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Detection and Analysis of Brain Tumors on the Basis of their Area and Density by Segmentation

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Abstract: Brain Cancer is recognized to be a deadly and most prevalent disease around the globe. The prime step in curing brain tumor is its detection, as it is required for diagnosis of this disease. With the help of Computer-Aided Diagnosis (CAD), the detection and diagnosis of brain tumors can be automated. The major issues that are encountered in designing these automated diagnosis systems are efficiency and accuracy. The tumors in Brain Magnetic Resonance imaging (MRI) may be visible clearly; however, the quantification of the tumor affected sites is required. In this regard, computerized image processing methods can provide great assistance. In this paper, the brain tumors have been identified and classified in two major types i.e., malignant and benign tumors, depending upon the texture and shape of the MRI image tumor. Four steps have been followed including preprocessing, skull stripping, segmentation and feature extraction. MATLAB image processing toolbox has been utilized to implement the approach. The results can conclude that shape features and texture of brain tumor in MRI images can be used for their classification with great degree of accuracy.

Keywords: Brain Cancer; Computer-Aided Diagnosis; Magnetic Resonance Imaging; Segmentation; Skull Stripping.

1. Introduction

In the field of medicine, Magnetic resonance imaging (MRI) has been used is many researches on a wide scale. MRI is noninvasive approach which uses radio waves to develop image of the body. This technique is suitable for examination of soft tissues injury, spinal cord and for brain tumors [1]. Analysis of images acquired by MRI is highly dependent on image processing techniques with the use of computer technology. Brain is most important part of body. Brain tumors have turned out to be among the most serious and frequent diseases in humans. The critical problem in treatment of Brain tumor is detection of its location and quick spreading. To aid in this regard image detection and segmentations are very helpful techniques [2]. Tumor is basically a useless mass of tissues. The benign tumors possess well-defined borders and grow very slowly. On contrary, malignant tumors don't possess defined borders and grow relatively faster.

Several works have been done for identifying brain tumors [3]-[7]. Methods of brain tumor detection have been proposed based on connected component analysis and Kmeans Clustering [5]. Another method that utilizes the approach of computing has also been devised [6]. However, the shortcoming in this method is tendency of false detection of tumor in the images. Brain tumor extraction can be carried out by Using

MATLAB [7]. In MATLAB many approaches are used to complement the overall detection and extraction of desired tumor image. Image segmentation is one of the most important approaches that can be performed in several ways i.e. watershed segmentation, histogram thresholding, K-means Clustering and region growing [8]. Preprocessing of the input brain image is crucial step to make the MRI image compatible for further processing and it eliminates the noise and makes the image smooth. Skull stripping is another approach to differentiate the brain tissues from non-brain-tissues [7]. Then the image can be segmented and tumor region can be extracted with the use of some other functions. The methods used for MRI tumor image segmentation are many including knowledge based, region based and boundary based. Other approaches of tumor segmentation that have been used earlier are pattern classification techniques [9], [10]. There are numerous approaches that have been devised for brain tumor detection as Sindhushree et al established a segmentation method for two MRI images and also presented the tumors in three dimensions [11].

Other techniques used in the process were histogram equalization, morphological operations with thresholding and segmentation. Volume of the tumors was also calculated. Another research followed an approach of K means clustering for watershed segmentation. Two stepped processes include the K means clustering for primary segmentation of the medical image followed by watershed segmentation for final segmentation of the image [12]. Another technique used so far is C-means clustering [13]. Classifiers have also been used to classify the given data in reference to the training data already defined in the system. Some challenges exist in the field of computational analysis of tumor. Apart from availability of a large number of algorithms for detection of tumors, the detection rate is not satisfactory.

The success of the tumor detection lies in partitioning and division of MRI images in meaningful areas (segments) during segmentation. Many promising outcomes have been achieved by segmentation, the characterization remains challenging due to a number of possible locations, shapes and intensities of different types of tumors. [14] Another approach used pattern classification strategy to segment the brain tumors [15]. The objective of this paper is to devise an automated computer aided algorithm to increase the MRI brain tumor detection efficiency and accuracy.

