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Article

Categorizing Brain Tumor in MRI using Digital Image Processing

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A B S T R A C T

A brain Tumor is an abnormal cell development within the brain tissues. Brain tumor can be categorized into two types as follows: Benign, without cancer cells, Malignant, with cancer cells that develop quickly. About 12% of worldwide deaths are caused because of brain tumor. Tumor identification itself involves a number of complex methods, as it requires a great deal of radiological knowledge and experience for accurate medical image detection. Mechanization of tumor detection is therefore needed, as there might be an unavailability of trained radiologists at the time of great need.

Here we have proposed a system for programmed cerebrum tumor discovery, i.e., pre-preparing, division and arrangement utilizing clinical imaging consequences of attractive reverberation imaging (MRI). In the principal stage, the MRI cerebrum picture is absorbed from patient's information base, commotion is taken out and the picture is sifted utilizing different channels, which help in upgrading the highlights of the picture. In the subsequent stage, we segment the image and then increase the intensity of the pixels on the detected part of the image using k-means algorithm. It makes the MRI image more reliable at a rational processing time. The proposed method successfully recognizes and segments the tumor portions of the images successfully.

Keywords: Brain Tumor, MRI, Preprocessing, Segmentation, Classification

Introduction

A brain is an organ which functions as the pivot control unit of the nervous tract in a human body. It is the most complex organ comprising soft, fine textured tissue mass. It is a uniform place for patterns to come in and stimulate among themselves. It comprises of brainstem, cerebrum and cerebellum. They regulate majority body's actions such as collecting, combining and organizing the details it collects from the nerve system.

Brain Tumor

A tissue which develops and multiplies due to the insufficient forces meant for governing the growing cells is known as tumor. The tumor will be small at first but grows over time. Brain tumor appears when unusual mass of cells are established inside the brain. There are two groups of brain tumor depending on the locality where the tumor starts. They are:

Primary brain tumor: Group of unusual cells which begins in the brain tissue or its immediate surroundings and tend to stay there are referred to as primary brain tumor.

Secondary brain tumor: These tumor begin elsewhere inside the body and move into the brain. These tumor are formed by cells which have spread out from the primary tumor and are distributed in the bloodstream. Secondary

tumor stops the part of the brain from working normally. As a result, the intracranial pressure increases.

The two common types of brain tumor depending on the cancerous cells are:

Benign brain tumor: Non-cancerous cell mass are called benign brain tumor. It grows slowly in the brain. They do not obey normal cell division and growth habits and develop into a cluster of cells that do not microscopically have the characteristic appearance of the cancer. Most of these are primary tumor. They are grade 1 or 2 tumor. They often have a border or edge that can be easily detected in scans. It can be caused due to family history, radiation or chemical exposure.

Malignant brain tumor: Malignant brain tumor are rapidly expanding cells of brain which spreads to backbone areas as well. They are grade 3 or 4 tumor. Most of these are secondary tumor. They most often grow from the glial tissue that helps the nerve cells of the brain and hence called gliomas. It is believed that a person is likely to develop malignant tumor if he has undergone any genetic or radiotherapy treatment to his head earlier.

Magnetic Resonance Imaging (MRI)

In comparison with all other methods, it is found that Magnetic Resonance Imaging (MRI) is considerably effective imaging technique as we obtain detailed results. Doctors most often recommend MRI scan to the patients who are suspected to have brain tumor.

In the medical field, an MRI is usually used to encounter and envisage the attributes in the interior body composition. MRI forms pictures of the physiological processes and anatomy inside the body. MRI uses powerful magnetic field to align the nuclear magnetization following changes in the magnetization alignment with radio frequencies using radio waves and magnetic gradients that the scanner can detect.

