FOREX Publication
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International Journal of
Electrical and Electronics Research (IJEER)
Research Article | Volume 10, Issue 4 | Pages 915-920 | e-ISSN: 2347-470X

Feed Forward Neural Network based Brain Tumor Diagnosis in Magnetic Resonance Images

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ABSTRACT- In the realm of medicine, value, resource use and final care are determined by good technological advancement. However, there are crucial components that must be present for a disease to be diagnosed. The monitoring of illness progression traditionally relies primarily on a subjective human judgment and is neither precise nor timely. One important aspect that utilizes data at various disease progression phases is to maintain routine disease surveillance. The Feed Forward Neural Network based Brain Tumor Diagnosis in Magnetic Resonance Images is provided in this paper as an automatic brain cancer diagnosis and grade classification method. It is highly helpful to have accurate information about the disease in order to classify it and make decisions. The suggested brain tumor diagnosis system can diagnose the condition and provide a reliable foundation for appropriate regulation, as opposed to manual approaches. Finally, the evaluated outcomes of the suggested model investigate numerous Magnetic Resonance Images of healthy and disease and demonstrate that, the proposed method has the highest accuracy.

Keywords: Brain tumor diagnosis, feed forward neural network, magnetic resonance images, grade classification.

ARTICLE INFORMATION

Author(s): M. P. Gaikwad, R. B. Dhumale, N. R. Dhumale, P. B. Mane, A. M. Umbrajkaar and A. N. Sarwade;

Received: 09/08/2022; **Accepted**: 05/10/2022; **Published**: 30/10/2022;
e-ISSN: 2347-470X;
Paper Id: 0822SI-IJEER-2022-11;
Citation: 10.37391/IJEER.100427
Webpage-link:
https://ijeer.forexjournal.co.in/archive/volume-10/ijeer-100427.html

Crossref member
CROSSREF.ORG
THE CITATION LINKING BACKBONE

This article belongs to the Special Issue on **Complexity and Uncertainty in Big Data Analytics, and Machine Learning in Real-World Applications**

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1. INTRODUCTION

Modern medical diagnosis uses the latest technologies to help doctors get disease information at low cost and easily accessible. The diagnosis of disease in modern medical technology is based on pattern recognition. The disease diagnosis adopts a *Pattern Recognition based Approach (PRA)* wherein the major mechanism of disease diagnosis is known for its potential profitability, as it is necessary to reduce the costs involved in diagnosing and treating diseases [1]. PRAs are appropriate to a large variety of systems and can be implemented in real-time applications. PRAs consist of artificial intelligence techniques that have been progressively applied to disease diagnosis. They have shown better performance over usual approaches. Nevertheless, it is not simple to apply artificial intelligence techniques in disease diagnosis of a plant in a different climate [2]. Because of the lack of well-organized measures for getting training data and specific knowledge, which are necessary for training the models. Hence, the development of pattern recognition based disease diagnosis systems is the most important challenge)[3]. Brain Tumor (BrTmr) is extremely complex to identify manually. It involves a remarkable amount of effort, knowledge in diseases, and also needs extreme processing time. For this reason, Image Processing (IP) is utilized for BrTmr Identification (BTI) [4]. BTI through some automatic method is helpful like it decreases a huge effort at an initial phase itself; it identifies the signs of diseases. A literature survey is done to study the various methods of IP systems, which facilitates to identify the plant disease using IP.

The affected piece of the Brain is scanned and examined through Image Segmentation Techniques (ISTs). There are different ISTs are existing which split the abnormal area in the brain. Additionally, many Feature Extraction Techniques (FETs) are believed to split the particular features of the segmented image. FET is a method which identifies the similar patterns in the segmented image as well as transferred to the subsequently classifier section in PDI. Different users clarify various classifiers in phase of prediction of the BrTmr diagnosis (BrTmrDgn) using Machine Learning (ML) algorithm. The most important principle of the literature survey has explained the advantages with application of a variety of *ISTs* throughout all stage of the BTI [5].

The Knowledge-Based Disease Diagnosis System is included to diagnose disease. In which technicians take samples to the laboratory and diagnose the disease. But this diagnosis can take time because the lack such a [6]. Therefore, the motivation of this work is to provide Doctors with a diagnosis of the disease at a low cost and in less time. The proposed Image Processing (IP) based System will work in such way that, Magnetic resonance imaging (MRI) of the BrTmr and using app to know BrTmr is there or not. Different tumors are encountered. The tumor must be identified precisely. In most disease diagnosis methods, intervention by a human being is unavoidable. Using artificial intelligence in the field of disease diagnosis can be an inspiration and avoid intervention of human being to improve accuracy [7]. Human intervention is found at every stage of the disease diagnosis, and it turns out that this is one of the best reasons for using artificial intelligence in this process [8].

