ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 12, December 2014

Applications of Fuzzy-Neural and FPGA For Prediction of Various Diseases- A Survey

Ketan K. Acharya[1], R.C.Patel[2]

PG Student [AI], Dept. of Instrumentation & Control, L.D. College of Engineering, Ahmedabad, India[1]

Associate Professor, Dept. of Instrumentation & Control, L.D. College of Engineering, Ahmedabad, India[2]

ABSTRACT:Purpose of this study is to evaluate the increasing usage of fuzzy neural networks and FPGA based implementations for predicting various physiological diseases. Various Fuzzy-Neural algorithms like back propagation, inverse delayed function and time averaging types are frequently used for overall prediction of various disease which help doctors in timely treatment and care and also help patients for taking remedial actions in advance. Strategy observed is about collecting pathophysiological data,and then preparing Fuzzy Rule bases as per the guidelines of doctors, and finally mapping these rule base using Neural Network for the prediction of specific disease based on the predecided parameters. The Fuzzy-Neural algorithm can be implemented in FPGA and it can be used as an expert system for the prediction of the disease.

KEYWORDS: NFS (Neuro Fuzzy System), ANN(Artificial Neural Network)FPGA, ANFIS(Adaptive Neuro Fuzzy Interface System)

I.INTRODUCTION

A medical system, also sometimes referred to as health care system is an organization of people, institutions and resources to deliver health care services to meet the health needs of target populations. Presently diseases in India have emerged as number one killer in both urban and rural areas of the country. It will be of greater value if the diseases are diagnosed in its early stage. Correct diagnosis of the disease will decrease the death rate due to different diseases. Many clinical tests are being done to find the presence of the disease. In last decade Neuro Fuzzy applications in medical system are getting huge attention and that is why much relevant research has been conducted. NFS are being used for various typical disease diagnosis like brain disorder, cardiac disease, breast cancer, thyroid disorder, leukaemia, hypotension, heart disease, renal disease etc.

As per the prevailing scenario in our country, there is only 1 doctor per 10000 patients in Indian rural areas. In such a situation, treating patients becomes so hectic and from patients point of view it becomes very demanding to cope up with health related issues. Under these circumstances, predicting future pathophysiological state of the patient is a need of time. Many doctors have suggested and are in fact opting for such devices or systems in which depending on the present results of pathological readings, future states of the patients can be predicted and it can be helpful to patients in taking some corrective measures with utmost and timely care.Various research publications have been studied to understand the way of preparing prediction system for different diseases as discussed below. FPGA implementation for such algorithm is done and it can provide a cost effective solution without using computers.

II.PREDICTION OF VARIOUS DISEASES

A.PREDICTION OF CORONARY HEART DISEASE:

Cardiovascular disease (CVD) is the leading cause of death in many parts of the world. Cardiovascular diseases include myocardial infarction, any disease of the heart or blood vessels (CHD), rheumatic heart disease, and stroke.
Classic risk factors for cardiovascular diseases as reported in the literature are age, sex, total cholesterol level, HDL, LDL, age, smoking status, hypertension, and pre-eclampsia. In the prediction of coronary heart disease based on the above parameters , experiments were conducted based on knowledge of individual's biomarkers, risk habits and demographic profiles using fuzzy neural network, a soft computing technique. The risk factors used in these experiments were a portion of many classical and newer risk factors found. The learning capability of neural networks can be combined with the expressiveness of fuzzy if-then rules using linguistic variables to produce Fuzzy Neural Network models. A neuro-fuzzy classifying system in general has n inputs (attributes or features) x1, x2, x3, ….,xn and

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 12, December 2014

an output which has the form of a possibility distribution over the set Y={y1,y2,…yH} of class labels. In medical field, each input xi represents one input medical attribute which could be either a 'symptom' for diagnostic purposes or a risk factor.Thirteen risk factors are used as input variables. The variables are body mass index, systolic blood pressure, diastolic blood pressure, blood sugar level at fasting, totalcholesterol level, triglycerides level, HDL , cholesterol, LDL cholesterol, smoking habit, pulse pressure, ratio of total cholesterol to HDL cholesterol, sex and age. The prediction output is the presence of any form of coronary heart disease. The logistic regression analysis has identified four risk factors namely body mass index, systolic blood pressure, total cholesterol level and age to have greater impact on the outcome as compared to the markers used. Based on these assumptions, fuzzy neural network models were created and trained using several different input sets consisting of the four suggested risk factors in Matlab SIMULINK environment. PC or separate hardware can be used as an overall diagnosis system.

