

Design And Implementation Of Fuzzy Rule-Based Expert System For Endocrine Glands Disease Diagnosis Using Particle Swarm Optimization Algorithm

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Abstract

Endocrinology and metabolism is the branch of medicine concerned with the study of the diseases of the endocrine organs, disorders of hormone systems, and their target organs and disorders of the pathways of glucose and lipid metabolism in health and disease. Medical diagnosis is an important but complicated task that should be performed accurately and efficiently and its automation would be very useful in this domain (medical domain). It encompasses the assessment of patients with such disorders and the use of laboratory methods for diagnosis and monitoring of therapy. In this project we will design expert system model to detect and diagnose endocrinology disease. The disease is determined by using a Particle Swarm Optimization Algorithm. The objective of this algorithm is to obtain a solution and result optimization and better by matching the rules resulting from the fuzzy logic with one of the rules of the disease, means that every rule of the disease represents the best solution - via simulate the behavior of birds in search of the best food ,Thus, any system based on this algorithm will be shaped in the beginning from the random aggregation (the rule resulting from fuzzy) of random solutions, and search within this assembly a perfect solution(looking for rule most match with one of the diseases) and by updating generations .

Keywords: Endocrine Glands Disease, Medical Expert System, Particle Swarm Optimization Algorithm, Fuzzy Logic , Knowledge based System.

1.Introduction

Most hospitals today employ sort of hospital information systems to manage their healthcare or patient data. These systems typically generate huge amounts of data. There is a wealth of hidden information in these data that is largely untapped. How data is turned into useful information that can enable healthcare practitioners to make intelligent clinical decisions.The diagnosis of diseases is a significant and tedious task in medicine. The detection of glands disease from various factors or symptoms is a multi-layered issue which is not free from false presumptions often accompanied by unpredictable effects .In addition ,the decisions are often made based on doctors' intuition and experience rather than on the knowledge rich data hidden in the database. This practice leads to unwanted biases, errors and excessive medical costs which affects the quality of service provided to patients[1].

The advent of computers and information technology in the recent past has brought a drastic change in the fields of medicine area diagnosis, treatment of illnesses and patient pursuit has highly increased. Despite the fact that these fields, in which the computers are used, have very high complexity and uncertainty and the use of intelligent systems such as fuzzy logic, artificial neural network and genetic algorithm have been developed [2][3]. Hence, Information gathered from the domain experts must be transferred to knowledge and must be used at the right time .These Knowledge can be incorporated in the form of fuzzy model in the detection and diagnosis of Glands diseases. Fuzzy relations enable the representation of uncertain medical associations. In addition, fuzzy logic enables the formal treatment of making approximate inferences on the basis of fuzzy data and fuzzy relations . The effectiveness of this method for diagnostic support has been proved by many successful applications of fuzzy concepts in different fields such as technology, economies and medicine[4][5] .Methods with better classification accuracy will provide more sufficient information to identify the potential patients and to improve the diagnosis accuracy. Hence, Met a heuristic algorithms (like particle swarm optimizations) have been applied in this area.

2.Expert System

An expert system is a computer program designed to model the problem solving ability of a human expert. Expert systems solve problems using a process that is very similar to the methods used by a human expert, using a structure shown in fig. 1[6].

