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Hybrid Fuzzy Expert Systems: an Application to Medical Diagnosis

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***Abstract*—Expert Systems are intelligent programs of Artificial Intelligence (AI). In many applications, information available to the expert system is incomplete like medical diagnosis. This incomplete information is fuzzy rather than probable. Hybrid fuzzy expert systems (HFMES) combination of different fuzzy expert systems of same type co-ordinate and co-operated. In this paper, Hybrid fuzzy medical expert Systems are studied. Fuzzy inference and fuzzy reasoning are discussed for HFMES Fuzzy knowledge representation is disused for HFMES. Some examples are given for HFMES.**

Keywords— medical knowledge representation, fuzzy inference, Fuzzy reasoning, fuzzy medical Expert Systems, hybrid fuzzy medical expert systems

I. INTRODUCTION

The Medical diagnosis is inexact, imprecise and uncertain reasoning rather than exact. Various theories are there to deal with inexact, imprecise and uncertain information in Medical diagnosis [1]. Fuzzy logic [15] will deal with the belief where as others are deal with probable (likelihood). The Medical diagnosis is of belief rather than likelihood.

. Hybrid fuzzy expert systems combination of different fuzzy expert systems of same type co-ordinate and co-operated. For instance, fuzzy medical expert systems are with symptoms and fuzzy medical expert systems are with medical tests. Hybrid Fuzzy Medical Expert Systems are in cloud environment.

The Medial diagnosis is Hybrid, This system may be viewed as a collection of Medical Expert Systems and these HFMS are to be co-operated and co-ordinate in cloud environment. The medical diagnosis will h deals with independent component in the diagnosis system, each of which reasons based on the Medical Knowledge available and combined for total systems.

II. FUZZY LOGIC AND FUZZY REASONING

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.,

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

The fuzzy conditional proposition is of the form "if <precedent> then <consequent-part>"

Zadeh [12] fuzzy conditional inference is given by
if x is A ten x is B

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

If x is A_1 and x is A_2 and,…, and x is A_n then x is B
$= \min\{1, 1-(A_1, A_2, \ldots, A_n) + B)$

Mamdani 5]fuzzy conditional inference is given by if x is A ten x is B

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

If x is A_1 and x is A_2 and,…, and x is A_n then x is B
$= \min\{A_1, A_2, \ldots, A_n, B)$

In medical diagnosis, the consequent part is derived from precedent part[6].

If x is A_1 and x is A_2 and,…, and x is A_n then x is B
$= \min\{A_1, A_2, \ldots, A_n)$

The Fuzzy propositions may contain quantifiers like "Very", "More or Less" etc. 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 ($A \rightarrow B$)

III. FUZZY MEDICAL EXPERT SYSTEMS(FMES)

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 based), 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, and 25].

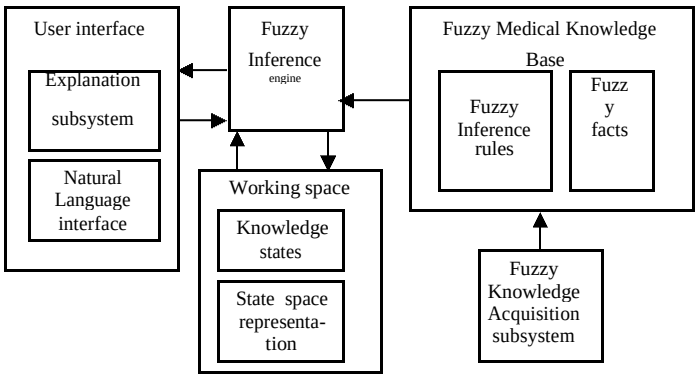

Fig.1. Fuzzy expert System

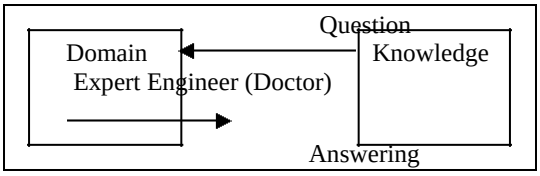

Fig.2. Question Answering Sub-System

Domain expert

The knowledge and experience have been used to specific area of interest to store it in the fuzzy expert system.

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.

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.

Context Block

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

Inference (Reasoning) Mechanism

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

Explanation Facility

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

Knowledge acquisition facility

New knowledge is generated with the assistance of this facility.

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.

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.

CF[h,e]=MB[h,e] - MD[h,e]

Where MB[h,e] and MD[h,e] are the probabilities of Belief and Disbelief. used in MYCIN

Fuzziness is considered instead of probabilities.

The fuzzy certainty factor (FCF) for proposition “x is A”is defined as

$FCF[x,A] = \mu_A^{FCF}(x) = MB[x,A] - MD[x,A]$.

$\mu_A^{FCF}(x) \longrightarrow [0, 1]$ is single membership function.

$\mu_A^{FCF}(x) = \mu_A^{Belief}(x) - \mu_A^{Disbelief}(x)$

for instance,

$\mu_{cough}^{FCF}(x) = \mu_{cough\ A}^{Belief}(x) - \mu_{cough}^{Disbelief}(x)$

The conjunction and disjunction, negation and implication are given below.