2. Research Methodology

The work performed includes the MRI images processing of patients affected with brain tumor. Detection and classification of these MRI images has been carried out. The database maintained and used consists of data from 25 brain tumor patients including over 100 MRI images, radiography reports and other known parameters. The whole data has been collected from a hospital and radiologists have been consulted to get other necessary information. The image processing steps involve

- Preprocessing of image
- Skull Stripping
- Erosion, Dilation of image and other filters
- Segmentation
- Feature extraction

The segmentation and feature extraction gives the calculated area of the tumor and then the edges of the tumors are detected by canny filter and these values are then used for classification of tumors in different categories i.e., benign, benign lesion and malignant. There are also cases when no tumor is detected in MRI image in case of no disease. MATLAB has been used to execute all the algorithms.

Table 1. Stepwise Methodology

Step 1	MRI brain tumor images have been entered.
Step 2	Preprocessing, application of filters, segmentation and feature detection has been Performed.
Step 3	Two situations will be deduced. Tumor detected

Step 4	Tumor not detected If tumor is detected, it will be classified in one of the two classes' i.e. Malignant and benign tumor.

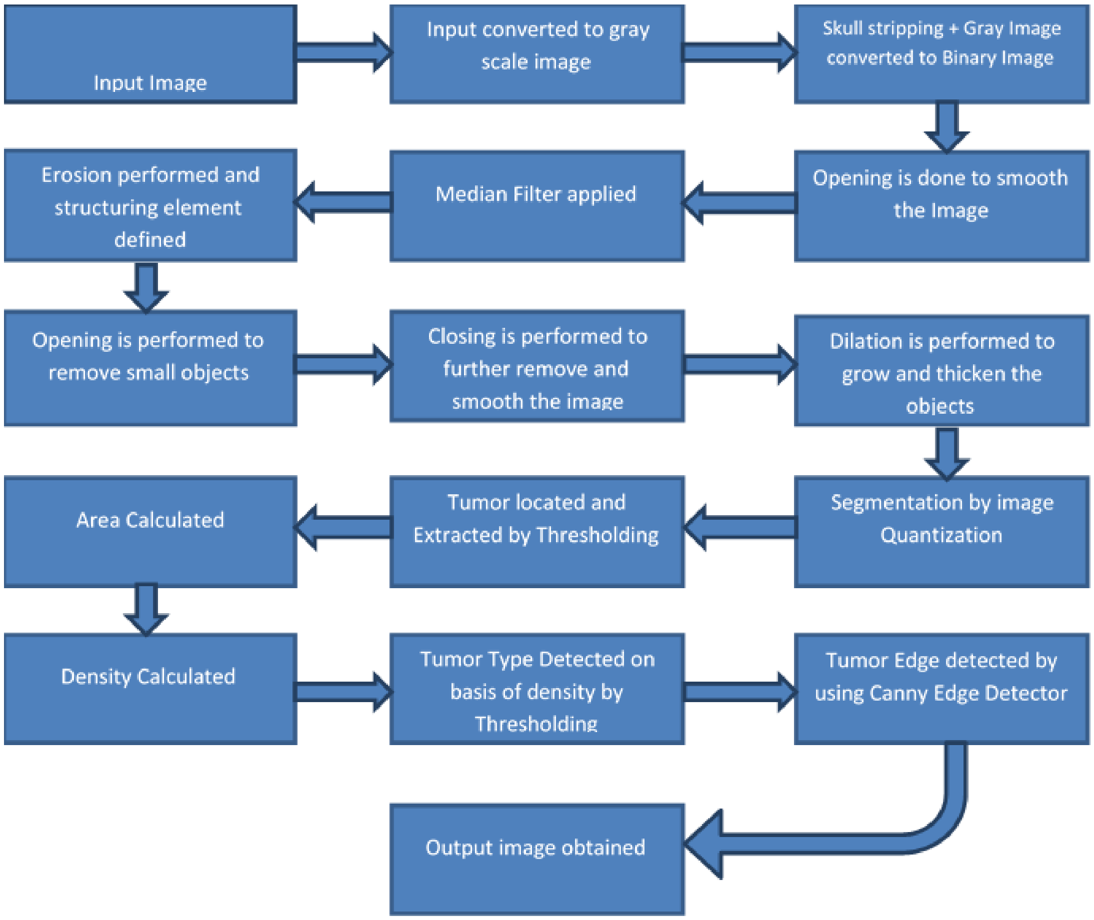


Figure 1. Block Diagram of Methodology

2.1. Implementation

2.1.1. Pre-Processing

Preprocessing is thought to be the most important step in analysis of any image. It involves the restoration and enhancement techniques to give a suitable image for further automated processes. In medical images, the removal of unwanted signals, artifacts and noise is crucial for critical therapeutic and diagnostic applications. In MRI primary sources of undesired effects and artifacts are patient movement during imaging, transitions in the magnetic field and other external noise. These undesired signals are the reasons of computational errors in analyzing the images by an automated tumor detection system. Depending on these facts it is crucial to eliminate these unwanted artifacts in the preprocessing of the image so that the analysis can be accurate. The preprocessing can be of many types like