Volume 3, Issue 10, October 2013 ISSN: 2277 128X
International Journal of Advanced Research in Computer Science and Software Engineering
Research Paper
Available online at: www.ijarcsse.com

S Fuzzy Assessment Methodology using S Value to Diagnosis Diabetes

M.Kalpana*
Department of Social Sciences,
Anbil Dharmalingam Agricultural College and Research Institute,
Tamil Nadu Agricultural University, Trichy, Tamil Nadu, India

Dr. A.V Senthil Kumar
Department of MCA,
Hindusthan College of Arts & Science,
Coimbatore – 641028,
Tamil Nadu,
India

Abstract—This paper expresses the framework of fuzzy expert system by applying the algorithm S Fuzzy Assessment Methodology. Fuzzy expert system consists of the following elements such as fuzzification interface, S Fuzzy Assessment Methodology and defuzzification. S Fuzzy Assessment Methodology uses the K Ratio to find overlapping between membership function, to measure the similarity between fuzzy set, fuzzy number and fuzzy rule, T Fuzzy similarity is used. Similar fuzzy sets are merged to form a common set; a new methodology was framed to identify the similarity between fuzzy rules with fuzzy numbers and S value to manage uncertainty in rules. T value and F value computes S value. The efficiency of the proposed algorithm was implemented using MATLAB Fuzzy Logic tool box to construct fuzzy expert system to diagnosis diabetes.

Keywords— S Fuzzy Assessment Methodology (S FAM), K Ratio, T Fuzzy similarity measure, S value, T value, F value, Diabetes application.

I. Introduction

Diabetes Mellitus is a heterogeneous group of diseases, which lead to high blood glucose levels due to defects in either insulin secretion or insulin action. Fuzzy Expert System is very important to diagnosis the patient suffering from diabetes with the algorithm S Fuzzy Assessment Methodology (S FAM). Chang and Lilly [1] a fuzzy classification system was derived directly from the data, at the beginning fuzzy classifier is empty with no rules and no membership function. Then rules and membership function are created in this process. Polat and Gunes[2] used principal component analysis to diabetes disease dataset, has 8 features which is reduced to 4 features and adaptive neuro-fuzzy inference is conducted to diagnosis diabetes. The American Diabetes Association [3] categorizes diabetes into two types as type-1 and type-2 diabetes. Type-1 is most common for children and young adults and type-2 diabetes is common form of diabetes that the body does not produce adequate insulin. Kahramanli and Allahverdi[4] developed a hybrid neural network that includes artificial neural network and fuzzy neural network.

Method used in hybrid neural network is classification which increases the reliability of the result for heart and diabetes data. Chang-Shing Lee [5] designed fuzzy expert system using the algorithm fuzzy decision making mechanism to diagnosis diabetes. Fuzzy ontology is applied to diabetes data. With the fuzzy expert system and fuzzy ontology medical staff decides the patient is affected by diabetes or not. M. Kalpana and A. V Senthilkumar[6] developed a fuzzy expert system using the algorithm fuzzy verdict mechanism to diagnosis the diabetes. The proposed fuzzy expert system uses the concept of fuzzification and defuzzification. A. V Senthilkumar and M. Kalpana[8] designed intensified fuzzy verdict mechanism which consists of fuzzy inference, implication and aggregation. M. Kalpana and A. V Senthilkumar[9] proposed a fuzzy expert system using Correlation fuzzy logic to find the relationship between two membership function. M. Kalpana and A. V Senthilkumar[10] Design and implemented Fuzzy Expert System using Fuzzy Assessment Methodology to diagnosis the diabetes. Harvey J. Gold et al. [11] derived a methodology for uncertainty, combining diverse sources of information within the frame work of expert system for soyabeans. Norman D. Clarke et al. [12] used certainty factor to represent uncertainty in expert system. The rule based expert system was used to test the uncertainty for tillage selection alternatives for corn and soyabean production. J. F. Baldwin [13] used bayesian decision theory for incomplete knowledge representation to manage uncertainty in expert system. P. Baraldi [14] characterized qualitative uncertainty to model the fuzzy expert system. Uncertainty analysis is a useful tool to analysis source of uncertain data in the fuzzy input and output mapping. Alauddin Alomary[15] projected a expert system to handle uncertainty in attractive domains of applications to deal with imprecise information. Andrew L.S. Gordon [16] a hybrid approach given for uncertainty, unexpectedness and complexity if risk. Expert system was developed using fuzzy logic for IT security risk assessment. Raouf ketata et al.[18] introduced a new approach for fuzzy rule reduction with new fuzzy set. This methodology was applied to truck backer upper control and liver trauma diagnostic. Vincent C. Yen [19] suggested a measure of nearness between rules for fuzzy expert system. This system finds the nearness of each rule to find the similarity. M. Kalpana et al. [21] designed fuzzy expert system using the algorithm Enhanced Fuzzy Assessment Methodology. Enhanced Fuzzy Assessment Methodology uses fact value to find the uncertainty between the rules.

