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NEURO-FUZZY INTEGRATED SYSTEM FOR BIOMEDICAL APPLICATION: A BRIEF REVIEW AND FUTURE OUTLINE

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Abstract: This paper surveys Neuro fuzzy systems (NFS) development in biomedical field. Paper gives brief literature review of articles for last decade (2005-2015) which explores various Neuro Fuzzy System methodologies that have been developed during this period of time, their work done and deficiencies. Use of Neuro fuzzy integrated systems in various biomedical engineering applications is summarised. The paper concludes with a discussion of future usage of Neuro-Fuzzy systems in the area of biomedical engineering.
Keywods: Artificial neural networks. Neuro-fuzzy system, Methodologies, Literature review.

I INTRODUCTION

Medical information systems in modern hospitals and medical institutions become larger and larger; it causes great difficulties in extracting useful information for decision support. Traditional manual data analysis has become inefficient and methods for efficient computer based analysis are essential. It has been proven that the benefits of introducing machine learning into medical analysis are to increase diagnostic accuracy, to reduce costs and to reduce human resource [1][2]. Biomedical Engineering is an interdisciplinary domain, which links many disciplines such as engineering, medicine, biology, physics, psychology, etc. This rapidly growing field must meet the needs of industrial, clinical, and scientific research communities. It involves the application of state-of the-art technology to the creation of methodologies and devices for human welfare and for better understanding of human biological processes. Artificial neural network (ANN) is one of the techniques that can be utilized in these applications. ANN is currently the next promising area of interest. Already it could successfully apply to various areas of medicine such as diagnostic systems, bio chemical analysis, and image analysis and drug development. The benefit of using Artificial Neural Networks is that they are not affected by factors such as fatigue, working conditions and emotional state.

Numerous advances have been made in developing intelligent systems, some inspired by biological neural networks. Researchers from many scientific disciplines are designing artificial neural networks to solve a variety of problems in pattern recognition, prediction, optimization, associative memory, and control. Conventional approaches have been proposed for solving these problems. Although successful applications can be found in certain well-constrained environments, none is flexible enough to perform well outside its domain. ANNs provide exciting alternatives, and many applications could benefit from using them [1].

The long course of evolution has given the brain many desirable characteristics not present in von Neumann or modern parallel computers. These include: massive parallelism, distributed representation and computation, learning ability, generalization ability, adaptively, inherent contextual information processing, fault tolerance, and low energy consumption. It is hope that devices based on biological neural networks will possess some of these desirable characteristics. Modern digital computers outperform humans in the domain of numeric computation and related symbol manipulation. However, humans can effortlessly solve complex perceptual problems at such a high speed and extent as to dwarf the world's fastest computer. Why is there such a remarkable difference in their performance? The biological neural system architecture is completely different from the von Neumann architecture. This difference significantly affects the type of functions each computational model can best perform. Numerous efforts to develop "intelligent" programs based on von Neumann's centralized architecture have not resulted in general-purpose intelligent programs. Inspired by biological neural networks, ANNs are massively parallel computing systems consisting of an extremely large number of simple processors with many interconnections. ANNs models attempt to use some "organizational" principles believed to be used in the human let us consider the following problems of interest to computer scientists and engineers.

II. NEURO FUZZY SYSTEMS IN MEDICAL AREA

Presently diseases in India have emerged as number one killer in both urban and rural areas of the country. It will be of great 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 diagnoses like brain disorder, cardiac disease, breast cancer, thyroid disorder, leukemia, hypotension, heart disease, fetal disorders etc [1]. Following is a brief outline that shows how NFS has been contributing in medical disease diagnosis since 2005.

