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An Efficient Detection Of Brain Tumor In MR Brain Images Using Particle Swarm Optimization

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Abstract— **This paper talks about image segmentation which can be attained through different ways such as water shed and contours, thresholding, region growing. In image classification, an image is classified according to its visual content. This paper also discuss how to extract information about the tumor, then in the first level i.e pre-processing level, the parts which are outside the skull and don't have any information are removed and then anisotropic diffusion filter is applied to the MRI images in order to remove the noise. In this paper we have tried to explain how by applying the algorithm, the tumor area is displayed on the MRI image and the central part is selected as sample points for training. Then Support Vector Machine classifies the boundary and extracts the tumor.**

Index Terms— **MRI images , Region growing , SVM classifier, Thresholding, Watershed**

I. INTRODUCTION

The doctors in the medical field unify their knowledge and the brain tumor in the MRI image while collecting medical characteristics of the tumor to finally decide the treatments necessary for the same. The difficulty occurs during manually detection of the tumor. Numerous algorithms were proposed for discovery but there are no expected methods which could be used by the doctors under the medical background owing to the causes related to the accuracy levels. In MRI images of Brain where bombastic amount of images are taken from every patient manually detections and then later on segmenting them from the tumor affected areas becomes dull and insistent, hence there is the necessity of computer vision for detecting the brain tumor and segmenting it further from the MR Images.

Magnetic resonance imaging (MRI) is an imaging technique in the field of image processing which produces high quality of images of an anatomical structures of the human body, especially in the brain, and provides rich information for clinical diagnosis and biomedical research [1-5].

Generally Brain Tumor are categorized into two main types i.e malignant and benign tumors [7]. Tumors are fast developing cancerous tissues. Benign are gradually increasing, stagnant cancerous tumor. The diagnostic values of MRI are greatly by the automated and accurate classification of the MRI images in the brain; Unusual cell growth is basically gives birth to the brain tumor. Almost all the tumors are life threatening, brain tumor is the one amongst them. The source of primary brain tumors is in the brain and in the Secondary type of brain tumor the tumor expands into the other regions of the brain which later increases from brain to the other parts of the body. Imaging tumors which are more accurate plays a crucial role in diagnosis of the same. diagnosis involves high resolution techniques such as PET(Positron Emission tomography), CT(Computed Tomography), and MRI etc. MRI is basically considered as the significant mean for analyzing the body's visceral structures [2]. MRI is preferably used because brain images and cancerous tissue's image are better as compared to the other medical imaging techniques such as Computed Tomography (CT) or X-ray. MRI are majorly used because of its non-invasive nature [12]. The basic principle on which the MRI works is to generate the images from MRI scan machine using the concept of the radio waves and strong magnetic fields of the body which helps in investigating the general anatomy of the body.

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An effective tool for the feature extraction from MRI images, because it allows analysis of images at certain levels of resolution due to its multi resolution analytical property. In recent years, researchers have proposed a lot of approaches for this goal, which fall into two categories. One category is supervised classification, including support vector machine (SVM) [11] and k-nearest neighbors (k-NN) [13]. The other category is unsupervised classification [14], including self-organization feature map (SOFM) [14] and fuzzy c-means [15]. While all these methods attained good results, even though the supervised classifier performs better as compared to unsupervised classifier in terms of classification accuracy (success classification rate). However, the classification accuracies of most existing methods were lower than 95% , so the goal of this paper is to find a more accurate method.

II. PROPOSED METHODOLOGY

To detect a tumor Image Processing techniques are deployed which are followed by steps such as Pre Processing, Feature Extraction, segmentation and Classification. In total, our method consists of four stages:

Step 1: Preprocessing includes Extracting information regarding tumor and removing unused information

Step 2: Anisotropic diffusion filter process is applied to the MRI images in order to remove noise.

Step 3: Training the kernel SVM with the help of Fast Bounding Box [FBB + PSO(Particle Swarm optimization)] in classifying central tumor boundary.

Step 4: Submit new MRI brains to the trained kernel SVM, and thus predicting the output.

