Classification of Brain Tumor Area for MRI images

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Abstract. The technical merit of the proposed method is using multiple techniques that fused in each processing part of filtering, segmentation, and features. The originality is to select the best technique depending on some measurements for implementation. Aiming for better enhancement of selected MRI of AlKindy Hospital Patients, as case study, to get efficient diagnose process is the purpose of the current technique using MATLAB that include smoothing, segmentation, feature extraction and classification. The method uses two filters (Median and Slantlet) and two segmentation methods are used (K-mean cluster and Morphological operation) and the area size is used in feature extraction. The experimental results classification is indicating that 50% of the used images are medium cases of brain tumor and 10% low stage both can be treated, while 40% is of high cases of brain tumor reflected that the treatment is difficult.

Keywords. Brain Tumor Detection, Image Segmentation, Morphological operation, Classification of MRI.

1. Introduction

The Brain cancer tumor is differentiated according to its stages by calculating its area. Accordingly, the detection of brain tumor and the stage of the tumor during diagnosis is made easy using K-means clustering and basic image processing over Magnetic Resonance Images (MRI). Using morphological operations is essential for detecting text depending on K-Means clustering algorithm as segmentation technique [1].

Brain cancer diagnosis using the existing Magnetic Resonance Imaging (MRI) techniques is found to have lesser accuracy as compared to other detection schemes. Therefore researchers develop new findings that subjected segmentation to new mechanism, the reason behind its cost effectiveness, consuming maximum memory little time of responding [2]. The segmentation refers the partitioning of an image into smaller regions to identify or locate the region of abnormality. Many techniques are available for image segmentation, but still it requires introducing efficient, fast medical image segmentation methods. K-means segmentation requires minimum computation time and considering the Classification as supervised learning [3and 4].

Therefore, it is essential to apply detection method of the brain of the human beings tumor using morphological operators and MRI image segmentation. It will take into consideration the Input Image, Preprocessing, Segmentation, Feature Extraction and Classification. The proposed technique start by reads the MRI brain image as Input image. Then continue to the preprocessing that is composed of image
enhancement and smoothing. The Image smoothing can be achieved by using Median Filter and Slantlet transform (ST) [5]. The application of median is good in removing noise from the image [6]. The segmentation stage is to segment the brain tumor using K-Means algorithm. Many segmentation methods have been implemented in the work to detect and extract the tumor region, in this type of segmentation some algorithms were adopted like K-mean cluster. The adaptive algorithm of pillar K-means applies Euclidean distance to define the distance between an object cluster centroid and the object itself. Applying the morphology operations on the image are to clearly locate the tumor part in the brain. Many researchers had their own contributions on segmentation methods such as, Jyothsna et. al. (2015) that concluded it is not so difficult to segment easily the various distribution intensity regions [7]. Sujan et. al. (2016) wrote on the methods of morphology to segment the tumor [8]. Madhi and Mohammed, 2018, proposed a program to detect and allocate of brain tumors according to YCbCr segmentation, the results reflected more than 99% better detection rate with speedy processing [9]. The performance of the proposed method is evaluated in terms of accuracy, Peak Signal to Noise Ratio (PSNR) and Mean Square Error (MSE). Then classifying MRI as abnormal or normal. Morphological operators is applied to the output image which provides a better detection of tumor.

The aim of this paper is to propose image processing techniques include smoothing, segmentation, feature extraction, and classification by using MATLAB for better enhancement of efficient diagnose process.

2. MATERIALS AND METHODS

It is possible to use several processes or methods to work the proposed system. The proposed system involves mainly 4 stages namely Input Image, Preprocessing, Segmentation, Tumor region detection and dimensions calculations that are involves two processes Feature Extraction and Classification (Figure.1).

