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Brain Tumor Classification and Identification using PSO and ANFIs

Jayashree S. Awati[1], Mahesh Kumbhar[2], C. Marimuthu[3], and J. Jayakumar[4]
[1,2]Electronics and Telecommunication Engineering, Rajarambapu Institute of Technology, Islampur, India;
[1]jayashree.awati@ritindia.edu, [2]mahesh.kumbhar@ritindia.edu
[3]EIE Department, Government College of Technology, Coimbatore, India; marimuthu@gct.ac.in
[4]Electrical and Electronics Engineering, Karunya Institute of Technology and Sciences, Coimbatore, India; jayakumar@karunya.edu

***Correspondence:** jayashree.awati@ritindia.edu; Mahesh.kumbhar@ritindia.edu

ABSTRACT- Fast Computer-Aided Diagnostic Systems (CAD) have become instrumental in diagnosing diseases. Brain tumors, in particular, pose a significant health challenge. Traditional tumor detection methods relied on radiologists and biopsy, which are time-consuming and detrimental to patients. Early detection is crucial for effective treatment. This system leverages image processing, SWARM intelligence, and Support Vector Machines (SVMs) to detect and classify brain tumors swiftly and accurately. Image processing encompasses preprocessing, segmentation, and feature extraction, with the Particle Swarm Optimization (PSO) method optimizing feature selection. SVMs identify tumor types. While various techniques exist for tumor detection, none achieve 100% accuracy. This system is engineered to provide precise detection.

Keywords: Magnetic Imaging Resonance (MRI), Local Binary Pattern (LBP), Principal Component Analysis (PCA), Otsu's Segmentation, Support Vector Machine (SVM) and Particle Swarm Optimization (PSO).

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1. INTRODUCTION

A brain tumor is an abnormal growth of cells or tissues within the brain, and it can seriously affect how the brain functions. Dealing with brain tumors can be especially tough for people leading busy lives. There are two main types of brain tumors: Benign and Malignant. Benign tumors are in their initial stages and can often be treated successfully. However, if left untreated, they can progress to a more severe form known as malignant tumors, which are cancerous and can lead to the patient's demise.

Traditionally, doctors would rely on manual methods such as biopsies to identify the type of tissues and determine the tumor's nature. This process, performed by experienced radiologists, is complex and time-consuming. However, now with the computers and advanced software are capable of swift operations. Magnetic Resonance Imaging (MRI) plays a pivotal role in capturing clear images of the inner workings of the body. This technology has revolutionized the ability to diagnose and understand brain tumors.

In recent years, significant advancements have been made in the field of brain tumor classification and identification, leveraging a variety of techniques and approaches. The literature review will delve into key research papers that have contributed to the development of brain tumor identification methodologies using feature extraction, feature selection, image preprocessing, and classification algorithms.

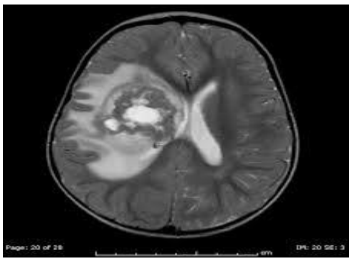

Figure 1. Input MRI

1.1 Feature Extraction

Salau and Jain (2019) conducted an extensive survey on feature extraction techniques in their paper titled "A survey of feature extraction: types, techniques, and applications." They explored various types of features, techniques, and their applications. Feature extraction plays a pivotal role in brain tumor identification as it aids in representing complex image data effectively. This survey provides valuable insights into the types of features that can be extracted from medical images, including those relevant to brain tumor analysis [1].

The authors addressed the critical issue of lung cancer by proposing a novel approach that combines optimized feature selection and image processing with machine learning techniques. By leveraging these methods, the research aims to enhance the accuracy and reliability of lung cancer detection. The paper recognized the significance of feature selection, as it plays a vital role in reducing the dimensionality of medical images while preserving relevant information. Additionally, the integration of image processing techniques further refines the quality of the data, making it suitable for machine learning algorithms. This research underscored the importance of early and accurate detection of lung cancer, which can significantly impact patient outcomes and treatment effectiveness. By utilizing advanced technologies and optimizing feature selection, the proposed approach shows promise in improving the diagnostic capabilities in the context of lung cancer [7].

