World Applied Sciences Journal 22 (1): 85-96, 2013
ISSN 1818-4952

DOI: 10.5829/idosi.wasj.2013.22.01.72188

Neural Networks in Medical Imaging Applications: A Survey

Mussarat Yasmin, Muhammad Sharif and Sajjad Mohsin

Department of Computer Science, COMSATS Institute of Information Technology, Pakistan

Abstract: The principal method of obtaining physical information about the biological human body is called medical imaging. It is accomplished by creation of specialized images of human body or its parts for clinical purposes. In broader definition it is part of biological imaging and assimilates many specialized fields like nuclear medicine, radiological sciences, thermography and microscopy. From the early invention of X-RAYS by Wilhelm Röntgen back in 1895, the research and development in medical imaging continued throughout the century which resulted in highly technological medical imaging applications of the current era like ultrasound, lungs monitoring applications etc. Over the past twenty to thirty years clinical applications are habitually utilizing medical imaging in different forms and helping in better disease diagnostic and treatment. In last decade or so the usage of Neural Networks in applications of Medical Imaging opened new doors for researchers, stirring them to excel in this domain. This survey is the summarized overview of research and development held in recent past highlighting the role of Neural Networks in advancement of Medical Imaging.

Key words: Association Rules Extraction · Disease Diagnostic · Medical Imaging · Neural Networks · Tomographic Images · Fuzzy Segmentation

INTRODUCTION

Introduction of medical imaging in hospitals and laboratories has shown growing benefits around the globe. In recent years plenty of research articles published highlighting the need of medical imaging in solving problems of healthcare institutions. Ideally the essence of deploying medical imaging applications is to step-up the efficiency in monitoring and observing patient's body for possible illness and/or injury. Usually diagnostic reports of patients include radiographic representation of human body or its parts. From a patient's point of view, usage of medical imaging improves quality of service provided to them, their decision making about the treatment become stronger as medical imaging provides ground for making decisions based on infection/disease evidence. Eventually overall healthcare services delivered to patients are improved as discussed in Fakhrodin Alimoradi *et al*. [1]. An overview of medical imaging applications is given in Figure 1.

Healthcare and medical imaging applications as discussed in Rahimi *et al.* [2] can be used to deliver even better performance, efficiency and well-focused treatment when neural networks become part of such applications [3]. Applying neural networks in medical imaging is one of the hottest research topics of last decade. As per our research statistics, we found more than thirty thousand articles on the topic of medical imaging and neural networks. In this research we have tried to find most effective and popular proposals focusing neural networks in medical imaging applications. We have discussed their research ideas, their implementations, results and future in a different perspective.

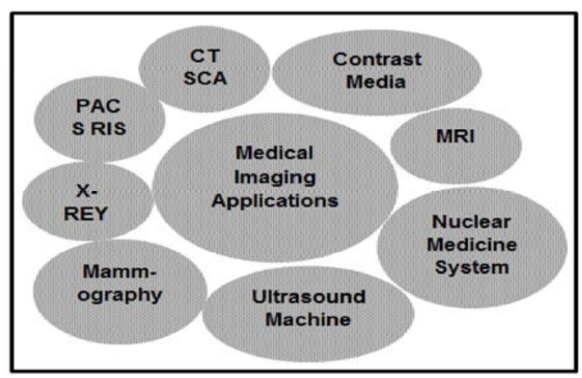

Fig. 1: Medical Imaging Applications

Corresponding Author: Mussarat Yasmin, Department of Computer Science, COMSATS Institute of Information Technology, Pakistan.

Table 1: Hop field model for reducing computational time of tomography images

Serial No#	Application	Advantages	Limitations	Results
1	Reducing computational time using Hopfield model [4]	With this approach the computational time is focused and reduced.	Iterative approach, fault at the end cannot be detected at process start.	The later approach of applying neural networks after waveform collection looks impressive.
2	Neural computations of decisions in optimization problems [5].	Effectively provides collective computational solution.	High integration makes the system tightly coupled.	High power and great speed can be used to effectively process biological information.

Research Proposals and Implementation Discussion

Reduction of Computational Time of Tomography Images Using Hopfield Model: Biological information of human body can be represented in many forms in medical imaging, among them the most popular form is tomography. In this [4] research proposal attempts are made to reduce the time required to manipulate and compute tomographic images. For achieving the goal two different approaches are used for enhancing the computational time of tomographic images. The first approach is about application of neural networks with the start of wave fronts collection. Whereas the second approach says to apply neural networks after the completion wave fronts collection and image reconstruction.

The Hopfield [5] model is a famous neural network model and is used to work on the tomographic data as this method works iteratively and provides better results over other Fourier theorems which usually return inaccurate results. Computational time complexity is the bottleneck of most of the algorithms. In Gan [4] the authors have proposed the usage of stochastic model. Whereas in Hopfield and Tank [5] principles of creating general networks for solving specified issue are discussed. The non- linear analog neurons and their strong connectivity play important role in effective computation.

Results showed that in the first approach if the neural network is applied with the beginning of the wave field collection, the algorithm needs around ten thousand iterations to complete the image reconstruction. Whereas if the later approach is used to apply the neural networks after the wave forms collection completion, algorithm takes around 200 iterations to complete the job. Note that these tests are made on a 256x256 image. Results can be different for higher resolution images. Table 1 shows the use of Hop field model for reduction of tomographic images computational time.

GMDH: Group Method of Data Handling (GMDH) is most widely used algorithm for data mining, forecasting, optimization and knowledge discovery. GMDH has many variations which provide wide range of attributes to this algorithm. Automatic inter-relations or correlations can be found using inductive GMDH for selection of ideal neural network thus increasing the correctness of the algorithm.

It has self-engineering methodology that is significantly different from other common methods of modeling. GMDH is basically a collection of multiple algorithms, each designed for solving different kind of problem. Its inductive methodology is based upon the concept of increasing complexity in selection of network model for providing the best solution with minimum impact of external factors. Some of the useful scenarios of GMDH can be listed as.

- When optimal complexity is known.
- When NN parameters are calculated automatically in hidden layers.
- When most accurate model should be selected.
- When simple programming is needed.
- When apriori assumptions of modeling should be minimized.