![Figure 1. Block Diagram of Brain Tumor Detection the proposed system.](image)

2.1. The Data Acquisition Stage

Ten different MRI Images are used for the experiments with dimensions of (256×256) were taken from AlKindy College of Medicine, University of Baghdad. These images are stored by laser disks from the MRI device (Figure 2).
2.2. PREPROCESSING
Preprocessing mainly includes image smoothing and image enhancement. Image smoothing can be achieved by using filters; moreover, the common Median technique was applied to get rid of the noise. Which is non-linear technique, actually Median filter is based on average value of pixels [10 and 11]. And second filter is Slantlet transform (ST), [12] Then comparing between Filters’ results by applying Peak Signal to Noise Ratio (PSNR) and Mean Square Error (MSE) to choose the best filter on the used primary image.

MSE is the cumulative squared error between the noise added image and the used primary image. MSE is defined as follow: [13]

\[
MSE = \frac{1}{mn} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [I(i,j) - K(i,j)]^2
\]

Where:
m is the height of the image.
n is the width of the image.
I(i,j) is the used primary image.
K(i,j) is the image reconstructing.

PSNR is mathematical measure of the quality of the image evaluation between noise added image and the original image. It represents the peak error value.

\[
PSNR = 10 \log_{10} \left( \frac{MAX^2}{MSE} \right)
\]

Where MAX is define as the maximum image pixels possible value.

2.3. SEGMENTATION
The procedure of Image Segmentation is the distribution of the image into small portions. Many sets of pixels were created within same image Assigns a tag to the image pixels and with the similar label the pixels will share distinctive features [13]. For further analyze Segmentation makes it easier to recognize vital information from the image. Steps for segmentation are as follows:

2.3.1. K-Means Algorithm
The clustering algorithm of K-means can also be applied for segmenting image. The mean distance from the particular point of data to its corresponding cluster centroid ensures the clustering quality. The proposed method is performing the Euclidean distance; therefore, adapting pillar K-means algorithm applies Euclidean distance for the determination of the distance between an object and its cluster centroid. [1-13]

\[ J = \sum_{j=1}^{k} \sum_{i=1}^{n} \| x_i^{(j)} - c_j \|^2 \]

2.3.2. Morphological Operations
The Morphological operations (i.e. opening and closing, dilation and erosion) are used on binary images [14 and 15]. These Morphological operations are applied in pre or post processing as for example: description of the shape of objects or regions, filtering, pruning or thinning or to get a representing value.

1) **Dilation:** the operation on image M containing labels 0 and 1 is known as Dilation. It is with fine structure that known as structuring element Q like diamond, disk, square etc., converting the pixel value \( h \) in M from 0 to 1 [15-16]. Determining the boundaries of the growing dilation is the element structure of a distinct place in the image.

\[ (M \oplus Q) \]

2) **Erosion:** it is close to dilation as an operation on an image M with structuring element Q [15-16]. But in case of Erosion the structuring element operates to determine the required thinning.

\[ (M \ominus Q) \]

3) **Opening and closing:** during the applications of image processing, the most common combination are opening and closing that involving same or different structuring elements in continuous application of dilations and/or erosions. The Opening of set A by structuring element B is the erosion of A by B, followed by dilation of the result. Smoothing the contours of object is the job of Morphological closing by jointing narrow break and filling gap finer than structuring element. [1-12-17]

2.4. FEATURE EXTRACTION
During feature extraction, it is essential considering some criterions like image location, form (shape), configuration and size. The tumor classification process is performed with respect to the results retrieved from extract features by applying the object Area:[13-14]. The output is the chosen region area using Region of Interest. Generally the region area is defined as:

\[ A(S) = \iint I(x,y)dydx \]

Where \( I(x,y) = 1 \), if the pixel is containing in a shape \((x,y) \in S\), and otherwise 0. The integrals are approximating by summations. As given:

\[ A(S) = \sum_{\Delta A} I(x,y) \Delta A \]

Where \( \Delta A \) is the one pixel area that the scale changing. When using a rotation transformation owing to discretization of the image, tiny errors in the computation of the area is expected.
CLASSIFICATION

There are normally three major operations within the fuzzy inference system one of them is the Rules Evaluation, which is the process of creating a mapping from a given input to an output by means of a fuzzy logic. Then, the mapping provides a basis from which decisions can be made, or patterns discerned. The process inference involves Membership Functions, Logical Operations, and If-Then Rules.

\[
\text{IF condition THEN conclusion.}
\]

Where the IF part is called the “antecedent” or “condition” and the THEN part is called the “consequent” or “conclusion”. Hence it is all right writing the rule in format as follow, namely, condition $\rightarrow$ conclusion [18].