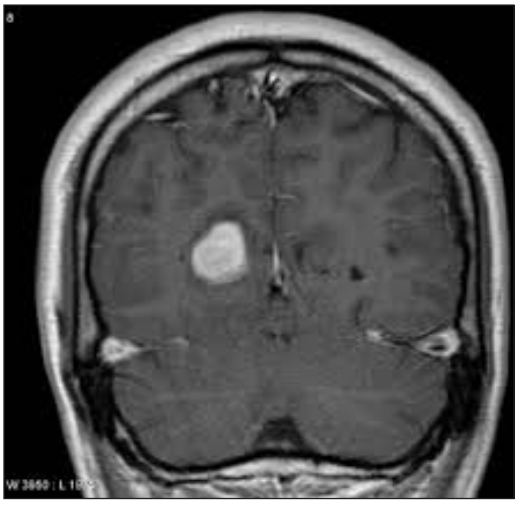

Figure 1.MRI of Brain Tumor

MRI scanner is a big tube-like structure and the person going through MRI scan should not contain any metal objects as magnets are used. Depending on the section of the body to be scanned, person must lie on a flatbed that proceeds into the scanner. Hydrogen and oxygen atoms in the water molecules present in human body consists of protons at the centre. During the scan, protons line up in the single direction. Once the radio waves turn on, these protons knock out of alignment and realign once it turned off. This sends signals to the radiologist providing information about the various tissues and fluids in the body as protons realign at different velocities and generate distinct signals. The combined signals create a detailed image on a computer screen.

Software Requirements

All the stages carried out in this project are implemented using MATLAB software. MATLAB abbreviated to Matrix Laboratory is a programming package, designed specifically to solve both easy and complex scientific calculations required. Hundreds of functions are built-in, which provide a wide variety of computations for various operations asked. Also, it contains toolboxes designed for specific disciplines of research in optimization, statistics, data analysis, engineering, signal processing, partial differential equations and many more.

MATLAB is a high-performance language with standard numerical computing environment, developed by Math works. It unites visualization, computation and programming into a single computing environment for better productivity for engineers and scientists. The basic functions present are plotting the data, creating user interfaces and matrix computation and manipulation.

Graphical User Interface (GUI)

GUI is a graphical representation in which users interact through graphical icons and audio indicators with the software or device. It provides point and-click control in software products and reduces the requirement of learning programming language. In order to run the request, it eliminates the need to type commands. GUI interface files are used to process and retain information of files in MATLAB.

OASIS Dataset Bank for MRI Images

The MRI image dataset input required for implementing the method are taken from OASIS dataset bank. The OASIS abbreviated to Open Access Series of Imaging Studies was started by a co-operation of few radiologists, who shared their works on cloud. The OASIS contains all the neurological images of the brain, specifically magnetic resonance images. It is open for all the scientist, engineers and the enthusiastic community of researchers who crave and delve for the innovation of novel techniques.

Block Diagram

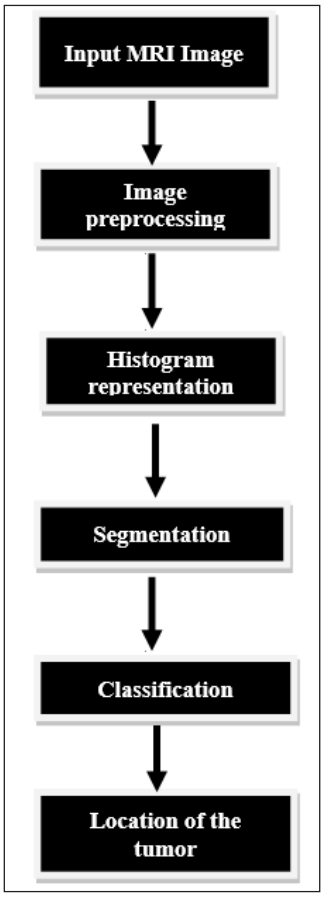

Figure 2

- **Input MRI image:** The MRI image is obtained from the patient's data base
- **Image Pre-processing:** The main objective of Pre-processing is to enhance image dataset by using filters to suppress unwanted image distortions andimprove those imagesfeatures which are necessary for furtherprocessing
- **Histogram Representation:** It is a graphical representation on a digital image of the tonal distribution. For each tonal value it plots pixel counts. The graph's horizontal axis reflects the tonal changes, while in that particular tone, the vertical axis is the pixel count
- **Segmentation:** It is the process of partitioning the acquired digital image dataset into multiple segments, which will simplify the representation of an image dataset and makes it simpler to study
- **Classification:** In this process the raw pixel data constituting the set of pixels separate one image region from another. It helps convert the data to a form suitable for computer processing. The boundary interpretation is necessary when the focus is on features of external shape such as corners and inflections. If the emphasis is on internal properties such as texture or skeletal structure, the regional representation is appropriate
- **Location of the tumor:** Finally, the location of the tumor is determined by recognizing the pixel data obtained during the segmentation and classification. Later, the dataset assign label to an object based on the classification of the input MRI image.

