Detection of Brain Tumor in MR Images using Multi-objective Particle Swarm Optimization with Support Vector Machine Classifier with RBF kernel

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Abstract - *Brain Tumor is a serious threat to Human life. Proper diagnosis and detection of brain tumor in its early stage is necessary in order to help doctors in planning treatment. In our proposed method, Magnetic Resonance Images are trained after pre-processing, segmentation, feature extraction and a database is created. Gray Level Co-occurrence Matrix is used for texture feature extraction and geometrical features are also extracted. Wrapper based Particle Swarm Optimization is used to select the best feature and also to optimize the parameters of Support Vector Machine. K-fold Cross validation is employed to check for the accuracy, precision of the developed system for brain tumor detection. Test image is then subjected to Support Vector Machine with RBF kernel for classification of image into Normal or Tumor. Classification accuracy of proposed Wrapper PSO with SVM method is 98 % which is better when compared to GA with SVM.*

***Key Words*: Bio-Medical Image processing, Brain tumor, Texture feature, Gray Level Co-occurrence matrix, Geometrical feature, Wrapper based Particle Swarm Optimization, Parameter selection, RBF kernel, Support Vector Machine.**

1 INTRODUCTION

In Today's world, there have been progress and advances in analysis, automated diagnosis methods and in computerized image visualization. There were major drawbacks like errors due to fatigue, wrong observation, distractions and limited experience etc in manually observing or visual analysis of medical images. Computerized analysis and processing of Medical imaging modalities is an important powerful tool which helps physicians. The field of medical imaging and image analysis has been evolved due to the overall contribution from many areas of medicine, engineering and basic sciences. Main objective of Medical Imaging is to acquire useful information associated with the physiological processes or organs of the body by using external or internal sources of energy. Major advancement in the field of science and medicine is the Three-Dimensional Medical imaging which plays a vital role in early detection, analysis, diagnosis and treatment of tumor.

1.1 BRAIN TUMOR

Normally, cells grow and divide to form new cells as the body needs them. Worn out and dead cells are replaced by new and fresh cells. But in certain conditions, brain cells grow rapidly and multiply uncontrollably because the mechanism which control normal healthy cells fails to control the unregulated growth of brain cells. Brain Tumor is the abnormal mass of brain tissue occupying space in the skull. Brain tumor interrupts normal functioning of brain and creates an increase in pressure causing shifting of some brain tissues. This results in damaging of nerves of other healthy brain tissues. Brain tumor is the most common life-threatening brain disease, through which many lives are affected. It may result in Coma, disability or sudden death. Around the world, millions of people are diagnosed with brain tumor per year with a huge mortality rate.

Basically there are two types of tumors. Benign and Malignant. A Benign brain tumor (Non-cancerous) do not have cancer cells and are slow growing. Benign tumor often has well-defined borders, so treatment can be done by surgically removing tumor. A Malignant tumor (cancerous) that grows and multiplies rapidly and may invade or destruct healthy areas of the brain. Malignant tumors are life-threatening.

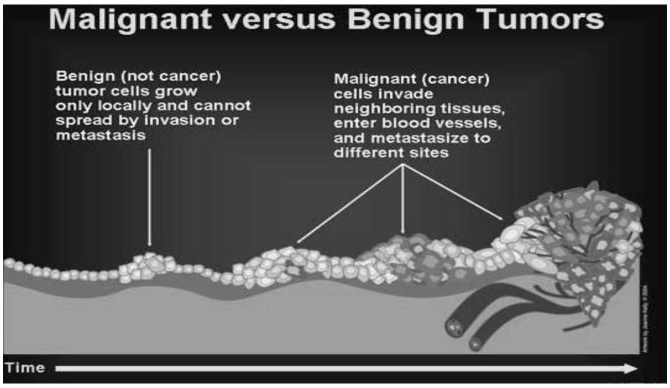

Fig-1.1: Benign and Malignant tumor.

Tumors can directly destroy all healthy brain cells. To combat this brain tumor, a strong collaboration between physician, medical expertise, radiologists, scientists and engineers is required for designing, implementing and validating complex medical system to accurately diagnose, segment, analyze and treat with proper medication and surgery.