image restoration and image enhancement. These processes can remove the noise and degradation in the image. Enhancement filters are applied on the images to remove noise and to smooth them for making them suitable for subsequent stages. Apart from removing noise, this step can also improve the contrast features of the image. Image is most important factor in giving false results as it can limit the capacity of the region growing filter to expand to greater area ultimately giving false edges. In our algorithms, first the images were converted to gray scale and then conversion to binary images has been done. Different type of noises can be removed by using different filters like salt and pepper and speckle noise can be eliminated with the use of median filter. The median filter, used in our algorithm is much more effective as compared to convolution as the objective was preservation of edges and elimination of the noise. Erosion (shrinking of foreground) and dilation (expanding of foreground) are then performed to further improve the quality of image for other steps like segmentation. Other approaches used are removal of holes from foreground i.e. closing and removal of stray pixels of foreground in the background i.e. opening similar to the work of Prof. Sagar B et al [16]. These morphological operations make the image fit for further analysis.

MEDIAN FILTER $$\hat{f}(x, y) = \underset{(s,t)\in S_{xy}}{\text{median}}\{g(s, t)\}.$$

DILATION: $$A \oplus B = \{z \mid (\hat{B})_z \cap A \neq \emptyset\}$$

EROSION $$A \ominus B = \{z \mid (B)_z \cap A^c \neq \emptyset\}$$

OPENING $$A \circ B = (A \ominus B) \oplus B$$

CLOSING $$A \bullet B = (A \oplus B) \ominus B$$

Figure 2. Expressions

2.1.2. Skull Stripping

In medical image analysis skull stripping is recognized as an important process. This process and approach are only used and applicable for brain images especially in MRI as it involves skull [17]. After preprocessing skull stripping has been performed on the MRI images to remove any chances of confusing the non-brain tissues with brain tissues. Extra-cerebral tissues have been removed so that we can get rid of skin, skull and fat in the MRI image

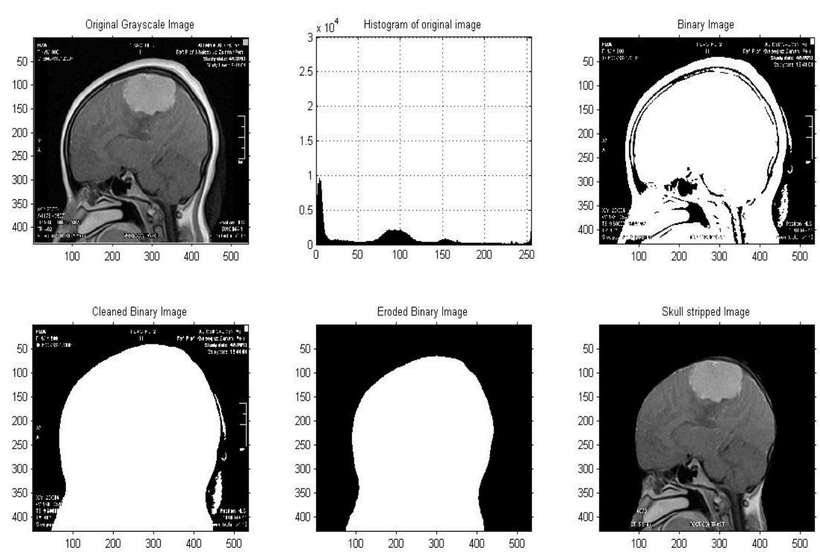


Figure 3. Skull stripping of MRI images to remove non-brain tissues for clearer brain analysis

