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Distributed Automated Fuzzy Reasoning Systems

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Abstract- Automated systems are to be programmed. Some time these automated has to deal with uncertain information. These Automated systems are to be co-ordinate and co-operated. The Fuzzy Expert Systems are automated systems to be co-operated and co-ordinate in distributed environment in the distributed environment. Distributed Fuzzy Medical Expert Systems are studied as an example.

Keywords- fuzzy logic, fuzzy reasoning, automated reasoning, distributed systems.

I. INTRODUCTION

Fuzziness occurs when the body of information is not clearly known. In medical knowledge [1] symptoms and diagnosis are fuzzy rather than likelihood. For example "John has headache (0.9)", "John has chest pain (0.6)" where 0.9 0.6 are fuzzy values. Given some universe of discourse X, a fuzzy subset A of X is defined by its membership function μA taking values on unit interval [0,1] , i.e.,

$\mu A : X \rightarrow [0,1]$

suppose X is finite set. The fuzzy subset A of X may be represented as

$A = \mu A(x1)/x1 + \mu A(x2)/x2 + \mu A(x3)/x3 + \mu a(x4)/x4 + \mu A(x5)/x5$

Where x1,x2,x3,x4,x5 are individuals and "+" is union.

The fuzzy subset "headache" may be represented as

Headache =0.4/x1 +0.6/x2 +0.8/x3 +0.7/x4 + 0.5/x5

The fuzzy set type 2 is given by

Headache= { 0.4/mild , 0.6/moderate, 0.9/severe, 0.45/normal}

John has "mild headache" with fuzziness 0.4 etc.,

The propositions may contain quantifiers like "very", "more or less", etc. these propositions can be reduced to simple propositions by using power operators. The square operator is used for "very", "most", (concentration), etc. the square root operator is used for "more or less"(diffusion), etc.

For instance,

Very headache = $headache^2$

=0.16/x1+0.36/x2+o.64/x3+0.49/x4+0.25/x5

The fuzziness in medical knowledge may be divided into two kinds, one is fuzzy number set and the other is discrete fuzzy set. The fuzzy number set contains usually integers or real numbers. The discrete fuzzy set contains usually linguistic variables.

For example, fuzzy number set in medical knowledge is given by

Fever(in F) = {0.4/98.5, 0.5/99, 0.6/101, 0.7/103}

Blood pressure { in mm.Hg} = {0.3/(110/70), 0.5/(120/80), 0.6/(125/100), 0.7/(130/120)}

Where 110, 120, 125, 130 are diastolic pressure and 70,80,100,120 are systolic pressure

Discrete fuzzy set in medical knowledge is given by

Rash ={ 0.4/mild, 0.6/moderate, 0.8/serious }

Conjunctivitis ={0.3/serious, 0.7/purulent, 0.8/chronic purulent}

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

$AoB = \min_x \{\mu_A(x), \mu_B(x)\}/x$ 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 is drawing conclusions from Fuzzy propositions using fuzzy inference rules[5]. 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 area 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)

II. FUZZY MEDICAL EXPERT SYSTEMS(FMES)

Expert Systems has been a rapidly developing field. A recent trend in Expert Systems is the development of Fuzzy Expert Systems for solving particular problems ranging from Medicine , Scientific, Engineering and Socioeconomic areas[1,7,8,11] . The object of the expert systems is to capture the knowledge of an expert in particular problem domain, represent it in a modular, expandable structure, and transform it to their users in the same problem domain. Many times knowledge available to the expert system fall under uncertain, imprecise, vague, incomplete, inconsistent and inexact. Zadeh[15] introduced fuzzy logic to deal such information which is based on belief rather than probable.

An Expert System is called Fuzzy Expert System if it reasons about fuzzy information. The components of fuzzy expert system are shown in fig.1. It is necessary to understand the components of fuzzy Expert system. The Fuzzy Expert System contains Fuzzy knowledge base (Fuzzy rule bsed), Interference engine, Working memory, Explanation subsystem, Natural language interference and knowledge question. We mainly concentrate on fuzzy knowledge bases because the others are vastly developed[11, 12, 25].

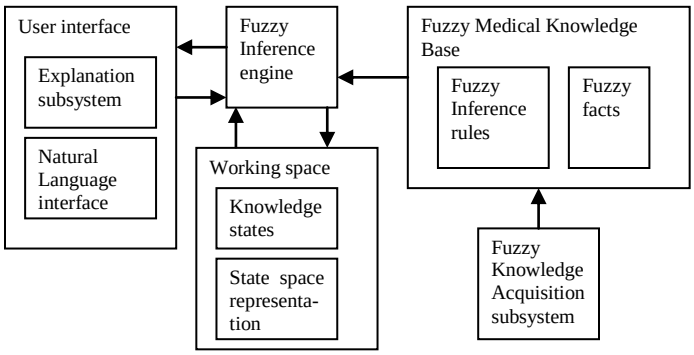
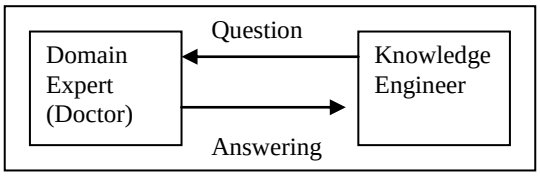


Fig.1



Question Answering Sub-System

A. Domain expert

A person whose knowledge and experience have been used to produce information about specific area of interest and to store it in the fuzzy expert system.