The rules are extracted from all features of each training slice. Values of these features are considered as inputs to the system and these features are collected and divided into three levels: High denoted by (H), Medium denoted by (M) and Low denoted by (L), and the output is divided into two levels: high (H) which indicates that there is an abnormal tissue (tumor) in the slice and Low (L) which indicates that the slice is normal [13].

Finally then the tumor size is efficiently detected from the brain image and determine the size of the tumor if it is small, medium or large to know the patient’s condition.

3. RESULT AND DISCUSSION

3.1. The Input Dataset

The input data of the proposed system is ten original MRI Images with dimensions of (256×256), the algorithm is started loading medical brain tumor images Figure (2).

3.2. Preprocess:

The enhancement and denoising was done using Median and the Slantlet filters. Comparison between these images was made by applying MSE and PSNR to detect the efficient parameters (Figure 3).

![Preprocess of MRI images](image)

**Figure 3.** Representative of the preprocess images for (MRI).

Assessment quality of the images is done depending on the method of pixel difference by measuring Peak Signal to Noise Ratio(PSNR) and Mean Square Error(MSE)amounts to compare images (Figure 4),(Table 1 and 2).
Table 1: MSE & PSNR values for Median

| No. of images | MSE    | PSNR   |
|---------------|--------|--------|
| 1             | 13.1924 | 36.9616|
| 2             | 8.3998  | 38.9221|
| 3             | 5.9886  | 40.3915|
| 4             | 16.5557 | 35.9753|
| 5             | 10.3917 | 37.9979|
| 6             | 11.3638 | 37.6096|
| 7             | 5.9732  | 40.4027|
| 8             | 2.7104  | 43.8345|
| 9             | 7.4656  | 39.4342|
| 10            | 9.5222  | 38.3774|

Table 2: MSE & PSNR values for Slantlet filters

| No. of images | MSR    | PSNR   |
|---------------|--------|--------|
| 1             | 0.276  | 53.7555|
| 2             | 0.1102 | 57.744 |
| 3             | 0.1331 | 56.9234|
| 4             | 0.6827 | 49.8223|
| 5             | 0.3603 | 52.5983|
| 6             | 0.7668 | 49.3182|
| 7             | 0.0893 | 63.5011|
| 8             | 0.1238 | 57.2367|
| 9             | 0.1327 | 56.9374|
| 10            | 0.0378 | 62.3956|

The results in Tables 1 and 2, show low values for MSE and high values for PSNR for both median and Slantlet filters in general but they are much less by using Slantlet filter. Where is well known that the Mean Square Error (MSE) is the cumulative squared error between the original image and the noise added image. The lower the level of MSE, lower the error. While the Peak Signal to Noise Ratio (PSNR) is mathematical measure for image quality assessment between original image and noise added image to show the measure of peak error [19], (Figure 4).

![Figure 4. MSE and PSNR value graph for (a) Median filter (b) Slantlet filter.](image-url)
The results in (Figure. 4) show low values for MSE and high values for PSNR for both median and Slantlet filters in general but they are much less by using Slantlet filter. Then the Slantlet filter was the best.

3.3. Segmentation brain tumors

The results of this step are showed in (Figure 5). It is obvious that the adaptive algorithm of pillar K-means applies Euclidean distance to define the distance between an object cluster centroid and the object itself. It is obvious that, the results of the clustering process of images of (4 clusters) could not isolate the tumor region as a distinct class, but it is clustered within the brain tissues where the tumor and the brain tissues intensities overlap.

![K-mean cluster](image)

**Figure 5.** Results of implementing K-Means clustering technique on images.

After segmenting the brain MRI, morphology operations are used on the image to define exactly the brain tumor part. To extract the tumor region only from other pixels that belong to skull or other tissues in the cluster that the tumor belongs to Morphological opening process of disk-shape structuring element with different mask values was employed with this proposed method. The disk-shape structuring element $5 \times 5$ to $9 \times 9$ mask (Figure 6).

