Identification of Brain Tumor using Image Processing Techniques

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Abstract - **At present, processing of medical images is a developing and important field. It includes many different types of imaging methods. Some of them are Computed Tomography scans (CT scans), X-rays and Magnetic Resonance Imaging (MRI) etc. These technologies allow us to detect even the smallest defects in the human body. Abnormal growth of tissues in the brain which affect proper brain functions is considered as a brain tumor. The main goal of medical image processing is to identify accurate and meaningful information using images with the minimum error possible. MRI is mainly used to get images of the human body and cancerous tissues because of its high resolution and better quality images compared with other imaging technologies. Brain tumor identifications through MRI images is a difficult task because of the complexity of the brain. MRI images can be processed and the brain tumor can be segmented. These tumors can be segmented using various image segmentation techniques. The process of identifying brain tumors through MRI images can be categorized into four different sections; pre-processing, image segmentation, feature extraction and image classification.**
Keywords - Brain Tumor, Image Processing, MRI, CT, X-Ray, Pre-Processing, Segmentation, Feature Extraction

I. INTRODUCTION

Brain tumors affect the humans badly, because of the abnormal growth of cells within the brain. It can disrupt proper brain function and be life-threatening. Two types of brain tumors have been identified as Benign tumors and Malignant tumors. Benign tumors are less harmful than malignant tumors as malignant are fast developing and harmful while benign are slow growing and less harmful.

Medical imaging technique is used to create visual representation of interior of the human body for medical purposes and noninvasive possibilities can be diagnosed by this technology. The various types of medical imaging technologies based on noninvasive approach like; MRI, CT scan, Ultrasound, SPECT, PET and X-ray [1]. When compared to other medical imaging techniques, Magnetic Resonance Imagine (MRI) is majorly used and it provides greater contrast images of the brain and cancerous tissues. Therefore, brain tumor identification can be done through MRI images. This paper focuses on the identification of brain tumor using image processing techniques.

The rest of the paper describes, background of identification of brain tumor using image processing (Section II) and Section III presents the related work. Section IV provides a description about methodology while Section V gives an acknowledgement of the research.

II. BACKGROUND

Brain Tumor is described as abnormal development of tissues in the brain. Nowadays the prevalence of tumors is growing fast. In 2016, an estimated 23,800 adults (10,350 women and 13,450 men) in the US will be identified with the harmful tumors of brain as well as spinal code [2]. Analysis of brain tumors is somewhat problematic as the varied shape, size, tumor location and the presence and appearance of tumor in brain. It's hard to detect brain tumors in beginning stage because the accurate measurement of tumor can't be found. But once the brain tumor is identified at the very beginning, the proper treatments can be done and it may be curable. At present, visual representation of the interior of the body is processed using medical imaging technique for clinical analysis and medical researches. MRI is the most effective and extensively used technique for brain tumor detection. Current diagnosis techniques are performed using the conventional methods based on human experience and this increases the possibility of false detection when identifying brain tumors. Present tools and methods to analyze tumors and their behavior have become more prevalent. Image processing technique can be used to identify brain tumors. Image processing methods converts images into digital and do operations on them, in order to get better and enhanced images [3]. This study will focus how to identify brain tumors using image processing techniques.

III. RELATED WORK

In recent years, image processing has applied to process images in medical stream, in cooperating cell detection. In 2012, 'S. Mokhled'[4] introduced several identification steps, including segmenting images to extract the object from the background through the threshold. This feature was introduced with the 'Gabor filter' in order to do more classification into cancer cells.

In 2013, 'H. G. Zadeh' [5] proposed further steps, which is image extraction and segmentation of images for diagnosing cancer cells. The Gaussian smoothing concept was introduced as a filtering purpose, previous to applying the 'Fast Fourier Transform' (FFT).

Machine Learning for tumor detection: 'NN', 'Fuzzy C-mean' algorithms was introduced for the identification of tumorous cells [6]. This takes lower computational time but the accuracy also lower.

In 2014, 'X. Chen' introduces gene counting technology[7]. But this technology is appropriate only for the complex formation of gene selection.

From the above-mentioned techniques and using other technologies, in this research paper focuses on the identification of brain tumor using image processing techniques.