1.2 BIO-MEDICAL IMAGING

Early imaging techniques were invasive and sometimes dangerous such as cerebral angiography. Modern imaging techniques opt for non invasive study of anatomical structure of body. People with brain tumor have symptoms such as fatigue, depression, blood, clot, behavioral and cognitive changes, headaches etc. Different symptoms refer to different type, location and size of tumor. Different tumors are treated differently as per their description and there exists various changing modalities which give visual representation and enable us to study the brain. Bio-medical imaging is an applied science where the principle of imaging science is used to diagnose and treat diseases and gain basic knowledge depth into the process of life. In Health care, Digital Image Processing is becoming more important day by day, due to increasing usage of direct digital imaging systems for medical diagnosing. Some digital imaging techniques are Computed Tomography Scan, Magnetic Resonance Imaging etc.

1.3 MAGNETIC RESONANCE IMAGING

MRI is an imaging technology based on the phenomenon of Nuclear Magnetic Resonance which produces three-Dimensional anatomical images without the use of ionizing radiation. MRI is useful for scanning and detection abnormalities in body's soft tissues structure such as cartilage tissue and soft organs like brain. MRI is the best choice in imaging modalities for studying brain due to its high tissue contrast and detail.

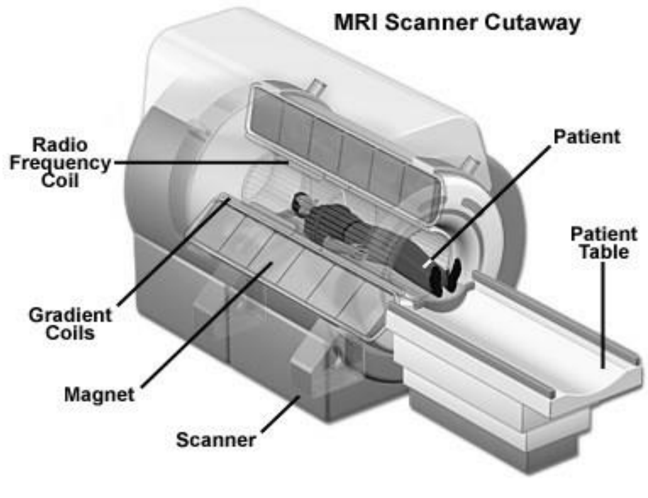

Fig-1.2: MRI Scanner

2. METHODOLOGY

For increasing the knowledge attained from medical images, analysis is necessary. In order to extract, quantify, interpret and understand the information from medical images effectively, we have to face challenges in processing and analyzing image. The designed system for brain tumor detection works in two phases namely

i. Learning/Training Phase and
ii. Recognition/Testing Phase.

The proposed methodology comprises of following steps for detecting brain tumor in MR Image

2.1 DATA ACQUISITION

The dataset used for training consists of 150, T2-weighted axial 256 × 256 MR brain images, out of which 100 are normal and 50 are abnormal (malignant and benign tumors) from human brain MRI dataset. On the other hand, 40 T2-weighted axial 256 × 256 MR brain images are used for testing where 18 are normal and 22 are abnormal images. T2 weighted images are used as most of the abnormalities can be accurately identified. MRI brain images cannot be fed directly as the input for the proposed technique. To transform the input image for further processing, it is subjected to a set of pre-processing steps.

2.2 IMAGE PRE-PROCESSING

The MRI image undergoes the series of steps for analysis using image processing techniques. The preprocessing include steps like RGB to Gray conversion, noise removal and image enhancement. Image binarization is conversion of an image in 0 to 255 gray levels to a black and white image. Image binarization is used by selecting a threshold value, and classifying all pixels with values above this threshold as white, and all other pixels as black. The preprocessing helps to identify different scale of signal intensities in different images which involves the operation to analyze the data by the extraction of information.

2.3 IMAGE SEGMENTATION

It is the process of sub-division of an image into constituent regions. Algorithms for Image segmentation are based basically on one of the two intensity values properties i.e. discontinuity and similarity. The approach by which an image is partitioned into regions based on similarity according to set of pre-defined criteria. In Thresholding approach, Image Segmentation is based on gray level intensity value of pixels. Each pixel's intensity of the image is compare with the threshold value, if the pixel's intensity is greater than threshold than pixel value is set to 1 otherwise set 0. Finally we get a segmented image. After segmentation the tumor part is detected.

