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Application of Fuzzy Logic for Presentation of an Expert Fuzzy System to Diagnose Thalassemia

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***Abstract* —** In this paper We have designed a Thalassemia diagnosis model under some fuzzy rules. The performance of the system is approximately similar as the clinical results. Also, through this system the category of Thalassemia disease can be predictable. We have used MATLAB tool of Mamdani Fuzzy Inference System (FIS) to identify the severity of the disease. The objective of this research is to create a Fuzzy model for Thalassemia disease diagnosis. The results in this work can be obtained by a simple and inexpensive method. This would generate, in economic terms, significant savings.

***Keywords*—** Fuzzy Logic, Mamdani FIS, Symptoms of Thalassemia, Thalassemia Disease.

I. Introduction

Hemoglobin (Hb) is a heterogeneous group of proteins made by four globin chains and four heme groups. It carries oxygen to the lungs and other parts of the body. There are three types of hemoglobin's such as **A**, $\mathbf{A_2}$ and **F** which are found out in adults. The most common example of hemoglobin disease is Thalassemia. It has been recently identified as one of the major public health problems in the world; it is applying for global eradication. The disease occurs when there is a change in the shape of the red blood cells. Which can be characterized by the lack of the corresponding globin chain synthesis, in beta-Thalassemia Major **HbA** is absent, **HbF** is 95-98%, and $\mathbf{HbA_2}$ is 2-5% [1]. Since defective **Hba** genes are responsible for the occurrence of Thalassemia. Thalassemia disease is a type of genetic blood disease and Thalassemia Major, Thalassemia Intermedia and Thalassemia minor are the different forms of Thalassemia disease. According to which we define the stages of Thalassemia such as primary stage and secondary stage where primary stage is the stage where Thalassemia Minor is generally not a severe condition of Thalassemia. People with the Beta –Thalassemia Major can advance to severe anemia, which is also known as Cooley's anemia.

A. *Symptoms of Thalassemia*

Newborn children with Thalassemia disease don't show any signs until they are more than 6 months old. Symptoms of Thalassemia disease vary, in some people it is mild, in others severe and requiring hospitalization. The most common signs and symptoms is anemia. Anemia is a condition when blood has a lower number of red blood cells than natural. People with anemia do not have enough red blood cells, which carries oxygen. Due to this reason, they may feel tired or weak. The following Table 1 shows the different type of symptoms which are associated with their related disease [2, 3, 21].

Rest of the paper is organized as follows, Section I contains the introduction of Thalassemia disease, Section II contain the related work of Fuzzy Inference System, Section III contain methodology used in this paper, Section IV contain the rule base for Thalassemia detection, section V describes the results of study and Section VI concludes research work with future directions.

Table 1. Different Types of Thalassemia with its Symptoms

S.N.	Type of Thalassemia	Different Symptoms
1.	Thalassemia Minor (Thalassemia Trait in both the forms of Alpha and Beta)	No signs or symptoms of the disorder.
2.	Anemia	People feel tired and weak.
3.	Severe Thalassemia	Bone deformities in the face, Fatigue, Slowed growth,

	(Also known as Cooley's Anemia and Thalassemia Major)	Delayed puberty, Shortness of breath, Yellow discoloration of skin (jaundice) or whites of the eyes, Weakness, Abdominal swelling, Dark urine (a sign that red blood cells are having problems), Poor appetite etc.