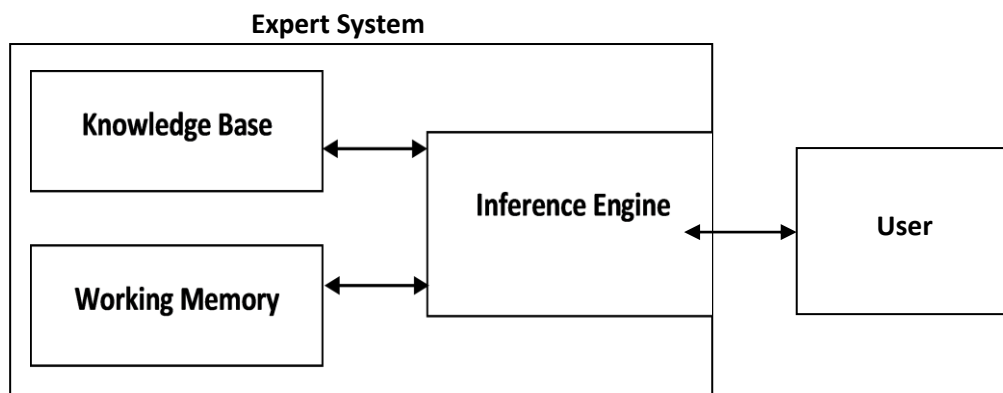


Figure 1. Expert system Problem solving

The knowledge base contains highly specialized knowledge on the problem area as provided by the expert. It includes problem facts, rules, concepts, and relationships. How this knowledge can be coded in the knowledge base is the subject of knowledge representation. Five of the most common knowledge representation techniques are used in the development of an expert system: (1) Object-attribute-value Triplets.(2) Rules: A knowledge structure that relates some known information to information that can be concluded or inferred to be known. (3) Semantic networks: A method of knowledge representation using a graph made up of nodes and arcs where the nodes represent objects and the arcs the relationships between the objects. (4) Frames: A data structure for representing stereotypical knowledge of some concept or object. (5) Logics. The inference engine is the knowledge processor which is modeled after the

expert's reasoning. The engine works with available information on a given problem, coupled with the knowledge stored in the knowledge base, to draw conclusions or recommendations. How this engine can be designed is the subject of inference techniques. There are two types of inference techniques:

1. Forward chaining: Inference strategy that begins with a set of known facts, derives new facts using rules whose premises match the known facts, and continues this process until a goal state is reached or until no further rules have premises that match the known or derived facts.
2. 2 Backward chaining: Inference strategy that attempts to prove a hypothesis by gathering supporting information[6][7].

3. Fuzzy Logic

Fuzzy logic is a set of mathematical principles for knowledge representation based on degrees of membership rather than the crisp membership of classical binary logic. Unlike two-valued Boolean logic, fuzzy logic is multi valued. Fuzzy logic is a logic that describes fuzziness. As fuzzy logic attempts to model human's sense of words, decision making and common sense, it is leading to more human intelligent machines [8]. Fuzzy systems are mathematically based systems that enable computers to deal with imprecise, ambiguous, or uncertain information and situations Traditional computer science has focused on absolutes based on precise mathematics and exact unambiguous syntax and semantics. Fuzzy set theory was proposed in 1965 by Zadeh to help computers reason with uncertain and ambiguous information. Zadeh proposed fuzzy technology as a means to model the uncertainty of natural language. He reasoned that many difficult problems can be expressed much more easily in terms of linguistic variables. Linguistic variables are words and attributes which are used to describe certain aspects of the real world. One important feature of linguistic variables is the notion of their utility as an expression of data compression. In domain of endocrine glands disease risk, X-ray, ALP, ECG, Blood Sugar, sex, and Weight Loss are main risk factors that affect on glands disease risk . Because of the many and uncertain risk factors in the endocrine glands disease risks, sometimes endocrine glands disease diagnosis is hard for experts. So, experts require an accurate tool that considering these risk factors and show certain result in uncertain term[1][8].

4. Data Set

Designed system based on the dataset [3][11][12]. This dataset is part of the collection of databases at the Medical. The purpose of this dataset is to diagnose of Endocrine Glands disease . In our research we use a subset of them and we have just used 35 attributes. This system uses 35 attributes for input and 1 attribute for result. Sample from input fields (attributes) are show in the Table1 and figures of membership function 2,3,4,5,6 and 7:

Table1.Input of disease

No	Input Field	Range	Fuzzy Set
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1	X-ray	<5 1-9 >5	Low Medium High
2	Potassium	3.5-5 Mmol / L	NORMAL
3	Alkaline Phosphatase (ALP)	<30 20-130 >100	Low Normal High
4	Smoking	< 3 cigarettes 3-7 cigarettes 7-12cigarettes 12-18 cigarettes > 18 cigarettes	Low smoking Moderate Above moderate High Very high
5	Sex	1 0	Male Female
6	Resting Electrocardiography (ECG)	(0) [-0.5, 0.4] (1) [2.45, 1.8] (2) [1.4, 2.5]	Normal ST-T abnormal Hypertrophy
7	Maximum Heart Rate	<141 111-194 152>	Low Medium High
9	Blood Sugar (Diabetes FBS)	> 126 mg/dl	True
11	body mass index	Bmi<18 19<Bmi<25 Bmi>24	Low Medium High
12	Calcium	<8.8 8.8-10.2 >10.2	LOW NORMAL HIGH
13	Weight Loss	<0.2 0.3 – 3.6 2.61 – 4.4 3.5 >	Low Medium High very high
19	Hormone aldosterone in the urine	(2-18)mecroGram/24 H	Normal
20	Magnesium	0.9 – 1.75 Mmol / l	Normal
22	Iodine in the body	10-30 Mg	Normal
23	ACTH	7 - 40 MI IU / L /Am	Normal
24	Concentration of cortisol	(165 - 744 Nmol / L).AM (83 - 358 Nmol / L) PM	NORMAL
28	T4	65-156 Nmol / L	Normal
29	T3	0.91 - 2.2 Nmol / L	Normal
30	TSH	0.5-5 MI IU / L	Normal
35	ADH	Man Femal	0-4.7 Pg / ml liters 0-4.7 Pg / ml liters