1.2 Feature Extraction Methods

Ansari and Ghrera (n.d.) contributed to the field with their work on "Feature extraction method for digital images." While the exact publication year is not specified, their research likely encompasses innovative methods for extracting features from digital images, which can be particularly useful in the context of medical image analysis. These techniques can be applied to brain tumor identification to enhance feature representation [3].

1.3 Feature Selection

Brezocnik (2016) presented a paper titled "Feature selection for classification using particle swarm optimization" in the 2017 IEEE EUROCON. Feature selection is a critical step in machine learning-based tumor identification, as it helps in choosing the most relevant features for classification. Particle Swarm Optimization (PSO) is a powerful technique that can significantly aid in this process, improving the efficiency and effectiveness of classification models [4].

Researchers introduced an Enhanced PSO algorithm for predicting accident severity, which incorporates two important modifications to improve its performance. The study demonstrated that IPSO achieves superior results in terms of accuracy, precision, and recall when compared to other techniques. It also highlighted the potential for using other meta-heuristic algorithms and feature selection techniques in future research to further enhance accident severity prediction [5].

The authors proposed a method that combines Particle Swarm Optimization (PSO) and Support Vector Machine (SVM) for the intelligent detection of heart diseases. This fusion of optimization and machine learning techniques is designed to enhance the accuracy and efficiency of heart disease diagnosis. The research demonstrated the potential of PSO in optimizing the SVM algorithm's parameters, making it more effective in classifying heart disease cases. By doing so, the study aimed to contribute to early and accurate detection of heart conditions, which is crucial for timely medical intervention and patient well-being [6].

1.4 Image Preprocessing

Chen et al. (2012) delved into "Image preprocessing algorithm analysis based on Robert's operator and connected region" during the 2012 International Conference on Computer Science and Service System. Image preprocessing is a fundamental step in enhancing the quality of medical images before analysis. The Roberts operator and connected region techniques discussed in this paper likely contribute to improving the accuracy and clarity of brain tumor images, making subsequent analysis more effective. [4]

1.5 SVM Classification

Ding et al. (2017) explored "Building an SVM classifier for automated selection of big data" during the 2017 IEEE 6th International Congress on Big Data. Support Vector Machines (SVM) are a popular choice for classifying medical images, including those for brain tumor identification. This study likely focuses on automating the selection of optimal features for SVM classification, which is crucial for achieving accurate and efficient tumor classification [5].

2. BLOCK DIAGRAM

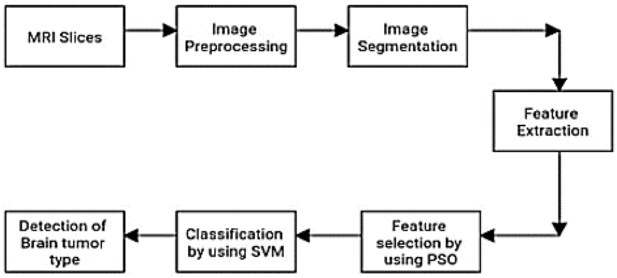

Figure 2: Block Diagram

2.1 Normal or Body Text MRI (Magnetic Resonance Imaging)

Please use a 10-point Times New Roman font, or other Times New Roman font with light, as close as possible in appearance to Times New Roman in which these guidelines have been set. The goal is to have a 10-point text, as you see here. Please use sans-serif or non-proportional fonts only for special purposes, such as distinguishing source code text.

If Times New Roman is not available, try the font named Computer Times New Roman light. On a Macintosh, use the font named Times New Roman. Right margins should be justified, not ragged.

3. PSO ALGORITHM

3.1 PSO Algorithm (Particle Swarm Optimization)

In feature extraction, calculated various features related to shape and texture. Particle Swarm Optimization (PSO) helps select the most optimal features. PSO is a population-based technique used in swarm intelligence. It evaluates and improves the fitness values of each particle in a group. The algorithm involves initializing particles' location and speed, evaluating fitness values, updating global and personal bests, adjusting particle velocities, updating positions, and ultimately concluding the algorithm.