2.1.3. Segmentation

Segmentation has been done by image quantization and thresholding has been used in the designing of this CAD system. Image segmentation divides the MRI image of the brain in many meaningful segments which is basically a division of Pixels. The objective of segmentation is to represent the image in a more interpretable way that is easier to perform further analysis. [18]

This approach is used in our system to locate the boundaries, lines and curves. This process assigns each pixel a label and pixels with common label share common visual properties. The approach results in a set of regions covering the whole image collectively. There can also be contours derived from image. Every pixel of a region is similar in some visual or computed characteristics like texture and intensity [19]

The main element that is kept under consideration is that segmentation process must stop when the tumor edges become able to be detected as our main aim was to separate the tumor from its background. Thresholding approach has been used. It is a simple process of image segmentation to separate the image of interest from background. Thresholding is based on difference if intensities between the background and foreground. Here the white pixels correspond to foreground and black pixels correspond to background. All the pixels are compared with the threshold. The pixels with higher intensity than threshold is set to white and those with lower intensity than threshold is set to black. [20]

2.1.4. Feature extraction

The toughest task in the whole procedure is the selection of features upon which the distribution in two classes will be based. After segmentation, the step of feature extraction decreases the amount of data by measurement of certain characteristics of the labeled pixels of object i.e., tumor. The features that are aimed to be extracted are the high degree representative of the shape and structure of the tumor and tend to preserve the data significant for tumor classification similar to the work of Ali et al [21] Structure and area are important characteristics in detecting the tumor in MRI image. In this paper, for feature extraction, region of interested has been extracted by making use of MATLAB and specific algorithms. This step limits the data and the features that are extracted, preserved the necessary information of the tumor image. This morphological operation is used to choose most useful parts and features of the image and finally the tumors have been classified in two mentioned classes. Moreover, canny Operator is used for making the appearance of tumor clearer as done by J. Canny [22]. The extracted part if filtered that map the edges of the tumor. The area and density of the tumors are then calculated and classification is done.

CANNY EDGE DETECTION

$$g(x, y) = [G_x^2 + G_y^2]^{1/2}$$

$$\alpha(x, y) = \tan^{-1}(G_y/G_x)$$

FORMULA FOR CALCULATING AREA **Syntax: Total = bwarea (BW)**

FORMULA FOR FINDING DENSITIES **Density= Area/Total number of pixels in the image**