	Childern	0-4.7 Pg / ml liters	
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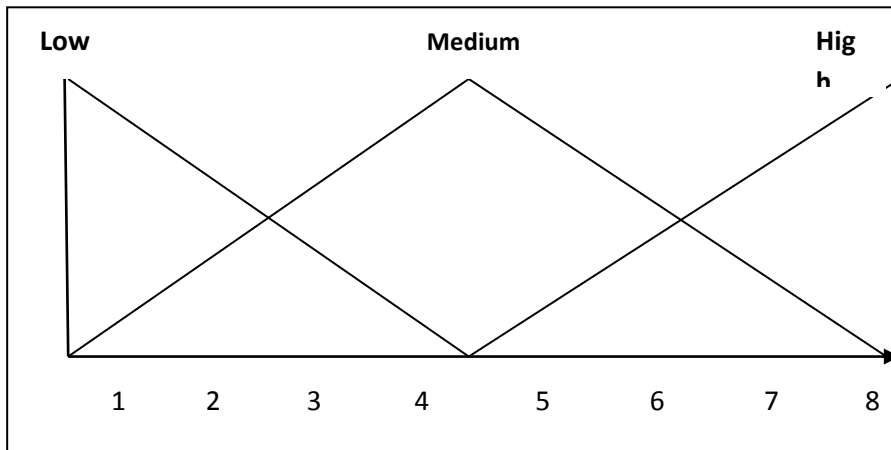


Figure 2. Membership function X-ray

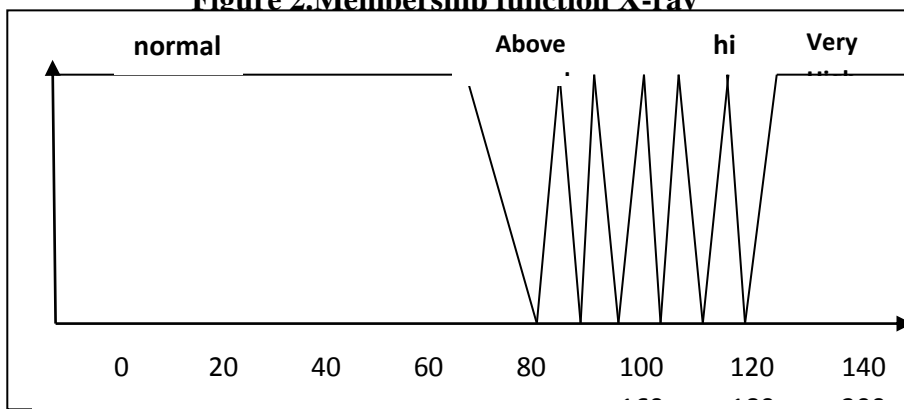


Figure 3. Membership function Blood Pressure(Systolic BP in mm Hg)