The PSO algorithm can be described through the following set of steps:

1. Initialization: The search space, velocity, and position are randomly generated.
2. Evaluate particles: The maximum iteration and minimum fitness value of each particle are determined.
3. Global best: The global best value of each particle is updated.
4. Personal best: The personal best of each particle is updated.
5. Velocity: The velocity of each particle is updated.
6. Position: The position of each particle is updated.
7. End: The algorithm concludes.

3.2 Feature Extraction

Feature extraction refers to the process of extracting relevant information from raw data and deriving significant information about important characteristics known as feature vectors. These feature vectors can be utilized instead of the entire data for further processing. The local binary pattern is comparing central pixel with neighborhood 3*3 pattern then subtracting each pixel from central pixel and producing local binary codes. If values of pixels are negative, then it is 0 and if it is positive then it is 1.

LBP operator with 3*3 cannot find out correct features of large image. For this programmer can use 3*3, 6*6, 8*8-pixel values. For large scale image LBP operator in decimal formula is $LBPP$,

$$R\ (xc, yc) = \Sigma(iP - iC)\ P-1P=02P \quad (1)$$

Where,
P = Surrounding pixels with radius R.
R = Radius
iP= Grey level values of surrounding pixel
iC= Grey level values of central pixel
S = values of pixel (x)= {0, x<01, x≥0

3.3 Application of PSO on MR Image

The process of feature selection involves the selection of specific features from a pool of many calculated features. For instance, in this particular system, the area, perimeter, and circularity features are chosen among a plethora of other features.

PSO algorithm, which is a form of swarm intelligence, has been found to be particularly effective for feature selection.

It is population-based technique which counts and improves fitness values of each molecule in group.

First step is to begin with each particle's location, speed. Second is find out fitness values of every molecule. Third one is improved fitness value replaces old one. Last one chooses all particles having best fitness values, calculating velocity of each and locates each molecule.

3.4 Performance Evaluation

Once *figure 1* is inputted, it undergoes a two-step process. The initial step involves converting the MRI image into a grayscale format. Subsequently, the second step entails the removal of noise from the grayscale image. Linear and non-linear filtering methods for removal of noise are used but they some disadvantages. Linear filter removes noise but degrades image quality and non-linear filters preserves edges. Here boundaries are sufficient. The NL filter is an effective tool for removing noise in an image. Image segmentation involves dividing a digital image into multiple parts, resulting in an image that is simpler to analyze. This technique is beneficial for identifying areas of interest. Here Otsu's automatic threshold selection-based segmentation technique is used. The approach based on similarity detection involves five distinct steps. These steps include the collection of pixels of equal size, thresholding, which involves converting a grayscale image to a binary image, organizing the pixels, separating regions of pixels with similar properties, and splitting and merging regions as needed.

Intra-class variance and Inter-class variance is calculated by probabilities of histogram. Maximum Inter-class variance is the desired threshold which has highest intensity.

4. RESULTS

The performance of the implemented system that has been configured with MRI and PSO based Selection is evaluated by measuring various results. All the mentioned steps are carried out on the brain MR image, which facilitates the identification of the type of tumor. The results obtained at each step are collected in this section. Despite various issues related to automated segmentation, a manual examination is performed to ensure the accuracy of the segmentation.

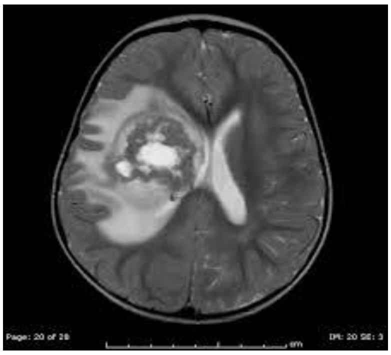

Figure 3. Input MRI

This is input slice is given to the system. Originally this image contains noise and unwanted part of image does not give correct result. In following output images noise is removed and image quality is improved by doing various operations.

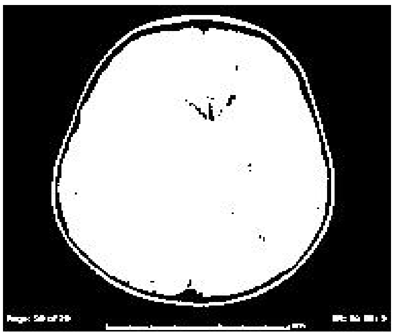

Figure 4. Masked Image.