The disease diagnosis problem is knowledge-based system at one hand as in most cases the probability of a disease occurrence is unclear and not well defined [9]. On the other hand, it is rules-based because the doctor has to make many intelligent practical decisions based on the available data [10]-[13].

The input slices are de-noised and improved using a Weiner filter with multiple wavelet bands. Potential Field (PF) clustering is used to identify tumor pixel subsets. The tumor location is additionally isolated in Fluid Attenuated Inversion Recovery (Flair) and T2 MRI using a global threshold and other mathematical morphological methods. Gabor Wavelet Transform (GWT) and Local Binary Pattern (LBP) features are combined for precise categorization [14]. Through the use of brain MRI pictures, a Convolutional Neural Network (CNN) has been used to find tumors. CNN was used to apply images initially. Images were classified with 98.67% accuracy using the Softmax Fully Connected layer. Additionally, the Radial Basis Function (RBF) classifier, with a 97.34% accuracy rate, and the Decision Tree (DT), with a 94.24% accuracy rate, were used to determine the accuracy of the CNN [15].

In order to automatically discover irregularities in the ROI, the under- and over-segmented brain tumor regions are analyzed in this article using an improved orthogonal gamma distribution-based machine-learning approach. The machine learning method samples more data imbalances caused by faulty edge matching in the aberrant region, compares the edge coordinates and sensitivity, and measures the selectivity parameters. The system is assessed in light of experimental findings that demonstrated the orthogonal gamma distribution method combined with the machine learning methodology achieved an accuracy of 99.55% in detecting brain cancers [16].

In [17], author extracted multimodal features from the brain tumor imaging database, including textural, morphological, entropy-based, Scale Invariant Feature Transform (SIFT), and Elliptic Fourier Descriptors (EFDs). Strong machine learning methods, such as Support Vector Machine (SVM) with kernels of polynomial, RBF, and Gaussian; Decision Tree (DT), and Nave Bayes, were used to find the tumor. The most popular 10-fold Jack-knife Cross-Validation (CV) method was used to test and validate the dataset. Texture features are followed by SVM polynomial kernel and Decision Tree classifier with accuracy 97.81%, and 94.63% respectively.

The research work is proposed to achieve following objectives to develop tomato disease diagnosis process with improved performances.

- To develop a model for the selection of BrTmr.
- To make an efficient use of Image processing technique for BrTmr diagnosis.
- To develop a cost-effective method, this will be user friendly.
- Strategy to improve economic loss, quality and quantity of BrTmr diagnosis.

2. METHODOLOGY

Medical diagnosis is used in various ways throughout the world. A variety of diseases have been reported in human beings. This work focuses on BrTmr Diagnosis. Different methods have been used to BrTmr Diagnosis. In which the direct and indirect method is adopted. The direct methods consist of Molecular techniques and Serological methods. In this work, an imaging technique is proposed. It has been used as a machine learning-based BrTmr Diagnosis method. This has the following main steps and is shown in *figure 1*.

- Image acquisition,
- Resize Image,
- Image Preprocessing,
- Feature Extraction,
- Feature Selection,
- Disease Classifier,
- Image Segmentation,
- Severity Calculation.

3. FEED-FORWARD NEURAL NETWORK BASED BRAIN TUMOR DIAGNOSIS

The goal of the ANN is to train the network to achieve stability between its reaction and reasoning abilities in response to inputs that are similar but not identical to those used in training. Different from other networks that are used to process weights derived during the learning stage is the BPNN algorithm. The multilayer perceptron's typical complexity is changing the hidden layer weights in a reliable way that would only slightly influence an output error that would otherwise be zero. When there are more hidden layers, network training is more complicated. Update weight requires calculation of error. Calculating the output layer error is simple. The buried layers are not directly used to calculate error information. The final objective is to lower the output error by applying other methods to lower the error on the hidden layer. The three phases of BPN training are as the computation and back-propagation of the error, changing the weights, and feed-forward of the input training pattern. The BPN test only considers measurements of the feed-forward phase. One hidden layer is sufficient, but adding additional hidden layers may be advantageous. Although network training is quite slow, the results can sometimes be obtained very quickly.