The flowchart of the tumor detection working model and the classification is shown in **Figure 1**. This is the first step in the image processing and is used to increase the probability of detecting the suspicious area. Pixels with finer details in the image are enhanced for further analyzing and the noise in the image is thus removed. MRI images when they are disturbed by noise, affects the image by reducing the its accuracy . Numerous filters can be used to remove these noise such as Anisotropic diffusion filter is helpful in removing the background noise, weighted median filter is capable of to removing the salt and pepper noise.

As shown in **Figure 1**, a canonical and standard classification method which has already been proven as the best classification method [16] in this flowchart. The discrete wavelet transform is considered as the effective execution of the WT using the dynamic scales and positions [18].

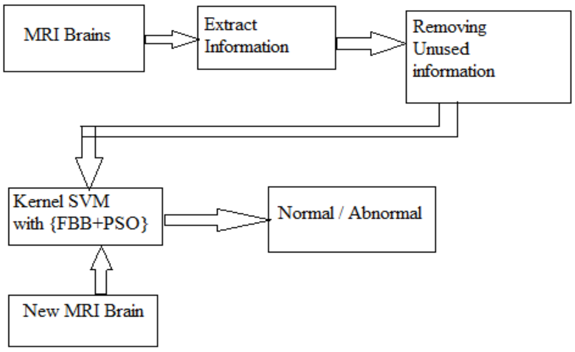

Fig 1: Methodology of proposed algorithm.

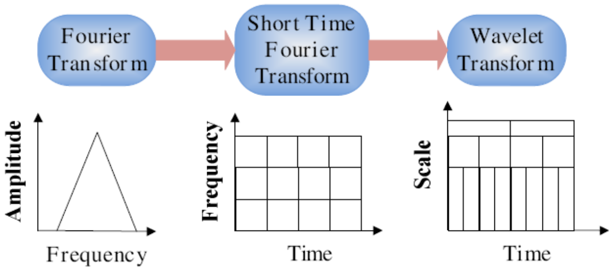

Fig 2 : Development Wavelet Transform Of Signals Analysis

For example, analyst could not tell when a specific event took place from a Fourier spectrum. Thus, the quality of the classification decreases as time information is lost. Suppose x(t) is an integral square function, then the continuous WT of x(t) relative to a given wavelet **Ψ(t)** is defined as

$$W_{\psi}(a,b) = \int_{-\infty}^{\infty} x(t)\, \psi_{a,b}(t)\, dt \quad (1)$$

$$\psi_{a,b}(t) = \frac{1}{\sqrt{a}}\, \psi \frac{t-a}{b} \quad (2)$$

Here, the wavelet factor $\Psi_{a,b(t)}$ is evaluated from its mother wavelet Ψ(t) by translation and dilation; a is the dilation factor and b is the translation factor (both real positive numbers).

There are several different kinds of wavelets which have gained popularity throughout the development of wavelet analysis. PCA(Principal Component Analysis) is an effective tool which can be used to reduce the dimensions of a data set containing a large number of interrelated variables for regaining most of the variations. It is achieved by transforming the data set to a new set of ordered variables according to their variances or importance. This technique effects the data set in three ways: in order to uncorrelate the input vectors with each other they are orthogonalized, it orders the resulting orthogonal components in such a way that those with the largest variation comes first and thus eliminating the least varied components in the data set. The introduction of support vector machine (SVM) is a turning point in the machine learning field. The advantages of SVMs include high accuracy, elegant mathematical tractability, and direct geometric interpretation [19]. Recently, quantity of improved SVMs have grown rapidly, among which the kernel SVMs are the most favorite and effective choice of researchers. Kernel SVMs have the following advantages [20]:

(1) work very well in practice and have been remarkably successful in such diverse fields as natural language categorization, bioinformatics and computer vision.