![Morphological Operations](image)

**Figure 6.** Results of implementing morphological opening process on images.
It is obvious that applying morphology operations on the image is clearly locate the tumor part in the brain and getting better results of K-mean to extract the tumor region images.

3.4. Tumor region detection and dimensions calculations
The tumor type diagnosis system composed of two phases: the feature extraction stage and the classification stage. The system inputs are the images that resulted from the tumor segmented being taken from the original image from the previous method.

3.4.1. Features extraction:
The most common descriptors that are used to describe any region are those describe its shape, such as the area, location (its center of mass), equivalent circular diameter, perimeter and eccentricity. In this step the size of the tumor is calculated after removing the other forms surrounding the tumor in the previous stage of the bilateral tumor image. It is computed as the total number of pixels inside the region including its boundary. It represents the zero order moment of the specified object (region). The results of the calculated size of the tumor of the used MR images are ranges from 1779 to 8843 pixels (Table 3).

3.4.2. Rule-based classification
The Rule-based classification is the process of the features extracting method to obtain the size of the tumor is an essential step to know the type of tumor if it is at the beginning of its growth and can start the process of treatment and disposal of the disease, or the tumor in the final stages where it cannot be treated.

Several advantages noticed for application the Rule-based classification such as it is natural representation for knowledge, easy for interpretation, easy to explain and it is competitive and better than other classification algorithms (Cohen, 1995 [20] and Xiao-Li and Liu, 2014 [21]).

The Rule-based classification indicated the following condition:
If area ≤ 2500 then is Low
If 2500 < area ≤ 5000 then Medium
If area ≥ 5000 then High

The results of applying the Rule-based classification are indicating that 50% of the used images are medium, 40% high and 10% low (Table 3).

Table 3. Show types of the diagnosis tumors.

| No. images | Tumor size | Shape | class | No. image | Tumor size | Shape | class |
|------------|------------|-------|-------|-----------|------------|-------|-------|
| 1          | 1779       | Low   | 6     | 3693      | Medium     |       |       |
| 2          | 3146       | Medium| 7     | 8843      | High       |       |       |
| 3          | 3440       | Medium| 8     | 4969      | Medium     |       |       |
Actually, the most investigated cases are mediumsizewhere it can be treated, the second case of tumors in the final stage where treatment is difficult.

Applying the Rule-based classification is indicating that 50% of the used images are medium cases of brain tumor and 10% low stage both can be treated, while 40% of high cases of brain tumorreflected that the treatment is difficult.

Moreover, many researchers have tackled the problem of brain tumor classification from different point of views by applying various techniques such as: (Kamil and Abbas) [22] used an automatic calculation of tumor area for CT scan images, (Ali et al) [23] applied Deep Learning approach, (Mukaram, at el.)[4] used Pillar K-mean algorithm, while (Seetha and Raja, 2018) [24] used the Convolutional Neural networks (CNN), all those methods reach good results to resolve the given problem. Comparing the proposed methods for brain tumor classification with other classification revealed that this paper provides a computer aided method for calculating the area of the tumor with high accuracy is better within MRI technique. This method determines the extracting position and shape of the tumor based on morphological operations (dilation and erosion), enhancement filters and segmentation. Then, calculation of tumor area is more beneficial and gives good, better and easy classification.

4. Conclusion
The proposed algorithm is easy for the indication of the affected tumor area from MRI. It dealing with the preprocessing and segmentation of the effected region of interest, morphological operation and it is good for calculation for brain tumor area. Although applying Median and Slantlet filters in the beginning stages proved beneficial in getting rid of MRI noise. The output image represents exactly the tumor cells that were pointed from the healthy cells. Classification has done to the pointed tumor referring to its malignancy level.

The experimental results classification is indicating that 50% of the used images are medium cases of brain tumor and 10% low stage both can be treated, while 40% is of high cases of brain tumor reflected that the treatment is difficult.

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