2.4 FEATURE EXTRACTION

During diagnosis of brain, acquisition of data is quite sophisticated, it is very difficult to perform classification without dimensionality reduction. The process of collection of higher level information of an image like texture, color, shape and contrast is called Feature Extraction. This is the process of reducing original data set by measuring certain properties that distinguish one input pattern from another. Using appropriate transformation, certain characteristics or features of any image are identified, which are used for evaluation of image and system producing the image.

Feature vector is an N dimensional vector, each element of which specifies some measurement of objects. Feature space is the N dimensional mathematical space spanned by feature vector used in classification problem. Training data is collection of feature vector used to build a classifier. Testing data is collection of feature vector used to test the performance of a classifier. Texture features are for recognition and interpretation measured from a group of pixels. Texture features are used in many applications directly or indirectly such as Classification (Determining the class or category to which observed feature belongs), Segmentation (Partitioning any image into different meaningful regions) etc. In applying texture analysis methods, MRI is preferred when it is related to brain diseases.

2.4.1 GRAY LEVEL CO-OCCURRENCE MATRIX

Statistical features can be extracted by Gray level co-occurrence matrix. In this work, 22 features GLCM are extracted from each image. It is a two-dimensional array, P, in which both the rows and the columns represent a set of possible image values. Gray-level Co-occurrence Matrix (GLCM) can be designed by computing some relationship between the number of the intensity (gray-level) value x occurs with the pixel having value y. The value of the matrix element (x, y) is the total number of pixel with value I in specified spatial relationship to another pixel with value J within the same input image.

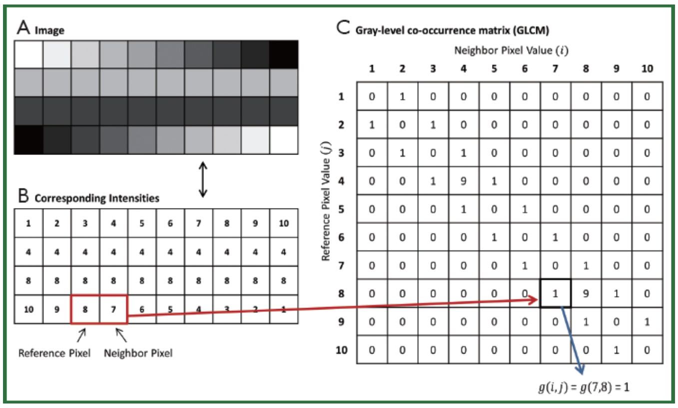

Fig-2.1: Gray Level Co-occurrence Matrix

Geometrical features of the brain image are extracted with the help of image processing toolbox of MATLAB. Nine features such as Area, Orientation, EquivDiameter, Extent, Solidity, Convex area, Minor axis length, Number of objects are extracted from image.

2.5 FEATURE SELECTION

It is one of the most important factors that influences the classification accuracy rate. Since some features are redundant, of little importance. So, best feature is selected among extracted features by discarding some redundant features such that better performance can be achieved. An efficient and precised feature selection technique eliminates irrelevant, noisy and redundant data. There are two categories of Feature subset selection algorithm:

(A) Filter feature selection algorithm: This algorithm involves Selection of feature subset before applying any classification algorithm and removal of less important features from the subset.

(B) Wrapper feature selection algorithm: This algorithm searches for the subset using the training data and the performance of the current subset. Wrapper based feature selection defines the learning algorithm, search strategy and the performance criteria.

In our proposed methodology, we used Wrapper based Particle Swarm Optimization model for feature selection, where meta-heuristic approaches are commonly employed to help in obtaining the best feature subset.

2.5.1 PARTICLE SWARM OPTIMIZATION

Particle Swarm Optimization was motivated from the simulation of simplified social behavior of bird flocking, bee swarming etc. PSO was firstly developed by Kennedy and Eberhart. It is a computational method for optimizing a problem by iteratively improving a candidate solution (i.e. particles) with respect to a certain measure of quality. PSO solves a problem by having a population of particles which moves around in search space. PSO is a meta-heuristic technique and can be implemented easily with few parameters. PSO is widely used for solving optimization problems and feature selection problems.