B-PREDICTION OF GLUCOSE:

Blood glucose measurement is an important feedback in the course of diabetes treatment and prognosis. However, predicting the blood glucose level is not an easy task in the course of insulin treatment. There are many factors influencing the results (internal, environmental and behavioral factors). Here a more generic approach is used for predicting blood glucose levels using Fuzzy Lattice Reasoning (FLR). FLR allows to deal with reasoning using specialist's knowledge acquisition and generation of rule base to increase the accuracy of predicting blood glucose level. In addition to the improved accuracy by FLR, the resultant rules contain some min–max ranges of variables making them flexible for diagnosis at the precise timing of the intervention and alarm.The basis of the diabetic therapy is to replace the lack of insulin by regular exogenous insulin infusion with a right dosage each time, for keeping the patients alive. However, maintaining the blood glucose levels in check via exogenous insulin injection is a tricky and challenging task.

Despite the fact that the reactions of human bodies to exogenous insulin vary, the concentration of blood glucose can potentially be influenced by many variables too (Ginsberg, 2009). These variables include but are not limited to BMI, mental conditions, hormonal secretion, physical well-being, diets and lifestyles. Their effects make a synthetic glucose regulation process in diabetic patients highly complex as the bodily reaction to insulin and other factors differ from one person to another.The resultant decision tree is in a form of predicate logics IF–THEN–ELSE rules which are descriptive enough for decision support when the rules are embedded in some predictor system, as well as for reference and studies by clinicians.

However, one major drawback on decision tree is the rigidity in conditional-testing at each decision tree node. A typical decision rule will look like this,

'IF last_insulin_inj_time 6 109.2mins AND Last_insulin_dose==2.5units AND Carbohydrate_in_lunch P87 grams AND . . .THENpredicted_glucose_next_hour==161.3 mg/dL.'

This should work fine as long as the daily routine of a patient is constant and his therapeutic measurements are always absolute.

C. CANCER DIAGNOSIS USING MODIFIED FUZZY-NEURAL NETWORK:

Research has been conducted in new intelligent decision support system for cancer diagnosis. The system is based on a modified version of fuzzy c-means method and radial basis functions neural network. It can be trained to establish a quality prediction system for a cancer disease with different parameters. Moreover the neuro-fuzzy inference system can be applied to many applications such as data approximation, dynamic system processing, urban water demand forecasting, identifying DNA splice sites and image compression. In general the model can be applied to any data needs classification, interpretation, adaptation or rules' extraction.Fuzzy-Neuro system can be designed by using various architectures. To improve the performance of the system, three matters must be handled: finding the optimal number of the rules, discovering the appropriate membership functions, and tuning of both. The following is a short overview of the major works in this area.

Fuzzy Adaptive Learning Control Network (FALCON): FALCON consists of five layers. Tow nodes for input data, one for the desired output and the rest is for the actual output. The supervised learning is implemented by using back propagation algorithm .

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 12, December 2014

Generalized Approximate Reasoning Based Intelligent Control (GARIC): Several specialized feedforward network are used to implement GARIC. The *UniCSE 1 (2), 73 -78, 2010* 74 main disadvantage of GARIC is the complexity of the learning algorithm.

Neuro-Fuzzy Controller (NEFCON): NEFCON Consists of two phases. The first is used to embed the rules and the second modifies and shifts the fuzzy sets. The main disadvantage of NEFCON is that it needs a previously defined rule base.

Adaptive Network Based Fuzzy Inference System (ANFIS): ANFIS works with different activation functions and uses un-weighted connections in each layer. ANFIS consists of five layers and can be adapted by a supervised learning algorithm.

Neuro-Fuzzy Classification (NEFCLASS) NEFCLASS can be created from scratch by learning or it can be refined by using partial knowledge about patterns.

Fuzzy Learning Vector Quantization (FLVQ): FLVQ is based on the fuzzification of LVQ and it is similar to Adaptive Resonance Theory (ART). The main disadvantage of FLVQ is not tested widely .

Evolutionary Fuzzy Neural Network (EFNN): EFNN uses evolutionary algorithms to train the fuzzy neural network, **Alie**vet. At. Train the recurrent fuzzy neural networks by using an effective differential evolution optimization (DEO) .

The proposed method is compared with ANFIS for two reasons: firstly ANFIS has been written in many programming languages including Matlab fuzzy logic toolbox. Secondly ANFIS is widely tested in various applications such as noise cancellation, system identification, time series prediction, medical diagnosis system.