In 2014, Samarjit Kar, Sujit Das, Pijush Kanti Ghosh [1], proposed "Applications of neuro fuzzy systems: A brief review and future outline". It surveys NFS development using classification and literature review of articles for last decade (2002-2012) to explore how various NFS methodologies have been developed during this period. The articles surveys and classifies NFS applications into ten different categories such as student monitoring system, medical system, economic system, electrical and electronics system, traffic control, image processing and feature extraction, manufacturing and system modelling, forecasting and predictions, NFS enhancements and social sciences. In 2013 Filippo Amato, Alberto Lopez [2] proposed, "Artificial neural networks in medical diagnosis" The paper presents the general philosophy of the use of ANNs in diagnostic approaches through selected examples, documenting the enormous variability of data that can serve as inputs for ANNs. In 2015 Tony Hao WU, Enid Wai Yung Kwong [3] proposed, " Biomedical application on predicting systolic Blood pressure using Neural Networks" Paper presents new study based on ANN for the prediction of systolic Blood pressure by correlated factors (gender, serum, cholesterol, fasting blood sugar and electrocardiographic signal). Back propagation neural network and Radical basis function neural network are used in this research. The average prediction error for the relationship between systolic blood pressure and the input attributes is at a acceptable level. In 2015 Murat Karabatak [4] proposed, "A new classifier for breast cancer detection based on Naive Bayesian". This paper deals with a new Naive Bayesian (Weighed NB) classifier and its application on breast cancer detection. Several experiments were realized with five fold cross validation test. Various performance evaluation techniques namely sensitivity, specificity and accuracy are verified.

In 2005 William W Melek, Alireza Sadeghian [5] Proposed, "A Neuro Fuzzy based Expert system for disease Diagnosis". Medical diagnosis expert system was developed that can be used by physicians in their daily practices. Differential artificial intelligence techniques are incorporated into the expert system to best represent the various stages of the diagnosis process. A rule based fuzzy expert system is used to interpret lab tests and imaging studies to confirm final diagnosis. Later In 2006 Chin-Ming Hong, Chin-Ming Chen [6], proposed "A Novel and Efficient Neuro-Fuzzy Classifier for Medical Diagnosis". The study shows neuro fuzzy network can efficiently used to solve medical diagnosis problems. It uses K-clustering algorithm and gradient –based learning rules to logically determine and adaptively turned the fuzzy membership functions. It also presents a feature reduction scheme based on the grey-relational analysis to simplify the fuzzy rules obtained from the employed neuro fuzzy network. In 2010, R R Janghel, Anupam shukla, Ritu tiwari [7] proposed, "Clinical decision support system for fetal delivary using artificial neural networks", It predicts the fetal delivary to be done normal or c-section, It has been observed 99% of accuracy by using Radical basis function network (RBFN). In 2015, R.EI.Hamdi, M.Njah [8] proposed, "An Evolutionary Neuro-Fuzzy approach to Breast Cancer diagnosis". This research uses design of TSK-type fuzzy model (TFM) to solve the breast cancer diagnosis problem. The computational experiments show that the presented approach can obtain better generalization than some existing methods reported recently in the literature using widely accepted Wisconsin breast cancer diagnosis database. In 2015 Yueh-Chin Cheng, Gwo-Lang Yan,Yu Hsien Chiu [9] proposed, "Efficient fetal size classification combined with artificial neural network for estimation of fetal weight" A noval analysis was undertaken to select a significant ultrasonographic parameter(USP) for classifying fetuses to support artificial neural network(ANN), and thus to enhance the accuracy of fetal weight estimation. In 2009 Paul Fergus, Ibrahim Idowu, Abir Hussian [10] proposed, "Advanced artificial neural network classification for detecting preterm births using EHG records". Electrohysterography signals have been used to detect preterm births. Open data sheet assessment has been done which contains 262 records for women who delivered at term and 38 who delivered prematurely. Seven different ANN were used to identify these records. The result showed that Lavenberg-Marquardt trained feed-forward Neural network, Radial Basis Function Neural Network and Random Neural network performed best with 91% for sensitivity,84% for specificity,94% for the area under the curve and 12% for the mean error rate. In 2010, Ahmad Taher Azar [11] proposed, "Expert system based on Neural fuzzy rules for Thyroid diseases diagnosis", The paper uses Linguistic Hedges Neural Fuzzy Classifier with selected features (LHNFCSF) for diagnosis of thyroid disease. Performance evaluation of this system is estimated by using classification accuracy and K-fold cross validation. In 2012, K.Viswanath, R. Gunasundari