II. Related Work

There are several diverse areas in the medical field where expert system used successfully. Disease diagnosis of various diseases like cancer, cardiovascular disease, endocrine diseases, diabetes, tumor, patient monitoring, treatment of illness, prognosis, determining the risk of disease, determination of drug dose [4]. Fuzzy sets are the most accurate tool to deal with imprecise data sets. There are a number of article publishing in medical applications using fuzzy environment [5, 6, 7, 8]. Fuzzy systems provide tools to analyze impreciseness of medical diagnostic reports. The use of Fuzzy Inference System (FIS) can be found in following medical applications. Shradhanjali [9], developed a Fuzzy Petri net application for Heart Disease Diagnosis. The rule based is associated with transition for certain factors. The fuzzy Petri net is drowning for the rule base and get the decision of the disease, truth value proposition is used. Lavanya [10], designed a Fuzzy rule based inference detection system for and diagnosis of lung cancer. The dataset is used for the domain expert with symptoms, stages and treatment facilities to provide an efficient and easy method to diagnose lung cancer. Adeli [11], proposed a Fuzzy expert system for the Heart Disease Diagnosis. The developed system uses fuzzy logic. In their system the crisp value is fuzzified to get fuzzy values. The expert system uses those fuzzy values and the output is also fuzzy. The fuzzy output is defuzzified to get a crisp output. Sony [12], designed an Intelligent and Effective Heart Disease Prediction System uses weighted associative classifiers. They used Java as front end and Ms Access as backend tool. They only consider two cases for prediction (Heart disease and No Heart Disease). Neshat [13], developed a Fuzzy Expert System for diagnosis of Liver Disorder. They considered two cases, people with healthy liver, and people with unhealthy liver along with calibration of disease risk intensity measure. The fuzzy inference system is developed in MATLAB software. Kadhim [14], implemented a fuzzy expert system which was to diagnosis the back pain. The rules were developed by experts and decision sequence is illustrated by a decision tree.

III. Methodology

A. *The Concept of Fuzzy Set Theory*

Fuzzy logic is a superset of conventional (Boolean) logic which has been extended to handle the concept of partial truth – values between "completely true" and "completely false" [15]. Fuzzy sets were introduced by Professor Lofti A. Zadeh in 1965 that lives in USA [16]. He and others, in the subsequent decades, found surprising applications in every field of science and knowledge: from engineering to sociology, from biology to computer science, from agronomy to linguistics, from medicine to economy, from psychology to statistics and so on. They are now cultivated in all over the world. We know that the subsets of a universe X can be represented as functions, the characteristic functions from X to the set $\{0, 1\}$. The notion of fuzzy subset generalizes that one of characteristic functions. A fuzzy set A in X X is characterized by its membership function defined by $\mu_A(x): X \rightarrow [0,1]$ and $\mu_A(x)$ interpreted as the degree of membership of element x in fuzzy set A for each $x \epsilon X$. Fuzzy logic is a method to provide a specific way for diagnosis and decision making because of their approaches to deal with uncertainties and ambiguity in the knowledge and information. In the field of medicine, fuzzy logic plays an important role for suggestive diagnostic remedies. The Medical practitioners identified possible and promising areas for implementation of fuzzy logic for medical diagnosis. Fuzzy systems have been effectively applied to problems in modeling, control, classification, and in a significant number of applications. In many fields of medicine, fuzzy logic based approaches have been used. Now a day's applying the fuzzy system is increasing in the field of medical diagnosis gradually. Currently, fuzzy sets are armed with their own mathematical foundations, rooting from set theory basis and multi-valued logic. Previously we have shows that Fuzzy Systems are effective to generate a fuzzy mathematical model which is very helpful in medical diagnosis. In this paper, we consider Fuzzy Inference System for Thalassemia disease diagnosis. This model can be helpful for the proficient and cost effective diagnosis of Thalassemia. Also, this model is beneficial for numerous areas where medical facility is not available

B. *Fuzzy Inference System*

Fuzzy Expert System is a collection of fuzzy membership functions and rules, instead of Boolean logic [17, 18]. In 1973 Mamdani and Assilian was proposed the most commonly used fuzzy inference model which is known as a Mamdani Fuzzy Model. Their work was inspired by Zadeh [19, 20], describe a general structure of a Mamdani type fuzzy inference system to be used as the core part of a fuzzy application. The structure can be summarized in the following four steps, carried out in order:

- **Fuzzification** is the first step of FIS in which the membership functions defined on the input variables are applied to their actual values, to determine the degree of truth for each rule premise.
- **Inference** is the second step of FIS in which for the premise we computed the truth value of each rule and applied to the conclusion part of each rule. This results in one fuzzy subset to be assigned to each output variable for each rule. Usually minimum or the product is used as inference rules. In the case of minimum, the output membership function is clipped off at a height corresponding to the rule premise's computed degree of truth. While selecting the product, the output membership function is scaled by the rule premise's computed degree of truth.
- **Composition** is the third step of FIS, in which all of the fuzzy subsets assigned to each output variable are combined together to form a single fuzzy subset for each output variable.
- **Defuzzification** is the fourth step of FIS, which is performed to convert the fuzzy output set to a crisp number. There are more defuzzification methods available, from which this work is done using the centroid method. This method gives the crisp value of the output variable that is computed by finding the variable value of the center of gravity of the membership function for the fuzzy value.