Fig. 1 illustrates the architecture of ANFIS. For simplicity, we assume that ANFIS has two inputs x and y and one output z, suppose that the rule base contains two fuzzy if-then rules of Takagi and Sugeno's type [16]:
Rule 1: *If x is A1 and y is B1, then f1 = p1x + q1y + r1*
Rule 2: *If x is A2 and y is B2, then f2 = p2x + q2y + r2*

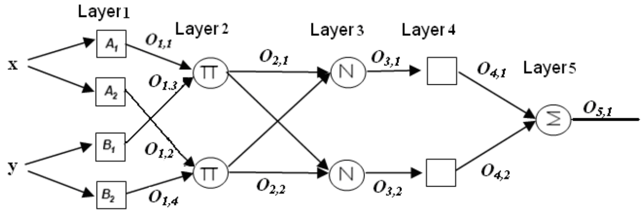

Fig:1-ANFIS Architecture[4]

Let *Oj,i*represents the output of the *ith*node in the layer j, the ANFIS output is calculated.

THE PROPOSED MODEL

The main purposes of the suggested model are to diagnose the cancer diseases by using fuzzy rules with relatively small number of linguistic labels, reduce the similarity of the membership functions and preserve the meaning of the linguistic labels. The learning algorithm of the proposed model consists of three phases:

Phase 1: Modified fuzzy c-means algorithm (MFCM). The standard fuzzy c-means has various well-known problems, namely the number of the clusters must be specified in advanced, the output membership functions have high similarity, and FCM is unsupervised method and cannot preserve the meaning of the linguistic labels.

On the contrary, the grid partitions method solves some of the previous matters, but it has very high number of the output clusters. The basic idea of the suggested MFCM algorithm is to combine the advantages of the two methods, such that, if more than one cluster's center exist in one partition then merge them and calculate the membership values

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 12, December 2014

again, but if there is no cluster's center in a partition then delete it and redefined the other clusters. Algorithm 1 illustrates the modified fuzzy c-means algorithm

Algorithm 1. Modified fuzzy c-means algorithm
Input: Pattern vector, target vector, K the number of the patterns and the partitions intervals of each attribute i kP,
Output: Centers, membership values and the new projected partitions. *UniCSE 1 (2), 73 -78, 2010* 75 1- Delete all the attributes that have low correlation with the target to produce unambiguous rules that are suitable for cancer diagnosis, a modified fuzzy c-means radial basis functions (MFRBF) is used. MFRBF is used to get high accuracy with fewer and unambiguous rules.Thus by using various fuzzy neural algorithms, prediction systems for different diseases can be prepared.

D. PREDICTION OF RENAL DISEASE

Based on the data of patient like BMI, Blood glucose, Creatinine, Urea, and blood pressure critical condition of the patient is predicted. Data of 20-30 days are collected and fuzzy rule bases are prepared which are mapped using neural network.

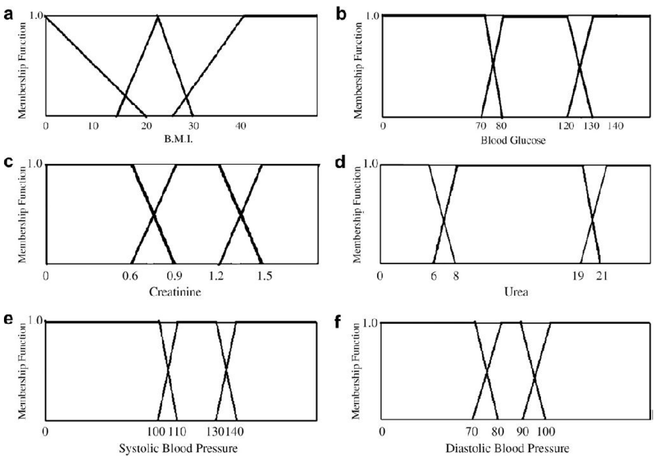

Fig.2- Fuzzy Rulebase for various parameters[3]

Based on these rule base crisp output can be generated to predict abnormal, normal or critical stage of the patient.
Typical rules for inferencing take the forms:
R1: If (body mass index is high) and (glucose is high) and (urea is high) and (creatinine is high) and (systolic blood pressure is high) and (diastolic blood pressure is high) then the (renal condition of patient is severe).
R2: If (body mass index is high) or (glucose is high) or (urea is high) or (creatinine is high) or (systolic blood pressure is high) or (diastolic blood pressure is high) then the renal condition of patient is moderately critical.
R3: If (glucose is high at time Ti) and (glucose is low at time Tj) and (T 6¼ Tj) then the (patient can be suggested to go for glycosylated haemoglobin.
R4: If (body mass index is moderate) or (glucose is moderate) or (urea is moderate) or (creatinine is moderate) or (systolic blood pressure is moderate) or (diastolic blood pressure is moderate) then the (renal condition of patient is normal) and so on.