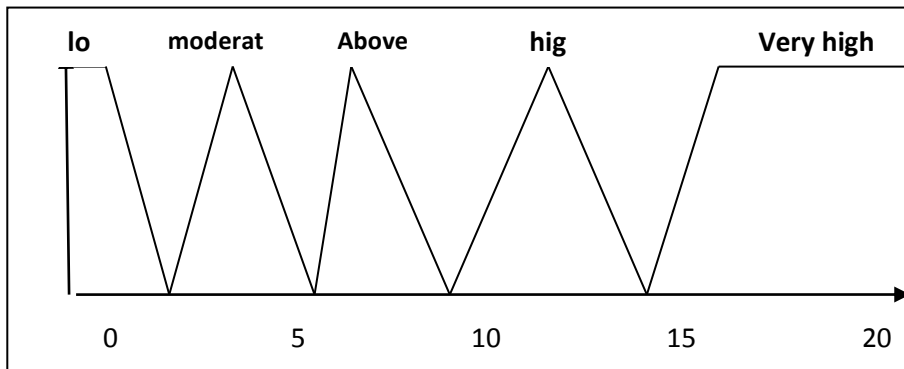
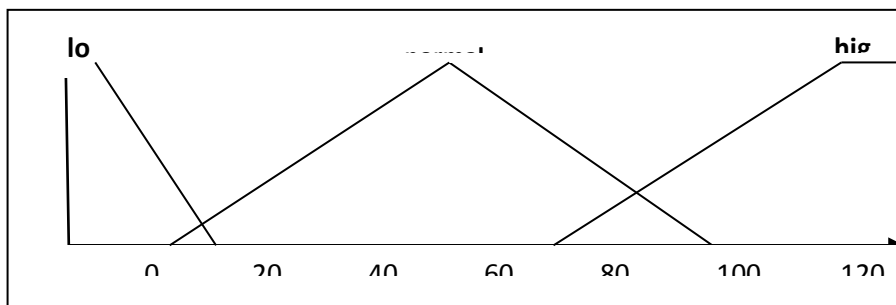


Figure 5. Membership function Smoking

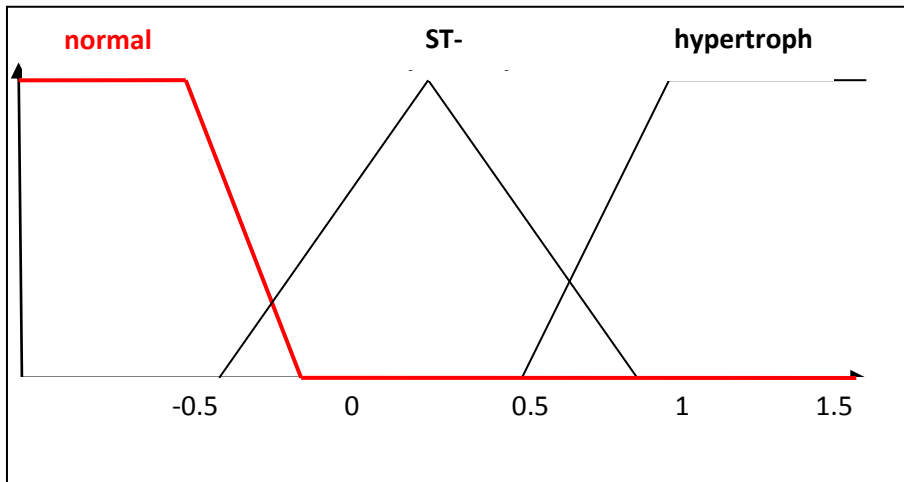


Figure 6. Membership function Resting Electrocardiography (ECG)

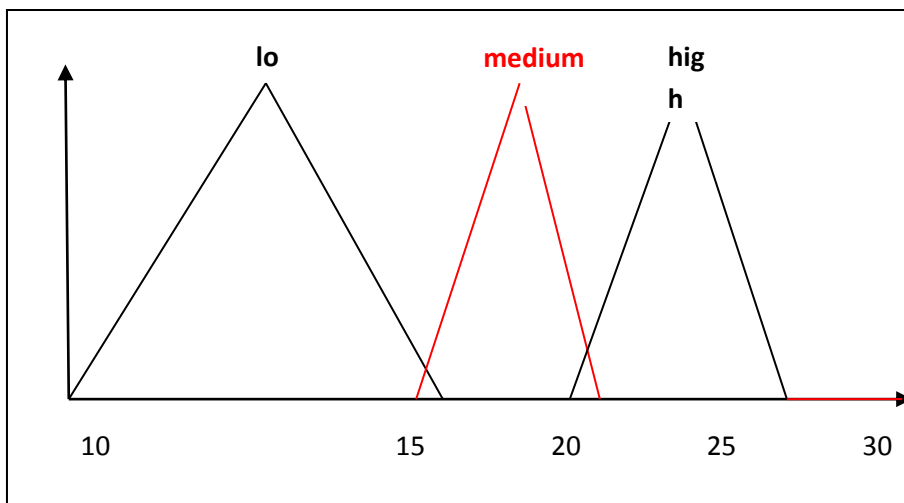


Figure 7. Membership function body mass index

5-PSO Algorithm

The particle swarm optimization (PSO) is a robust stochastic optimization technique based on the movement and intelligence of swarms. PSO is a population-based search algorithm based on simulation of the social behavior of birds within a flock [9]. PSO is widely used to solve the optimization problems and also the feature selection problem [10]. PSO uses a number of particles that constitute for a swarm moving around in the search space looking for the best initialized randomly. A swarm consists of N of particles, where each particle represents a candidate solution moving around D-dimensional search space. All of the particles have fitness values, which are evaluated by a fitness function to be optimized, and have velocities which direct the movement of the particles. During movement, the changes to a particle within the

