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# Novel Method to Diagnose Brain Tumor in its Early Stage Using Brain MRI Images

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## ABSTRACT

Automatic and Exact location and characterization of tumors in Brain MRI images is significant for the clinical investigation and understanding. Tumors which are recognized and treated in the beginning phase gives preferred long haul endurance over those distinguished of late. In this paper, Computer aided detection is used for diagnose brain tumor in its beginning phase using Mathematical Morphological Reconstruction. First, the image is pre-processed to eliminate noise and artifacts, and then segmented to find areas of interest where tumors may exist. A large number of texture and statistical features are extracted from the segmented image to classify whether the brain tumor in the image is benign or malignant. The experimental results show that the segmented images have a high precision while generously diminishing the calculation time. The proposed method can be utilized to diagnose brain tumor in patients to have a high success rate.

**Key words:** MRI Images, Tumor Detection, Mathematical Morphological reconstruction, computer aided detection

## 1. INTRODUCTION

Abnormal growth of cells inside the skull is a brain tumor. There are two types of tumors based on growth, namely benign (non-cancerous) and malignant (cancerous) tumors. Benign tumors are slow growing tumors, and malignant tumors, are rapid growing tumors that can spread into surrounding brain. Tumors harm the regular brain cells functioning by producing Inflammation, exerting pressure on brain parts and raising pressure within the skull.

The detection of brain tumors means not only identifying the affected part of the brain, but also identifying the shape, size, boundary and location of the tumor. Different imaging techniques such as magnetic resonance imaging (MRI), computer tomography (CT), and positron emission tomography (PET) are used to image the brain. Most commonly, an MRI scan or CT scan can be used to examine the anatomical structure of a brain tumor. However, CT scans contain radiation that is harmful to the human body, and MRI can accurately show the anatomical structure of brain tissue. MRI is a device that conducts magnetic fields and radio waves to generate detailed images of organs and tissues. Image obtained from the MRI machine may contain film artifacts or label such as patient name, and age, etc. Computer-aided detection (CAD) systems use advanced image processing and pattern recognition technology to help detect abnormalities in medical images. CAD has advantages in accelerating decision-making and reducing the human error in detection process. In this study, a CAD framework is created which depends on morphological recreation and arrangement strategies with the utilization of morphological features of the districts important to distinguish brain tumors from Brain MRI Images.

The general CAD brain tumor detection process follows the following steps: preprocess the image to remove noise and artifacts, segment the preprocessed image to identify possible tumor regions, extract useful features from the tumor regions, and Classify whether there is a tumor or not. The purpose of this study is to address the above limitations of existing methods-use image processing tools to improve the accuracy of brain tumor detection and reduce the calculation time of the steps involved so that brain MRI images can be identified as malignant or benign in the least computation time possible.

## 2. PROPOSED METHOD

A new method for early detection of brain tumors is proposed. The phases involved in the solution and the corresponding tools for each phase are as follows:

1. Use median filter for image pre-processing.
2. Use mathematical morphological operations to segment the pre-processed image.
3. Feature extraction and reduction (extract the first statistical feature and texture feature).
4. Use principal component analysis for feature simplification.
5. Use a support vector machine with GRB kernel for classification.
6. Evaluation of the classification.

The proposed method, mathematical morphology based segmentation, overcomes all the shortcomings of the FCM algorithm. It always produces the same segmentation result because it is independent of any initial membership value. Since the influence of image intensity is minimal, the segmentation accuracy is high. Finally, since simple, fast and standard morphological operations are used, the proposed segmentation algorithm requires less computational time.