In Expert system there are incomplete, inconsistent, unreliable or inaccurate data. To deal with vagueness and uncertainties fuzzy logic is an excellent tool for dealing with vague knowledge base. Fuzzy rule and Fuzzy membership functions are very important part to extract the knowledge from the system. So S Value is derived from fuzzy rules. S Value (SV) represents the piece of evidence. There are numerous ways in which uncertainty can be defined and combined during the inference process. The new rule validation approach is given to manage the uncertainty in Fuzzy Expert System. The new S Value of the rule is promoted with T Value and F value. The final diagnostic decision is taken based on S Value.

The proposed S Fuzzy Assessment Methodology (SFAM) finds the similarity between the fuzzy set, fuzzy number and fuzzy rule. The methods proposed compares the three fuzzy set at the time and the sets are reduced. With the reduced set the similarity between the rules are achieved and the rules are reduced to improve the accuracy of the fuzzy expert system. The proposed algorithm uses S value to manage the uncertainty in fuzzy expert system. This paper is organized as follows: Section II deals with the Design of fuzzy expert system. The experimental results, implemented in MATLAB fuzzy logic toolbox are presented in Section III and experimental results indicate that the proposed method are compared with other methods [1] [2] [4] [5] and [17] in section IV.

II. DESIGN OF FUZZY EXPERT SYSTEM

The fuzzy expert system includes Fuzzification interface, S Fuzzy Assessment Methodology (SFAM) and Defuzzification interface for diabetes represented in Figure 1.

A. Pima Indians Diabetes Database

The Pima Indians Diabetes Database [17] is used to test the proposed algorithm S Fuzzy Assessment Methodology.

B. Modeling Fuzzy Expert Systems

Fuzzy expert system can be designed using the following steps.

1. Fuzzification interface
2. S Fuzzy Assessment Methodology
3. Defuzzification interface

Fuzzy set and fuzzy numbers are listed in Table I.

C. Fuzzification Interface

The transformation of crisp inputs into fuzzy values is achieved through fuzzification interface. The fuzzy values are taken as the input for the S Fuzzy Assessment Methodology. Membership function adopted is triangular function with the parameter set [a, b, c] as shown in eqn. (1). The parameter is fixed with Minimum value, Mean, Standard Deviation, Maximum value for each variable [7]. Then the membership function μ(x) of the triangular fuzzy numbers [22] is given by

$$\mu(x) = \begin{cases} 0, x \le a \\ (x-a)/(b-a), a < x \le b \\ (c-x)/(c-b), b < x < c \\ 0, x > c \end{cases} \quad --(1)$$

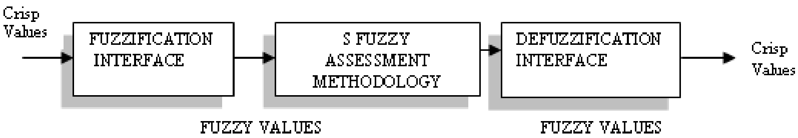

Fig. 1 Diagram of the Fuzzy Expert System for diabetes

D. S Fuzzy Assessment Methodology

S Fuzzy Assessment Methodology (S FAM) three triangular membership functions (MFs) are used for each input variable(D_1,D_2,D_3,D_4,D_5) and four triangular MFs for the output variable (O) using eqn. (1) with parameters D_1 to D_5 {low [Min, Mean-SD, Mean], medium [Mean-SD, Mean, Mean+SD], high[Mean, Mean+SD, Max]} listed in Table I[7]. In SFAM T-norm operator used is algebraic product and T-conorm operator used is algebraic sum [23].

K ratio

For the input variable the numbers of membership functions are designed. The membership functions overlap between each other. K ratio lies between 0 to 1[24].