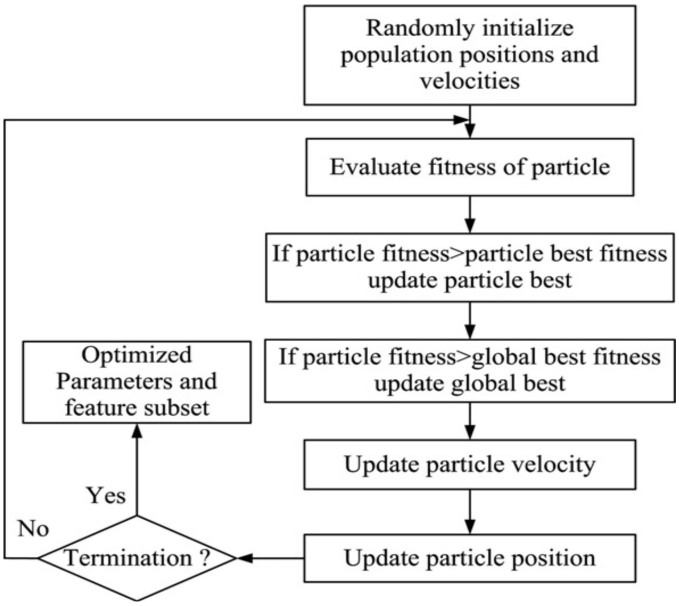

Fig- 2.2: Feature selection and parameter optimization using Particle Swarm Optimization

Multi-objective PSO will not only select best feature to be used for classification of MRI images but also help in parameter optimization of SVM classifier.

2.6 SUPPORT VECTOR MACHINE

SVM is a data classification technique proposed by Vapnik (1995). In the Support Vector Machine, the model for classification is generated from the training process with the training data. After Optimization, the global best feature is fed to the SVM classifier for training. Later on, classification of testing data is executed based on the trained model.

The main concept of SVM is using hyper-planes for defining decision boundaries that separates between data points of different classes. Optimal hyper-plane is the hyper-plane with the maximum margin of gap separating two classes, where the margin is the sum of the distances from the hyper-plane to the closest data points of each of the two classes. These closest data points are called Support Vectors (SVs).

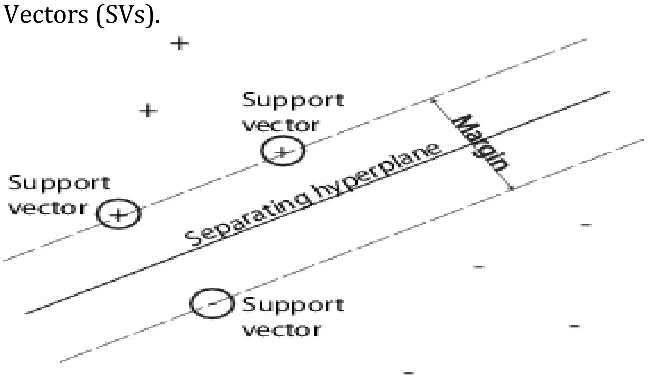

Fig- 2.3: Support Vector Machine

The largest problems which we faced while setting up the SVM model are the selection of kernel function and their parameter values. Inappropriate parameter settings lead to poor classification results

To obtain a good performance, some parameters in SVM have to be chosen carefully. These parameters include the regularization parameter 'C', which determines the tradeoff between minimizing the training error and minimizing model complexity; and parameter 'r'. These "higher level" parameters are usually referred as hyper-parameters. Tuning these hyper-parameters is usually done by minimizing the estimated generalization error such as the k-fold cross-validation error. K-fold cross-validation is an efficient technique for tuning SVM hyper-parameters.