### 2.1 Strength of the Proposed Segmentation Method

The accuracy of segmentation can be achieved from high peak signal-to-noise ratio (PSNR). PSNR is calculated as follows

PSNR-10LOG10(R2/MSE) (1)

Here, for the 8-bit unsigned integer data type, R=255. MSE stands for mean square error. For the original image and reconstructed image, the calculation of MSE is as follows:

$$MSE= \left[\frac{1}{MN}\right] \sum_{x=0}^{M-1} \sum_{y-0}^{N-1} \left[F(x,y) - F^{\wedge}(x,y)\right]^2 \qquad (2)$$

The input image with high segmentation accuracy has higher PSNR in the extracted area of interest. PSNR can be improved by reducing MSE, and MSE can be reduced by reducing the difference between the input image and the reconstructed image. Therefore, in order to obtain higher accuracy, the reconstructed image (with the region of interest) should retain the structure existing in the input image.

The proposed segmentation method of mathematical morphology operation can better preserve the structure in the segmented image. As a result, this leads to better accuracy. In terms of calculation time, the proposed mathematical morphology operation only involves a few steps, each of which takes only a few seconds, and is generally faster than the iterative method used in FCM.

## 3. PROPOSED ALGORITHM

First, the median filter is used to preprocess the brain MRI image to remove noise, artifacts and labels. The skull tissue can be stripped by the skull stripping method. After that, the image is subjected to segmentation. The proposed segmentation method involves the following steps:

1. A normalized global threshold is found and the brain MRI image is converted from gray scale to binary.
2. The resultant image is opened by reconstruction. The process includes identifying the appropriate structural element, determining the size of the structural element and using the structural element to obtain an eroded image.
3. The resulting image is then morphologically closed. In this process, determine the appropriate structural elements, fine-tuned their dimensions, and obtain a closed image.
4. Finally, multiply the reconstructed and morphologically closed image to obtain a segmented image.
5. The algorithm for the segmentation process is shown below and the proposed Solution is given in figure.

The algorithm for the segmentation process is shown below and the proposed solution is given in figure 1.

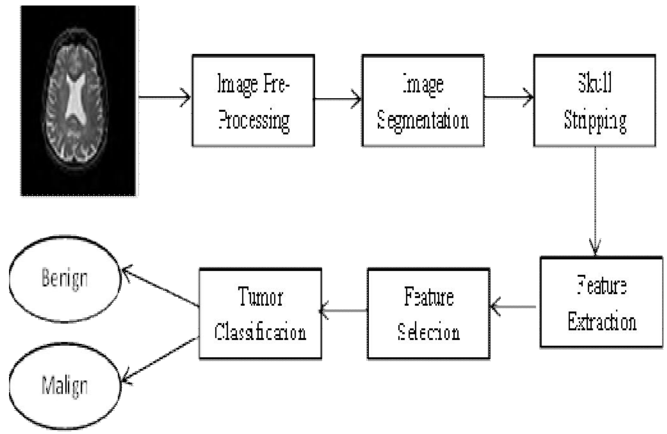



**Figure 1:** Proposed Solution

### 3.1. Image Pre-Processing

At this stage of the CAD system, the image is pre-processed to improve image quality and remove noise. The main goal of the pre-processing process is to prevent possible misleading results in the segmentation and classification process. First, apply a 3x3 median filter to eliminate small noise and parasites. Subsequently, histogram equalization is used to remove the roughness on the MR images.

### 3.2 Image Segmentation

Image segmentation phase aims to segment the tumors on MR images. This study proposed spatial-FCM method to segment the brain tumors. FCM feature analysis is an Computer-Aided Diagnosis of Malign and Benign Brain Tumors on MR Images.

### 3.3 Skull Stripping

This phase aims to completely strip the skull from the entire brain image to remove unnecessary regions. At this stage, a modified novel threshold processing method (MNTA) is used to strip the skull. Using this method, it is found that the average value of the skull section of the pre-processed MR image is between 0.2 (low) and 0.7 (high).

### 3.4 Feature Extraction

Following the segmentation of the tumor regions, it is necessary to distinguish whether the tumor is benign or malignant. Although the decision is made with the help of a classifier, certain recognition functions on the tumor help the decision-making process. Therefore, the tumor features on the MR image showing the characteristics of benign or malignant tumors should be extracted.