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Figure 5 shows Otsu's thresholding-based segmentation mask. Essential stage before image segmentation, which is helpful for edge detection. This process is like Photoshop i.e., revealing a part, which need in next processes of research and unveiling the unwanted parts of MRI.

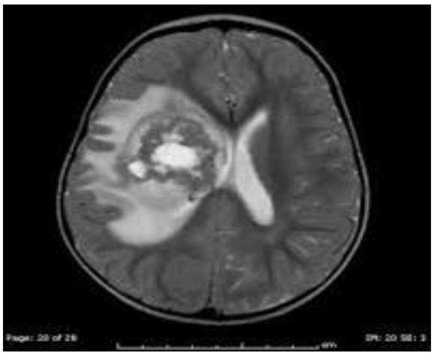

Figure 5: Segmented Image

The output obtained from the segmentation process is illustrated in the displayed figure. This image is easier to read than input MRI. This image gives clear view of tumor, which is easily, gets edge detected. The Otsu's method is used for segmentation.

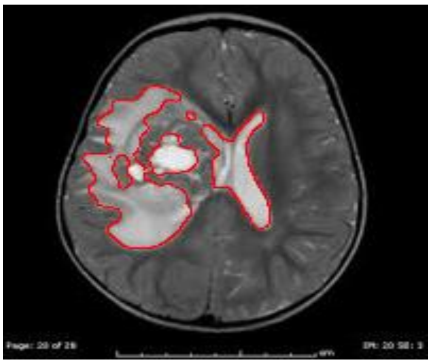

Figure 6: ROI

The Region of Interest that is being referred to is clearly depicted in the displayed figure. Edge detection technique is used. Feature extraction process is become easy only because of this.

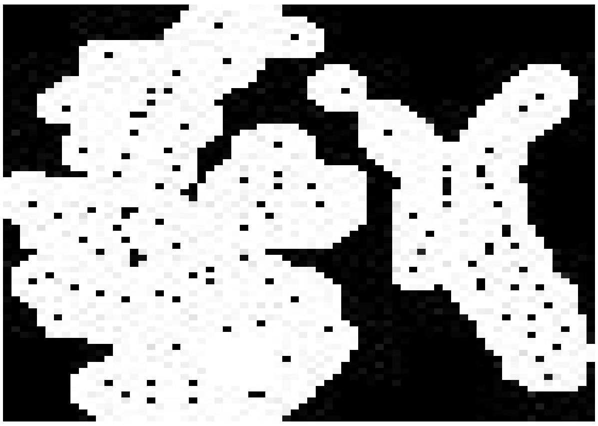

Figure 7. LBP Feature

Figure 7 shows the spatial feature extraction. The shape and texture features are calculated. Area, Perimeter, Centroid are calculated. Texture feature is calculating.

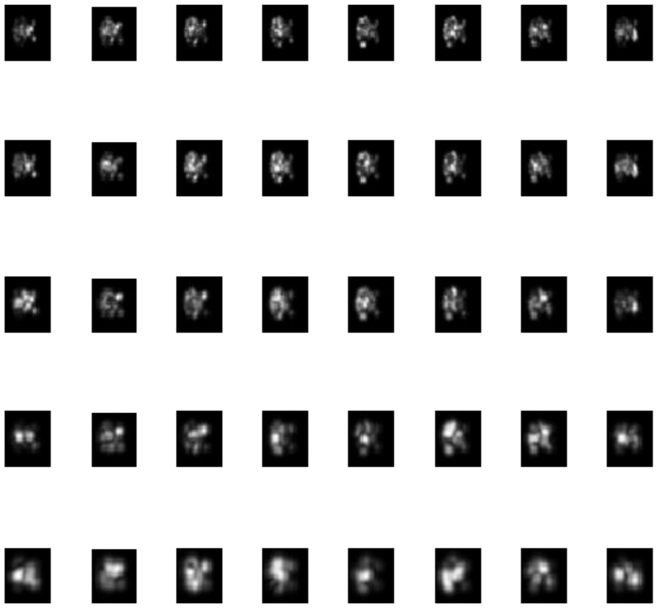

Figure 8: Gabor Filter bank

The diagram labeled as *figure 8* depicts the Gabor Filter Bank. These are convolution of signals with each pixel gives *figure 10* as an output of feature vector value.