swarm are influenced by the experience, or knowledge, of its neighbors and each particle adjusts its position according to two fitness value, pbest and gbest, to avoid being trapped in a local optimum by fine-tuning the inertia weight. pbest is a local fitness value, whereas gbest constitutes a global fitness value. If the gbest value is itself trapped in a local optimum, a search of each particle limit in the same area will occur, thereby preventing superior results of classification. Procedure of the PSO algorithm can be summarized as in the following.

- 1) Initialize: Initialize parameters and population with random position and velocities.
- 2) Evaluation: Evaluate the fitness value (the desired objective function) for each particle.
- 3) Find the pbest: If the fitness value of particle i is better than its best fitness value (pbest) in history, then set current fitness value as the new pbest to particle i .
- 4) Find the gbest: If any pbest is updated and it is better than the current gbest, then set gbest to the current value.
- 5) Update velocity and position: Update velocity and move to the next position according to Eqs. (1) and (2) the mentioned in end of algorithm1[10][11].
- 6) Stopping criterion: If the number of iterations or CPU time are met, then stop; otherwise go back to step 2.

The modification of the particle's position can be mathematically modeled according the following equations (1), (2). Algorithm 1 gives the pseudo code of the PSO procedure as given in [10].

Algorithm 1

Initialize particles with random position and velocity vectors.

While The number of generations (N), or the stopping

criterion doesn't meet **do**

Begin

Evaluate the fitness of particle swarm.

for $p = 1$ to N (number of particles) **do**

if The fitness of $x_p >$ the fitness of pbestp **then**

update pbestp = x_p .