Pre-Processing

Pre-processing helps to improve certain parameters of MR images, when an image is being sent electronically from one place to another due to Sensor heat, varying ISO Factor, light interference and extra device vibrations noises occur in the MRI scanned image due to which the analyses to locate the tumor becomes difficult.

Pre-processing helps enhance some MR image parameters, like increasing the SNR value, increasing the pictorial quality of the MR image, eliminating unnecessary noise and useless parts in the background, smoothing the region's inner portion and retaining its edges. This process includes a number of noise additions and filtering processes.

Noises

Image noise is the impulsive change in image luminosity and color, which is generally a element of electronic noise. This may be produced by the image sensor and circuitry because of some unwanted electrical inconsistency is known as noise. In digital images, noise is often present during the steps of image retrieval, coding, transmission and processing.

Filters

In image processing, filters are mostly used to suppress high frequencies or low frequencies present in the image. There are different ways to filter a picture. Filtering is a technique used for removing the noise that is present in the image.

Segmentation

Segmentation of image is commonly used to analyse and separate an image into multiple parts or sectors in digital image processing, frequently based on element characteristics in the image. Segmentation could involve separating forefront and backdrop, clustering pixel regions based on colour or shape similarities.

Requirement for Image Segmentation

During cancer diagnosis, pathologists stain the Haematoxylin and Eosin (H&E) tissues of the body to determine different types of tissues and then use a photo apportionment technique called clustering to locate these tissues. Clustering is a means to discrete object groupings within an arena. The K-means clustering is a design realize the segregations.

Apportionment of Image

Segmentation of images involves converting images into a group of regions of elements and representing by a mask

or image labelling. The image segments are processed by apportioning an image into segments, rather than processing the entire image. The utilized techniques of image segmentation are:

- **Thresholding:** Image diagnosis and segmentation method which seclude the image groups by converting the monochrome image into binary image
- **Clustering:** This is a technique of segregating images elements into groups such that the images elements in particular groups are similar to each other
- **Region Growing:** Growing region is method of segmentation based on a region

Clustering at K-Means

The K-mean classification a divisive approach. The task of k-means is to apportion data into clusters that are collectively exclusive to k, returns the cluster index to which each observation is assigned. K-means treats each observation in features as a recipient with a location in space and realize a partition in which recipients are close to each other within each cluster and far from objects in other clusters.

K-mean division, each cluster is composed of membership objects and a Centre. K-means decreases the distance between the Centre and individual members of the cluster. For the distance metrics supported, K-means compute the centroid clusters differently.

K- Means Benefits

- If variables are enormous then K-Means computationally faster than hierarchical clustering most of the time, if we keep k small
- K-Means generate tight bunches, mainly when the bunches are spherical, then hierarchical clusters

Feature Extraction

Feature Extraction plans by generating new highlights from the current ones to decrease the number of highlights in a dataset. Extraction of the feature includes a decrease in the number of assets required to depict a huge information arrangement. Feature extraction methods may also head to other benefits such as:

- Accuracy advancements
- Over fitting possibility limiting
- Increase the Speed in training
- Upgraded Data Visualization
- Growth in explain ability of the model

Statistical Features in Image Processing

Normal features incorporate moments, for example, mean, change, scattering, mean square. Worth or normal vitality, entropy, Skewness and kurtosis.