T Fuzzy similarity measure between fuzzy set and fuzzy numbers

To get the adequate rule base, membership functions and sufficient number of fuzzy set are very essential [22]. Fuzzy set similarity always considers the two fuzzy set, the proposed T Fuzzy similarity measure considered three fuzzy set A,B, and C. Consider the fuzzy variable glucose with its fuzzy number low, medium and high.

Glucose low d_{11} (A)

medium d_{12} (B)

high d_{13} (C)

$$S(A,B,C) = \left(\frac{\max(A,B) - \min(A,B)}{3}, \frac{\max(B,C) - \min(B,C)}{3} \right) --- (2)$$

$$Glu\cos e(A,B,C) = \left(\frac{148.12 - 71}{3}, \frac{196 - 94.41}{3} \right) = (25.7, 33.9)$$

With eqn. (2) similarity for the variable Glucose is calculated. The values are not similar, so the fuzzy set cannot be merged.

Consider BMI with its fuzzy numbers low, medium and high and the similarity are measured using the eqn. (2)

BMI low d_{31} (A)
medium d_{32} (B)
high d_{33} (C)

$$BMI(A,B,C) = \left(\frac{43.03-0}{3}, \frac{67-24}{3}\right) = (14.1, 14.3)$$

The values of BMI low d_{31} (A), medium d_{32} (B) and high d_{33} (C) are similar, the three sets can be merged into two sets as BMI low and BMI high. Rule 5 has BMI medium. It can be merged with Rule 1; all the parameters in Rule 1 are same except BMI medium. Rule 8 has BMI medium. It can be merged with Rule 2; all the parameters in Rule 2 are same except BMI medium. Finally Rule 5 and Rule 8 are merged with Rule 1 and Rule 2.

T Fuzzy similarity measure between fuzzy rules

The rule base consists of nine if-then rules with antecedent[23]. The Antecedent of rule are $d_{11},d_{12},d_{13},d_{21},d_{22},d_{23},d_{31},d_{32},d_{33},d_{41},d_{42},d_{43},d_{51},d_{52},d_{53}$. The antecedent part of the rule evaluated with OR operator. Compute the degree of similarity between all rules in the order.

Consider two rules

Rule 3: If (D1 is d12) or (D2 is d23) or (D3 is d33) or (D4 is d42) or (D5 is d51or d52) then (O is O3).

Rule 4: If (D1 is d13) or (D2 is d21ord22) or (D3 is d33) or (D4 is d43) or (D5 is d51or d52) then (O is O4orO5)[9].

Degree of Similarity (DS) =

Total number of similar parameter between the rules
-- %
Total number of input and output parameter

$$= \frac{2}{6} = 33\%$$

DS = 33% < 50%, Rule 3 and Rule 4 are dissimilar.

TABLE I. REPRESENTATION OF FUZZY VARIABLES AND NUMBERS

Fuzzy Variables	**Representation of Fuzzy Variables**	**Fuzzy Numbers**	**Representation of fuzzy numbers**	**Fuzzy triangular numbers**
Glucose	D_1	low	d_{11}	[71 94.41 121.27]
		medium	d_{12}	[94.41 121.27 148.12]
		high	d_{13}	[121.27 148.12 196]
INS	D_2	low	d_{21}	[0 15.16 89.82]
		medium	d_{22}	[15.16 89.82 194.81]
		high	d_{23}	[89.82 194.81 579]
BMI	D_3	low	d_{31}	[0 24.46 33.24]
		medium	d_{32}	[24.46 33.24 42.03]
		high	d_{33}	[33.24 42.03 67.1]
DPF	D_4	low	d_{41}	[0.13 0.21 0.44]
		medium	d_{42}	[0.21 0.44 0.67]
		high	d_{43}	[0.44 0.67 0.96]
Age	D_5	young	d_{51}	[21 21 22]
		medium	d_{52}	[21 22 24]
		old	d_{53}	[22 24 25]
DM	O	verylow	O_1	[0 0.1 0.2]
		low	O_2,	[0.1524 0.2524 0.3]
		medium	O_3	[0.287 0.327 0.3997]
		high	O_4	[0.329 0.623 0.762]
		veryhigh	O_5	[0.731 0.831 1]

Consider another two rules

Rule 4: If (D1 is d13) or (D2 is d21ord22) or (D3 is d33) or (D4 is d43) or (D5 is d51or d52) then (O is O4orO5) [9].
Rule 6: If (D1 is d12) or (D2 is d21ord22) or (D3 is d33) or (D4 is d42) or (D5 is d51or d52) then (O is O4orO5) [9].