There are many other situations where GMDH becomes the best choice for researchers and application programmers. GMDH is being researched since it was first developed in 1968 and is evident of some of the best algorithms as it is being used by many software applications.

GMDH and its Variations: In this section we will discuss different implementations of GMDH and their pros and cons.

GMDH based algorithm is proposed in Kondo and Kondo [6] for identification of medical images. Heart images are analyzed in 3D using this algorithm. GMDH can detect the properties of medical images more accurately by using feedback loop methodology. GMDH algorithm for 3D modeling of the heart uses neurons based function for organization of selectable neural network.

The revised GMDH is proposed in Kondo and Kondo [6], capable of conducting 3D analysis of heart and self-selecting the neural network. In this research medical images for heart are analyzed and processed using revised GMDH approach. The selection of neural network is automatically done by the algorithm. Image densities of neighboring regions have better statistics for extraction of image features. In this approach only those image features are selected which can be useful.

Results of testing showed that the revised GMDH neural network technique appeared as one of the most accurate methods for image recognition. Especially for heart image recognition revised GMDH outperformed other conventional methods of image recognition and analysis.

Another revision of GMDH with radial basis neural network selection is researched in Kondo and Pandya [7]. Study presented revolves around the identification of radial basis neural networks using GMDH algorithm. Feedback loop is also used in this as in Kondo and Kondo [6]; further modified GMDH is applied to the image recognition of brain. As GMDH can self-engineer itself using heuristic method, the useful parameters such as input parameter, count of layers and neurons count to be entertained in hidden layers are automatically selected too. Therefore, the organization of neural network compatible for complexity of non- linear system becomes easy. Conventional radial basis function contains only one hidden layer keeping the architecture simple but lacking the ability to learn the parameters. This is why it results in poor approximation of non- linear systems. The modified GMDH with feedback loop tunes the network considering the complexity of the system.

Results of experiments showed that the radial basis functions are identified by modified GMDH algorithm successfully using the feedback loop methodology. This algorithm is an extension to an earlier existing basic GMDH algorithm using feedback loop mechanism. In this [7] research the newly proposed GMDH algorithm was applied to recognition of brain and it was observed that these radial basis function networks had pretty nice ability and they can be used in medical image recognition of brain.

Another research on radial basis function with GMDH based neural network algorithm for abdominal x-ray is proposed in Kondo and Ueno [8]. The goal of this research is to properly and accurately identify the organs of abdominal region and extract them for further observation and analysis. This approach makes use of six layers for focusing the accuracy of the algorithm. Many intermediate temporary set of variables are generated to fit the most appropriate neural network.

A logic based neural network algorithm is proposed in Kondo and Pandya [9] for application of medical image recognition. This research is based upon another research [10] of the same authors. This algorithm makes use of polynomials and sigmoid representation of neurons. A collection of complex nonlinear intermediate input variables are generated so that the neural network system is adjusted automatically but only those input variables are selected in organization of neural networks which can be useful. It is observed that the conventional and logistic based GMDH algorithms have almost similar accuracy in image recognition.

Prediction error criterion using feedback GMDH [11] discusses about the minimization of prediction error criterion. The intentional application of this algorithm is to be applied over images of brain. It is observed that this method of image recognition works perfectly for image analysis of brain in all dimensions. Other neural network selections are done automatically as they are performed in conventional GMDH.

Another approach of image identification based on neural networks is proposed in Kondo, Pandya and Zurada [12]. It is focused that conventional neural networks could not select the best neural network architecture and selection of input variables was also invalid. So the conventional algorithms failed in recognizing lungs from a chest X-Ray. While using GMDH not only the shapes of lungs are extracted successfully but intersection regions are also identified. In Kondo [13] lung cancer detection using GMDH is discussed. The goal of this research is to automatically extract the regions of lungs where possibility of cancer occurs. This algorithm works on multi-detector row images and two phase approach is followed. In first phase the lungs themselves are detected and in second phase areas where cancer is detected are extracted. This research is based upon the earlier GMDH researches of the same authors [14, 15].

Cancer of liver diagnostic mechanism is proposed in Tadashi Kond *et al*. [16] where GMDH is further extended to use polynomial and radial basis functions for image recognition. The properties of image and interested regions are very well identified by using feedback loop calculations and results show that images of patients suffering from cancer of liver are identified and processed fine.

Table 2: GMDH based neural networks used in medical imaging

Serial No#	Application	Advantages	Limitations	Results
1	3D image recognition of heart [6]	Shows good performance in extracting features of the image.	Algorithm involves complex computations.	Efficiently recognizes heart images and overall approach is good.
2	Revised GMDH with feedback loop [7]	Good approximation of complex nonlinear network system.	With larger resolution images the recognition errors can increase.	Brain image recognition is done quite nicely by the introduction of radial basis function.
3	GMDH-type based abdominal detection [8]	Same algorithm works for different shaped organs.	Can only work with CT type images.	Overall good extractor of lungs, stomach and spleen.
4	Logic based algorithm [9]	Polynomial type of neurons can be used.	No considerable accuracy gain.	Generally a changed system but with no performance gains.
5	Logic based algorithm for X-ray Films [10]	Improved accuracy over multiple regression analysis method.	No proper computational guidelines.	X-Ray film curve characteristics detection is done for the first time. Modeling with the logistic GMDH improved accuracy over multiple regression analysis method.
6	Feedback GMDH based on prediction error [11]	No need for separate training and test data sets.	PSS values are huge in initial iterations of the loop.	Brain image is very efficiently extracted and analyzed.
7	Lungs detection using GMDH [12]	Works fine in recognition and extraction of lungs as well as the intersection lines.	Plenty of post processing involved.	The process effectively recognizes the lungs and intersecting regions with preserving image quality and details.
8	Cancer Detection from lungs using GMDH [13]	Cancer detection from lungs images is achieved using GMDH.	Works only with multi detector row images.	This implementation works on detection of cancer in two phases. In first phase the lungs are detected and in the next phase the cancer areas are detected. Overall performance of the algorithm is promising.
9	Elimination of useless neurons from GMDH [14]	Effective in comparison to other implementations as useless neurons are removed from the network.	Every time checking for useless neurons creates more computations.	These implementations have a good generalization ability to eliminate the useless neurons from the neural network.
10	Liver cancer detection using GMDH [16]	Cancer detection from liver images is extracted using GMDH.	In all iterations feedback loop calculation needs to be checked.	Generally a good implementation for diagnostic of liver cancer.
11	GMDH based feature ranking system [17]	Disease ranking is the unique feature which can reduce data dimensions.	Difficult to manage as disease ranking needs to be saved and preserved.	A good solution if properly managed and implemented.