end if

if The fitness of any particle of the particle

swarm $>$ gbest **then**

gbest = particle position

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end if  
end for  
for D = 1 to maximum dimension do  
update particle's velocity and position using  
equations 1 and 2  
end for  
end while
```

Algorithm 1: PSO pseudo-code

$$v = v + c_1 * rand * (pBest - p) + c_2 * rand * (gBest - p) \quad (1)$$

$$p = p + v \quad (2)$$

where

- p : particle's position
- v : path direction
- c_1 : weight of local information
- c_2 : weight of global information
- $pBest$: best position of the particle
- $gBest$: best position of the swarm
- $rand$: random variable

6-PSO plus fuzzy logic with an example

The following example is a simple demonstration of applying the PSO algorithm with fuzzy logic. This example shows how applying PSO algorithm after applying fuzzy logic to get more efficient output. We have three diseases as in the table3 and four attributes for each disease.

As we know that the solution of this system will be divided into two parts , the first fuzzy logic and

the second algorithm of PSO. Thus, the following step1 make be applied:

The first step :asking the user to enter the symptoms are as follows:

ECG	Exercise	Maximum Heart	Fatigue
1	66	122	2

The second step :PSO algorithm will send these values to fuzzy logic to determine the correct number of attributes for each disease and know the extents

Result of fuzzy logic:

ECG	Exercise	Maximum Heart	Fatigue
2	5	1	2
2	5	2	2

Now to send the same values for the triangle function to extract the other ranges for each division:

ECG	Exercise	Maximum Heart	Fatigue
1	0.4	0.463415	1
1	0.4	0.268293	1

Table2:Sample from table of diseases data

Disease\ Diagnosis	ECG	<u>Exercise</u>	Maximum Heart	Fatigue
First Disease	ST-T abnormal=2	Very less effective=1	Medium=2	Few=1
Second disease	Hypertrophy=3	less effective=2	High=3	Average=2
Third disease	Hypertrophy=3	Moderate=3	Low=1	Strong=3

Thus we have finished the first section, the fuzzy logic to come to the second section PSO algorithm.

Third step(PSO Algorithm): The change in the size of the flock and which mean the number of rules which came from fuzzy logic, two rules(means 2 birds) as well as Iteration of the same value :

(Iteration =2 , Swarm_size=2 , C1=2 , C2=2 , W=0.5 , Rand=0.2)

Fourth step: The rules test sent by the fuzzy logic with rules of diseases to extract the *pbest*.

Fifth step: Extract the *gbest* (best position of the swarm) rules, which owns the largest number of correct attributes with ranges.

Sixth step: In this step will apply the equations (1), (2) to change the locations of birds.

