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Performance Improved Iteration-Free Artificial Neural Networks for Abnormal Magnetic Resonance Brain Image Classification

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ABSTRACT

Image classification is one of the typical computational applications widely used in the medical field especially for abnormality detection in Magnetic Resonance (MR) brain images. The automated image classification systems used for such applications must be significantly efficient in terms of accuracy since false detection may lead to fatal results. Another requirement is the high convergence rate which accounts for the practical feasibility of the system. Among the automated systems, Artificial Neural Network (ANN) is gaining significant positions for solving computational problems. Besides multiple advantages, there are also few drawbacks associated with the neural networks which are unnoticed for most of the applications. The main drawback is that the ANN which yields high accuracy requires high convergence time period and the ANN which are much quicker are usually inaccurate. Hence, there is a significant necessity for ANN which satisfies the criteria of high convergence rate and accuracy simultaneously. In this work, this drawback is tackled by proposing two novel neural networks namely Modified Counter Propagation Neural Network (MCPN) and Modified Kohonen Neural Network (MKNN). These networks are framed by performing modifications in the training methodology of conventional CPN and Kohonen networks. The main concept of this work is to make the ANN iteration-free which ultimately improves the convergence rate besides yielding accurate results. The performance of these networks are analysed in the context of abnormal brain image classification. Experimental results show promising results for the proposed networks in terms of the performance measures.

1. Introduction

Medical image classification is a pattern recognition technique in which different images are categorized into several groups based on some similarity measure. One of the significant applications is the tumor type identification in abnormal MR brain images. Conventional techniques are based on human observation which is highly prone to error. This leads to the necessity for automated systems which can categorize the abnormal brain images with high accuracy. Apart from high accuracy, the convergence rate of the automated system also must be practically feasible. Based on these criterions, several automated systems have been developed for brain image classification. Most of them are based on Artificial Intelligence (AI) techniques because of multiple advantages. ANN is one of the significant AI techniques which are widely used for medical image classification.

Literature survey reveals the extensive work performed on ANN for various applications. A survey on the different applications of ANN is reported in [1]. In this report, a detailed analysis on the applicability of ANN for medical image classification is performed along with the comparative analysis between various ANNs. The merits and demerits of various ANNs are also analyzed in this work. The gradient training methodology of multilayer perceptron is discussed in [2]. This work confirms the superior nature of ANN over the conventional classifiers such as Linear Discriminant Classifiers. A Bidirectional Associative Memory (BAM) neural network based gray level pattern classification system is available in [3].

A self-convergent iterative learning is performed in this approach with a non-linear function but this approach suffers from the drawback of handling non-linearly separable problems. Kohonen neural networks are also successfully used for image classification [4]. The classification accuracy of these neural networks is usually low since these systems are unsupervised neural networks. Support Vector Machine based classification of various levels of MR glioma images was performed by Guo-Zheng et al. [5]. This method was claimed to be better than rule based systems but

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the accuracy reported in the paper is low. Backpropagation neural networks (BPN) are also widely used for classification but the requirement for high convergence time period limits the usage of BPN in practical applications [6]. Thus, the conventional neural network based classification system suffers from multiple disadvantages.

Several modified neural networks have been developed to improve the performance of the conventional neural networks. An improved Probabilistic Neural Network (PNN) based image classification system is reported in [7]. The combination of PNN and non-linear transformation technique are used to improve the accuracy of the automated system. This computer aided system is used for discriminating the primary and secondary brain tumors. Feed-forward neural networks with modifications in the architecture are used for brain abnormality detection in [8]. A linear output layer is included along with the hidden layer in this architecture. The accuracy of the neural classifiers used in this work is very low. The usage of Cellular Neural Networks for abnormality detection in abnormal images is explored in [9]. Earlier works also concentrated on minimizing the computational complexity of the ANN based automated systems. Modifications in the training methodology of Multilayer Perceptron (MLP) are performed to improve the convergence rate of the network [10]. This approach employed a novel training procedure for the hidden layer neurons which is usually complex for the conventional MLP network. Huang et al. [11] have experimentally proved the training capability of ANN for real-time applications. A novel neural network based on iteration-free methodology is employed in this work to minimize the stabilization time period. The computational complexity of the proposed system is also significantly low.