- **Mean:** It is the most basic of all measurement statistics. Filtering using mean in the context of image processing is classified as spatial filtering and used for noise reduction
- **Standard deviation:** A measure of variability or diversity which is widely used in statistics. As for the processing of images. It indicates how much difference or "dispersion" exists
- Entropy is defined as corresponding intensity level states that can be adapted to by individual pixels. It is used in the quantitative analysis and image details assessment. RMS (Root Mean Square) value of the signal can be manipulated by squaring each and every value, detecting the arithmetic mean of the squared values, then accessing the square root of the outcome
- **Variance image:** it is an image of the variances in the values of the input or output images, that is, the squares of the standard deviations
- Kurtosis values are elucidated in digital image processing, in conjunction with the measurement of noise and resolution. Peak kurtosis values will go for low noise and low resolution at the same time
- Skewness refers to distortion or unevenness in a symmetrical bell curve, or normal distribution, in a data set. A normal distribution has a skew of zero
- IDM measures the local homogeneity of an image. The amount of accompaniment of pixel pairs is increased when they are near to Gray-scale value and thus intensifies the IDM value
- Contrast is the dissimilarity in luminance or colour that makes arecipient distinguishable. Contrast isdetermined by the dissimilarity in the colour and brightness of the object and other objects within the same field of view
- Correlation and Convolution are fundamental operations that are performed to extract information from images
- 'Energy' is used in typical object detection or segmentation tasks where it is posed as an Energy minimization problem
- Homogeneity of a region is similar to local homogeneity of any permutation of the pixel's intensities of the region

Classification

The process of labeling of a picture element or a cluster of picture elements depending upon their grey value is known as classification. The process of drawing out the details from an image with multiple band grid is called as image classification. During classification, depending on the interaction between the computer and the analyst it is categorized into two different types, they are:

- **Supervised Classification:** In supervised classification, difference in the reflectance or emittance regarding wavelengths procured from training specimen are

utilized to classify an image. Training samples can be easily created using the guidance of the image classification toolbar to represent the classes you want to separate. Accurate results depend on the number of training sites and ability of analyst to acknowledge if they can be shifted from one image to another

- **Unsupervised Classification:** Unsupervised classification is performed without the intervention of inquisitor where the spectral types or clusters are recognized in multiband image. It provides potentiality to scrutinize the quality of the clusters as well

Classification using Support Vector Machine (SVM)

An algorithm used to monitor binary regression/ classification is known as Support Vector Machine (SVM). Optimal hyper plane is a judgmental surface constructed by a support vector machine. SVM refers to a minor division under training examinations which supports optimal decision surface location as it escalates the distance between two groups. They are the class of machine learning algorithms known as kernel machines or kernel methods. It generates model file and validates result with the help of training and test datasets. Some of the validation methods are sensitivity, specificity, cross validation, ROC and AUC. It deals with segmentation and classification/ regression problems. It is used for data analysis, pattern recognition, protein composition prognosis, intrusion perception, hand writing identification, noticing steganography in digitized images, breast malignancy interpretation and in most of the applications in which neural network is utilized.

Outputs and Result

Pre-Processing Output

As shown in the below Figure, an MRI image of a brain with tumor is taken as input. We have deliberately induced few noises in variable percentage and filtered using all possible filters to find which filter removes maximum noise and gives the filtered image as output. As per the pre-processing carried out in our project, the result obtained are as follows:

- Median filter removes salt and pepper noise and Gaussian noise at its best
- Image with Poisson noise is maximum filtered by wiener filter
- Adaptive filter showed better results in filtering speckle noise
- Higher the signal to noise ratio depicts higher the accuracy in filtering

The above filters are used to de-noise the images and are simultaneously evaluated based on the following parameters:

- The noise variance is the noise energy per samplePeak SNR is equated as the ratio of the maximum possible signal power to the power of corruptingnoise that affects representational reliability. More the (PSNR) Peak SNR better the standard of compressed and reconstructed image
- The SNR (Signal Noise Ratio) is used to evaluate and characterize the image quality, the sensitivity of an image system is usually defined in terms of the threshold level of the image of the signal that is produced
- MSE (Mean Square Error) is a cumulative squared error between the compressed and the original image
- MSE and PSNR are used to compare image compression quality PSNR==20
- Therefore 20 20 log_10 (MAX1)-10 log_10(MSE)

In k-means clustering technique, the cluster analysis is performed where the partition of an image data set into a number of disjoint groups or clusters are carried out. The Figure 7, represents the histogram plot of element distribution of image during segmentation with particular brightness and tonal value. The x-axis represents number of iterations and y-axis represents mean value. Major outcome of this graphical analysis is arithmetic mean movement. An average mean movement is the arithmetic mean of given set of k-values. The target number which refers to the number of centroids needed for the data set is called as k-value. We have obtained the colored image as the output in which different segments are assigned with different colors based on normal brain cells consisting of gray matter, white matter, cerebrospinal fluid and tumor brain cells.