[12] proposed, "Design and analysis performance of Kidney Stone Detection from Ultrasound Image by Level Set Segmentation and ANN Classification". The ultra sound images of kidney contain speckle noise and are of low contrast which makes the detection of kidney abnormalities a challenging task. To address this issue a modified level set segmentation is used to identify the location of the stone, wavelets subbands to extract energy levels of stone and MLP-BP ANN algorithms for classification. In 2011, Oleg Yu. Atkov, Svetlana G Gorokhova [13] proposed, "Coronary heart disease diagnosis by artificial neural networks including genetic polymorphisms and clinical parameters". An ANN based diagnostic model for coronary heart disease using a complex of traditional and genetic factors of this disease. The best accuracy was obtained in models that included both genetic and non genetic factors associated with the disease. In 2010, Rafal Dlugosz, Vitaliy Kolodyazhniy [14] proposed, "Power Efficient Hardware Implementation of a Fuzzy Neural Network". This paper presents a digital, transistor level implemented neo-fuzzy neural network which is well suited for real time applications like signal processing and nonlinear system identification. In 2012, A.Q Ansari, Neeraj Kumar Gupta [15] proposed, "Automatic Diagnosis of Asthma using Neuro-fuzzy system". Adaptive Neural Fuzzy Interface system (ANFIS) is put in the framework of adaptive systems to facilitate learning and adaption which uses back propagation algorithm to reduce the error in the output.

Table 1: Shows the Literature review of the referred papers

Sl.no	Author	Title	Work done	Conclusion	Deficiency
1	Samarjit Kar,Sujit Das, Pijush Kanti Ghosh	Applications of neuro fuzzy systems: A brief review and future outline	It surveys NFS development using classification and literature review of articles for last decade (2002-2012) to explore how various NFS methodologies have been developed during this period.	The article surveys and classifies NFS applications into ten different categories	
2	Filippo Amato, Alberto Lopez	Artificial neural networks in medical diagnosis	The paper presents the general philosophy of the use of ANNs in diagnostic approaches through selected examples.	ANNs have proven suitable for satisfactory diagnosis of various diseases	
3	Tony Hao WU, Enid Wai Yung Kwong	Biomedical application on predicting systolic Blood pressure using Neural Networks	Paper presents new study based on ANN for the prediction of systolic Blood pressure by correlated factors	The average prediction error for the relationship between systolic blood pressure and the input attributes is at acceptable level.	Can be further implemented to access patient Heart risks conditions
4	Murat Karabatak	A new classifier for breast cancer detection based on Naive Bayesian	This paper deals with a new Naive Bayesian (Weighed NB) classifier and its application on breast cancer detection	Sensitivity=99.11% Specificity=98.25% Accuracy=98.54%	It uses a grind search mechanism, which is expensive
5	William W Melek, Alireza Sadeghian	A Neuro Fuzzy based Expert system for disease Diagnosis	Differential artificial intelligence techniques are incorporated into the expert system to best represent the various stages of the diagnosis process	A rule based fuzzy expert system is used to interpret lab tests and imaging studies to confirm final diagnosis.	
6	Chin-Ming Hong, Chin-Ming Chen	A Novel and Efficient Neuro-Fuzzy Classifier for Medical Diagnosis	It uses K-clustering algorithm and gradient – based learning rules to logically determine and adaptively turned the fuzzy membership functions	Experimental results show that the proposed neuro fuzzy network with feature reduction can discover very	