Currently all the available disease diagnostic applications usually mark the presence or absence of disease from medical imaging. An approach for ranking disease based on GMDH is proposed in Abdel-Aal [17]. Here a default mode of complexity is introduced which can be used in dimensionality reduction in diagnostic of breast cancer and cardiac diseases. Mode of complexity can be altered as per requirement and the system will behave accordingly. Results of experiments elaborated that the system is efficient and performs the claimed tasks acceptably. Table 2 summarizes the use of GMDH based neural networks in medical imaging.

Fuzzy Neural Networks: A system that is created by combining different fields of artificial intelligence like fuzzy logic is called a fuzzy neural network. Fuzzy neural networks are world widely known as Neuro-Fuzzy hybridization. The core of neuro fuzzy systems incorporate the two opposing factors i.e., correctness and ability to interpret. Generally at one given time only one factor can be focused. There are three broad categories of fuzzy neural networks naming concurrent fuzzy neural networks, cooperative fuzzy neural networks and hybrid fuzzy neural networks. Fuzzy systems have also played their part in advancement of medical imaging and there are several researches which are based on fuzzy systems. Let us discuss some of them and highlight the pros and cons of proposals.

Fuzzy Neural Networks in Medical Imaging: Medical images can be analyzed for anomalies and it can be the prime objective of every medical imaging application. This task can be achieved though many of the proposed and available methodologies including fuzzy logic based applications; neural network based applications and can also be done using genetic algorithms. A hybrid approach combining each of the above stated disciplines is proposed in Benamrane *et al.* [18]. Combining the benefits and strong aspects of all independent fields authors have proposed a new system which makes use of independent algorithms in order to advance the usage of medical imaging. In Benamrane *et al.* [18] the hybrid fuzzy neural network claims that the unsure aspects a priori collected from human experts can really help in making decision. Furthermore, this algorithm takes benefits from the parallel architecture of neurons. The expected delivery of the system is to interpret an image with respect to hybridizing between different algorithms. The process of anomaly detection starts when filtered linear images are passed to the system as an input. The system tries to extract the surface, compactness, mean grey level, variance, elongation, continuity and homogeneity from the input images. These attributes belong to predefined set of classes where they have set of values against each attribute. There is a detailed anomaly detection process which goes through each step for carrying out the specified task and result of the detected anomalies is returned. In short the hybrid algorithm proposed in Benamrane *et al.* [18] takes benefit of the three different factors and combines them into a single architecture. In this hybrid architecture the role of fuzzy systems is very vital and important as non-numerical and unpredictable fuzzy decisions usually carried out by doctors is the most important part. The proposed hybrid approach claimed the performance up to 76% - 79 %. Another approach of fuzzy image fusion based upon multimodal neural networks is proposed in Yang-Ping Wang *et al.* [19]. The scheme fuses multiple images from the same source to achieve better accuracy and performance. Image fusion and pattern recognition is used in this approach to deliver high end services to the field of medical imaging. The system is capable of gaining better results when compared to different algorithms of the same domain. Performance of images can be measured by the ratio of available noise and data. The results of experiments showed that the system delivers quality results while dealing with blurry images. When it comes to the disease diagnostic systems, Chinese research always supersedes with noticeable margin. An approach for tongue image retrieval is proposed in Qin Jian, Meng Jun *et al*. [20]. Chinese medical treatment has a very old diagnostic system; they diagnose the sickness and causes of sickness from the color of the tongue coating. Earlier human doctor's eye inspection was used to diagnose the disease but in current days they have in place computerized systems tongue's color monitoring. The new scheme is expected to overcome the flaws and inabilities in the existing systems of the same domain. The control of image retrieval is kept in the hand of doctor/operator who performs the image retrieval in the field though parameters. Adjusting these parameters affect the quality respectively. Algorithm of tongue image retrieval has test run over more than 300 images obtained from different sources. The results of the comparisons with weighted fuzzy algorithms are calculated and it is evident that the fuzzy CMAC performs better in each type and color of tongue image with average of 91% retrieval results. Conclusion can be extracted that the proposed CMAC based approach can be implemented and deployed at Chinese medical diagnostic center with enough confidence. Fuzzy logic based neural networks are also applied in the field of tissue classification. An approach for classifying human body tissues is presented in Banerjee *et al*. [21]. Medical images of different types are passed as input to the algorithm. Algorithm then works and generates a fuzzed classification of data. As a result, prominent features of corresponding image data are displayed. Medical imaging often requires information about the ability of connectedness of human skin. This may vary from person to person as each human has different physical properties. This factor is very helpful in surgical operations and is usually calculated before any surgical treatment is provided. An automated proposal of the above described scenario is proposed in Christopher Gammage and Vipin Chaudhary [22]. The algorithm is re implemented to improve the performance. Multi processer and threading is implemented to perform the independent tasks in parallel. Results of experiments show performance gain of more than twenty percent. The process of detecting and segmenting abnormalities in mammograms is one of the core parts of medical imaging. Mammogram segmentation is one of the most complex processes in medical imaging. An optimal approach is proposed in [23] to cater the issue. Mammogram anomaly detection can be based on several factors. The algorithm proposes a dynamic method of updating pixel compactness based on the change in pattern of neighbor areas. The results and experiments showed that system successfully detects edges of breast and abnormalities. A proposal to decide between two of the edge detection is proposed in Noor Elaiza *et al*. [24]. There is no new proposal discussed in this paper, instead the comparison shows that the Gaussian method of edge fusion performed better then rule based methods. Information of medical image processing usually deals with huge set of information, this information is usually passed through the system but not brought in use of simplifying and updating the process of image processing. A method of image classification using soft information fusion is proposed in Hariton Costin and Cristian Rotariu [25]. A magnetic plate coated image of brain with inline provision of rectification is the hot topic in research of medical imaging. An approach for brain MRI segmentation is proposed in Kannan *et al*. [26]. Algorithm makes use of fuzzy c means in order to remove field level noise and tries to generate high end results. This algorithm works for both noisy and homogeneous images. Furthermore, the performance is improved by decreasing the number of iterations. While observing in broader view the algorithm can be rated as good. There are several approaches being proposed for