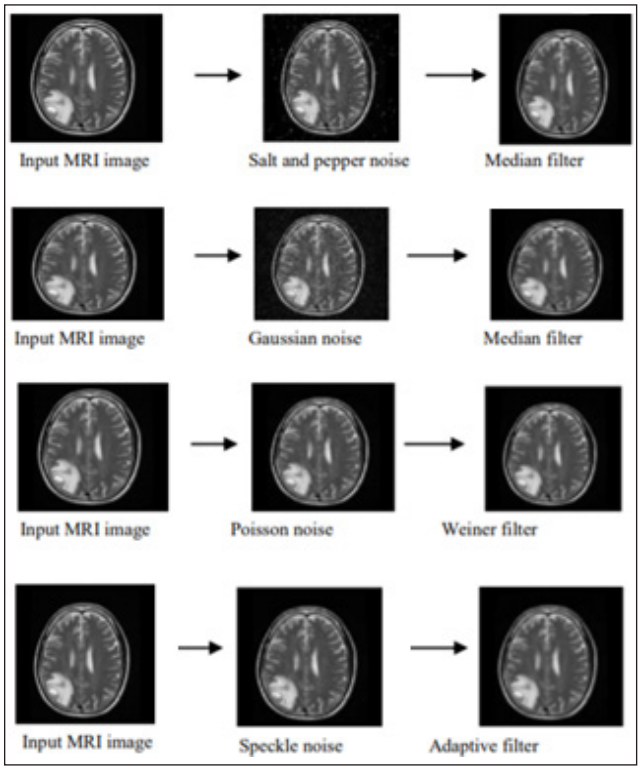

Figure 3

Table 1.The Various Parameters used and Their Measures

Type of Noise	Best Filter	Noise Variance		Peak SNR value	MSE	SNR value
Salt and pepper noise	Median filter (medfilt2)	0.02	0.05	26.83	77.56	21.22
Gaussian noise	Mean filter or Imgaussfilt3	0.02	0.05	23.50	54.99	14.49
Speckle noise	Adaptive filter (wiener2)	0.02	0.05	25.30	54.99	16.30
Poisson noise	Wiener filter (wiener2)	0.02	0.05	27.72	54.99	18.71