In percentage: Density x 100

Figure 4. The diagram presents key formulas and methods used in image processing

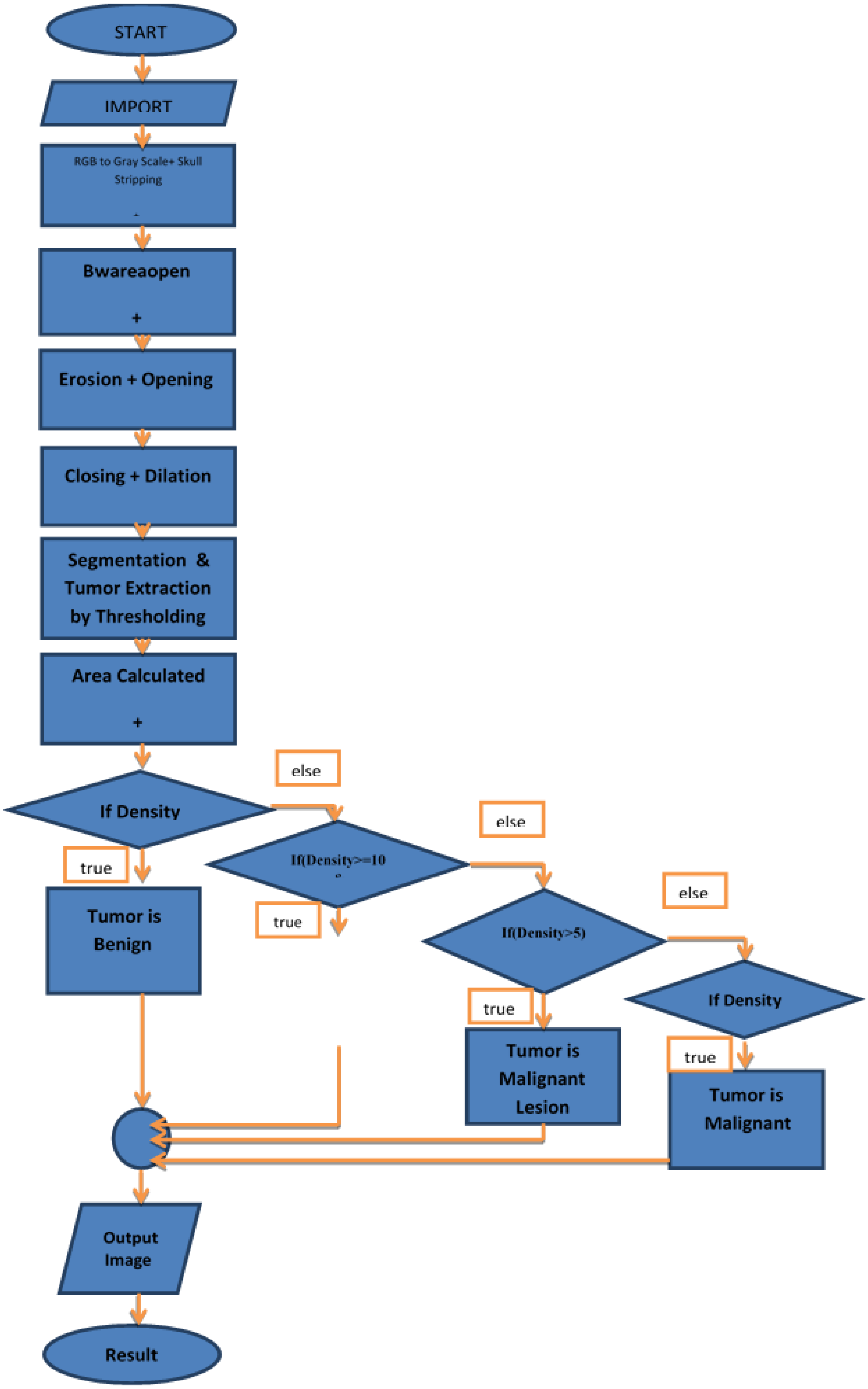
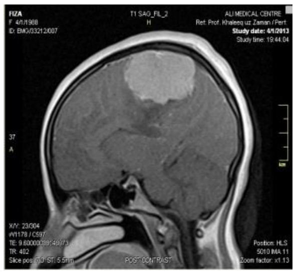
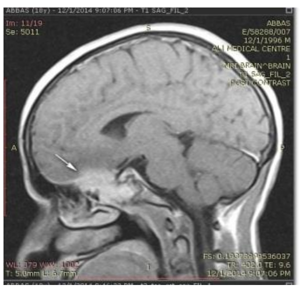
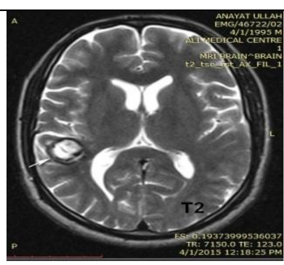
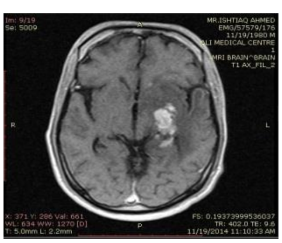
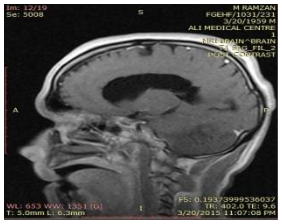
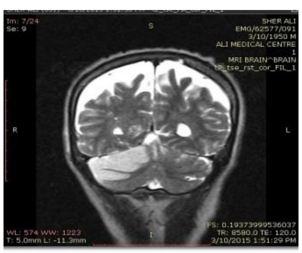
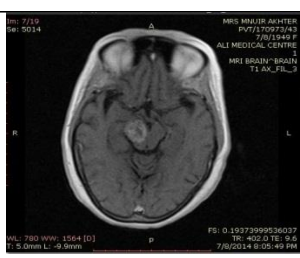