Degree of Similarity (DS) =

$$\frac{\text{Total number of similar parameter between the rules}}{\text{Total number of input and output parameter}} \%$$

$$= \frac{4}{6} = 66\%$$

DS = 66%>50%

Rule 4 and Rule 6 are similar. Dissimilar parameters in the rule are Glucose (d_{12} and d_{13}) and DPF (d_{42} and d_{43}). Let us consider the dissimilar parameter Glucose (d_{12} and d_{13})

$$Glu\cos e(cvalued_{12}) = \frac{94.41+121.27+148.12}{3} = 121.3$$

$$Glu\cos e(cvalued_{13}) = \frac{121.27+148.12+196}{3} = 155.13$$

$$Glu\cos e(kcalvalue) = Glu\cos e(cvalued_{13}) - Glu\cos e(cvalued_{12}) = 155.13 - 121.3 = 33.83$$

$$Glu\cos e(kbase) = \text{First tria ngular number of } d_{13} \text{ - First tria ngular number of } d_{12}$$
$$= 121.27 - 94.41 = 26.86$$

Glucose(Kcalvalue) >Glucose(Kbase) ie, d_{12} and d_{13} are reduced. Minimum value d_{12} is deleted, Maximum value d_{13} is considered in rule.

Let us consider the dissimilar parameter DPF(d_{42} and d_{43})

$$DPF(cvalued_{42}) = \frac{0.21+0.44+0.67}{3} = 0.44$$

$$DPF(cvalued_{43}) = \frac{0.44+0.67+0.96}{3} = 0.69$$

$$DPF(kcalvalue) = DPF(cvalued_{43}) - DPF(cvalued_{42}) = 0.69 - 0.44 = 0.25 \quad 21.3 = 33.83$$

$$DPF(kbase) = \text{First tria ngular number of } d_{43} \text{ - First tria ngular number of } d_{42}\, \ell_{12}$$
$$= 0.44 - 0.21 = 0.23$$

DPF (Kcalvalue) > DPF (Kbase) ie, d_{42} and d_{43} are reduced. Minimum value d_{42} is deleted, Maximum value d_{43} is considered in rule.

So the rules Rule 4 and Rule 6 can be reduced into one Rule as

If (D1 is d13) or (D2 is d21ord22) or (D3 is d33) or (D4 is d43) or (D5 is d51or d52) then (O is O4orO5).

By using the T Fuzzy similarity measure between fuzzy set, fuzzy number and rules nine if-then rules are reduced to six rules to get accurate result and to reduce the time in the construction of rules.

If (D1 is d11) or (D2 is d21ord22) or (D3 is d31) or (D4 is d41) or (D5 is d51or d52) then (O is O1orO2).
If (D1 is d11) or (D2 is d21ord22) or (D3 is d33) or (D4 is d41) or (D5 is d51or d52) then (O is O1orO2).
If (D1 is d12) or (D2 is d23) or (D3 is d33) or (D4 is d42) or (D5 is d51or d52) then (O is O3).
If (D1 is d13) or (D2 is d21ord22) or (D3 is d33) or (D4 is d43) or (D5 is d51or d52) then (O is O4orO5).
If (D1 is d13) or (D2 is d21ord23) or (D3 is d31) or (D4 is d41) or (D5 is d53) then (O is O4orO5).
If (D1 is d11) or (D2 is d21ord22) or (D3 is d31) or (D4 is d41) or (D5 is d53) then (O is O1orO2).

S Values for fuzzy rules

Uncertainty plays an important role in decision making. To handle the uncertainty a methodology derived for the fuzzy expert system is fact value. The fuzzy expert system should able to manage uncertainties, to cope with all the inconsistent, incomplete or even missing data fact values are arrived for each fuzzy rules. Knowledge is almost incomplete and uncertain. The S Values (SV) is calculated with T value (TV) and F Value (FV). The antecedent part of the rule evaluated with OR operator.

