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Hybrid Fuzzy Medical Expert Systems

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Hybrid Fuzzy Medical Expert Systems

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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.,

$: X \rightarrow [0,1]$

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

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

The fuzzy set type 2 is given by

Headache= {0.4/mild, 0.6/moderate, 0.9/severe

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

Similarly

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

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

Malaria-test {in cycles}={0.0/1), 0.3/2 + 0.5/3 + 0.55/4 + 0.6/5 + 0.8/6}

Dengue-test (in lines)={0.1/1 + 0.3/2 +0.4/3 +0.6/4+0.65/5 + 0.7/6}

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

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

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Suppose A, B, C is Fuzzy sets, and 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 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 $A \wedge B$

R2: x is A
x or y is B
---
y is $A \vee B$

R3: x and y are A
y and z are B
---
x and z area $A \wedge B$

R4: x or y are A
y or z is B
---
x or z are $A \vee B$

R5: x is A
if x is A then y is B
---
y is Ao $(A \rightarrow B)$

III. Fuzzy Medical Expert Systems(fmes)

Expert Systems have 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, and 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 falls 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 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].

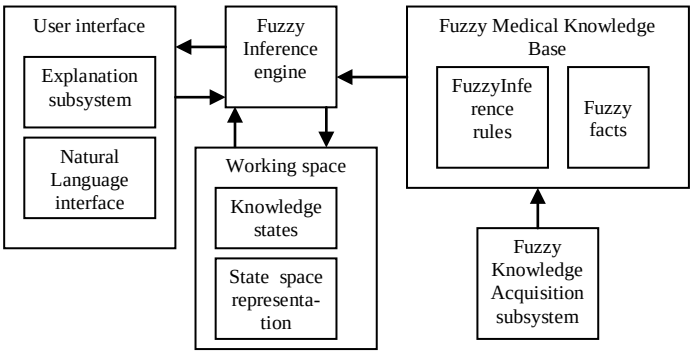

Fig. 1: Fuzzy expert System

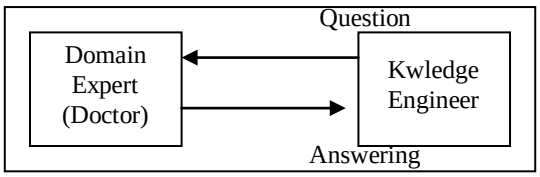

Fig. 2: Question Answering Sub-System

Domain expert

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

a) 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.

b) 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.

c) Context Block

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

d) 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.

e) Explanation Facility

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

f) Knowledge acquisition facility

New knowledge is generated with the assistance of this facility.

g) 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.

IV. 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.

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].

$\mu_{A}^{FCF}(x) \rightarrow [0, 1]$ 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→B] = {FCF [x , A] }
FCF[x , A1, A2, An→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

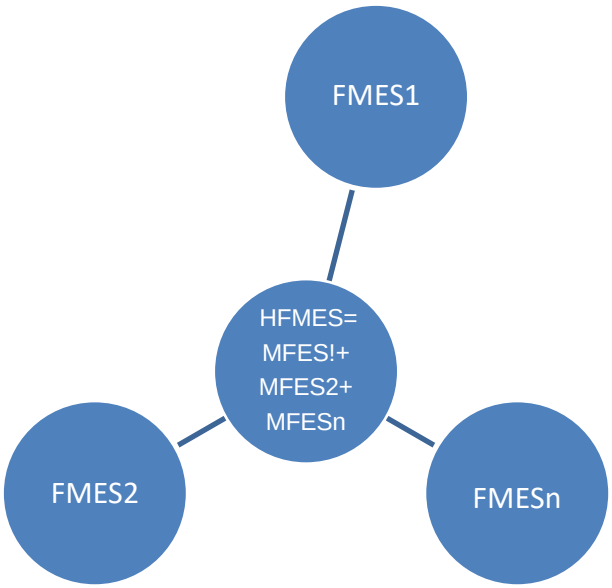

Fig. 4: HFMES

FMES 1 contains
Patient has Malaria
Patient has Dengue
If Malaria-test and Dengue-test then Viral fever
F1: [Malaria] lab test (Patient, Malaria)

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.

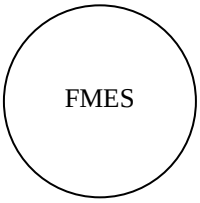

Fig. 3: FMES

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.

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

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

FMES 2 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 FMES 2 =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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