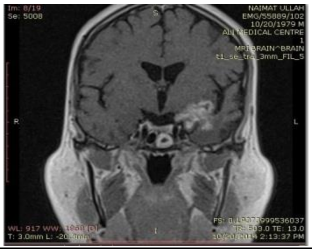
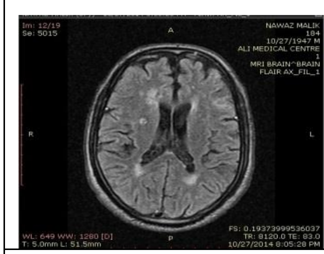
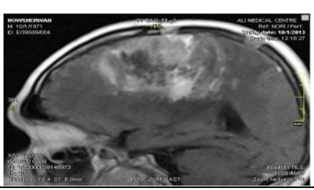
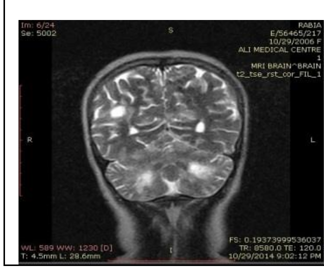
Figure 5. Flow Chart of Methodology

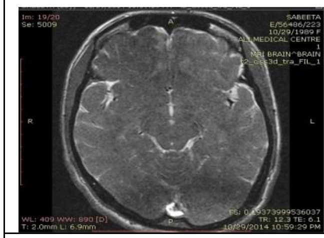
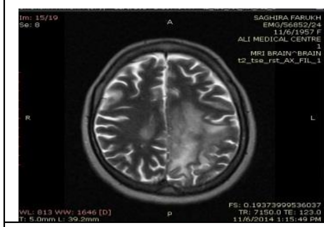
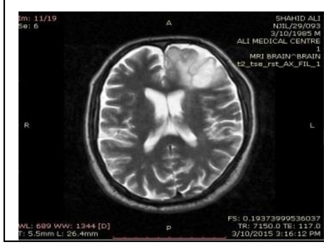
3. Results:

The algorithms were applied on patients with different type of tumors and following results were obtained. These classifying the tumors in different categories depending upon the calculated tumor area and density. The algorithms give no result on a normal brain MRI and the tumors are detected in diseased.

MRI image	Patient	Total Tumor Area	Total Tumor Density	Tumor Type
	Patient 1	59713	23.7106	Malignant
	Patient 2	13553	5.3513	Benign Lesion
	Patient 3	1.0436e+004	5.3197	Benign Lesion
	Patient 4	1.0470e+004	4.3410	Benign

	Patient 5	1.1430e+004	5.4930	Benign Lesion
	Patient 6	1.3976e+004	5.6692	Benign Lesion
	Patient 7	1.6834e+004	7.0079	Benign Lesion
	Patient 8	1.3286e+004	5.5791	Benign Lesion
	Patient 9	928.8750	0.3676	Benign

	Patient 10	1.2749e+004	5.3212	Benign Lesion
	Patient 11	1.705e+004	4.3103	Benign
	Patient 12	1.9340e+004	8.0383	Benign Lesion
	Patient 13	1.9138e+003	0.8947	Benign
	Patient 14	1.1977e+004	4.9860	Benign

	Patient 15	1.1249e+004	4.6677	Benign
	Patient 16	1.1741e+004	4.9318	Benign
	Patient 17	3.0200e+004	12.5840	Malignant Lesion

4. Conclusion

In this paper, an automated diagnosis method has been proposed that classifies the brain tumor to two classes' i.e., benign and malignant tumor depending upon the well-defined features like area of tumor in the MRI image. Four basic steps have been performed including preprocessing that involves the enhancement of image quality for further processes, removal of noise by erosion and dilation, third process is segmentation and fourth is feature extraction that identified the required tumor on a site and then use its features to classify it in the two classes of benign and malignant tumors. Canny filter has been used to map the edges of the tumor. Implementation of the algorithms over more than 100 images give considerable results which clears the useful application of these algorithm in automated diagnosis of brain tumors.

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