In Mamdani model the fuzzy inference is modeled by Mamdani's minimum operator, the conjunction operator is *min*, the *t-Norm* from compositional rule is the min and for the aggregation of the rules the *max* operator is used. They used this proposed method to explain the working with the rules, Such that

$$Rule1: IF\ x\ is\ A\ OR\ y\ is\ B\ THEN\ z\ is\ C$$

$$Rule2: IF\ x\ is\ A\ AND\ y\ is\ B\ THEN\ z\ is\ C$$

$$Rule3: IF\ x\ is\ A\ THEN\ z\ is\ C$$

In above rules if part of the rule, *"x is A"* called antecedent or premise, while then part of the rule, *"z is C"* is called consequent or concluded.

C. Description of the proposed system

This work has been harnessed using Mamdani type. Based on the expert's knowledge, experience and by the information fuzzy rules was created. These formed rules provide a way to find the disease using the Mamdani Fuzzy Inference System. The inputs of the system are Symptoms_Score, HbA and Hba where Symptoms_Score is the score of symptoms and through the blood test we consider the value of HbA (Adult hemoglobin) also Hba is a Thalassemia gene, indicating that the parents of the patients are TH_m or not that means the Thalassemia gene in both the parents is present or absent. Finally the output of the system is to get a value 1 to 0 through which we can predict the Thalassemia stages that indicates the severity of the Thalassemia disease.

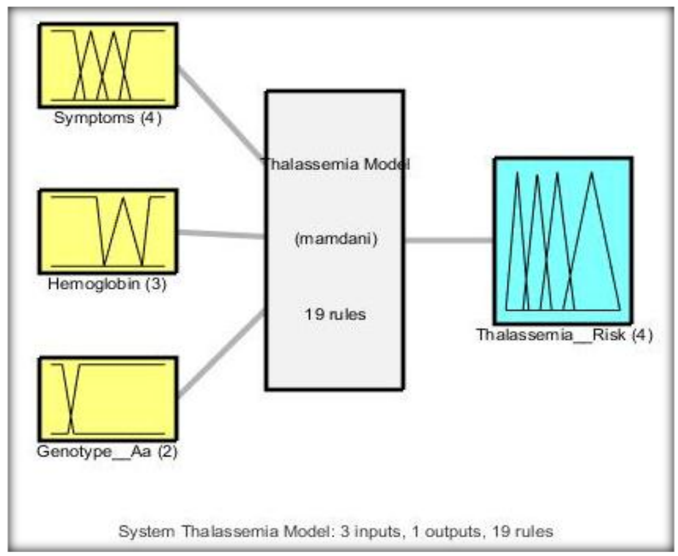

Figure 1. Three input variables (Symptoms, Hemoglobin and Genotype_Aa)

D. Ranges for Input/output fields of the system

In the present study Symptoms, Hemoglobin and Genotype_Aa are the input variables of the system such as Symptoms is divided into four labels such as Mild, Moderate, Severe and Very_Severe. Hemoglobin is divided into three labels such as Low, Medium and Normal and Genotype_Aa is dividing into two labels such as Absent and Present. Each term is defined by the individual membership functions. The following subsection shows the description of each input:

Symptoms: We divide Symptoms score into four categories Mild, Moderate, Severe and Very_Severe, then design a table (see Table 2) for their ranges and define mathematical interpretation in subsequent equations. Figure 2, shows the membership function of input Symptoms in each term as Mild, Moderate, Severe and Very_Severe. Membership functions of Mild and Very_Severe are trapezoidal and membership function of Moderate and Severe are triangular.

Table 2. Classification of Symptoms

Input Field	Range	Fuzzy sets
Symptoms	$x_1 \leq 0.2$	Mild
	$0.2 \leq x_1 < 0.5$	Moderate
	$0.4 \leq x_1 < 0.7$	Severe
	$x_1 \geq 0.7$	Very_Severe