Some of the researches depend on hybrid systems for performance enhancement of the neural networks. Yas et al. [12] have proposed a hybrid approach involving MLP and GA for pattern recognition. GA is used for optimizing several parameters of the neural network to improve the performance in terms of accuracy and convergence time period. The concepts of wavelets and Principal Component Analysis (PCA) are combined together for feature selection in image classification system. These features are further used for training the ANN [13]. This work has proved the fact that ANN trained using the optimal features show superior performance than any neural classifier trained with the entire dataset. Hybrid techniques such as the mixture of fuzzy logic and neural networks have been implemented to improve the performance of the ANN classifiers. One such work is reported in [14] which have improved the classification accuracy results of the fuzzy ARTMAP neural network.

A two level Self Organizing Map (SOM) is proposed for image classification in [15]. An unsupervised technique is involved in the first layer and the supervising concurrent SOM is used in the second layer for classification of the image. The results tabulated in this work reveal the superior classification accuracy of the network over the other conventional approaches. Radial Basis Function neural networks based image classification is implemented in [16]. The concepts of nearest neighbour classification are also used in this work. This approach shows high performance in terms of accuracy even in the presence of noise. Park et al. [17] have developed a content based image classification system using BPN. Another approach for image classification using modified neural networks is proposed in [18].

Even though several modifications of ANN are proposed in the literature, most of them are unable to tackle the problem of accuracy and convergence rate simultaneously. In this work, modified versions of conventional ANN are proposed for performance enhancement in terms of accuracy and convergence rate. The performance of these networks is tested in the context of abnormal brain image classification. Several abnormal MR brain images from four different classes are used in this work. An extensive feature set is extracted from the input images. These feature set is then used to train the modified neural classifiers. The performance of the networks is analyzed in terms of classification accuracy and convergence rate. Experimental outputs show promising results for the proposed networks in terms of the performance measures.

2. Materials and methods

This research paper proposes an efficient methodology based on ANN for classification of abnormal brain images. The flow diagram of the automated image classification system is shown in Fig. 1.

Real time MR brain tumor images from four different categories are collected from the scan centres. The four categories are metastase, glioma, meningioma & astrocytoma. A sufficiently large database is used in this work for pattern recognition. 540 retinal images from the four different categories are used in this work

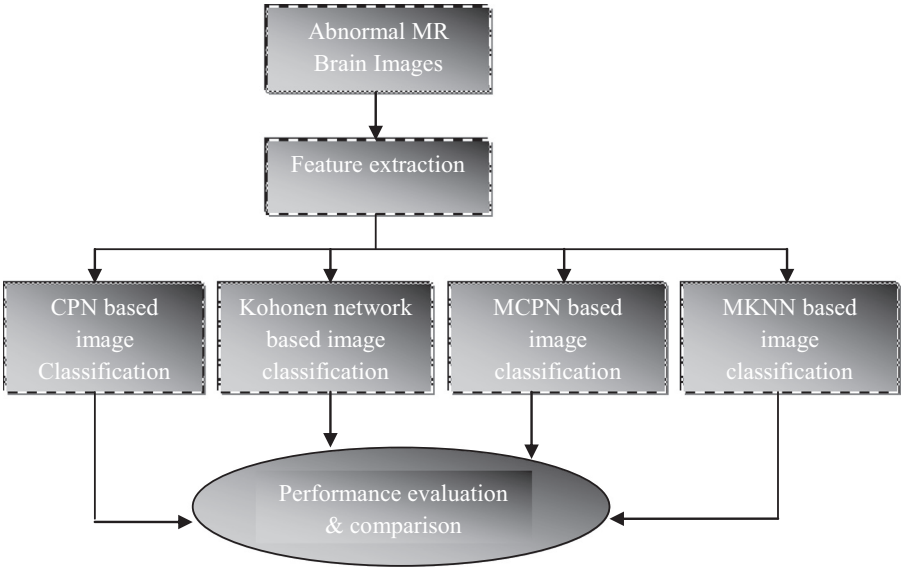

Fig. 1. Proposed Methodology.