IV. METHODOLOGY

According to the following steps, Brain tumors can be detected using Image Processing techniques.
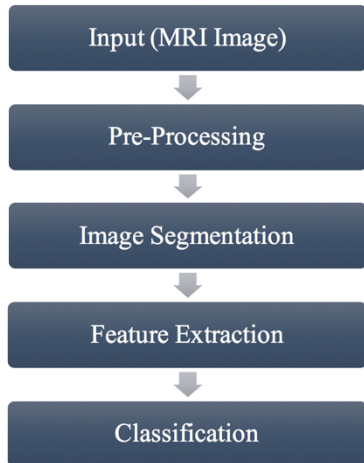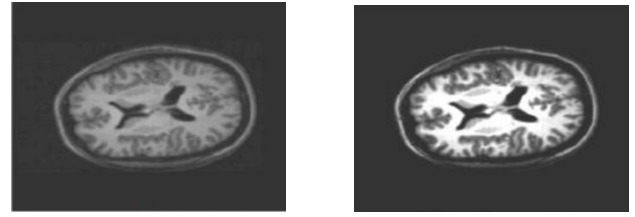

Figure 1. Steps for image processing

4.1 Image Pre-Processing

It is very difficult to process an image. Before any image is processed, it is very significant to remove unnecessary items it may hold. After removing unnecessary artifacts, the image can be processed successfully. The initial step of image processing is Image Pre-Processing [8].


Original Image   Enhanced Image
Figure 2. Image Enhancement [8]

Pre-Processing involves processes like conversion to greyscale image, noise removal and image reconstruction. Conversion to greyscale image is the most common pre-processing practice [9]. After the image is converted to greyscale, then remove excess noise using different filtering methods.

A. Median Filter

This the most common technique which used for noise elimination. It is a 'non-linear' filtering technique. This is used to eliminate 'Salt and Pepper noise' form the greyscale image [10]. Median filter is based on average value of pixels. The advantages of median filter are efficient in reducing Salt and Pepper noise and Speckle noise. Also, the edges and boundaries are preserved. The main disadvantages are complexity and time consumption as compared to mean filter.
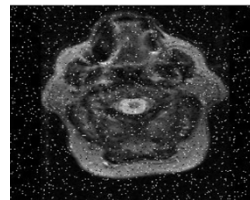
Salt and pepper noise   Median Filter

Figure 3. Applying Median filter [12]

B. Mean Filter

This filter is also a de-noising filter that is based on average value of pixels. Advantages of mean filter are it reduces Gaussian noise and the response time is fast. Main disadvantage is it distorted boundaries and edges.

C. Wiener Filter

The Wiener Filter is also a de-noising filter that is based on the inverse filtering in the frequency domain. Efficient to eliminate images in the form of blur is the main advantage of the Wiener Filter. Because of working in the frequency domain, it has low speed and is not suitable for Speckle noise.

D. Hybrid Filter

The Hybrid filter consists both Median filter and Wiener filter. It can eliminate Speckle noise, Impulse noise and blurring effects from images. But the complexity and time consumption is the main disadvantage of the Hybrid filter.

E. Modified Hybrid Median Filter

This filter is also a de-noising filter which consists both Mean and Median filter. It is very efficient to eliminate Speckle noise, Salt and Pepper noise and the Gaussian noise. But the main disadvantage of this filter is high time consumption compared to the simple Median filter.

F. Morphology Based De-noising

This filter is based on Morphological operations of opening and closing. Producing results better than other de-noising filters and the efficiency are the main advantage of this filter.

4.2 Image Segmentation

'Image Segmentation' is the procedure of distributing an image into minor portions. It creates several sets of pixels within same image. Assigns a tag to every pixel in an image and the pixels with the similar label share particular features [11]. Segmenting makes it easier to further analyze and recognize important information form a digital image.

A. Threshold Segmentation

'Segmentation' is the technique that has been introduced to divide a digital image into number of segments that include sets of pixels and set of super pixels. Objectives to be accomplished through the process of segmentation are simplifying and changing the format of representation of an image in a way that it will become more detailed , meaningful and easy for the process of analysis. Placing of objects and boundaries in images such as lines, curves could be performed through Image segmentation. Throughout the procedure of image segmentation, every pixel in an image is assigned a label and the pixels consist of same label share certain visual features. Each pixel in the region is similar in relation to some features or computed properties, such as color, intensity or texture. Adjoining regions are particularly different in regard to the same features. Thresholding methodology is the simplest technique of image segmentation. This technique involves a threshold value that is used to converting a gray-scale featured image to a binary image. The major advantage of this method is selecting the threshold value to be used.