Table 3: Fuzzy logic based neural networks used in medical imaging

Serial No#	Application	Advantages	Limitations	Results
1	Hybrid Fuzzy logic based approach [21]	Efficiently incorporates three factors and generates new architecture for better image retrieval overcoming uncertainties.	Tightly coupled to three independent factor based systems.	Very vital to be used, non-numerical and un predictable fussy decision support.
2	Multimodal fuzzy image fusion [22]	Image quality is preserved even with blurry images.	No observed limitations.	Works very nicely with blurry images and can be trusted.
3	Fuzzy EMAC based Tongue image retrieval [23]	Can extract different color coatings of tongue images.	Not world widely used, only applicable in Chinese disease diagnostic and treatment systems.	The method outperforms weighted fuzzy algorithm and delivers accurate image retrieval.
4	Fuzzy C means based classification of tissues [21]	Simple methodology for computing classifications.	Advanced image attributes cannot be detected and less performance over the edges.	Not a very good system. Can perform only under limited set of requirements.
5	Fuzzy connected segmentation [22]	Performance improvement techniques are significantly considerable. Much performance gain is observed.	Cost will increase for specialized hardware purchase to boost up the performance of the system.	Huge performance gains and logical approach for handling intra operation environment.
6	Dynamic Fuzzy Classifier [23]	Good approach of dynamic pixel compactness based on connecting pixels.	Needs to incorporate more factors for segmentation.	Overall an average proposition, real time results can vary from the test run.
7	Comparison of GRBF and RBH [24]	Good comparison of both approaches is shown.	No observed limitations.	A good implementation proposal to start with new comers and major enhancement can be accommodated.
8	Soft information fusion for segmentation [25]	Good generic fusion concept of soft information.	Information management is hard and complex when bulk of information is to be handled.	Real time deployment shows promising results on basic soft information fusion.
9	Fuzzy C Means based segmentation [26]	Good to have less number of iterations and pre initialized model.	Complexity level is high.	An average system of brain image segmentation.
10	Fuzzy Segmentation and tomography images [27]	A good cluster based approach with comparison system.	Cluster size can be trivial on large data sets.	Adoptable solution if the data sets are not huge and comparison system works fine with high data sets.
11	Fuzzy interface for MRI detection [28]	Best extractor of light abnormalities.	Low performer on dark regions of the image.	Can be used in applications of light abnormalities detection.
12	K-Nearest Neighbors [28]	Best extractor of dark abnormalities.	Low performer on light regions of the image. Calculation time is not mentioned.	Can be used in dark abnormalities detection.

segmentation of tomography images. One fuzzy segmentation methodology is proposed in Martin Tabakov [27]. According to the algorithm, image segmentation can be achieved by properly defined cluster methods. Similarity based clustering of data is introduced which in turn is compared by specialized comparison method. Clustering quality and size cannot be determined beforehand and can lead to huge computations on larger set of images. MRI (magnetic resonance imaging) is one of the most important and usable format for picturing human body. Several methodologies and approaches have been proposed in recent years to handle it. In Noor Elaiza *et al*. [28] a short comparison of three basic methodologies i.e., Fuzzy interface system, k-nearest neighbor and fuzzy c means that work on top of MRI based images is shown. For a primary test, full component extraction is executed. The extraction capabilities of each algorithm are measured and recorded. The results of experiments were calculated by creating dummy abnormalities on brain image and tested all sample data with each of three algorithms. End results showed that the fuzzy interface system was the best performer on light abnormalities. K-nearest neighbor worked well on dark abnormalities. Table 3 gives description of fuzzy logic based neural networks usage in medical imaging.

Wavelet Transforms: Wavelet transforms are part of primary methods used for signaling, compression, watermarking, segmentation and other kinds of image processing from more than two decades. Image data is set of sequence and it is evident that wavelets are best performers in signaling.

Wavelet transforms are very flexible in their nature as they provide base selection, frequency tuning, threshold options and many other characteristics. Besides this wavelet transforms are fast and they best represent the images as signals. There are also several types of wavelet transforms which allow the user to choose between available signaling techniques according to the requirement.

Wavelet Transform Based Neural Networks: There are several proposed wavelet based neural network methods. In this section we will try to cover some of those which are applicable in medical imaging field.