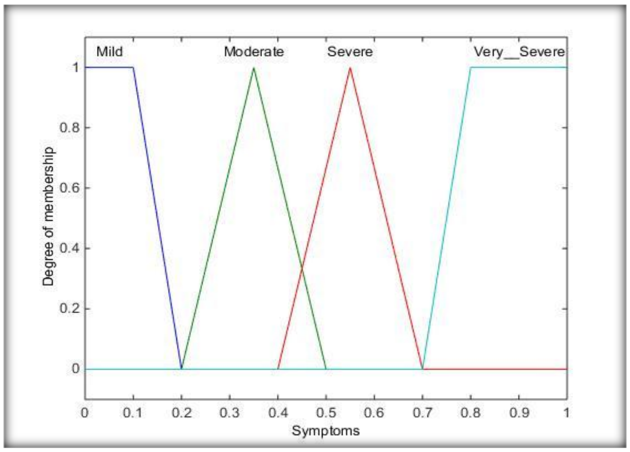

Figure 2. Membership Functions of Symptoms

Hemoglobin: It contains three fuzzy sets they are Very_Low, Low and Medium. Table 3, represents the ranges of these fuzzy sets Very_Low, Low and Medium. Membership functions of Very_Low and Medium are trapezoidal and membership function of Low is triangular. Figure 3, shows the membership function of input Hemoglobin for each term.

Table 3. Classification of Hemoglobin

Input Field	Range	Fuzzy Sets
Hemoglobin	$x_2 < 7$	Very_Low
	$7 \leq x_2 \leq 10$	Low
	$x_2 > 10$	Medium

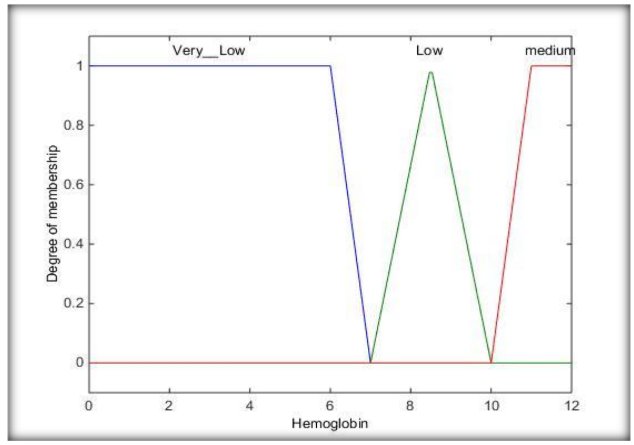

Figure 3. Membership Functions of Hemoglobin

Input field Genotype_Aa: In this field, we take two terms such as Absent and Present see Table 4.

Table 4. Classification of Genotype_Aa

Input Field	Range	Fuzzy Sets
enotype_Aa	$x_3 < 0.1$	Absent
	$x_3 \geq 0.1$	Present

The input **Genotype_Aa** is Absent in the parents that means they are free of Genotype Aa in this case there is no possibility of Thalassemia Major or severe Thalassemia disease. Also, if the input **Genotype_Aa** is Present that means the parents of the patients carry Thalassemia gene and there are different possibility arises for Thalassemia disease in patients. Figure 4, shows the Mf for Genotype_Aa:

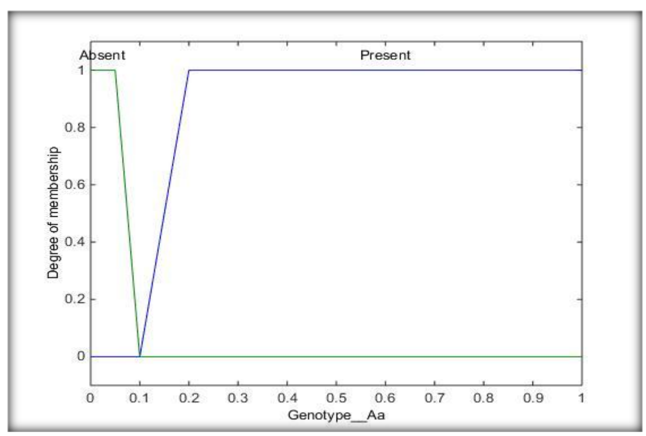

Figure 4. Membership Functions of Genotype_Aa

Output Fields: The output field **Thalassemia_Risk** is divided into four stages, Mild, Moderate, Severe and Very_Severe (see Table 5). It means if the result appears in Mild range, then into the patient the risk of Thalassemia is very minimum.