B. Morphological Based Segmentation

'Morphology' refers to describing the properties of the shape and structure of any entity. Binary images may comprise many defects. Particularly, the binary regions constructed by simple thresholding are deformed by texture and noise. Morphological image processing seeks to achieve the goals of eliminating these defects by accounting for image shape and structure. Generally, this denotes recognizing objects or boundaries within the image. Morphological operations are logical conversions based on comparison of pixel neighborhoods with a pattern. Usually, morphological operations are implemented on binary images under the pixel values; 0 or 1. Many of the morphological operations target on binary images.

C. K-Means algorithm

Most image processing techniques use K-Means algorithm for image segmentation. It is very useful for large images with poor contrast. But it has been realized that K-Means is susceptible to selection of samples and establishments of fuzzy sets [12] [13].

J: Objective Function
K: Number of c
N: Number of cases
Cj: Centroid of cluster 'j'

$$J = \sum_{j=1}^{k} \sum_{i=1}^{n} \left\| x_i^{(j)} - c_j \right\|^2 \quad \text{---------- (1)}$$

Table 1 represents the different segmentation methods with different characteristics.

Segmentation Technique	Usage	Susceptible To
Threshold method	Use gradient magnitude to find the potential edge pixels [15].	Hard to be used for images with poor contrast.
Region Based	Correctly separate regions according to the similarity of properties [15].	Noise may lead to quality of final result
Fuzzy C Means, K Means and Level Set Techniques	Useful for large images with poor contrast.	Sample selection and establishing fuzzy sets may be difficult [16].

TABLE 1. VARIOUS IMAGE SEGMENTATION TECHNIQUES

4.3 Feature Extraction

Accurate tumor extraction is a critical task in the case of brain tumor due to the complex structure of the brain. There are some criterions that are being considered to extract features such as configuration, form (shape), size and image location. With respect to the results retrieved from extract features the process of tumor classification is performed.

A. Edge Detection.

An edge happens when there is an sudden and unexpected intensity modification of the image. Whenever it is detected an abrupt modification or a chane in the intensity of a certain image, the associated pixel would be treated as an edge pixel. The algorithm that has been put forward for the detection of edge pixel supports in identifying the quality of the edge. But sometimes these edges are not displayed in the final result. Hence the algorithms are adjusted to determine the edges[17].

1. "Prewitt" edge detection.

The "Prewitt Mask" is considered as a distinct differentiation operation. Accordingly, approximated derivative values in both the directions, such that horizontal and vertical, are calculated using two 3×3 masks [17]. Prewitt masks approximates both horizontal derivative and the vertical derivative.

2. "Robert edge" detection.

Through the "Roberts edge" detection operation, the image gradient is estimated via distinct differentiation. In addition, "Robert Mask" is a matrix and the regions of high spatial frequency are highlighted, that often correspond to edges in the image[17].

3. "Sobel edge" detection.

The "Sobel Mask" is mostly work as the "Prewitt mask". It can only be distinguish as the Sobel operator has values; '2' and '-2' which are allocated in the center of 1st and the 3rd columns of the horizontal mask and 1st and 3rd rows of the vertical mask. Hence it provides high edge intensity[17].

B. "Histogram of Oriented Gradient" Feature Extraction

The extraction process of the "Histogram of Oriented Gradient" (HOG) is having following calculations. First, the pre-processed cell image will be distributed into "32 × 32" pixels. The intensity of each pixel is '0' or '1'. Then the result will be added to "HOG" [18]. Figure. 4 shows the architecture of "HOG" feature. Then the image will be distributed into "8 × 8" pixels that is called box. Here, the box will be already added into a single block. Again each box will be distributed into 9 bins which is "3 × 3". Pixel gradient is used for the creation of the feature in each and every bin[18]. Therefore there are 9 features, it will lead to "9 × 4" characteristics for each block. In the all "32 × 32" pixels, "HOG" feature extraction allows to create '9 blocks' and finally, it will having "9 × 9 × 4" features in single dimension or "1 × 324" in the vector image.
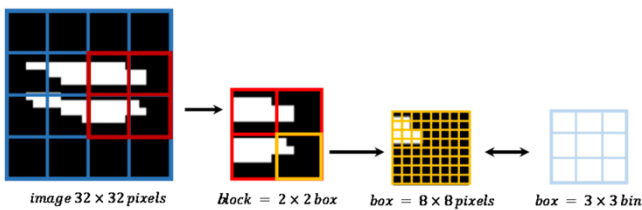