When it comes to image analysis and diagnostic based upon medical imaging, it is very essential to observe the image with reference to its direction. An approach for finding directions using wavelet transforms is presented in Li *et al*. [29]. The proposal says that the wavelet transforms have been frequently used in medical imaging. But in direction calculation and identification wavelet transforms are not good performers. The author has proposed usage of wavelet transforms on different decompositions and applied the proposed methodology on mammography and lung nodule detection. The results of experiments showed that the wavelet transforms can also perform better in directional extraction and can be used in medical imaging in this perspective. There is essence of utilizing the wavelet transforms appropriately. While working with medical imaging there are times when we need to transfer, backup and restore medical images. The industry standard of medical imaging is DICOM. A wavelet based compression technique is proposed in Vidhya and Shenbagadevi [30] for medical imaging. Using this technique one can compress existing medical images from DICOM format easily. Quality of the image is persisted and results are compared with JPEG and other fractal algorithms available for compression. Wavelet transformed based fusion method for images are proposed in Zhang *et al*. [31]. This approach works upon self-engineering and creates mapping rule. The image recognition process is simulated to behave like human visionary system. The output of algorithm is judged and reveals that the proposed system passed the basic acceptance criteria but still lot more needs to be done to match it with human visionary system. In Chinese medical diagnostic system pulse monitoring is very trivial part of disease diagnostic process. A wavelet based approach for recognizing pulse is proposed in Chunbao Huo *et al*. [32]. In the proposed system wavelet transforms are utilized to simulate human pulse and then tries to recognize its behavior. This system is really practical with evident results of high speed and accurate recognition. Liver disease diagnostic with the help of computer aided tool is proposed in Sriraam *et al*. [33]. The system proposed tries to perform all the pre requisite steps which are usually carried by a doctor to diagnose a liver disease. The proposed system takes 64x64 blocks of images out of 256x256 images and performs Gabor wavelet based transformation which does the liver classification based upon the input image. Based on the liver classification the disease is diagnosed. The results of experiments showed that the accuracy of the system is 94 % which is very much promising. In the current era of medical research the diagnostic of breast cancer is one of the most researched topics. There are systems proposed to improve the accuracy of diagnosing breast cancer. A similar proposition is made in Carlson [34]. The approach discussed in this research follows a genetic algorithm for wavelet neural network. The weight of neural network is optimized by genetic algorithm and a learning engine is implemented to build a model for diagnosing breast cancer disease. The results of experiments have shown that the system can be used confidently in the field of diagnosing breast cancer disease. A tissue segmentation system is proposed in Zafer Iscan *et al*. [35]. The tissue segmentation is determined by 2D wavelet transforms and grey level moments are computed. Results of experiments showed that incremental supervised networks perform better than learning algorithms. Heart disease is thought to be a deadly disease of all times. A heart disease diagnostic system is proposed in Alireza Akhbardeh *et al*. [36]. The authors have proposed a wavelet based technique to capture heart activates and its condition while the patient sits on a specialized chair with installed sensors to monitor heart movements and motions. For handling the signaling part of the proposed system they have used a kind of orthogonal wavelet transformation method to extract required features and then neural networks take them for further processing. The results of experiments are shown from different age group people and it looks that it is a reliable solution. While studying medicine and especially heart specialization it is very crucial for doctors to differentiate between the normal and abnormal sound of the heart. In Sepideh Babaei and Amir Geranmayeh [37] a system for generating heart sound based on the collected characteristics is proposed. The system takes well known heart disorders and normal sounds using wavelet based algorithm. Involving neural networks and Daubechies wavelet filter the multilayer perceptron is trained. The results of experiments showed 94 % accuracy. Tumor detection is very helpful if it is detected at the start of disease. A system for detecting tumors is proposed in Fitzsimmons *et al*. [38]. The system makes use of wavelet transforms and artificial neural networks to do the job. The number of required neurons in hidden layers is calculated based upon the experimental results. The proposed system was tested to identify tumors in lungs cancer patients and the results were acceptable. In Abdou and Tayel [39] a bi-channel

Table 4: Wavelet based neural networks used in medical imaging

Serial No#	Application	Advantages	Limitations	Results
1	Wavelet based direction extraction [29] information extraction.	Wavelet transforms can perform in direction	Proper implementation lacking. can be relied upon for directional extraction.	The results show that the wavelet transforms
2	Medical image compression using wavelet transforms [30]	Image quality is persisted.	Proper control over the wavelet coefficients is required. this compression technique.	One of the most important requirements in the field of medical imaging is fulfilled with
3	Wavelet based feature mapping [31] visionary system.	Proposed system simulated human	Not a complete system. to make it a usable system.	Basic acceptance is met. Needs to do lot more
4	Wavelet based pulse recognition [32] recognizing human pulse.	Very fast and accurate system for	No visible limitations.	Nice and practical system.
5	Wavelet based liver classification [33]	Very high accuracy rate. be incorporated.	Learning from diagnostics should A practical system to be used in diagnosing	A nice tool to aid in liver disease diagnostic.
6	Wavelet based breast cancer diagnosis [34]	Reliable system with proven accuracy.	None	disease.
7	Wavelet based medical image segmentation [35]	Medical image segmentation is achieved from MR and CT types of images.	Complex and low performance system.	If improved, can be used as image segmentation system.
8	Wavelet based heart disease diagnostic [36] made very easy.	Heart disease diagnostic has been	None diagnostic process very easy.	A nice system that makes heart disease
9	Wavelet based heart sound reproduction [37]	Heart sounds can be reproduced and used to train medical students.	Complex system	Quite complex but a handsome approach.
10	Wavelet based tumor detection system [38]	Early tumor detection can save many lives.	Complex system level. Can save many lives.	A very useful system if utilized at hospital
11	Wavelet based image compression [39] medical images.	Saves time and space to manage	None medical images.	Very useful system for storing and managing
12	Discrete wavelet transform based medical image compression [40]	Saves time and space to manage medical images.	None	Very useful system for compressing low significant areas of medical images.
13	Wavelet based ECG data optimization [41] reduced in size and becomes easy to manage.	With wavelet transformation the data is	Lacking backward compatibility and optimization.	A good approach of utilizing wavelet capabilities

compression technique is proposed. The purpose of compression is as obvious to save time, space and resources of the system. The system makes use of artificial intelligence and compression techniques to achieve the goal. Results of experiments showed promising performance and quality over several MRI images and other images. Another medical image compression technique is proposed in Tamilarasi and Palanisamy [40] which uses neural network based fuzzy logic technique. The idea is to compress the less significance area using discrete wavelet transforms. This way more fine compression is achieved. An approach for compressing ECG signals is presented in Tom Froese *et al*. [41]. This proposed algorithm is used to convert the ECG data from time domain to wavelet domain which reduced the dimensionality many times. Two level decomposition of wavelet transform is conducted. The results of experiments showed that the accuracy of the system is around 95.9 %. Table 4 shows the use of wavelet based neural networks in medical imaging.

Probabilistic Neural Networks: Probabilistic neural networks are also known as feed forward networks. They work on the basis of training set and are supposed to be quick trainers. They have one pass for filling the training vector and are classified based upon training samples.

Probabilistic Neural Networks in Medical Imaging: In this section we will elaborate some of the algorithms of probabilistic neural networks.