The antecedent part of the rule are $d_{11}, d_{12}, d_{13}, d_{21}, d_{22}, d_{23}, d_{31}, d_{32}, d_{33}, d_{41}, d_{42}, d_{43}, d_{51}, d_{52}, d_{53}$. The process of mapping result of fuzzification from antecedent part into consequence is termed as implication [20]. Our new fuzzy logic rule approach can be explained as follows

The S value can be calculated using the formula

S Value = Max (T value, F value) -------> (3)

T value =

Number of Consequent part match with antecedent part

Number of antecedent part of rule

F value =

Number of Consequent part doesn't match with antecedent part

Number of antecedent part of rule

Consider the rule

if (D_1 is d_{12}) or (D_2 is d_{21} or d_{23}) or (D_3 is d_{33}) or (D_4 id d_{42}) or (D_5 is d_{51} or d_{52}) then (O is O_3) using eqn. (3)

S Value = Max (T value, F value)

T value =

Number of Consequent part match with antecedent part

Number of antecedent part of rule

F value =

Number of Consequent part doesn't match with antecedent part

Number of antecedent part of rule

$$T\ value = \frac{2}{4} = 0.4$$

$$F\ value = \frac{3}{5} = 0.6$$

S Value = Max (T value, F value)
= Max (0.4, 0.6)
= 0.6

For the set of rules S values are calculated using the eqn. (3) and results are displayed in Figure 3.

1. If (D1 is d11) or (D2 is d21ord22) or (D3 is d31) or (D4 is d41) or (D5 is d51ord52) then (O is O1orO2) (1)
2. If (D1 is d11) or (D2 is d21ord22) or (D3 is d33) or (D4 is d41) or (D5 is d51ord52) then (O is O1orO2) (0.8)
3. If (D1 is d12) or (D2 is d23) or (D3 is d33) or (D4 is d42) or (D5 is d51ord52) then (O is O3) (0.6)
4. If (D1 is d13) or (D2 is d21ord22) or (D3 is d33) or (D4 is d43) or (D5 is d51ord52) then (O is O4orO5) (0.6)
5. If (D1 is d13) or (D2 is d23) or (D3 is d31) or (D4 is d41) or (D5 is d53) then (O is O4orO5) (0.6)
6. If (D1 is d11) or (D2 is d21ord22) or (D3 is d31) or (D4 is d41) or (D5 is d51ord52) then (O is O1orO2) (0.8)

Fig. 3 Rule for Fuzzy Expert System in MATLAB

MIN and SUM operator

Antecedent part of the rule gives a single number for implication process. To fire more than one fuzzy rule at same time, MIN operation is used by the system. The output of each rule is combined into single fuzzy set by aggregation process using SUM operation.

E. Defuzzification Interface

The result obtained from the aggregation is fuzzy value. To convert the fuzzy value obtained from SFAM into crisp value defuzzification process is conducted. Centroid method is used for defuzzification process.

S Fuzzy Assessment Methodology analyzes the personal physical data, converts the results into knowledge and the patterns of statement for output descriptions. The pattern of the statement helps the medical practitioner to diagnosis the patient from diabetes.

Proposed Algorithm: S Fuzzy Assessment Methodology (SFAM)

BEGIN

1. Input: Terms (D_1,D_2,D_3,D_4,D_5) are selected as fuzzy input variables
2. Output: Output term O as fuzzy output variables
3. Input PIDD with N cases
4. Initialize i←1

Method

Step 1: Create input fuzzy set $D_1(d_{11},d_{12},d_{13})$, $D_2(d_{21},d_{22},d_{23})$, $D_3(d_{31},d_{32},d_{33})$, $D_4(d_{41},d_{42},d_{43})$, $D_5(d_{51},d_{52},d_{53})$ and output fuzzy set $O(O_1,O_2,O_3,O_4,O_5)$

Step 2: Calculate the value of min, max mean and standard deviation
DO UNTIL (i>N)
D_{ilow} [Min, Mean-SD, Mean]
$D_{imedium}$ [Mean-SD, Mean, Mean+SD]
D_{ihigh} [Mean, Mean+SD, Max] using triangular membership function.
END DO UNTIL
Step 3: Calculate K ratio

$$K = \frac{P1 + P2}{LM - UM}$$

If ($K \geq 1$) then
LMK = 0.5 points are moved after LM
UMK= 0.5 points are moved before UM
Else
LM and UM
Step 4: Call procedure (S Value)
Step 5: DO UNTIL (i>N)
If (D_{1i} is d_{11}) or (D_{2i} is d_{21}) or (D_{3i} is d_{31}) or (D_{4i} is d_{41}) or (D_{5i} is d_{51})then O_i is O_3 (S Value)
END IF
END DO UNTIL
Step 6: Call procedure for T Fuzzy Similarity measure for fuzzy set, fuzzy numbers and rules
Step 7: Antecedent part (D_{1i} is d_{11}) or (D_{2i} is d_{21}) or (D_{3i} is d_{31}) or (D_{4i} is d_{41}) or (D_{5i} is d_{51}) into consequent (O is O_3) by MIN operator