Figure 4. Architecture of HOG feature (elongated cell) [18]

V. DISCUSSION

The most significant thing in image processing is image segmentation, while diagnosing brain tumor from a digital image. Table 2 represents the different segmentation methods with different characteristics such as accuracy and complexity.

| Segmentation Method	Complexity (algorithm)	Accuracy (%)
Seed Region Growing	10	92.5
Threshold Segmentation	8.22	91
Watershed	5.67	88.5
Fuzzy C-Mean	5.29	85
Histogram Thresholding	7.61	81

TABLE 3. DIFFERENT TUMOUR SEGMENTATION METHOD

Main goal of Pre-Processing is the edge preservation of the image. Among the edge detection mechanisms, Sobel is the best option then both the Gaussian and the Median filter. The different edge detection algorithms like 'Sobel', 'Prewitt' and 'Robert' are shown in the Table 3 with different characteristics such as computation time in seconds and computation number of flip-flops used.

|	Sobel	Robert	Prewitt
Advantages	Simplicity	Better noise suppression	Mask simpler as compared to Sobel
Disadvantages	Discontinuity in edges	Not accurate results	Discontinuity in edges
Computation time in sec.	0.3	0.2	0.4
Number used as Flip Flops	343	219	339
Number used as logic	450	322	450

TABLE 3. PERFORMANCE OF EDGE DETECTION

The following figures show the steps of brain tumor detection using image processing techniques. That is original MRI image, grayscale image, filtering image using Median filter, segmenting using threshold method, morphological operation applied image and finally diagnosed tumor from MRI image.
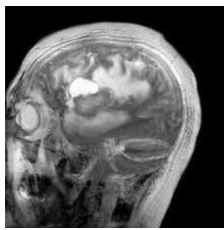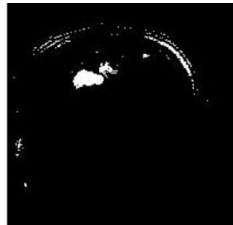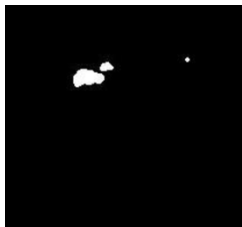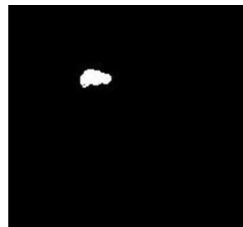
MRI image of tumor
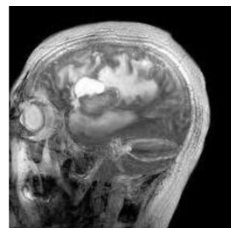
Grayscale image
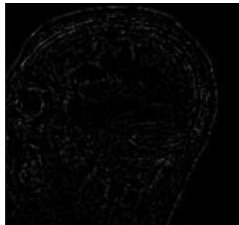
Median Filtered

Threshold Segmented

Morphological operation
applied image

Final Tumor detected
image

Figure 5. Steps of brain tumor detection [20]

VI. CONCLUSION

Abnormal growth of tissues in the brain which affect proper brain functions is considered as a brain tumor. The main goal of medical image processing is to identify accurate and meaningful information using images with the minimum error possible. Brain tumor identifications through MRI images is a difficult task because of the complexity of the brain. These tumors can be segmented using various image segmentation techniques. The process of identifying brain tumors through MRI images can be categorized into four different sections; pre-processing, image segmentation, feature extraction and image classification.

Median filter is the most commonly used filtering technique among various filtering techniques. Less complexity and the efficiency in eliminating 'Salt and Pepper noise' are the main advantages of median filter. Not like Gaussian filter, it is a non-linear filter, Median filter is an edge preserving filter. Also, Gaussian filter is a low pass filter hence the edge information will be lost and edges getting displaced and blurred. Although, less complexity and the cheapness to implement than the Median filter are the main advantages of Gaussian filter. Another advantage is the Gaussian filter is very applicable in smoothening Gaussian noise. Thresholding is the best and easiest approach among image

segmentation techniques. It easy to implement and widely used these days. When the contrast between foreground object and background object is comparatively high, threshold technique works well.

VII. ACKNOWLEDGEMENT

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