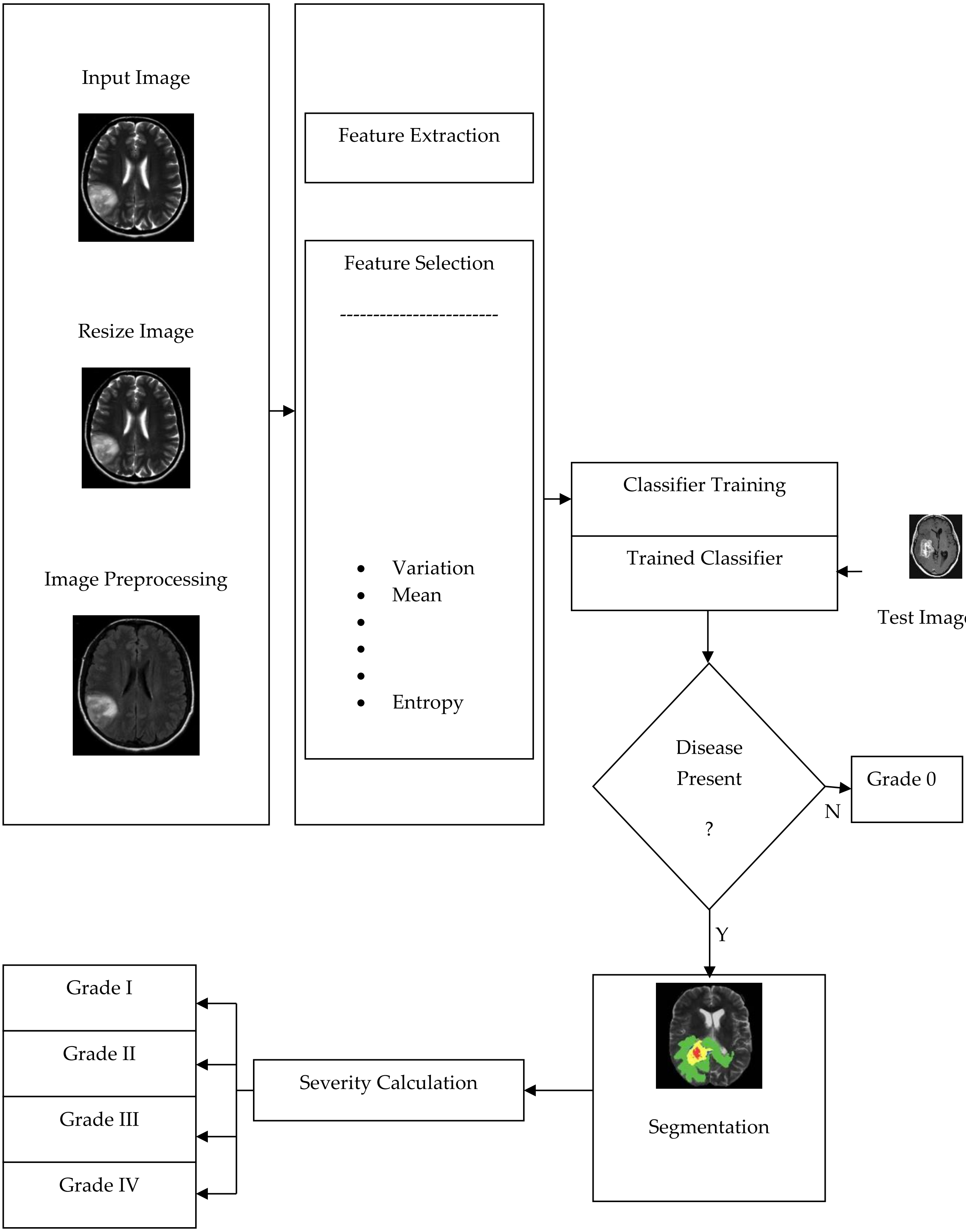
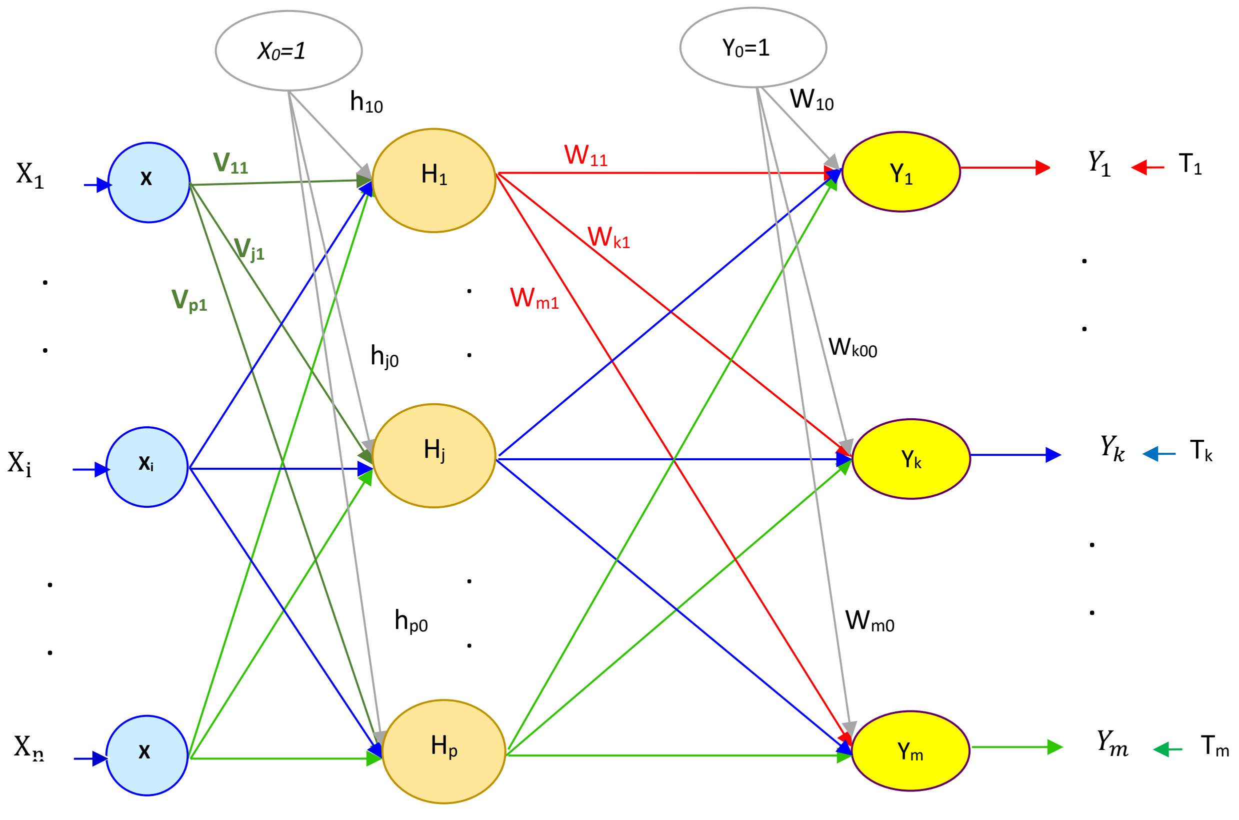