B. Knowledge Engineering

The knowledge engineering is the problem solving strategy consists of problem solution such as control architecture(search strategies), Fuzzy knowledge representation and problem solution strategy, which determine, what knowledge to apply.

C. Inference engine

It is responsible for interpreting the contents of the Fuzzy knowledge base in order to reach a goal or conclusion. The inference engine can be divided into three parts.

D. Context Block

This part contains the current state of the problem and solution.

E. Inference (Reasoning) Mechanism

This part search the appropriate set of knowledge and data with the help of context block in order to reach a goal or conclusion.

F. Explanation Facility

The facility helps the user to understand the line of reasoning.

G. Knowledge acquisition facility

New knowledge is generated with the assistance of this facility.

H. Work Space

It is storage structure of problem description and the levels of problem states (knowledge sources). The Fuzzy rule based knowledge to be stored can be schematically represented in a net form.

G. User Interface

The module of the Fuzzy expert system permits the user to benefit from the system.

EMYCIN]is Medical expert system shell in which medical diagnosis shall be defined[7,8]. The fuzzy information shall also be possible to define in EMYCIN.

The proposition “x is A” may be represented as
$\mu A(x) = MB[x,A]$ and is member in the unit interval [0,1].
The conjunction and disjunction, negation and implication are given below.

$MB[x, A \vee B] = \max \{ MB[x, A] , MB[x, B]$
$MB[x, A \wedge B] = \min\{ MB[x, A], MB[x, B]$
$MB [x , A']= 1-MB[x, A]$
$MB[x , A \rightarrow B] = \min \{ 1, 1- MB[x , A] + MB[x , B] \}$
$MB[x , A1, A2, An \rightarrow B] = \min \{ 1, \min \{1- MB[x , A1] + MB[x , B] , 1- MB[x , A2] + MB[x , B] , 1- MB[x , An] + MB[x , B] \}$

The FMES(Fuzzy Medical Expert Systems) is problem solving system using Fuzzy reasoning with Fuzzy facts and rules. These Fuzzy facts and rules are modulated to represent the Medical Knowledge available to the system. The Fuzzy Medical Expert System is independent component which performs Fuzzy reasoning in FMES.
Suppose , we have following fuzzy facts and fuzzy rules.

Rule 1: if fever (0.7)
and rash(0.65)
and body ache(0.6)
and chills(0.75)
Then the patient has chicken_pox(0.65)
Rule 2:if couff(0.75)
and swollen glance(0.7)
Then the patient has diagnosis mumps(0.65)
Rule 3: if there is couff(0.75)
and sneezing(0.65)
and runny nose(0.7)
Then the patient has diagnosis wooping_cough(0.7)

The fuzzy expert system is given fever , rash, body_ ache and chills the sysyem will reasone diagnose chiken_pox with fuzziness of 0.9.

III. FUZZY MEDICAL KNOWLEDGE REPRESENTATION AND FUZZY MEDICAL REASONING

The knowledge representation is essential module of all Fuzzy expert systems[15]. It is a formal representation of the fuzzy information provided by domain expert(Doctor) as encoded by the knowledge engineer.

Information provided by the domain expert may be certain and uncertain, imprecise, vague, incomplete, inconsistent and inexact in Medical diagnosis. v

Fuzzy Medical knowledge representation deal with the structure used to represent the knowledge provided by the Domain expert. Fuzzy medical expert systems used standard techniques for representing Fuzzy medical knowledge including fuzzy facts and Fuzzy rules.

For instance,
"Patient has Cold" is represented as
[Cold] Symptom(Patient, Cold)

The Fuzzy position "Patient has Headache" may be modulated as
[Headache] Symptom(Patient, Headache)

Patient has Cold or cough
may be represented as
[Cold V coughs] (Symptom(Rama, Cold)V Symptom(Rama, cough))

Some of the Fuzzy Reasoning rules are

R1: [A]R(x)
[B](R(x) or R(y))

[AΛB]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))

[AΛ 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)

Patient has Cold
If Patient has Cold then Patient has Headache

The inference is given as Using the above Fuzzy fact and Fuzzy rule
[Cold] Symptom(Patient, Cold)
if [Cold]Symptom(Patient, Cold) than THEN [Headache]Symptom(Patient, Headache)

The Fuzzy reasoning is given as using Fuzzy Knowledge Base
[Cold] ^[Cold → Headache] Symptom (Patient, Headache)

IV. DISTRIBUTED FUZZY MEDICAL EXPERT SYSTEMS (DFMES)

Fuzzy logic and Fuzzy reasoning are discussed in the following for the Fuzzy modulations and Fuzzy Medical Expert Systems. These Fuzzy modulations and Fuzzy Medical Expert Systems are used to study the Distributed Fuzzy Medical Expert Systems (DFMES).