Table 5. Classification of Thalassemia Stage

Output Field	Range	Fuzzy Sets
Thalassemia_Risk	$0.0 \leq y \leq 0.2$	Mild
	$0.2 \leq y \leq 0.4$	Moderate
	$0.4 \leq y \leq 0.6$	Severe
	$0.6 \leq y \leq 1.0$	Very_Severe

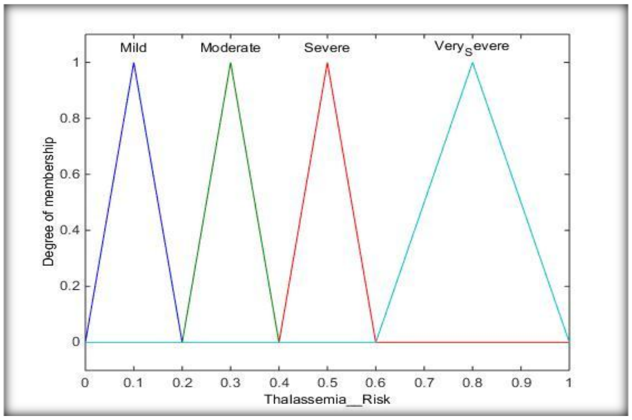

Figure 5. Membership Functions of Thalassemia_Risk

Similarly in other cases such as Moderate, Severe and Very_Severe the risk of Thalassemia in a patient is increased as shown in the output . In Very_Severe stage, it confirms that the patient has maximum possibility of the disease. Ranges for these stages are presented in Table 5, and the mathematical expression is presented in subsequent equations. Membership function for each stage is triangular (see Figure 5).

IV. THE RULE BASE FOR THALASSEMIA

On the basis of the input and output variables, 19 rules have been constructed by selecting an item in each input and output variable box and one connection (AND). Table 6, shows the rule base for the Thalassemia inference system. On the basis of these rules, the rule map of the whole fuzzy inference system is shown in Figure 6, Figure 7 and Figure 8.

Table 6. Illustrations of applied rules with Respect to MF

Rule No.	ANTECEDENT			CONSEQUENCE
	Linguistic Variable1 (Symptoms)	**Linguistic Variable2 (Hemoglobin)**	**Linguistic Variable3 (Genotype_Aa)**	**Results**
1	Mild	Very_Low	Present	Very_Severe
2	Mild	Low	Present	Severe
3	Mild	Medium	Present	Mild
4	Mild	Very_Low	Absent	Mild
5	Mild	Low	Absent	Mild
6	Mild	Medium	Absent	No_Thalassemia
7	Moderate	Very_Low	Present	Very_Severe
8	Moderate	Low	Present	Very_Severe
9	Moderate	Medium	Present	Moderate
10	Moderate	Very_Low	Absent	Severe
11	Moderate	Low	Absent	Moderate
12	Moderate	Medium	Absent	Mild
13	Severe	Very_Low	Present	Very_Severe
14	Severe	Low	Present	Very_Severe
15	Severe	Medium	Present	Moderate
16	Severe	Very_Low	Absent	Severe
17	Severe	Low	Absent	Moderate
18	Very_Severe	Very_Low	Present	Very_Severe
19	Very_Severe	Low	Present	Very_Severe

V. RESULT AND DISCUSSION

The process of fuzzy inference model can be described as: First step is Fuzzification in which crisp value of the input data is gathered and converted to a fuzzy membership value using degree of membership functions and fuzzy linguistic variables. After that an assumption is made based on a set of rules, and finally in the defuzzification step resulting fuzzy output value is converted into crisp output value using the membership functions. Using fuzzy linguistic variable and membership functions is defined based on the expert's knowledge and advice.

