→ Very Young)

7 CONCLUSION

Fuzzy problems are used directly the Knowledge base to solve in the programming. systems. It is difficult to directly transforming fuzzy propostions in to logic programming. Fuzzy Problems need intermediate Knowledge Representation for Fuzzy propostions before defining in to programming. The Fuzzy Knowledge Representation is proposed as intermediate Knowledge Representation for the fuzzy propositions. The Fuzzy Knowledge Representation is proposed. These Fuzzy Knowledge Representation are used by Fuzzy Agents for the reasoning in the AFRS. In DAFRS, Fuzzy Agents are to be co-operated and co-ordinated in the Distributed environment. The AFRS and DAFRS are discussed. An example is given to study DAFRS. Distributed Fuzzy Expert systems are the main applications for DAFRS. Fuzzy

Medical expert systems are usually consist of imprecise, inconsistent and inexact information from various sources and these are to be co-ordinate and co-operate in distributed environment.

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