In Mohd Fauzi Othman and Mohd Ariffanan Mohd Basri [42] a probabilistic neural network based image processing technique is proposed. The proposed algorithm is designed to work with MRI images to detect tumor. Probabilistic approach instructs to carry out the decision in second step. The performance of this system is measured as the training performance and accurate classification performance. A comparison of probabilistic neural networks and multi-layer perceptron is shown in Kalatzis *et al.* [43]. The comparison is made based upon the presence of diabetes among the patients and results showed that the multi-layer perceptron based approach showed high performance results. In Luka Šajn and MatjaKukar [44] a probabilistic evaluation system is proposed. The authors have proposed that the system accuracy and performance is dependent upon the machine learning and sub-feature selection. Results of experiments showed some suspected results as the authors themselves are not having confidence in their system. A contour detection system based upon probabilistic filter is proposed in Pavlina Konstantinova *et al.* [45]. The algorithm used Gaussian density function with reference to current point and edge magnitude.

Table 5: Probabilistic neural networks used in medical imaging

Serial No#	Application	Advantages	Limitations	Results
1	Probabilistic neural network based tumor detection [42]	Fast process and involves less complexity.	None	A good performer and can be helpful in detection of tumors.
2	PNN vs. MLP [43]	Multi-layer perceptron is high performer. performance than MLP.	Probabilistic has less	In some cases MLP is better performer.
3	Image evaluation based on PNN [44]	Better decision making is achieved with machine learning.	Compound of dual systems and less reliable.	A good tool to be considered as a helping program but cannot fully rely on this system.
4	Contour detection in ultrasound [45]	Effective for 3D data.	Computationally complex and expensive.	The proposed method accelerates the reconstructions by roughly a factor of three on average for typical 3-D multi slice geometries.
5	Probabilistic Shape representation [46]	Easy mapping of simplex to real world units.	No reverse mapping.	An average algorithm to be used in helping medical imaging.
6	Image registration using random coefficient [47]	Minimized energy function.	None	The experiments showed satisfactory results.
7	Probabilistic image validation [48]	Improved accuracy	No detailed performance testing. for performance.	Accuracy is more focused whereas no stats
8	Kidney contour detector [49]	Simple user interface	None	A good system with light weight application.
9	Deformable density matcher [50]	None	Relatively complex computations.	Shape detection in 3D aspect was discussed in this approach. No promising results are shown.
10	Probabilistic validation tool [51]	Improved reliability	None	Significance improvement in reliability of the tool for extraction of 3D shapes is proposed. A good implementation work.
11	Temporal analysis of brain MRI [52]	Brain disease can be detected earlier.	Complex system	Shown good results but performance is missing.
12	CT image reconstruction [53]	Reconstructs the series of 2D image and displays the result as 3D.	A variety of problems exist in the method that needs improvement.	The results obtained by the method are satisfactory.

The authors have proposed a novel method of mapping complex contours of ultrasound result. The shapes of medical images are very necessarily required to be in correct form. Many algorithms in probabilistic domain have been proposed to handle the issue of creating proper shape of the organ. One such algorithm is proposed in Neda Changizi and Ghassan Hamarneh [46] in which a novel approach of mapping simplex to real space data is presented. The results of experiments showed successful testing on brain images. Image registration is the requirement of almost all imaging utilities. A polynomial based local geometric image transformation technique is proposed in Edgar *et al.* [47]. Image characteristics definition has always been a challenging task. An approach to provide automated image segmentation with low error rate is proposed in Simon *et al*. [48]. The algorithm is capable of performing assessment and direct comparison on segmented image. Results of experiments showed good results. Most of the imaging applications are complex to use with lots of mathematical units and settings. There is always a need for a simple user interface application for analyzing medical imaging. Such a proposal is presented in Marcos Mart and Carlos Alberola [49]. In this approach a simple user interface allows the user to work on detection of kidney images with simple user interface. In Arunabha S. Roy *et al*. [50] a shape matching technique is presented. The authors have claimed the comparison compatibility with different set of attributes like lines, polygons etc. The results of experiments showed the approach of deformable density matcher created problems while registration. But the proposed thin place spline technique minimized the distance and worked fine. MRI and CT are volumetric images and they contain 3D image details. These details are required to be extracted and analyzed as discussed in Guido Gerig *et al*. [51]. In this approach the probabilistic series of segmentation is carried out over the input image and resulted images are overlapped to each other. The results of study showed that the reliability can be increased by using this approach for 3D shape extraction. In Ying Wang *et al.* [52] a 4D brain image analysis mechanism is reported. The idea is to determine the possible upcoming change in the brain with respect to its age. The tests are performed on different people from variable age groups. Results showed that the system is capable of detecting pathological change in brain. A multi shape modeling technique is proposed and discussed in Wilson *et al.* [53]. A comprehensive comparison and multi shape representation is presented. The object labeling technique in multi shape representation is discussed. The authors have focused more on the clear object identification from its label when multiple shapes are being analyzed and viewed. The system showed good research work but no experimental results are shown or no conclusion is extracted. Table 5 summarizes the probabilistic neural networks usage in medical imaging.

DISCUSSION

In this research study we have highlighted the role of neural networks in the applications of medical imaging. We have observed neural networks of specific types in advancement of medical imaging. Comparison table at the end of each section further elaborates the pros and cons of the proposed schemes. The usage of medical imaging and its applications is also highlighted in this research. If medical imaging is properly used and deployed with technical staff in hospitals and diagnostic centers especially in developing countries, it can really help in providing improved quality of care and treatment to the patients. Of-course there are certain limitation of computer aided diagnostic mechanisms and human involvement is required beyond that limitations to run the system properly. But certainly we can improve the algorithms and methodologies of working with it.

CONCLUSION

In this short research we have tried to enlighten the role of neural networks in advancement of medical imaging. We have discussed some of the existing techniques that make use of neural networks in order to deliver better medical imaging services. We have also discussed many kinds of neural networks taking part in medical and health field to enhance the capabilities, efficiency, usability and accuracy of medical imaging applications. We can conclude that the current high technology medical imaging applications would not have achieved such technological heights without neural networks and also the future of medical imaging is also bound with the neural networks. According to the exceeding requirements, more sophisticated algorithms and techniques are required to be developed to further assist the human doctors in medical diagnosis and treatment process.