DFMES is Intelligent problem solving system in the distributed environment in which the Fuzzy Medical Expert Systems are to be co-ordinate and co-operated in the Distributed environment when the inconsistent, incomplete and inexact Medical Knowledge is available to the system.. DFMES performs reasoning with the Fuzzy Medical Expert Systems and Fuzzy modulations in the Fuzzy Medical Expert Systems are to be co-ordinate and co-operated with the other Medical Expert Systems in the Distributed environment. The co-operation is in three steps. In the First, the Fuzzy Medical Expert System and Fuzzy modulations are defined for the Fuzzy information. In the Second, if the local Fuzzy Medical Expert System has no sufficient information, it connects to other Fuzzy Medical Expert System for required information. Third, the DFMES is to co-operate and co-ordinate to get the final solution DFMES is the problem solving system in the Distributed environment with the Fuzzy Dist Medical Expert Systems. The Fuzzy Medical Expert Systems in DFMES are to be co-ordinate and co-operated in the Distributed environment. The DFMES system is shown in Fig.

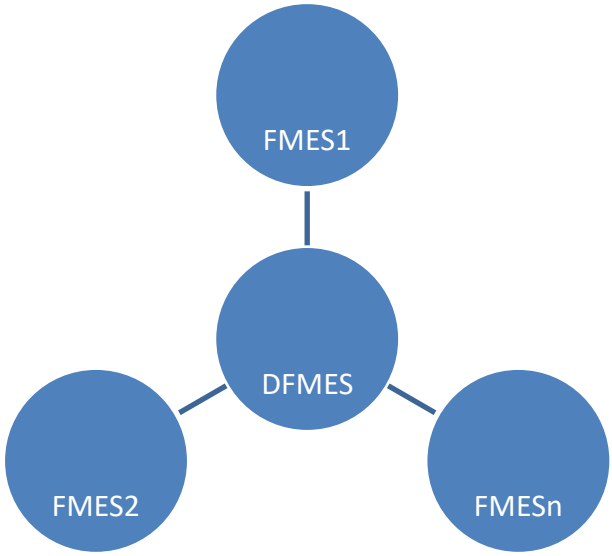


Fig.. DFMES.

Example1
Patient has Sugar
If Patient has Sugar Then Patient has Blood pressure DFMES1 consists of

F1: [Sugar] Symptom(Patient, Sugar)

F2: If [Sugar] Symptom(Patient, Sugar) Then [Blood pressure] Symptom(Patient, Blood pressure)
From F1 and F2 infer

F3:[Sugar] o [Sugar Λ Blood pressure] Symptom(Patient, Blood pressure)
DFMES2 consists of

F4: [Sugar] lab test(Patient, Sugar)

F5: If [Sugar] lab_test (Patient, Sugar) Then [Blood pressure] lab_test (Patient, Blood pressure)
For F4 and F5 infer

F6:[Sugar] o [Sugar Λ Blood pressure] lab_test (Patient, Blood pressure)
From DFMES1 and DFMES2 usingF3 and F6 infer

Sugar] o [Sugar Λ Blood pressure] V Symptom(patient, Blood pressure
Sugar o [Sugar Λ Blood pressure] lab_test (Patient, Blood pressure)

Example 2

A Medical example is considered in the following to discuss DFMES

FMES1 has following facts and rules
Patient has Cold
If Patient has Cold Then Patient has Sneezing
If Patient has Cold Then Patient has Headache
The above Fuzzy facts may be modulated as
F1:[Cold] Symptom(Patient, Cold)
F2:If [Cold] Symptom(Patient, Cold) Then
[Sneezing] Symptom(Patient, Sneezing)
F3: If [Cold] Symptom(Patient, Cold) Then
[Headache] Symptom(Patient, Headache)
From F1 and F2 infer
F4:[Cold o (Cold → Sneezing] Symptom(Patient, Sneezing)
From F1 and F3 infer
F5:[Cold o (Cold → Headache] Symptom(Patient, Headache)
FMES2 has following rules
If Patient has Sneezing Then Patient has Fever
If Patient has Headache Then Body pains
The above Fuzzy facts may be modulated as
F6:If [Sneezing] Symptom(Patient, Sneezing) Then
[Fever] Symptom(Patient, Fever)
F7:If [Headache] Symptom(Patient, Headache) Then
[Body_pains] Symptom(Patient, Body_pains)
From F4 and F6 infer " What is about Patient fever" as
F8:([Cold o (Cold → Sneezing] o
[Sneezing→Fever])Symptom(Patient, Fever)
From F5 and F7 infer" What is about Patient body_pains" as
F9: ([Cold o (Cold → Headache] o
[Headache →. Body_pains]) Symptom(Patient, Body_pains)

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