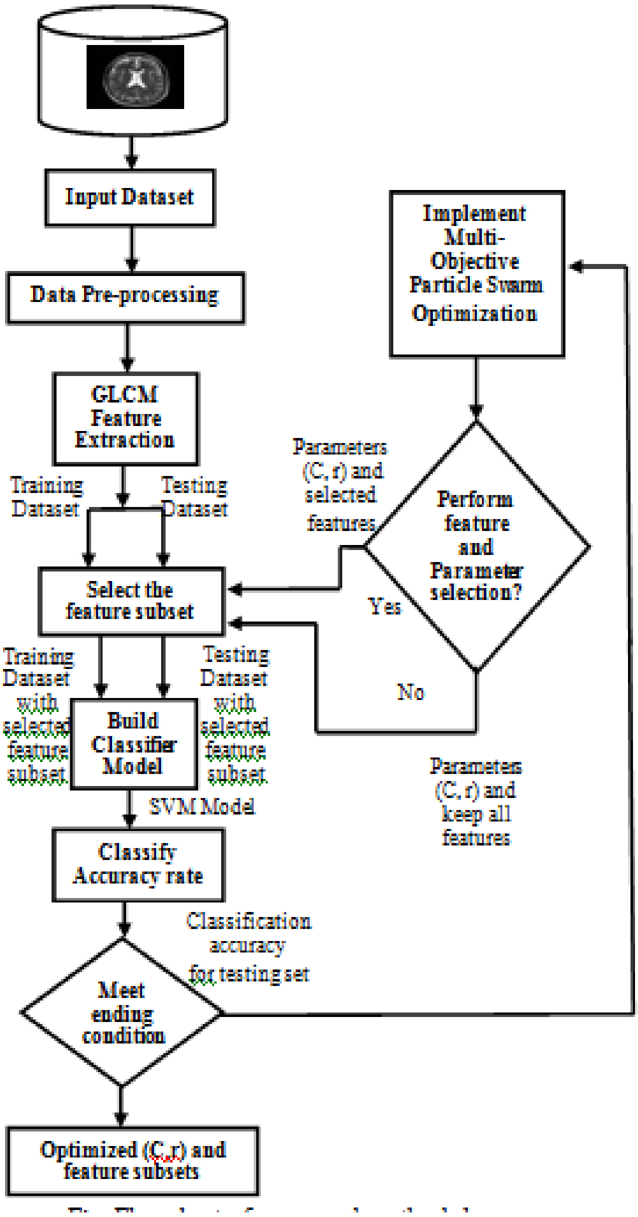

Fig-2.4: Flowchart of proposed methodology

2.6.1 SVM VALIDATION

Cross-validation is a widely used approach, was used to tune the parameters of the SVM model (C). A K cross fold validation strategy generally splits the sample set into K equal size disjoint subsets D1, D2...DK. The model is trained K times, using all the data subsamples except for one, which is left out as validation set. K-1 subset is referred as training set, is solely used for fitting the model, i.e., to estimate the model parameters, such as, the normal vector of the separating hyper-plane of an SVM. One remaining subset is solely used for validating the expected model on an independent data set and is therefore termed validation set. In our method, the value of 'K' in cross validation approach is set to 10. Thus, the dataset is divided into 10 subsets, with each subset of the data having the same proportion of each class of data. Nine data subsets were applied in the training process, while the remaining one was utilized in the testing process.

2.6.2 EXPERIMENTAL SETUP

The experiments were carried out on the platform of Intel(R) Core i3 with 2.53GHz processor and 3 GB RAM, running under Windows 7, 64-bit operating system. The implementation of the project is carried out in MATLAB R2015a with Image Processing Toolbox. The programs can be run or tested on any computer platforms where MATLAB is available.

2.6.3 PERFORMANCE MEASURE AND EVALUATION

The expected performance of the model needs to be evaluated on the common basis of the given data sample. Quantitative evaluation of the proposed system and its performance comparison with other state-of-the-art techniques were analyzed using different statistical measures

Confusion matrix was used to calculate the performance of the proposed method. Confusion matrix contains information about actual and predicted classifications. For evaluating the proposed algorithm based on the confusion matrix, we used the metrics of sensitivity, specificity and accuracy respectively.