FCF[x, A v B] = max { FCF[x, A] , FCF[x, B]

FCF[x, A^B] = min{ FCF[x, A], FCF[x, B]

FCF [x , A’]= 1-FCF[x, A]

FCF[x , A $\rightarrow$ B] = { FCF[x , A] }

FCF[x , A1, A2, An $\rightarrow$ B] = min { FCF[x , A1] , FCF[x , A2] + FCF[x , B] , FCF[x , An] }

The fuzzy medical expert systems are is problem solving systems using Fuzzy medical reasoning with Fuzzy medical 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 HFMES.

Consider the following fuzzy facts and fuzzy rules.

Rule 1: if fever (0.8,0.1)
and rash(0.95,01)
and body ache(0.9,0.3)
and chills(0.9, 0.25)
Then the patient has chickenpox
Rule 2:if cough(0.85,0.1)
and swollen glance(0.9,0.2)
Then the patient has diagnosis mumps
Rule 3: if there is cough (0.95,0.2)
and sneezing(0.8,0.15)
and runny nose(0.8,9.15)
Then the patient has diagnosis wooping_cough(0.7)

The fuzzy medical rule are given by using FCF
Rule 1: if fever (0.7)
and rash(0.65)
and body ache(0.6)
and chills(0.75)
Then the patient has chickenpox(0.65)
Rule 2:if cough(0.75)
and swollen glance(0.7)
Then the patient has diagnosis mumps(0.65)

Rule 3: if there is cough (0.75)
and sneezing(0.65)
and runny nose(0.7)
Then the patient has diagnosis wooping_cough(0.7)

For rule-1, fuzzy expert system is given fever , rash, body_ ache and chills the system will reason diagnose chickenpox with fuzziness of 0.9.

IV. FUZZY MEDICAL KNOWLEDGE REPRESENTATION

The knowledge representation is essential module of all Fuzzy expert systems for learning[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(Rma, Cold)V Symptom(Rma, 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 more or less Sugar

If Patient has Sugar Then Patient is diabetes

F1: [more or less Sugar] Symptom(Patient, sugar)

F2: If [Sugar] Symptom(Patient, Sugar) Then [Diabetes] Symptom(Patient, Diabetes)

From F1 and F2 infer

: [more or less Sugar] o [Sugar → Diabetes]

FKR is useful for learning fuzzy propositions.

V. HYBRID FUZZY MEDICAL EXPERT SYSTEMS

HFMES is collection of expert system and is combined the solutions of the different type of expert systems in the cloud environment in which the Fuzzy Medical Expert Systems are to be co-ordinate and co-operated HFMES performs reasoning with the Fuzzy Medical Expert Systems. 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 HFMES is to co-operate and co-ordinate to get the final solution .

FMES is the individual problem solving expert system. It will give individul solution. The HFMES system is shown in Fig.3.

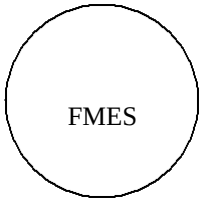

Fig.3 FMES

Hybrid Fuzzy Medical Expert Systems. is collection of different types of Medical Expert Systems, individual solution will be found and combined for total solution. The HFMES system is shown in Fig.4.

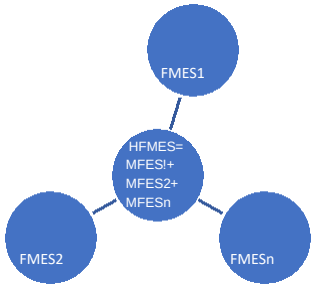

Fig..4. HFMES.

FMES1 contains

Patient has Malaria

Patient has Dengue

If Malaria-test and Dengue-test then Viral fever

F1: [Malaria] lab test(Patient, Malaria)

F2: [Dengue] lab test(Patient, Dengue)

If [Malaria] lab test(Patient, Malaria) ^[Dengue] lab test(Patient, Dengue) then[viral-fever]Symptom(Patient, fever)

FMES2 contains

Patient has Cold
Patient has Body-ache
Patient has Headache
Patient has Chills

If Patient has Cold and Patient has Body-ache and Patient has Headache and Patient has Chills then viral fever

[cold] Symptom(Patient, Cold)
[body-ache] Symptom(Patient, Body-ache)
[headache] Symptom(Patient, Headache)
[chills] Symptom(Patient, Chill)
Then [very-fever] Symptom(patient, very-fever)

If [cold] Symptom(Patient, Cold) ^ [body-ache] Symptom(Patient, Body-ache) ^
[headache] Symptom(Patient, Headache) ^
[chills] Symptom(Patient, Chill)

The two hybrid systems FMES1 and FMES2may are stored in two different clouds or single cloud.
The hybrid systems are combined to give diagnosis
FMES1 and FMES2 =min{FMES1, FMES2}

For example
Suppose, the fuzziness is given as
Patient has Malaria(0.65)
Patient has Dengue(0.7)

The FMSE2 is give by

0.65

Suppose, the fuzziness is given as
Patient has Cold(7.75)
Patient has Body-ache (0.7)
Patient has Headache (0.8)
Patient has Chills (0.85)

The FMSE2 is give by

0.7

The hybrid expert system by combining is given by
HFMES=FMES1 Λ FMES2= 0.65

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