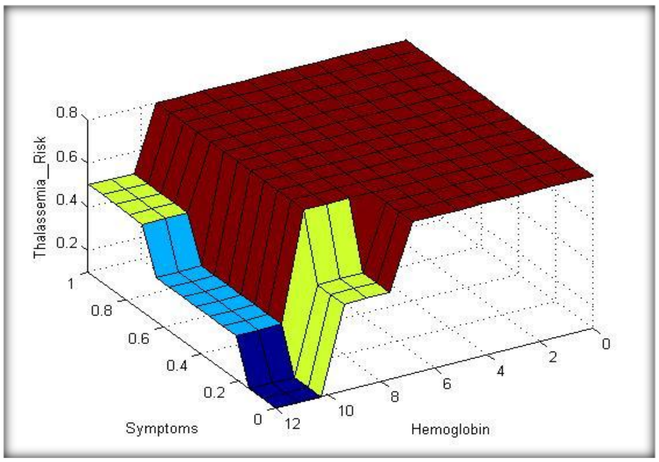

Figure 6. Surface plot of Symptoms, Hemoglobin and Thalassemia_Risk

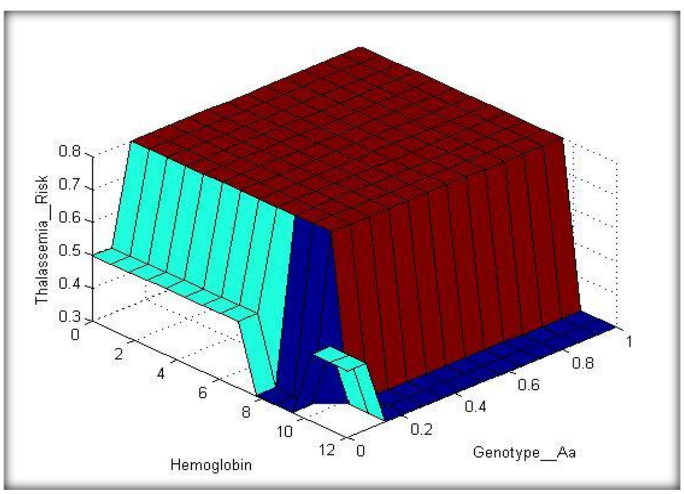

Figure 7. Surface plot of Symptoms Score, Hba and Thalassemia_Stage

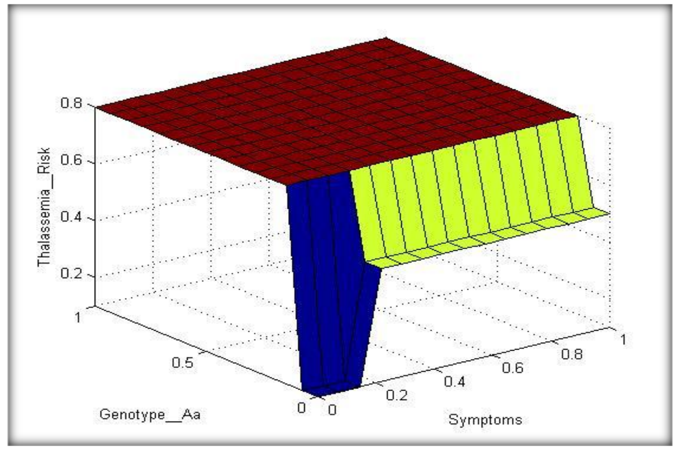

Figure 8. Surface plot of Hba, HbA and Thalassemia Stage

The output field refers to the presence and absence of Thalassemia disease in the patient. Clearly, Figure 6, shows the Thalassemia_Risk in a patient as the symptoms are increasing and **Hemoglobin** decreases the Thalassemia_Risk is increasing, as Symptoms increase after 0.2, the Thalassemia_Risk stage is very high while the Genotype_Aa is Present see Figure 7, it shows that when Genotype_Aa is less than 0.1 there is no chance for Thalassemia disease, but as Genotype_Aa is greater than 0.1 it mans Hba(Thalassemia Trait) is present there is surely Thalassemia disease. Figure 8, shows that symptoms and Genotype_Aa together increases the level of Thalassemia and is also increasing.

VI. CONCLUSION AND FUTURE SCOPE

In this model we present graphical decisions for the detection of Thalassemia disease in the patients. This model is based on the Mamdani Fuzzy Inference system and programmed in MATLAB 8.4. This model is based on three basic diagnostic inputs (named: Symptoms, HGB and Genotype_Aa) and the model has a number of decisions to identify the level of Thalassemia disease. A result of this model is very satisfactory and has been approved by expert doctors. This model has ability to predict that the patient is Thalassemia or not and the stage of disease. Experimental results show that the model is quite well than non-expert urologist. The proposed model proves to be more capable, proficient and cost effective in diagnosing Thalassemia disease. This system can be used at hospital level by doctors and physicians to classify the patient's Thalassemia status. In future this model can be extended to diagnose other diseases such as Diebities, G6PD deficiency etc.