(2) have few tunable parameters.
(3) training often involves convex quadratic optimization. With the give set of data the p-dimensional N-size training dataset in the form

$$\{(x_n, y_n) | x_n \in R^p, y_n \in \{-1, +1\}\}, \ n=1,\ldots N \quad (3)$$

where y(n) is either -1 or 1 corresponds to the class 1 or 2. Each X(n) is a *p*-dimensional vector. The KSVMs allow fitting the maximum margin hyper plane in a transformed feature space. The transformation may be nonlinear and the transformed space higher dimensional; thus though the classifier is a hyper plane in the higher-dimensional feature space, it may be nonlinear in the original input space. For each kernel, there should be at least one adjusting parameter so as to make the kernel flexible and tailor itself to practical data. Traditional SMVs constructed a hyper plane to classify data, so they cannot deal with classification problem of which the different types of data located at different sides of a hyper surface; the kernel strategy is applied to SVMs [17]. The algorithm used is formally similar instead of every dot.

III. EXPERIMENTAL DISCUSSION

The experiments were carried out on the platform of Intel core i5-2450M CPU with 2.50GHz processor and 6GB RAM, running under Windows 7 operating system. The algorithm was in-house developed via the wavelet toolbox, the bio-statistical toolbox of MATLAB R2014a. We have downloaded the open SVM toolbox which was further extended to the Kernel SVM, and was implemented on MR brain images classification. The programs can be run or tested on any computer platforms where MATLAB is available.

A. Database

The abnormal brain MRI images of the dataset are affected due to the diseases such as: glioma, sarcoma, meningioma, Pick's disease, Huntington's disease ,Alzheimer's disease and Alzheimer's disease plus visual agnosia. We have randomly selected 20 images for each type of brain. Since there is only one type of normal brain and seven types of abnormal brain are available in our dataset, thus 160 images are selected which consist of 20 normal and 140 abnormal brain images to be used for result analysis.

Diseases discussed above are shown in figure 3,which could be helpful in differentiating the type of tumors.

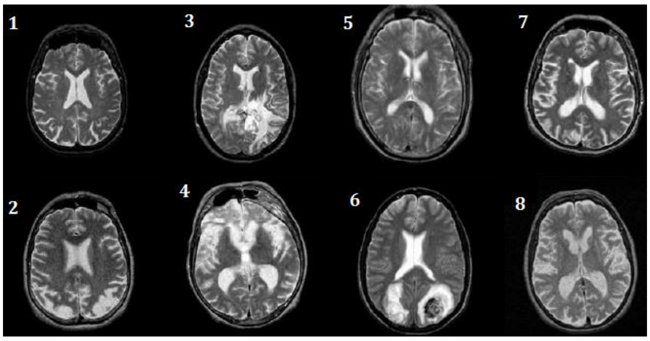

Fig 3: Brain MRI Samples: (1) Normal Brain (2)Alzheimer's Disease (3) Glioma (4) Pick's Disease (5) Meningioma (6) Sarcoma (7) Alzheimer's Disease (8) Huntington's Disease

B. *Feature Extration*

Wavelet decomposition greatly reduces the input image size from top left corner of the wavelet coefficients image, whose size is only 32 X 32 = 1024.

C. *Feature Reduction*

As discussed above, the number of selected features was reduced from 65536 to 1024. However, it is still too large for calculations to be done to get the desired result. Thus PCA, tool to reduce the size of an image is used further to reduce the dimensions of features up to higher scale, which shows only 19 principle components which are only 1.86% of the original extracted and is able to preserve 95.4% of total variance.

D. *CLASSIFICATION ACCURACY AND TIME ANALYSIS*

SVMs with different kernels like *LIN, HPOL, IPOL, and GRB* are tested. In the case of using linear kernel, the KSVM degrades to original linear SVM. The results showed that the proposed **DWT+PCA+PSO+FBB+KSVM** method obtains quite excellent results on all training and validation images. Moreover, we compared our method with six popular methods such as

- DWT+SOM, DWT+SVM with linear kernel,
- DWT+SVM with RBF based kernel
- DWT+PCA+ANN
- DWT+PCA+kFNN and
- DWT+PCA+ACPSO+FNN

Described in the recent literature using the same MRI datasets and same number of images. The comparison results indicates that our proposed method ***DWT+PCA+PSO+FBB+KSVM*** performed best among the 10 methods, achieving the best classification accuracy as **99.61%.** The next is DWT+PCA+ACPSO+FNN method with **98.75%** classification accuracy. The third is our proposed DWT+PCA+KSVM with IPOL kernel with **98.12%** classification accuracy. The most time consuming is 0.020 s at feature extraction stage. The feature reduction costs 0.019 s. The SVM classification costs the least time only 0.0026 s.