REFERENCES

1. Fakhrodin Alimoradi, Mohammad R. Aabaadiaan, Ameneh Langari and Mohsen Gh. Kharaji, 2012. Reactive Oligomer to Improve the Impact Characteristics of Structural Composites Used in Civil and Medical Applications. World Applied Sciences Journal, 19(11): 1596-1601.
2. Rahimi, M., M.H. Alizadeh, R. Rajabi and N. Mehrshad, 2012. The Comparison of Innovative Image Processing and Goniometer Methods in Q Angle Measurement. World Applied Sciences Journal, 18(2): 226-232.
3. Majid Ebrahimian, Rahman Soroush, Azizolah Yosefi Salekdeh, Mehran Abazari, Ameneh Langari and Mohsen G.H. Kharaji, 2012. Analyze of ZnO-Based Ethanol Bio-Sensor for Medical Processes. World Applied Sciences Journal, 19(11): 1602-1606.
4. Gan, W.S., 1991. Application of neural networks to the processing of medical images. Neural Networks, 1: 300-306.
5. Hopfield, J.J. and D.W. Tank, 1985. Neural Computation of Decisions in Optimization Problems. Biological Cybernetics, 5(2): 114-152.
6. Kondo, C. and T. Kondo, 2009. Three-dimensional medical image recognition of the heart by revised GMDH-type neural network algorithm. ICCAS-SICE, pp: 2504-2509.
7. Kondo, T. and A.S. Pandya, 2002. Revised GMDH-type neural networks with a feedback loop and their application to the medical image recognition. Neural Information Processing, 5: 2274-2278.
8. Kondo, T. and J. Ueno, 2007. Medical Image Recognition of Abdominal X-ray CT Images by RBF GMDH-type Neural Network. In the Proceedings of the 2007 SICE Conference, pp: 1112-1116.
9. Kondo, T. and A.S. Pandya, 2001. Medical Image Recognition by using Logistic GMDH-type Neural Networks. In the Proceedings of the 2001 SICE Conference, pp: 259-264.
10. Kondo T., A.S. Pandya and J.M. Zurada, 1999. Logistic GMDH-type neural networks and their application to the identification of the X-ray film characteristic curve.
11. Kondo, T., 2008. Feedback GMDH-type neural network using prediction error criterion and its application to 3-dimensional medical image recognition. In the Proceedings of the 2008 SICE Conference, pp: 1050-1055.
12. Kondo, T., A.S. Pandya and J.M. Zurada, 1999. GMDH-type Neural Networks and their Application to the Medical Image Recognition of the Lungs. In the Proceedings of the 1999 SICE Conference, pp: 1181-1186.
13. Kondo, T., 2011. Revised GMDH-type Neural Network Using Artificial Intelligence and Its Application to Medical Image Diagnosis Hybrid Intelligent Models and Applications (HIMA), pp: 76-83.
14. Kondo, T., 1998. GMDH neural network algorithm using the heuristic self-organization method and its application to the pattern identification problem In the Proceedings of the 1998 SICE Conference, pp: 1143-1148.

15. Kondo, T. and J. Ueno, 2008. Multi-layered GMDH-type neural network self selecting optimum neural network architecture and its application to 3-dimensional medical image recognition of blood vessels. International Journal of innovative computing, information and control, 4(1): 175-187.
16. Tadashi Kondo, Chihiro Kondo, Shoichiro Takao and Junji Ueno, 2010. Feedback GMDH-type neural network algorithm and its application to medical image analysis of cancer of the liver. Artif. Life Robot, 15(3): 264-269.
17. Abdel-Aal, R.E., 2005. GMDH-based feature ranking and selection for improved classification of medical data J. of Biomedical Informatics, pp: 456-468.
18. Benamrane, N., A. Aribi and L. Kraoula, 1993. Fuzzy Neural Networks and Genetic Algorithms for Medical Images Geometric Modeling and Imaging--New Trends, pp: 259-264.
19. Yang-Ping Wang, Jian-Wu Dang, Qiang Li and Sha Li, 2007. Multimodal Medical Image Fusion Using Fuzzy Radial Basis Function Neural Networks Wavelet Analysis and Pattern Recognition, 2: 778-782.
20. Qin Jian, Meng Jun, Wu Guozhen and Liu Hongjian, 2005. The Retrieval of the Medical Tongue-coating Images Using Fuzzy CMAC Neural Network Industrial Technology, pp: 465-468.
21. Banerjee, S., D.P. Mukherjee and D. Dutta Majumdar, 1999. Fuzzy c-means approach to tissue classification in multimodal medical imaging. Inf. Sci., pp: 261-279.
22. Christopher Gammage and Vipin Chaudhary, 2006. On Optimization and Parallelization of Fuzzy Connected Segmentation for Medical Imaging 2004.
23. A Dynamic Fuzzy Classifier for Detecting Abnormalities in Mammograms. In Proceedings of the 1st Canadian Conference on Computer and Robot Vision, pp: 172-179.
24. Noor Elaiza, Abdul Khalid, Mazani Manaf, Mohd Ezane Aziz, Noorhayati Mohamed Noor and Norsyuhaiza Zainol, 2008. Gaussian Rule Based Fuzzy (GRBF) Membership Edge Detection on Hand Phantom Radiograph Images. In Proceedings of the 2008 Fifth International Conference on Computer Graphics, Imaging and Visualization, (CGIV '08): 265-270.
25. Hariton Costin and Cristian Rotariu, 2011. Medical image processing by using soft computing methods and information fusion In Proceedings of the 13th WSEAS international conference on mathematical methods, computational techniques and intelligent systems and 10th WSEAS international conference on non-linear analysis, non-linear systems and chaos and 7th WSEAS international conference on dynamical systems and control and 11th WSEAS international conference on Wavelet analysis and multi rate systems: recent researches in computational techniques, non-linear systems and control, pp: 182-191.
26. Kannan, S.R., S. Ramathilagam and R. Pandiyarajan, 2010. Modified bias field fuzzy C-means for effective segmentation of brain MRI in Transactions on computational science, pp: 127-145.
27. Martin Tabakov, 2007. A fuzzy segmentation method for Computed Tomography images Int. J. Intell. Inf. Database Syst., 1(1): 79-89.
28. Noor Elaiza, Abdul Khalid, Shafaf Ibrahim and Mazani Manaf, 2011. Brain abnormalities segmentation performances contrasting: adaptive network-based fuzzy inference system (ANFIS) vs. K-nearest neighbors (k-NN) vs. fuzzy c-means (FCM). In Proceedings of the 15th WSEAS international conference on Computers, pp: 285-290.
29. Li, L., F. Mao, W. Qian and L.P. Clarke, 1997. Wavelet transform for directional feature extraction in medical imaging. In Proceedings of the 1997 International Conference on Image Processing 3.
30. Vidhya, K. and S. Shenbagadevi, 2009. Performance Analysis of Medical Image Compression. In Proceedings of the 2009 International Conference on Signal Processing Systems, pp: 979-983.
31. Zhang, Q.P., M. Liang and W.C. Sun, 2004. Medical Diagnostic Image Fusion Based on Feature Mapping Wavelet Neural Networks. In Proceedings of the Third International Conference on Image and Graphics, pp: 51-54.
32. Chunbao Huo, Yu Shi and Yang Zhang, 2008. System for Recognition of Chinese Medical Pulse Signal Based on Wavelet Analysis and Back Propagation Neural Network.
33. Sriraam, N., J. Roopa, M. Saranya and M. Dhanalakshmi, 2009. Performance Evaluation of Computer Aided Diagnostic Tool (CAD) for Detection of Ultrasonic Based Liver Disease J. Med. Syst., 33(4): 267-274.
34. Carlson, J.W., 1989. MRI data acquisition and image reconstruction from multiple, non-interacting receiver coils, In the Proceedings of the 1989 IEEE Engineering Conference, pp: 607-608.
35. Zafer Iscan, Ayhan, mray Dokur, Mehmet Kor and Tamer lmez, 2009. Medical image segmentation with transform and moment based features and incremental supervised neural network. Digit Signal Process, 19(5): 890-901.