We will see through the application of the laws that the best solution in each cycle that the speed equal to zero and fixed location either The rest of the solutions are on the rise to reach the best solution.

Seventh step: Final result after apply the law of PSO ,we will get :

gbest=2.92156

number rang of sick=2.53659 then

Patient No. 1 infected in first disease.

7. Implementation

Implementation module is used to determine disease and stage based on the user selected symptoms. Report module is used to display disease, stage, recommendations and treatment for the particular disease. Some the system interfaces is shown in Figures 8,9,10,11 and 12.

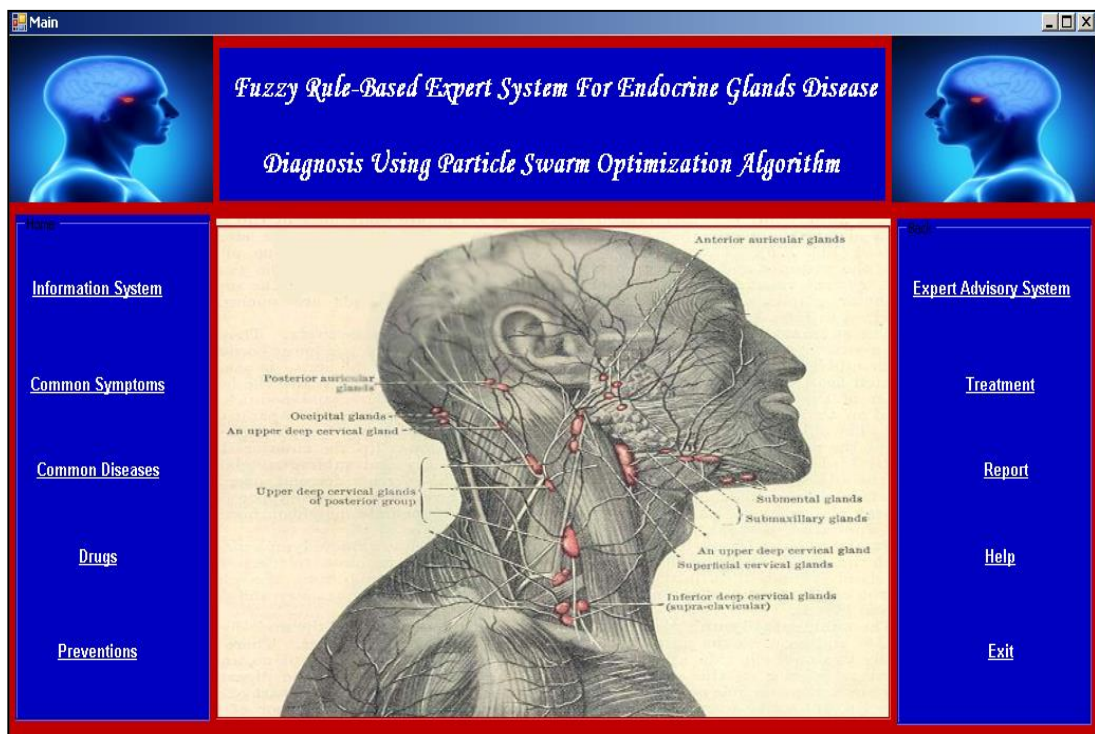


Fig 8:The Main Form Of Expert System

Fig 9: Doctors enter the patient information for diagnosis

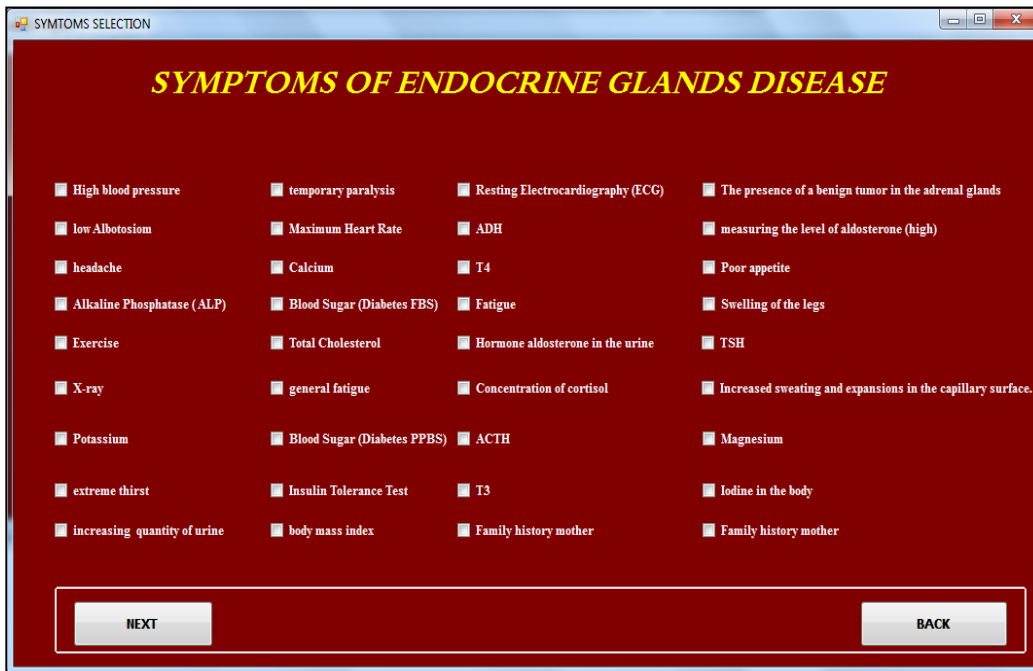


Fig 10: Details for the patients about a particular symptom.

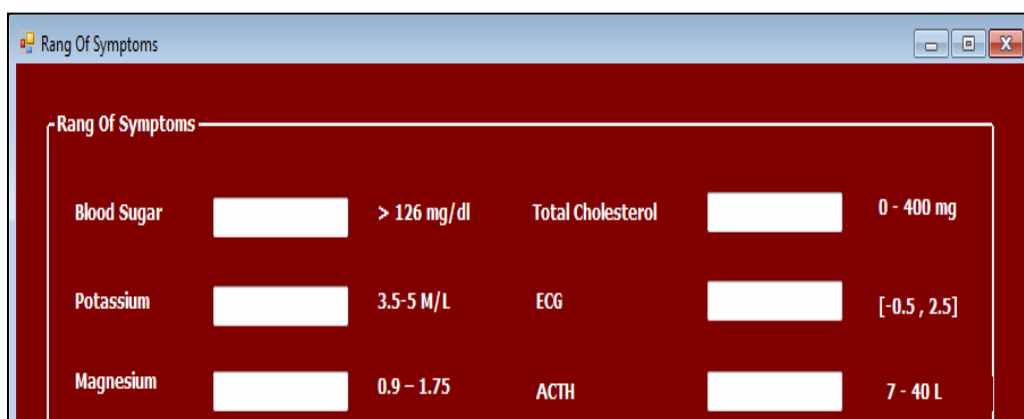


Fig 11:Select the rang of Symptoms

Rang Of Symptoms

ALP	<input type="text"/>	0 - 100 mg	Maximum Heart Rate	<input type="text"/>	0 - 300
X-ray	<input type="text"/>	0-20	ADH	<input type="text"/>	0-4.7 mL
TSH	<input type="text"/>	0.5-5 M/L	T3	<input type="text"/>	0.91 - 2.2 IU/L

NEXT BACK

Fig 12:Select the rang of Symptoms

Report And Diagnosis

RESULT OF ENDOCRINE GLANDS DISEASE

Name

Disease

Stage

About Disease

Fig 13 .Results of patient diagnosed with disease name, stage and the diagnostic treatment for the endocrine glands based on the patient symptoms.

8-Future work and Conclusion

Diagnosing disorders and diseases is one of the most difficult physician's responsibilities. An incorrect diagnosis can endanger . In this regard, the use of different methods of artificial intelligence and expert system has become common and it is tried to minimize the error amount of these methods. In this research, the combination of two methods of PSO and fuzzy logic has been used to diagnose the endocrine glands disease. First fuzzy logic can help us to deal with human parameters have imprecise behavior and no one can states those parameters precisely. PSO is responsible for deter mining being patient or not, being patient of each record and specifies to which class each record belongs. In this research we have got high quality results which can be used as reference for hospital decision making and research workers. In future research, we not only continued to ameliorate the process of data mining but applied to the various domains so that improved the medical quality.

Reference:

- [1]Mrs.G.Subbalakshmi, Mr. K. Ramesh and Mr. M. Chinna Rao ," Decision Support in Heart Disease Prediction System using Naive Bayes", Vol. 2 No. 2 Apr-May 2011.