### 3.5 Feature Selection

It is crucial to select the most appropriate features from the original feature vector to increased classification accuracy. Therefore, Principal Component Analysis (PCA) was used in the current study as a feature reduction method to reduce dimensionality.

### 3.6 Tumor Classification

Classification is the process of classifying whether the input image has a tumor or not by using the extracted features. Support vector machines are used in the classification stage of the proposed CAD system to distinguish benign and malignant tumors. SVM is an effective learning method for classification problems.

After classifying many brain MRI images as benign or malignant in the data set, the classification results must be evaluated. The most common assessment tool is the accuracy of the diagnosis of tumors. The accuracy is defined as follows:

$$Accuracy=(((TP+TN)/(TP+TN+FN)))*100 \qquad (3)$$

TP means 'True Positive' which is the number of pixels exactly detected as tumor pixels.
TN means 'True Negative' which is the number of pixels exactly detected as not tumor pixels.
FP means 'False Positive', that is Number of pixels incorrectly detected as tumors Pixels.
FN means 'False negative', that is Number of pixels incorrectly detected as non-tumor Pixels.

High accuracy means that the MRI image has been correctly classified, so the CAD algorithm is good. Computation time is another evaluation criterion. The calculation time is the sum of the time required for image processing, segmentation, feature extraction, feature reduction, classification, and evaluation. The calculation or processing time should be as short as possible without affecting the accuracy of classification.

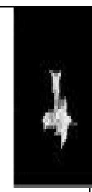
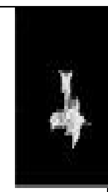
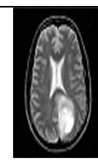
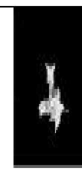
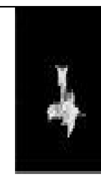
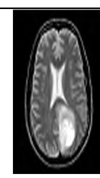
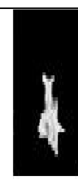
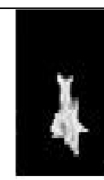
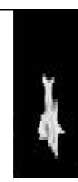
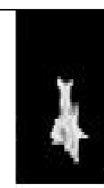
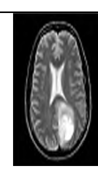
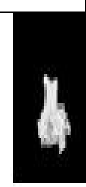
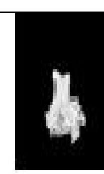
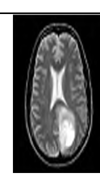
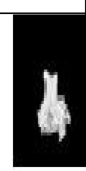
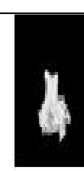
## 4. IMPLEMENTATION

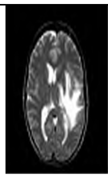
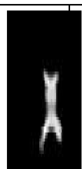
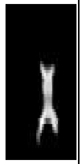
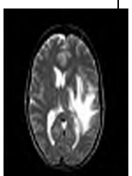
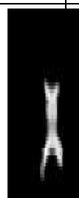
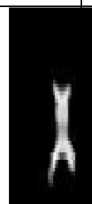
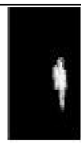
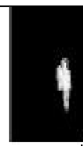
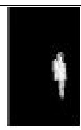
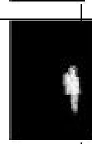
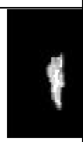
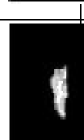
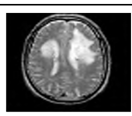
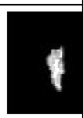
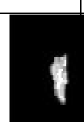
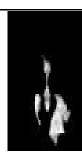
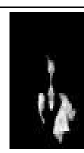
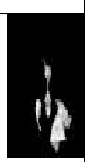
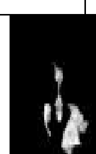
The proposed segmentation method is implemented in a set of 19 brain images affected by four different types of tumor - Glioma, Metastatic_Adenocarcinoma, Meningioma and Sarcoma. The size of tumor can be big, small or large. After pre-processing the image using median filter, the proposed segmentation algorithm is applied on the image.