36. Alireza Akhbardeh, Sakari Junnila, Mikko Koivuluoma, Teemu Koivistoinen, Vain, Turjanmaa, Tiit bi and Alporri, 2007. Towards a heart disease diagnosing system based on force sensitive chair's measurement, bi orthogonal wavelets and neural networks. Engg. Appl. Artif. Intell., 20(4): 493-502.
37. Sepideh Babaei and Amir Geranmayeh, 2009. Heart sound reproduction based on neural network classification of cardiac valve disorders using wavelet transforms of PCG signals. Comput. Biol. Med., 39(1): 8-15.
38. Fitzsimmons, J.R., Rui Yan and D. Erdogmus, 2005. MRI Image Reconstruction via Homomorphic Signal Processing In the Proceedings of the 2005 IEEE conference on Acoustics, Speech and Signal Processing, pp: 121- 124.
39. Abdou, M.A.R. and M.B. Tayel, 2008. An automatic bi-channel compression technique for medical images Int. J. Robot Autom., 23(1): 15-21.
40. Tamilarasi, M. and V. Palanisamy, 2009. Counterlet Based Medical Image Compression Using Improved EZW. In Proceedings of the 2009 International Conference on Advances in Recent Technologies in Communication and Computing, pp: 800-804.
41. Tom Froese, Sillas Hadjiloucas, Roberto K.H. Galvo, Victor M. Becerra and Clarimar Jos. Coelho, 2006. Comparison of extra systolic ECG signal classifiers using discrete wavelet transforms Pattern Recognition. Lett., 27(5): 393-407.
42. Mohd Fauzi Othman and Mohd Ariffanan Mohd Basri, 2011. Probabilistic Neural Network for Brain Tumor Classification In Proceedings of the 2011 Second International Conference on Intelligent Systems, Modeling and Simulation, pp: 136-138.
43. Kalatzis, I., N. Piliouras, D. Pappas, E. Ventouras and D. Cavouras, 2003. Probabilistic neural network classifier versus multilayer perceptron classifier in discriminating brain spect images of patients with diabetes from normal controls. In Proceedings of the international conference on Computational methods in sciences and engineering, pp: 3074-3076.
44. Luka Šajn and MatjaKukar, 2011. Image processing and machine learning for fully automated probabilistic evaluation of medical images Comput. Methods Prog Biomed, 104(3).
45. Pavlina Konstantinova, Dan Adam, Donka Angelova and Vera Behar, 2006. Contour determination in ultrasound medical images using inter acting multiple model probabilistic data association filter. In Proceedings of the 6th international conference on Numerical methods and applications, pp: 628-636.
46. Neda Changizi and Ghassan Hamarneh, 2010. Probabilistic multi-shape representation using an isometric log-ratio mapping In Proceedings of the 13th international conference on Medical image computing and computer-assisted intervention, pp: 563-570.
47. Edgar, R., Arce-Santana and Alfonso Alba, 2009. Image registration using Markov random coefficient and geometric transformation fields Pattern Recogn, 42(8): 1660-1671.
48. Simon, K. Warfield, Kelly H. Zou and William M. Wells, 2002. Validation of Image Segmentation and Expert Quality with an Expectation-Maximization Algorithm, pp: 298-306.
49. Marcos Mart and Carlos Alberola, 2002. A Bayesian Approach to *in vivo* Kidney Ultrasound Contour Detection Using Markov Random Fields, pp: 397-404.
50. Arunabha, S. Roy, Ajay Gopinath and Anand Rangarajan, 2007. Deformable density matching for 3D non-rigid registration of shapes In Proceedings of the 10th international conference on Medical image computing and computer-assisted intervention, pp: 942-949.
51. Guido Gerig, Matthieu Jomier and Miranda Chakos, 2001. A New Validation Tool for Assessing and Improving 3D Object Segmentation In Proceedings of the 4th International Conference on Medical Image Computing and Computer-Assisted Intervention, pp: 516-523.
52. Ying Wang, Susan M. Resnick and Christos Davatzikos, 2010. Spatio-temporal analysis of brain MRI images using hidden Markov models. In Proceedings of the 13th international conference on Medical image computing and computer-assisted intervention, pp: 160-168.
53. Wilson, J.M., S.G. Ross, T. Deller, E. Asma, R. Manjeshwar and T.G. Turkington, A phantom study of regularized image reconstruction in PET. In the Proceedings of the Nuclear Science Symposium Conference.