Step 8: Set rules output $\xrightarrow{\text{SUM operator}}$ {output term O}
END

Procedure S Value (SV)
Begin
Step 1: Calculate S Value (SV), True Value (TV) and False Value (FV) for all Rules
S Value = Max(T value, F value)

T value =
Number of Consequent part match with antecedent part

Number of antecedent part of rule

F value =
Number of Consequent part doesn't match with antecedent part

Number of antecedent part of rule
Step 2: Compute SV for each Rule
For all rules ($Rule_1$ to $Rule_i$)
$Rule_i$ (S Value) = Max(T value, F value)
End

Procedure for T Fuzzy Similarity measure for fuzzy set, fuzzy numbers and rules
BEGIN
Step 1: Generate initial fuzzy set, fuzzy numbers and rules for diabetes data.
Step 2: In this step, we propose a new similarity measure between three sets A, B and C by the equation

$$S(A,B,C) = \left(\frac{\max(A,B) - \min(A,B)}{3}, \frac{\max(B,C) - \min(B,C)}{3} \right)$$

We conclude that set A, B and C are similar if they have both the values equal otherwise not equal. If the two values in the above equation are equal then merge into two sets A1 ad B1.
Step 3: Apply the merged set in rules.
Step 4: compute the degree of similarity between all rules in the order.
Consider two rules
Rule 1: if (x1 is A1) or (x2 is B1) or (x3 is C1) or (x4 is D1) or (x5 is E1) then Y is O1
Rule 2: if (x1 is A1) or (x2 is B1) or (x3 is C2) or (x4 is D2) or (x5 is E1) then Y is O1
Degree of Similarity (DS) =
Total number of similar parameter between the rules
---%
Total number of input and output parameter

DS = 4/6%= 66%

Step 5

Constant degree of similarity (CDS) is set to 50%
If (DS >CDS) then
Goto step 6
else
Stop the algorithm

Step 6

Calculate cvalue of dissimilar input and output parameter
cvalue for c1 and c2 are calculated
Kcalvalue = cvalue(c2) – cvalue(c1)
Kbase = First triangular number of c2 – First triangular number of c1
If (Kcalvalue > Kbase) two fuzzy number ie, c1 and c2 are reduced. Minimum value c1 is deleted, Maximum value c2 is considered in rule.
Else
not reduced.
Similarly cvalue, Kcalvalue, Kbase values of D1 and D2 are calculated and the Rule 1 and Rule 2 are merged into one rule.

END

III. EXPERIMENTAL RESULTS

MATLAB Fuzzy Logic toolbox was used to evaluate the performance of the proposed fuzzy expert system with the algorithm S Fuzzy Assessment Methodology, using Pima Indian diabetes dataset. Table II indicates the result obtained from SFAM and knowledge are transferred and presented in the human understandable form.

IV. PERFORMANCE ASSESSMENT

Performance Assessment Statement can be assessed based on the accuracy level. The True Positive (TP) and the True Negative (TN) denote the correct classification. False Positive (FP) is the outcome when the predicted class is yes (or positive) and actual class is no (or negative). Still, a False Negative (FN) is the outcome when the predicted class is no (or negative) and actual class is yes (or positive). Table III lists the various outcomes of a two-class prediction [17]. Accuracy is the proportion of the total number of predictions that were correct. The eqn. (4) show the formula for accuracy.

$$Accuracy = \frac{TN + TP}{TN + FP + FN + TP} X100\% - -(4)$$

<table>
<tr><th rowspan="2">Data</th><th>Glucose (mg/dl)</th><th>INS (mu U/ml)</th><th>BMI (Kg/m^2)</th><th>DPF</th><th>Age</th></tr>
<tr><td>177</td><td>478</td><td>34.6</td><td>1.072</td><td>21</td></tr>
<tr><td>Statement study</td><td colspan="5">If(Glucose is Gh) or(INS is INSm) or (BMI is BMIh) or (DPF is DPFh) or(Age is Agey) then (DM is DMh)</td></tr>
<tr><td>Assessment Statement</td><td colspan="5">The Assessment Statement justifies that the possibility of suffering from diabetes for this person is high(possibility:0.642)</td></tr>
<tr><td>Justification by Medical Practitioner</td><td colspan="5">Medical practitioner justification is the person is diabetes</td></tr>
</table>