Sensitivity (Recall or True positive rate)= TP / (TP +FN) * 100

Specificity (False positive rate) = TN /(TN+FP)*100

Accuracy: percent of all samples correctly classified= (TP + TN) / (TP + TN + FP +FN) * 100

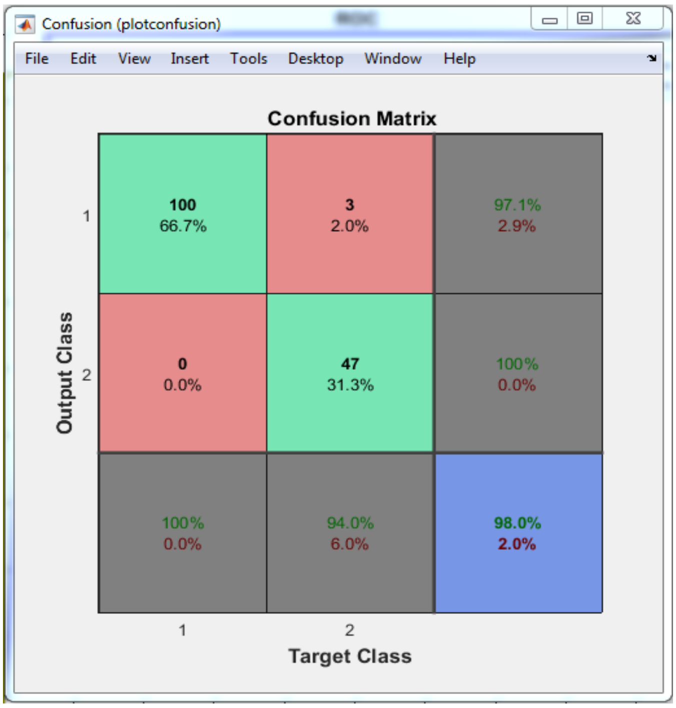

Fig-3.1: Confusion matrix

where: TP: (true positive) is the correctly classified positive cases,
TN: (true negative) is the correctly classified negative cases,
FP: (false positive) is the incorrectly classified negative cases
FN:(false negative) is the incorrectly classified positive cases.

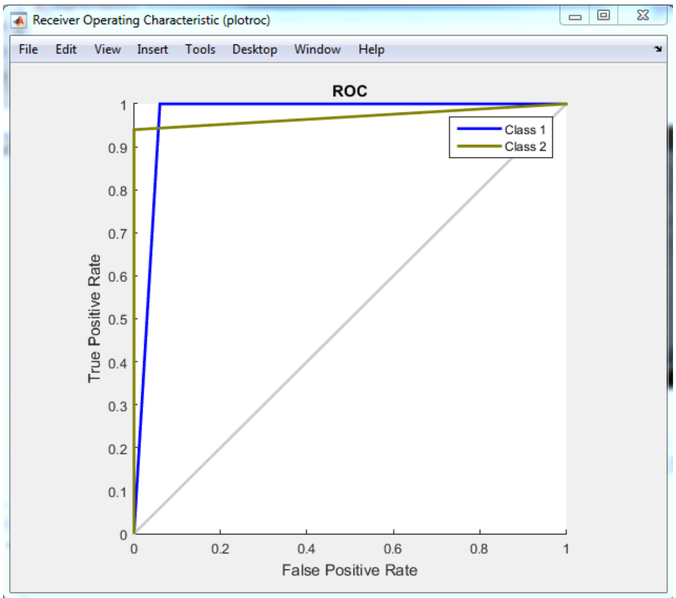

Fig-3.2: Reciever Operating Characteristic of the proposed method

ROC curves are plotted using true positives rate versus false positives rate, as the discrimination threshold of classification algorithm is varied. In this aspect, a ROC curve compares the classifiers' performance across the entire range of class distributions and error costs

Table-1: Classification performance in terms of Accuracy with comparison with other method.

S. No	Method	Accuracy
1.	Proposed method (Wrapper PSO+SVM with RBF Kernel)	98 %
2.	Genetic Algorithm with SVM	95.65 %

3. CONCLUSION

This method presents a Wrapper based particle swarm optimization approach for feature selection as well as parameter optimization. This multi-objective PSO is used for searching the best parameter values for SVM to obtain a subset of beneficial features which is used in training and testing to obtain the output in image classification. Proposed Wrapper PSO + SVM with RBF kernel approach can determine the parameter values and also find a subset of features improving the overall classification results of Support Vector Machine. The tumor detection is validated using K-fold Cross validation and evaluated through performance metrics namely, sensitivity, specificity and accuracy. On Comparing the results obtained in this method with other approaches proves that the developed PSO + SVM approach has better classification accuracy.

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