Defuzzification involves taking a crisp action based on the inference drawn. Such actions can be implemented by glowing of an LED or by means of some output data. In various schemes, the approaching criticality of patients is indicated by the glowing of LEDs.

Algorithm for medical diagnosis:

The algorithm for diagnosis computes the time weighted mean of the membership functions of the patient's pathophysiological data. The possibility that the next pathophysiological data will be low or moderate or high is computed as

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 12, December 2014

$$PR(x) = \sum_{i=1}^{n} im(x) / \sum_{i=1}^{n} i$$

where the summation is done from i = 1 to n, and the value of n is the sequence number of the time instantat which the current pathological data of the patient is taken and R 2 {low, moderate, high}. l(x) is ll(x), lm(x) or lh(x) accordingly as the membership function concerned refers to low, moderate or high fuzzy set respectively.

For predicting the fuzzy set in which the next state input of a certain pathophysiological parameter is going to lie, the value of P(x) is considered for which P(x)P PR(x).

III. SMART AGENT FOR PREDICTION AND ANALYSIS

Smart agent or smart processing system is prepared based on the data collected from the laboratories considering the patients' profiles. Depending on the types of pathophysiological parameters, rule base is prepared in MATLAB-SIMULINK. Rule base preparation and mapping using neural network is like an inference engine, which helps in preparing an expert system for the diagnosis purpose. Rule bases are of course prepared as per the suggestions of doctors and also considering the research work done in the area of medical science.
Figure shows the overview of preparing A Smart Processing system or a smart agent.

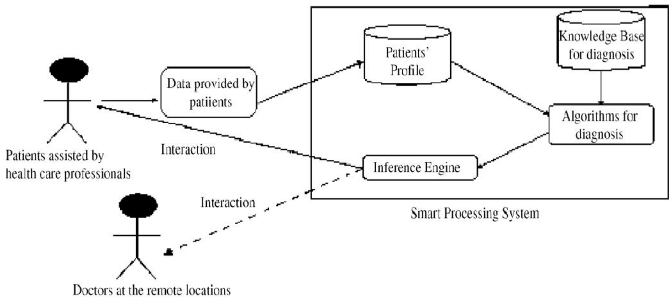

Fig.3-FPGA module for Smart Diagnosis System[3]

The main disadvantage of the software solution is that a powerful computer is to be used to run the software for achieving reasonable speed and accuracy. However, employing a powerful computer would be too costly a solution and would require a steady supply of electricity in rural sectors. The enormity of the cost could stand out as an impediment in the implementation of the smart diagnostic system in the rural health care centres in the third world countries. Considering this fact, and the reconfigurable nature of FPGA makes it a preferred choice for the implementation of the smart device.

The main reason for a hardware based implementation is the need for an inexpensive portable diagnostic system. The main disadvantage of an ASIC based hardware is the high development cost and the low reconfigurability it allows for. The FPGA solution ensures that new changes in the proposed diagnostic algorithm can be mapped onto the hardware without having to make costly changes.

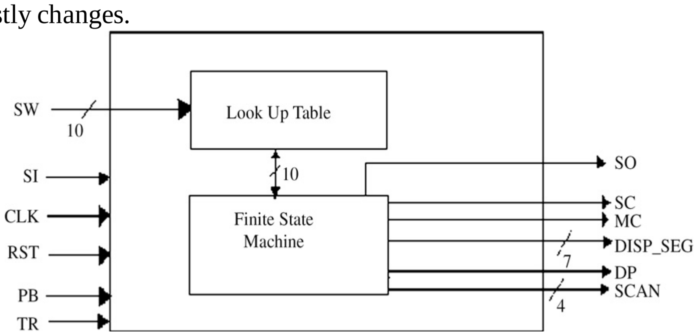

Fig.4- VHDL Module for disease prediction system.[3]

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 12, December 2014

Implementation using VHDL or VERILOG makes a complete FPGA based device which works as a smart agent and using rule base of fuzzy-neural or a similar look up table can be prepared and it can be implemented using FPGA. Input switches for entering parameter values and output display as well as LEDs for various stages of patient conditions can provide a user friendly and cost effective approach for these types of smart diagnosis systems

IV.CONCLUSION

Various techniques using Fuzzy-Neural algorithms are studied for the prediction of various diseases. Medical diagnosis is being a field where more and more fuzzy-neural based techniques are implemented for the prediction of various disease as well as critical stage of the patients, so that timely remedial actions can be taken and it can prevent a major damage to the health of patient. Cost effective solution is prepared using FPGA because of its reconfigurable nature and it can provide a complete smart solution for the prediction of any disease. Such types of smart prediction systems are in demand and more and more doctors are opting for such devices considering very poor patient doctor ratios in the countries like India.