Table 1 shows the segmentation results of glioma images. The implementation was completed in MATLAB 2015a. The current best model does not have satisfactory accuracy results and does not classify the degree of cancer of the detected nodules. Therefore, a new system was proposed. The proposed system is used to detect cancerous nodules from lung CT scan images, and uses watershed segmentation for detection, and SVM is used to classify nodules as malignant or benign. The proposed model detects cancer with 92% accuracy, which is higher than the current model, and the accuracy of the classifier is 86.6%.Overall, we can see improvement in the proposed system in comparison to current best model.

## 5. RESULTS

**Table 1:** Segmentation Results Proposed and current Solution.

| | | Proposed Solution | | | Current Solution | | |
|---|---|---|---|---|---|---|---|
| **Tumor Image** | **Input Image** | **Segmented Image** | **PSNR** | **Comparison Time** | **Segmented Image** | **PSNR** | **Comparison Time** |
| Group-1 Glioma | | | | | | | |
| Small |  |  | **26.38** | **0.07** |  | **26.18** | **0.7** |
| Small |  |  | **26.34** | **0.06** |  | **26.06** | **0.7** |
| Medium |  |  | **26.84** | **0.05** |  | **26.68** | **0.7** |
| Medium |  |  | **27.69** | **0.06** |  | **27.56** | **0.8** |
| Large |  |  | **27.89** | **0.05** |  | **27.63** | **0.8** |
| Large |  |  | **27.78** | **0.06** |  | **27.58** | **0.8** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Group-2 Metastatic_Adenocarcinoma | | | | | | | |
| Medium |  |  | **24.75** | **0.05** |  | **24.68** | **0.7** |
| Medium |  |  | **24.86** | **0.06** |  | **24.04** | **0.7** |
| Group-3 Meningioma | | | | | | | |
| Medium |  |  | **26.56** | **0.06** |  | **26.12** | **0.7** |
| Medium |  |  | **26.54** | **0.06** |  | **26.03** | **0.7** |
| Large |  |  | **26.54** | **0.05** |  | **25.19** | **0.6** |
| Large |  |  | **26.48** | **0.07** |  | **26.18** | **0.7** |
| Group-4 Sarcoma | | | | | | | |
| Small |  |  | **27.90** | **0.06** |  | **26.48** | **0.8** |
| Small |  |  | **26.98** | **0.06** |  | **26.58** | **0.7** |

The Group 1 is a collection of Glioma images. It can be seen that the PSNR of the image is segmented using the proposed segmentation method. However, as the quality of the tumor increases, the difference in PSNR values decreases. This can be attributed to the fact that the area of heavy tumor cannot be easily distinguished by the proposed method. It can be further observed that the computation time of the proposed method is approximately ten times better than the current solution. Use the suggested method and the current best method to obtain the average PSNR value of each of the four brain tumor types. Obviously, the average PSNR value of the proposed method is better than the average PSNR value of the current solution.

For Glioma, the difference in PSNR between the proposed system and the current system is smaller than other diseases. This can be attributed to the presence of a large number of tumors in the Glioma image. Therefore, current solutions are not as effective as small-mass tumors in distinguishing large-mass tumors. Obviously, the proposed method is better than the current solution in all cases.

## 6. CONCLUSION

This study proposes a new method for early diagnosis of brain tumors using brain MRI images. Among the available solutions, the following solutions implement median filter for preprocessing, spatial fuzzy C-means for segmentation, first statistical feature and texture feature for feature extraction, and principal component analysis for feature reduction and support A vector machine (with a non-linear kernel) found that classification is the most effective. The existing technology that uses the preprocessing and segmentation stages to detect brain tumors cannot distinguish whether the segmented region is normal or abnormal. Moreover, existing work using other stages (such as feature extraction and classification) can also classify the extracted regions as normal or abnormal, but the accuracy is low. Therefore, this task will continue to model advanced technologies to automate the work of detecting brain tumors, so that better results can be obtained compared to existing methods.

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