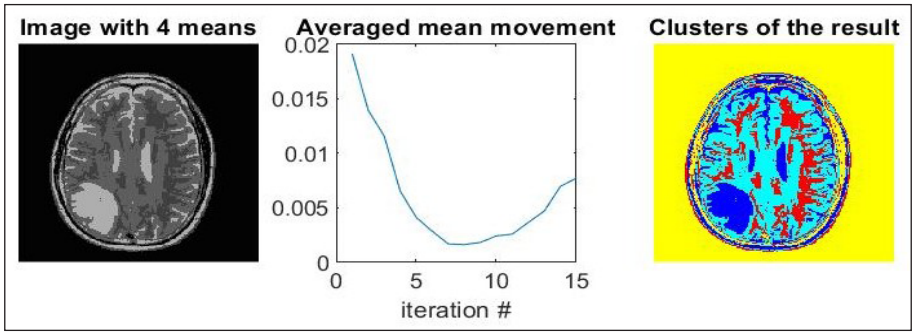

Figure 4.MRI Image Segmented using 4-iterations k-means Clustering

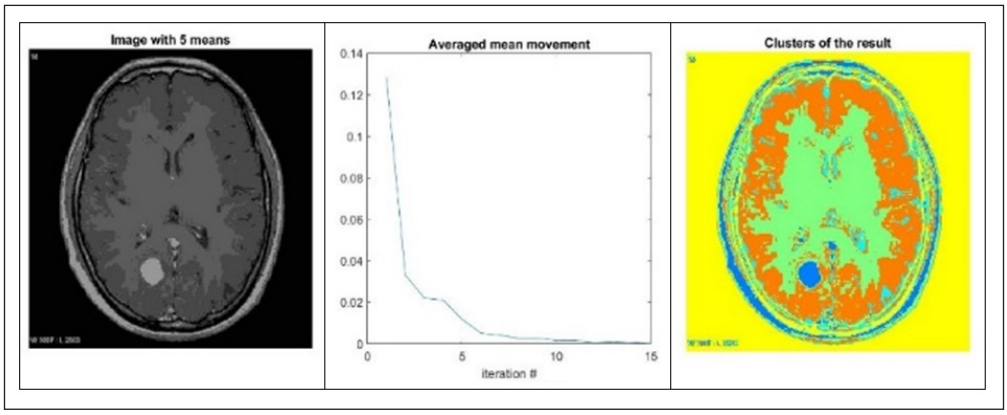

Figure 5.MRI image segmented using 5-iterations of k-means clustering

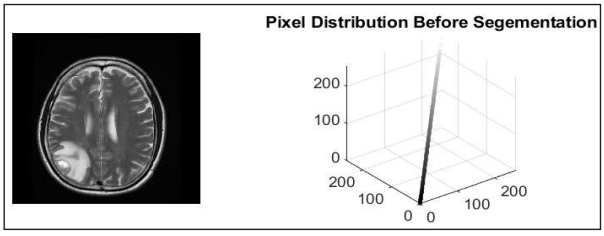

Figure 6.MRI Image Before Segmentation

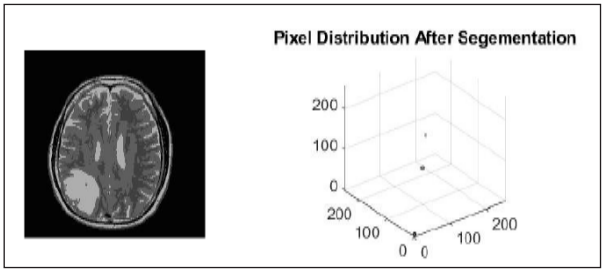

Figure 7.MRI Image After Segmentation

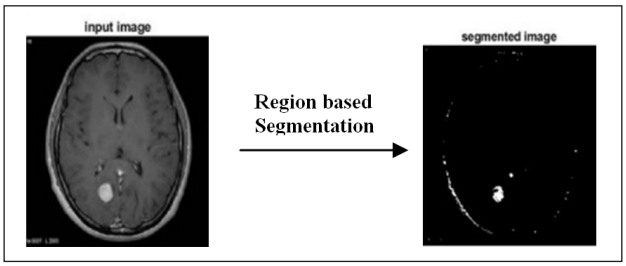

Figure 8.MRI Image Segmented using Region Based Segmentation

Using region-based segmentation, we obtain a binary output as shown in the Figure. In this segmentation, particular threshold value is taken as reference added to average of minimum and maximum pixel values. The output obtained is based on the condition that if the pixel value in an input MRI image is greater than the threshold value then the segmented output is white in colour (i.e, 1) else segmented output is black in colour.

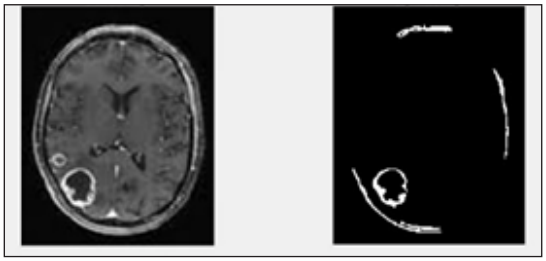

Figure 9.Classified Output of the MRI Image of a Malignant Brain Tumor

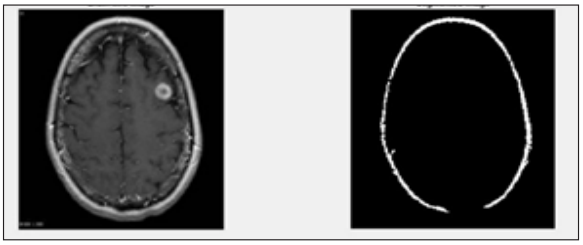

Figure 10.Classified Output of the MRI Image of a Benign Brain Tumor

Classification Output

In classification output, the tumor is classified as either benign tumor or malignant tumor which is helpful in deciding the treatment for the patient. Along with the information regarding type of tumor, we also obtain the percentage of primary and secondary features of the tumor and accuracy of the output. The classification output is obtained by analyzing the following parameters:

- Quadratic accuracy
- Polygon accuracy
- Linear accuracy
- RBF accuracy

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