REFERENCES

[1] Simon Fong,SabahMohammed,JinanFiaidhi,CheeKeongKwohUsing causality modeling and Fuzzy Lattice Reasoning algorithm for predicting blood glucose ELSEVIER journal vol-7354-7366pp 1-3,2013
[2]Samarjit Kara,SujitDasb, PijushKantiGhosh, Applications of neuro fuzzy systems: A brief review and future outline ELSEVIER journal vol-243-259 pp-2, 2013.
[3]Shubhajit Roy Chowdhury a, DipankarChakrabarti b, HiranmaySaha,FPGA realization of a smart processing system for clinical diagnostic applications using pipelined datapath architectures ELSEVIER- Science direct conference-Microprocessors-vol-107-120 pp- 2-3,2008
[4]Essam Al-Daoud,Cancer Diagnosis using modified fuzzy Neural Network-Universal Journal of Computer Science and Engineering Technology vol- (2), 73-78, pp-2-3, Nov. 2010.
[5] ArpneekKaur et al,Artificial Intelligence in Hypertension Diagnosis: A Review, / (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 5 (2) , 2633-2635,pp1-3,2014
[6]Hassan Bagher-Ebadian, Neural Network and Fuzzy Clustering Approach forAutomatic Diagnosis of Coronary Artery Disease inNuclear Medicine. IEEE Transactions on nuclear Science, VOL. 51, NO. 1, pp-1-3 FEB-2004
[7] Cheng-Jian Lin, Chi-Yung Lee Implementation of a neuro-fuzzy network with on-chip learning and its applications pp-1 ELSEVIER-2010
[8]Gang Leng, Thomas Martin McGinnity,Design for Self-Organizing Fuzzy Neural Networks Based on Genetic Algorithms IEEE-2006
[9] Javier Echanobe, Member, IEEE Inés del Campo, Associate Member, IEEE, Efficient Hardware/Software Implementation of an Adaptive Neuro-Fuzzy System, -2008
[10] R. R. Janghel-IIIT GwaliorDecision Support System for Fetal Delivery usingSoft Computing Techniques.
[11]SuhapSahin, YasarBecerikli, and SuleymanYazici, Neural Network Implementation in Hardware Using FPGAs
[12] AbdulkadirSengur,An expert system based on linear discriminant analysis and adaptiveneuro-fuzzy inference system to diagnosis heart valve diseases .ELSEVIER vol-214-222 ,2007
[13])Neagoe, V.E., Iatan, I.F., Grunwald, SA neuro-fuzzy approach to classification of ECG signals for ischemic heart disease diagnosis. (Article
[14] P.A. Mastorocostas, C.S. Hilas, A dynamic fuzzy-neural filter for the analysis oflung sounds, IEEE International Conference on Systems, Man and Cybernetics3 vol- 2231–2236,2004
[15] P.A. Mastorocostas, J.B. Theocharis, A recurrent fuzzy-neural filter for real-time separation of lung sounds, Proceeding of IEEE International JointConference on Neural Networks 5 vol-(2005) 3023–3028,2005
[16] I. Guler, E.D. Ubeyli, Adaptive neuro-fuzzy inference system for classificationof EEG signals using wavelet coefficients, Journal of Neuroscience Methods148 (2) (2005) 113–121.
[17]R.J. Oweis, M.J. Sunna, A combined neuro–fuzzy approach for classifyingimage pixels in medical applications, Journal of Electrical Engineering 56(5–6) (2005) 146–150.
[18] D. Stavrakoudis, P. Mastorocostas, J. Theocharis, A pipelined recurrent fuzzyneural filter for the separation of lung sounds, Proceedings of Fuzzy SystemsConference, FUZZY-IEEE, IEEE International vol-1 pp 1–6,2007.
[19] K. Polat, K. Gunes, An expert system approach based on principal componentanalysis and adaptive neuro-fuzzy inference system to diagnosis of diabetesdisease, Digital Signal Processing 17 (4) (2007) 702–710.pp-1-4, 2006
[20] J.C. Obi, A.A. Imainvan, Interactive neuro-fuzzy expert system for diagnosis ofleukemia, Global Journal of Computer Science and Technology vol11 (12),pp-1-3 2011
[21]JOSÉ VIEIRA , FERNANDO MORGADO DIAS,ALEXANDRE MOTANeuro-Fuzzy Systems: A Survey,