				simplified and easy interpretable fuzzy rules to support medical diagnosis.	
7	R.EI.Hamdi, M.Njah	An Evolutionary Neuro-Fuzzy approach to Breast Cancer diagnosis	It uses design of TSK-type fuzzy model (TFM) to solve the breast cancer diagnosis problem	The presented approach can obtain better generalization than some existing methods reported recently in the literature using widely accepted Wisconsin breast cancer diagnosis database	
8	Paul Fergus, Ibrahim Idowu, Abir Hussian	Advanced artificial neural network classification for detecting preterm births using EHG records	Electrohysterography signals have been used to detect preterm births.	RBNC performed best with 85% sensitivity, 80% specificity, 90% for the area under the curve and 17% for the mean error rate.	Oversampling to increase the number of preterm samples. The better way would have been to balance the dataset using actual recordings obtained from pregnant women who delivered prematurely
9	Yueh-Chin Cheng, Gwo-Lang Yan,Yu Hsien Chiu	Efficient fetal size classification combined with artificial neural network for estimation of fetal weight	1)Correlation analysis was used to determine a significant USP for fetal grouping. 2)K-means algorithm was utilized for fetal size classification based on the selected USP. 3)Finally stepwise regression analysis was used to examine iputt parameters of ANN model	The estimated fetal weight (EFW) of new model showed Mean absolute percentage error (MAPE) of 5.26±4.14% and Mean absolute error (MAE) of 157.91±119.90g.	
10	RR.Janghel, Anupam shukla, Ritu tiwari	Clinical decision support system for fetal delivery using artificial neural networks	Predicts the foetal delivery to be done normal or C-section	BPA=93.75% **RBFN=99%** LVQN=87.5%	To increase efficiency, foetal health prediction.
11	Rafal Dlugosz, Vitaliy Kolodyazhniy	Power Efficient Hardware Implementation of a Fuzzy Neural Network	This paper presents a digital, transistor level implemented neo-fuzzy neural network which is well suited for real time applications like signal processing and nonlinear system identification.	Digital implementation of a non-linear synapse of a neo-fuzzy neuron was proposed. **Advantages**: reduced redundancy, efficient utilization of chip area, low power consumption and	

				high operation speed.	
12	A.Q Ansari, Neeraj Kumar Gupta	Automatic Diagnosis of Asthma using Neurofuzzy system	Adaptive Neural Fuzzy Interface system (ANFIS) is put in the framework of adaptive systems to facilitate learning and adaption.	It uses back propagation algorithm to reduce the error in the output. It is capable of dealing with complex systems which includes rule chaining.	In rural areas where there is no easy availability of a doctor, this proposed research work can be considered for preliminary diagnosis of asthma via mobile message.
13	A.Q Ansari, Neeraj Kumar Gupta	Neuro Fuzzy Integrated system and its VLSI Design for Generating Membership Function	The paper presents a Neuro fuzzy integrated system to construct an input output mapping based on fuzzy if-then rules and the tuning of the parameters of membership function.	The membership function for NFIS has been realized using OTA. Attention is given to design the circuits with low power consumption 2.91mw and size less than 0.65mm^2 within the neuro-Fuzzy chip.	

III. DISCUSSIONS AND FUTURE OUTLINE

In this paper, most of the articles are mainly retrieved from IEEE Xplore, Elsevier and Springer. From this literature review it is clear that the computing world has got a lot to gain from the world of artificial intelligence specifically from neural networks and fuzzy systems. Their ability to learn by example makes them very flexible and powerful. A large number of claims have been made about the modelling capabilities of neural networks, some exaggerated and some justified. Hence to best utilize ANNs and fuzzy systems for different problems, it is essential to understand the potential as well as limitations of these systems. Even though, ANNs and fuzzy networks have a huge potential, best results can be obtained from them when they are integrated, therefore neuro-fuzzy systems performance is assessed and compared with neural networks and fuzzy systems.

Since Neuro-fuzzy is an interdisciplinary research topic so future trends of NFS developments might be the integration of different methods and techniques in promising areas. As it can inherit the learning capability from past experiences, one can easily predict that NFS is going to be one of the pillars of scientific research. In medical system it should be noted that no system was designed to give required prescription of various drugs to patients for subsequent treatment, which might be expanded in subsequent research. Some proper adjustments in the learning schemes or the training sets can also increase the efficiency of the system. A system of this nature that has the ability to diagnose a person suffering from specific disease should be introduced in health care systems to help ease the work of physicians.

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