Figure 1: Machine Learning based BrTmr Diagnosis Method



4. DETERMINATION OF BRAIN TUMOR AREA

When all the above steps are completed, it is important to find the area of the infected area. The grade is determined by the infected area. The infected area in this work is calculated using following algorithm.

Step 0: Coordinate the run-length position of the original image coordinate system.
Step 1: Compare these coordinates to determine the extreme points to the left, right, top and bottom of the image.
Step 2: Rotate the coordinate system by angle, image $\theta = 7^0$ to give the image a new X and Y Cartesian axis like:

$$X' = Xcos\theta + Ysin\theta$$
$$Y' = Ycos\theta - Xsin\theta$$

Step 3: Determine and store the extreme features of this new image co-ordinate system.
Step 4: E = 10 °, 17 °, 20 ° and so on again process (2), and (3), and for 17 different angles.
Step 7: For the region represented by n polygon vertices (X_b Y_k), and (X_o, Y_o) = (X_n, Y_n), the bounding area is given as:

$$Area = \frac{1}{2}\sum_{k=0}^{n-1} X_k \bullet Y_{k+1} - X_{k+1} \bullet Y_k$$

Step 7: C*ompare the infected area with threshold values defined earlier to predict grade of GBNV disease.

5. RESULTS AND DISCUSSION

The FFBP neural network is used to determine whether the supplied BrTmr picture is infected. Sections 3 and 4 provide a thorough analysis of the algorithm that was used to train this network. 4X220 data was generated using four features to train this network. Its fifth column presents the results, and the features that were gathered there indicate whether or not they are diseased or not. In this study, four MRI features were retrieved, and the Artificial Neural Network was trained using these features. Different structures were trained during the selection process to determine the best-performing structure, and the appropriate structure was chosen.