- [2]M. A. Saleem Durai¹, N. Ch. S. N. Iyengar¹, A. Kannan²," Enhanced Fuzzy Rule Based Diagnostic Model for Lung Cancer using Priority Values", Vol. 2 (2) , 2011.
- [3] Novruz Allahverdi & Serhat Torun & Ismail Saritas, Design Of A Fuzzy Expert System For Determination Of Coronary Heart Disease Risk, International Conference On Computer Systems And Technologies - Compsystech'07.

- [4] Adlassnig KP. Fuzzy set theory in medical diagnosis. IEEE Trans Systems, Man Cybern ; 16;1986.
- [5] Adlassnig KP, Scheithauer W, Kolarz G. Fuzzy medical diagnosis in a hospital. In: Prade H, Negoita CV, eds. *Fuzzy Logic in Knowledge Engineering*. Kaln: Verlag TOV Rheinland GmbH 1986.
- [6] Durkin J., 1994, "Expert Systems Design and Development".Macmillan Publishing Company,1994.
- [7] Dan W. Patterson , "Introducation to Artificial Intelligence And Expert System",2010.
- [8]S.Rajase karan & G.A.Vijayalakshmi Pai , Neural Networks,Fuzzy Logic,Gentic Algorithm,2010.
- [9] Andries P. Engelbrecht, "Computational Intelligence: An Introduction", Second Edition, John Wiley & Sons, Ltd, The Atrium, Southern Gate, Chichester, West Sussex PO19 8SQ, 2007.
- [10] Li-Yeh Chuang, Hsueh-Wei Chang, Chung-Jui Tu, and Cheng-Hang Yang, "Improved binary PSO for feature selection using gene expression data", Computational Biology and Chemistry, Vol.32, PP. 29-38, 2008.
- [11] T. Sousa, A. Silva, A. Neves, "Particle Swarm based data mining algorithms for classification tasks," Parallel Computing J., vol. 30, pp.767-783, 2004.
- [12] Robert Detrano & M.D & PhD, V.A. Medical Center, Long Each and Cleveland Clinic Foundation. Available:www.archive.ics.uci.edu/ml/datasets/Heart+Disease
- [13] . <http://forum.te3p.com/346505.html>

تصميم وتنفيذ نظام خبير مضرب لتشخيص امراض الغدد الصماء باستخدام خوارزمية الطيور

الخلاصة

أمراض الغدد الصماء والتمثيل الغذائي هو فرع من فروع الطب المعنية بدراسة أمراض أجهزة الغدد الصماء، واضطرابات نظم الهرمونات، والأعضاء المستهدفة واضطرابات في مسارات أيض الجلوكوز والدهون في الصحة والمرض. التشخيص الطبي هو مهمة هامة ولكن معقدة ينبغي أن تقوم بدقة وكفاءة والتشغيل الآلي من شأنه أن يكون مفيدا للغاية في هذا المجال(المجال الطبي). في هذا المشروع سوف نقوم بتصميم نموذج نظام خبير مضرب لكشف وتشخيص مرض الغدد الصماء. يتم تحديد المرض من خلال استخدام خوارزمية الطيور. الهدف من هذه الخوارزمية هو الحصول على الحل والنتيجة الأمثل والأفضل بواسطة تطابق القاعدة الناتجة من الضبابي مع قاعدة احد الأمراض إي إن كل قاعدة للأمراض تمثل الحل الأمثل- عبر محاكاة سلوكيات الطيور في البحث عن الطعام الأفضل - وبالتالي فإن أي نظام يعتمد على هذه الخوارزمية سيتشكل في البداية من تجمع عشوائي(أي القاعدة الناتجة من الضبابي) من الحلول العشوائية , ويتم البحث ضمن هذا التجمع عن الحل الأمثل(أي يبحث عن القاعدة الأكثر تطابق مع احد الأمراض) وذلك عبر تحديث الأجيال.