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REFERENCES

[1] Grow K, Vashist M, Abrol P, Sharma S, Yadav R. "*Beta Thalassemia in India: Current Status and the Challenges Ahead*". International journal of Pharmacy and Pharmaceutical Science , Vol.3, Issue.4, pp.28-33, 2014.

[2] G. Vijay, G. David, "*Thalassemia: An Overview of 50 Years of Clinical Research*", Elsevier- Hematology/Oncology Clinics of North America, Vol.24, Issue.6, pp. 1005-1020, 2010.

[3] S. Thakur, R. Sharma, "*Prevention Measures for Thalassemia in Chhattisgarh, India: with the help of mathematical models*", American Journal of Mathematics and Mathematical Sciences Vol.2, Issue.2, pp.193-200, 2013.

[4] F. Aversa, E. Gronda, S. Pizzuti, C. Aragno, "*A fuzzy logic approach to decision support in medicine*", Proceedings of the Conference on Systemics, Cybernetics and Informatics, 2002.

[5] A. Novruz, "*Design of Fuzzy Expert Systems and Its Applications in Some Medical Areas",* International Journal of Applied Mathematics, Electronics and Computers , Vol 2, Issue.1, pp.1-8, 2014.

[6] C. Tamalika, C Tridib, "*Intuitionistic fuzzy sets: Application to medical image segmentation",* Studies in Computational Intelligence, Springer, Vol.85, pp.51-68, 2008.

[7] C. Schuh, "*Fuzzy sets and their application in medicine",* Proceedings of the North American Fuzzy Information Society, pp.86-91, 2005.

[8] K. Yamada, "*Diagnosis under compound effects and multiple causes by means of the conditional causal possibility approach*", Fuzzy Sets and Systems, Vol.145, pp.183-212, 2004.

[9] Shradhanjali, "*Fuzzy Petry Net Application: Heart Disease Diagnosis",* International Conference on Computing and Control Engineering, 2012.

[10] K. Lavanya, M.A. Durai, S.N. lyengar, "*Fuzzy Rule Based Inference System for Detection and Diagnosis of Lung Cancer",* International journal of Latest Trends in computing, Vol.2, pp.165-169, 2011.

[11] A. Adeli, M. Neshat, " *A Fuzzy Expert System for Heart Disease Diagnosis",* Proceedings of the International Multi Conference of Engineers and Computer Scientists , Vol .1, pp.136-139, 2010.

[12] J. Soni, U. Ansari, D. Sharma, "*Intelligent and Effective Heart Disease Prediction System using Weighted Associative classifiers",* International Journal on Computer Science and Engineering, Vol.3, Issue.6, pp.2385-2392, 2011.

[13] M. Neshat, M. Yaghobi, M.B. Naghibi, A. Esmaelzadeh, "*Fuzzy Expert System Design for Diagnosis of liver Disorders",* IEEE Proceeding International Symposium on Knowledge Acquisition and Modeling, pp.252-256, 2008.

[14] M. Kadhim, M. Alam, H. Kaur, "*Design and Implementation of Fuzzy Expert System for Back pain Diagnosis",* International Journal of Innovative Technology & Creative Engineering, Vol .1, Issue.9, pp.16-22, 2011.

[15] H.J. Zimmermann, "*Fuzzy Set Theory And its Application",* Third Edtion, Kluwer Academi Publishers, 1996.

[16] L.A. Zadeh, "*Fuzzy Sets*", Information and Control, Vol. 8, pp. 338-353, 1965.

[17] S. Hemba, N. Islam, "*Fuzzy Logic: A Review*", International Journal of Computer Sciences and Engineering, Vol.5, Issue.2, pp.61-63, 2017.

[18] T. Kasbe, R. S. Pippal, "*Dengue Fever: State-of-the-Art Symptoms and Diagnosis*", International Journal of Computer Sciences and Engineering, Vol.4, Issue.6, pp.26-30, 2016.

[19] T. Takagi, S. Sugeno, "*Fuzzy identification of systems and its applications to modeling and control*", IEEE Transactions on Systems Man and Cybernetics, Vol.15, Issue.1, pp.116-132, 1985.

[20] E.P. Dadios, "*Fuzzy Logic Controls, Concepts, Theories and Applications*", InTech, pp. 325-350, 2012.

[21] J. Alain, M.D.Marengo-Rowe, "*The Thalassemias and related Disorders*", Baylor University of Medical Center Proceedings, Vol. 20, pp.27–31, 2007.

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