The size of the input was fixed at 4 during the initial training phase. There are four input nodes altogether. To determine if it is an illness or not, one output is sufficient. An artificial neural network's hidden layer determines how well it performs. Knowing the learning step size when training is also crucial. As a result, the training of various networks' structures is represented in *table 1*. The concealed layer's dimensions ranged from 2, 4, 7, 10, 17, and 20. The constructed structure is zero, too. One, 0.07, and 0.07 learning rates were practiced. In the trained algorithm, the 4-10-1 structure has the best learning rate (0.06), as shown in *figure 3*. The training's results are shown in *figure 3*. 0.0014 at epoch 13 has the best validation performance. *Table 2* displays specific findings from the suggested technique for diagnosing brain tumors.

Table 1: Performance of BP Neural Network for different parameters of ANN

Structure of Neural Network	Learning Rate (η)	Mean Square Error (%)
4-4-1	0.1	0.0137
4-7-1	0.1	0.0747
4-10-1	0.1	0.0712
4-17-1	0.1	0.0194
4-20-1	0.1	0.0192
4-2-1	0.07	0.0270
4-4-1	0.07	0.0237
4-7-1	0.07	0.0249
4-10-1	0.07	0.1313
4-17-1	0.07	0.0272
4-20-1	0.07	0.0029
4-2-1	0.07	0.0270
4-4-1	0.07	0.0017
4-7-1	0.07	0.0290
4-10-1	0.07	0.0012
4-17-1	0.07	0.0193
4-20-1	0.07	0.0134

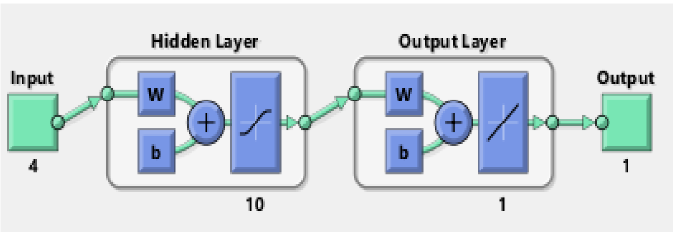


Figure 3: Structure of Artificial Neural Network with Four Input Nodes 10 Hidden Layers and One Output Node

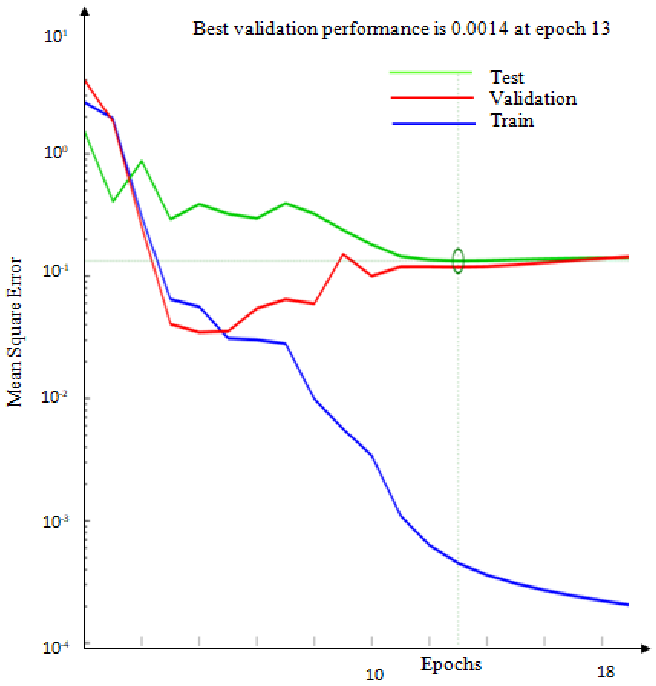


Figure 4: Neural Network Training Performance

Table 2: Proposed method results for brain tumor diagnosis

Datasets	Accuracy	Specificity	Recall	Precision
BRATS2018	97:60 ± 0:16	97:00 ± 0:26	96:00 ± 0:07	94:00 ± 0:02
BRATS2019	97:60 ± 0:09	97:20 ± 0:16	96:00 ± 0:17	97:70 ± 0:17
BRATS2020	98:00 ± 0:16	97:60 ± 0:18	97:00 ± 0:26	97:00 ± 0:06

6. CONCLUSION

The optimum for computerized brain tumor diagnosis and grade prediction is based on artificial neural networks. Through the use of MR scans, the brain tumor is professionally and precisely diagnosed. Low contrast MR images are processed through preprocessing and post processing procedures. In order to enhance classification performance, characteristics from brain MR images are also removed using artificial neural network approaches. For the classification of MR images, a back propagation neural network design has been used. BRATS2018, BRATS2019, and BRATS2020 datasets are used to train and test the suggested method. The proposed model requires less time for computation and for execution. The computational time and error rate have been reached.

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Research Article | Volume 10, Issue 4 | Pages 915-920 | e-ISSN: 2347-470X

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