IV. PSO-SVM

Particle swarm optimization is an phylogenesis computational technique proposed by Eberhart and Kennedy. It is a technique based on population stochastic search processes which was modeled after analyzing the social behavior of a bird flock.

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Objective Function:

f(x),X=(x1,x2,x3,......,xd)
Generate an initial population of n host nests;
while (t<MaxGeneration) or (stop criterion)
    Get a cukoo's nest i randomly and replace its solution by performing Levy fligh
    Evaluate its quality/fitness Fi
    Choose a nest j among n randomly;
    if(Fi>Fj) ,
        Replace j by thr new solution;
    end if
    A fraction (Pa) of the worse nests are abondoned and new ones are built;
    Keep the best solutions/nests;
    Rank the solutions/nests and find the current best;
    Pass the current best solutions to the next generation;
end while
```

Algorithm PSO + SVM

SVM has certain drawbacks which limits its use on academic and industrial platforms: there are free parameters such as SVM kernel parameters and SVM hyper parameters which are needed to be defined by the user. Since the quality of SVM regression models depends on a proper setting of these parameters, the main issue is for practitioners who are trying to apply SVM in order to set these parameter values (to ensure good generalization performance) for a given set of data. SVM based on PSO optimizes two important hyper parameters and using PSO. The hyper parameter determines the trade-off between the model complexity and the degree to which deviations larger than are tolerated. A poor choice of will lead to an imbalance between model complexity minimization (MCM) and empirical risk minimization (ERM). The hyper parameter controls the width of the -insensitive zone, and its value affects the number of SVs used to construct the regression function. If is set too large, the insensitive zone will have ample margin to include data points; this would result in too few SVs selected and lead to unacceptable “flat” regression estimates.

V. RESULTS

The results of the implemented algorithm i.e FBB along with the PSO, after denoising the image with the help of analog diffusion filter are shown in the figures below. The image which contained the tumor region in MRI image is being filtered with the help of ADF is shown in **Figure 4**.