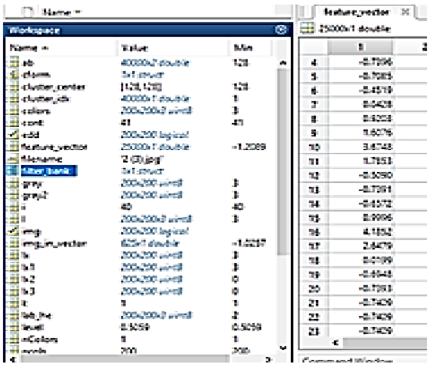

Figure 9. Feature vector values

```
Test input 1 is detected as Normal
Test input 2 is detected as Malign
Test input 3 is detected as Malign
Test input 4 is detected as Malign
Test input 5 is detected as Benign
Test input 6 is detected as Benign
Test input 7 is detected as Normal
Test input 8 is detected as Normal
Test input 9 is detected as Normal
Test input 10 is detected as Benign
Test input 11 is detected as Benign
Test input 12 is detected as Benign
Test input 13 is detected as Benign
Test input 14 is detected as Benign
Test input 15 is detected as Normal
Test input 16 is detected as Normal
Test input 17 is detected as Malign
Test input 18 is detected as Benign
Test input 19 is detected as Malign
Test input 20 is detected as Benign
Test input 21 is detected as Benign
Test input 22 is detected as Benign
Test input 23 is detected as Benign
SVM accuracy = 86.956522
SVM Specificity = 100.000000
SVM Sensitivity = 75.000000
```

Figure 10. Detected output

Above figure shows output of detected tumors types. This CAD system is designed for single MR image and for multiple MR

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images. SVM accuracy, specificity, sensitivity is also calculated.

Figure 11. GUI setup

Figure 12. ROI

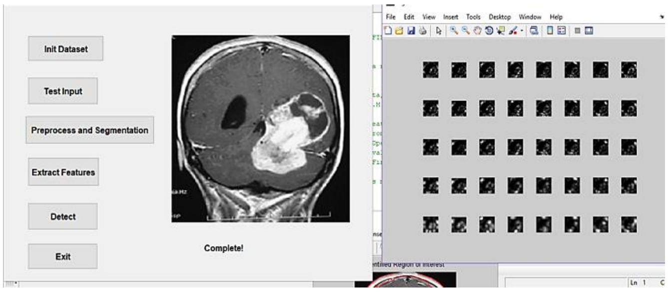

Figure 13. Gabor Filter Bank

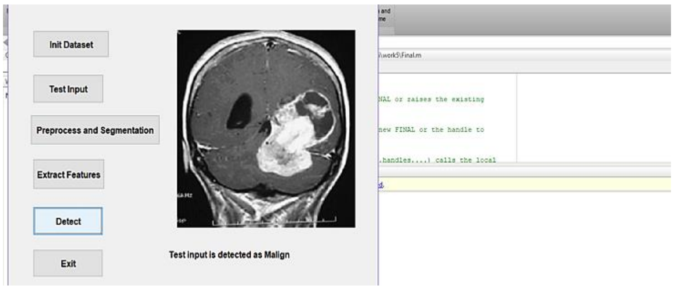

Figure 14. Output

Figure 11 shows setup of GUI for this system. In this one MR image is considered as an input. Test input is switch to get input. *Figure 12* shows preprocessed and segmented MR image. Edge detection stage is also added here. So region of interset step is also included here. *Figure 13* shows convolution of pixels with signals called as Gabor Filter Bank. this is used forfeature selection. *Figure 14* shows the input image taken for testing the tumor. Detect button in GUI shows whether tumor is present in brain or not.

4. CONCLUSION

The system simplifies the process of identifying brain tumors through a sequence of steps, including image preprocessing, segmentation, and feature extraction. The integration of PSO for feature selection and SVM classification significantly improves accuracy. This approach offers a fast and precise solution for detecting brain tumors, with potential applications in both single and multiple MR images. To enhance accuracy, feature selection is performed using Particle Swarm Optimization (PSO). PSO selects the minimum number of features, optimizing results. Finally, the system employs a Support Vector Machine (SVM) classifier to categorize the type of tumor using the selected features.

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