TABLE III. DIFFERENT OUTCOMES OF A TWO-CLASS PREDICTION

<table>
<tr><th rowspan="2">Actual class</th><th colspan="2">Predicted class</th></tr>
<tr><th>Yes</th><th>No</th></tr>
<tr><td>Yes</td><td>True positive (*TP*)</td><td>False Negative (*FN*)</td></tr>
<tr><td>No</td><td>False positive (*FP*)</td><td>True Negative (*TN*)</td></tr>
</table>

The final experiment compares the accuracy of the proposed method with results of studies involving the Pima Indians Diabetes Database [1] [2] [4] [5] and [17]. The proposed method achieves the highest accuracy value for "very very young: (AGE: 0-25)" than earlier methods which is indicated in the Table IV.

V. CONCLUSION AND FUTURE RESEARCH

This paper presents application of fuzzy expert system for diagnosis of diabetes using S Fuzzy Assessment Methodology. The S Fuzzy Assessment Methodology uses K ratio to find the overlapping between the membership function, T similarity measure is used to find the similarity between fuzzy set, fuzzy numbers and fuzzy rules and S value to manage uncertainty in fuzzy expert system. Finally defuzzification is adopted to convert the fuzzy output set to a crisp output. Accuracy achieved through this method is 83.52% which can also improved through future works. Future works includes to modify rules and to add rules to fuzzy expert system to perform similar accuracy.

TABLE IV. COMPARISON OF ACCURACY OF PROPOSED METHOD WITH EARLIER METHODS

Method	**Accuracy (%)**	**Author**
Our study for Very Very Young(AGE:0-25)	83.52	M.Kalpana and Dr. A.V.Senthil Kumar
HNFB-1[6]	78.26	Goncalves et al.
Logdisc	77.7	Statlog
IncNet	77.6	Norbert Jankowski
DIPOL 92	77.6	Statlog
Linear discr. Anal	77.5-77.2	Statlog, ster and Dobnikar
A FES for Diabetes Decision very very young[12]	77.3	Lee and Wang
VISIT[5]	77	Chang and Lilly
SMART	76.8	statlog
GTO DT(5 X CV)	76.8	Bennet and Blue
ASI	76.6	Ster and Dobnikar
Fisher discr. Analysis	76.5	Ster and Dobnika
MLP+BP	76.4	Ster and Dobnika
LVQ(20)	75.8	Ster and Dobnika
LFC	75.8	Ster and Dobnika

REFERENCES

[1] X. Chang and J. H. Lilly, "Evolutionary design of a fuzzy classifier from data," *IEEE Trans. Syst., Man, Cybern. B, Cybern.* vol. 34, no. 4, pp. 1894–1906, 2004.

[2] K. Polat and S. Gunes, "An expert system approach based on principal component analysis and adaptive neuro-fuzzy inference system to diagnosis of diabetes disease," *Dig. Signal Process*, vol. 17, no. 4, pp. 702–710, 2007.

[3] American Diabetes Association, "Standards of medical care in diabetes—2007,"*Diabetes Care*, vol. 30, no. 1, pp. S4–S41, 2007.

[4] H. Kahramanli and N. Allahverdi, "Design of a hybrid system for the diabetes and heart diseases," *Expert Syst. Appl*. vol. 35, no. 1/2, pp. 82–89, 2008.

[5] Chang-Shing Lee," A Fuzzy Expert System for Diabetes Decision Support Application" *IEEE transactions on systems, man, and cybernetics part b: cybernetics*, vol. 41, no. 1, pp. 139-153, 2011.

[6] M.Kalpana and A.V Senthilkumar, "Fuzzy Expert System for Diabetes using Fuzzy Verdict Mechanism", *Internationl Journal of Advanced Networking and Applications*, Vol. 03, Issue:02, pp.1128-1134, 2011.

[7] M.Kalpana and A.V Senthilkumar, "Enhanced Fuzzy Verdict Mechanism for Diabetes using Fuzzy Expert System" , *Journal of Computational Intelligence and Information Security*, Vol. 2, No. 8, pp. 43-54,2011.