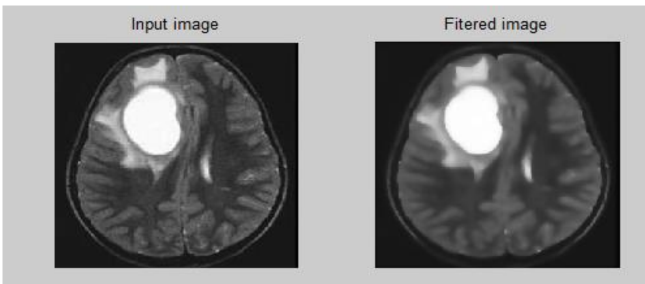

Fig 4: Filtered Image Of The Tumor Affected Brain MRI Image.

The filtered image when applied through the combination of FBB and PSO algorithm supported by the kernel SVM is able to detect the tumor effectively which is shown in **Figure 5.**

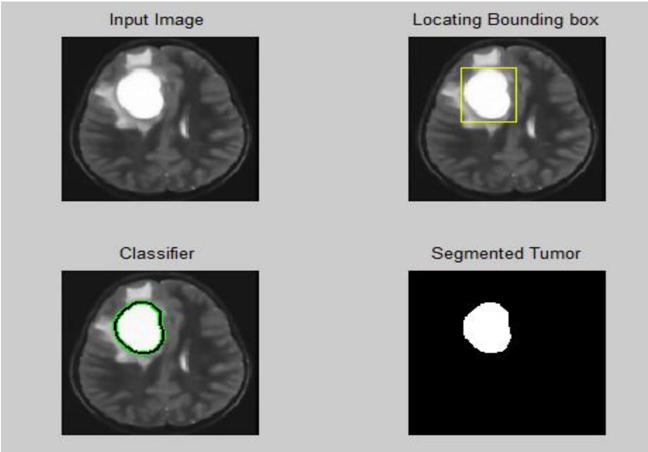

Fig 5: Image showing the exact tumor by locating the area

The images which were not affected by the tumor and were the normal MRI images when filtered were showing the result as shown in **Figure 6** below

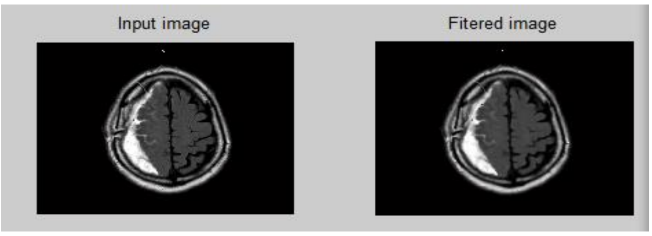

Fig 6: Normal MRI Image After Denoising

Figure 6 when applied through the detection algorithms were showing the absence of tumor as shown in **figure 7**.

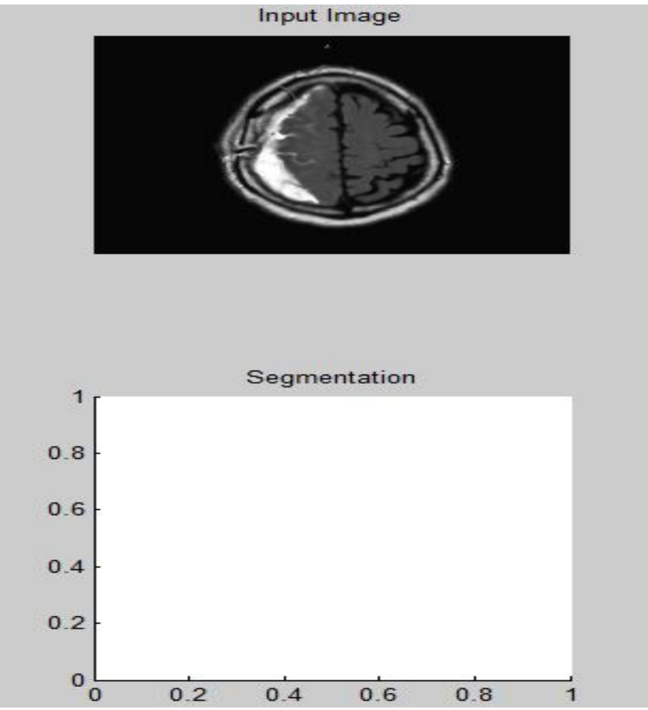

Fig 7: The Segmented Image Without Tumor Area

Thus with the help of SVM training the FBB+PSO algorithm is able to detect the tumor with an accuracy of 99.61%. If future enhancements could be made and SVM if used along with other algorithms may develop the results which could be close enough to 100%.

Objective Function:

$f(x), X=(x_1, x_2, x_3, \ldots\ldots, x_d)$

Generate an initial population of *n* host nests;

while (t<MaxGeneration) or (stop criterion)

  Get a cukoo's nest i randomly and replace its solution by performing Levy fligh

  Evaluate its quality/fitness F_i

  Choose a nest *j* among *n* randomly;

  if(F_i>F_j) ,

    Replace *j* by thr new solution;

  end if

  A fraction (P_a) of the worse nests are abondoned and new ones are built;

  Keep the best solutions/nests;

  Rank the solutions/nests and find the current best;

  Pass the current best solutions to the next generation;

end while

Algorithm PSO + SVM

VI. CONCLUSIONS

A novel ***DWT+PCA+PSO+FBB+KSVM*** method distinguish between normal and abnormal MRIs of the brain with four different kernels as LIN, HPOL, IPOL and GRB. The experiments demonstrate that the GRB kernel SVM with PSO + FBB obtained 99.61% classification accuracy on the 160 MR images, higher than HPOL, IPOL and GRB kernels, and other popular methods in recent literatures.

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