[8] A.V Senthilkumar and M.Kalpana ,"Diagnosis of Diabetes using Intensified Fuzzy Verdict Verlag Mechanism", *A. Abd Manaf et al. (Eds.): ICIEIS 2011*, (Part III, CCIS 253)(Springer-Berlin Heidelberg,),pp. 123–135,2011.

[9] M. Kalpana and A.V Senthil Kumar, "Diagnosis of Diabetes using Correlation fuzzy logic in Fuzzy Expert System", *International Journal of Advanced Research in Computer Science*, Vol. 3, No. 1, pp. 244- 250, 2012.

[10] M. Kalpana and A.V Senthil Kumar," Design and implementation of Fuzzy Expert System using Fuzzy Assessment Methodology", *International Journal of Science and Applied Information Technology,* Volume 1, No.1, pp. 39-45, 2012.

[11] Harvey J. Gold, Gail G. Wilkerson, Yanan Yu and Ronald E. Stinner, "Decision Analysis as a Tool for Integrating Simulation with Expert Systems when Risk and Uncertainty are Important", *Computers and Electronics in Agriculture, Elsevier Science Publishers B.V., Amsterdam*, Vol. 4, pp. 343-360, 1990.

[12] Norman D. Clarke, Mary D. Mcleish and Tony J. Vvn, "Using Certainty Factors and Possibility Theory Methods in a Tillage Selection Expert System", *Expert Systems With Applications*, Vol. 4, pp. 53-62, 1992.

[13] J. F. Baldwin, "Fuzzy Sets and Expert Systems", Information Sciences, Vol. 36, pp. 123-156, 1985.

[14] P. Baraldi, M. Librizzi, E. Zio, L. Podofillini and V.N. Dang, "Two techniques of sensitivity and uncertainty analysis of fuzzy expert systems", *Expert Systems with Applications, Elsevier Ltd*., Vol. 36, pp. 12461–12471, 2009.

[15] Alauddin Alomary and Mohammad Jamil, "An Approach to Strengthen Expert System Shell with Knowledge Illustration Established on Peak of the Fuzzy Logic", *The International* Arab Journal of Information Technology, Vol. 3, No. 3, pp. 210-218, July 2006.

[16] Andrew L.S. Gordon, Ivan Belik, Shahram Rahimi, "A Hybrid Expert System for IT Security Risk Assessment", *International Conference on Parallel and Distributed Processing Techniques and Applications, Las Vegas*, pp. 430-434, 2010.

[17] C. S. Lee and M. H. Wang, "Ontology-based intelligent healthcare agent and its application to respiratory waveform recognition," *Expert Systems with Applications*, vol. 33, no. 3, pp. 606–619,2007

[18] Raouf Ketata, Hatem Bellaaaj, Mohamed Chtourou and Mohamed Ben Amer, "Adjustment of membership functions, generation and reduction of fuzzy rule base from numerical data", *Malaysian Journal of Computer Science*, Vol. 20, Iss. 2, pp. 147-169, 2007.

[19] Vincent C Yen, "Rule selections in fuzzy expert systems", *Expert systems with applications*, vol.16, pp. 79-84,1999.

[20] Arazi Idrus, Muhd fadhilg Nuru system to Estimate Iddin, M. arif Rohman, "Development of project cost contingency estimation model using risk analysis and fuzzy expert system" ,*Expert System with applications*, vol. 38 pp.1501-1508,2011.

[21] M.Kalpana and A.V Senthilkumar," Diagnosis of diabetes using Enhanced Fuzzy Assessment Methodology", *European Journal of Scientific Research*, Volume 97 Issue 1.pp. 14-27, 2013.

[22] William Siler and James Buckley,"Fuzzy Expert System and Fuzzy Reasoning" *Wiley & Sons, Inc* ,pp,40,49-50,60-62,2005.

[23] Peter H.Sydenham and Richard Thorn, "Handbook of measuring system Design" *John Wiley & sons*, Ltd., ,pp. 912-917,2005.

[24] Kalpana. M and Senthilkumar A.V, "Design and Implementation of Fuzzy assessment Methodology using K Ratio for Fuzzy Expert System", *N.R Shetty et al. (Eds.): Proceedings of International Conference on Emerging Research in Computing, Information, Communication and Applications, Elsevier Science and Technology pub*lication, Pp. 62-67, 2013.

