International Journal of Mechanical Engineering and Technology (IJMET)
Volume 9, Issue 5, May 2018, pp. 514–523, Article ID: IJMET_09_05_056
Available online at http://www.iaeme.com/ijmet/issues.asp?JType=IJMET&VType=9&IType=5
ISSN Print: 0976-6340 and ISSN Online: 0976-6359

BRAIN TUMOR SEGMENTATION AND DETECTION USING MRI IMAGES

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ABSTRACT

Brain tumor is caused due to the increased abnormal in brain. It is not something that we might say is limited to aged people alone, but is known to affect newborn babies as well. It affects many people worldwide. With the applications of Machine Learning (ML) and Image Processing (IP), the early detection of brain tumor is possible. In this research work, the different stages in image processing which help to detect brain tumor, is addressed vividly. This work provides information about the various sets of filtering and segmentation methods which can be used to detect whether it is brain tumor or not. All of the filtering methods are defined in image pre-processing techniques. The next procedure is to apply segmentation methods namely watershed segmentation and gray level threshold segmentation. After this, certain features are considered for feature extraction such as area, major axis, minor axis and eccentricity. According to the outcomes from the feature extraction technique, the classification of the tumor is done. In this paper, we achieve an accuracy of 92.35 by using K-Nearest Neighbor (KNN) algorithm.

Key words: Brain Tumor, MRI, Image Processing, Median Filter, Gaussian Filter, Watershed Segmentation, Gray-level threshold Segmentation, Canny Edge Detection.

Cite this Article: Binu Thomas and P K Nizar Banu, Brain Tumor Segmentation and Detection Using MRI Images, International Journal of Mechanical Engineering and Technology, 9(5), 2018, pp. 514–523.
http://www.iaeme.com/IJMET/issues.asp?JType=IJMET&VType=9&IType=5

1. INTRODUCTION

Brain tumor increases because of the increasing rate of damage cells within the brain. Most brain tumors that happen in kids are called primary brain tumors, implying that they began in the brain first and did not spread from different regions of the body. Tumors can be neighborhood where it stays in one region or they may spread into nearby tissues, moves over to different areas of the body also. Tumors are mainly classified as benign (non-cancerous) or malignant (cancerous). Brain tumors are classified by which part of the brain they are found in, what type of tissue they are composed of, whether they are normal or abnormal and by many other factors. A few tumors have a tendency to be hereditary, where they are known to keep running in the families. *Craniopharyngioma* is a type of tumor that is developed before the birth. Ultimately, the reason for most brain tumors isn't known.

Brain tumor can happen at any age. Tumors of Central Nervous System make up around 20 percent of all young cancers. The yearly frequency of brain tumor in kids under the age of 15 is around 3 of each 100,000. More than 1200 new instances of brain tumor happen every year. Retinoblastoma is the main primary type of brain tumor that is ordinarily found in the beginning phase of our life. The symptoms of a brain tumor relies upon a few elements including the particular range of a tumor, the kind of tumor and the age and wellbeing of a patient. Symptoms may change in view of the status of tumor. In the case of swelling decreases, side effects could decrease.

This research represents the detection of brain tumor in an easy and efficient way without consuming much time. The image is properly analyzed and produces an accurate outcome. Once the image is loaded it undergoes several steps such as Filtering, segmentation, Gray level threshold, canny filter, fusing and feature extraction methods such as finding area, eccentricity, major axis and minor axis. The outcome of each step is served as an input to the next step. Once the images undergo all of these steps, the resultant image specifies if it is affected by tumor or not. This research yields results within a small amount of time and serves as a second opinion by re verifying the doctor's result. Section II discusses the related works, section III discusses methods, materials and section IV discuss the experimental results.

2. BACKGROUND

Hebli et al [1] have discussed about a survey regarding detection of brain tumor using brain MRI images. In their paper, the different stages of image processing are discussed and it provides a gist about the various technologies that can be used to predict brain tumor. Several methodologies are used in the different stages and also analyzed in individual segmentation methods. Comparisons between k-means and fuzzy c-means, GA and PSO have also been discussed.

Rajeswari et al [2] have presented tumor identification using watershed segmentation and hierarchical clustering algorithms. Their work presents the use of watershed approach for brain tumor segmentation and hierarchical clustering algorithm is employed to classify brain tumor detected images. Compared with other clustering techniques, the hierarchical clustering has an important role. The state of each patient is identified by this process, to understand if the patient can be healed by medical aid or not. Also, the size and shape of tumor is described.

Samy et al [3] worked on improvised image segmentation techniques which can be applied on brain tumor detection using MRI images. Their work also specified probabilistic neural networks (PNN) model that is based on learning vector quantization (LVQ) with image and data analytics. The specified PNN classification model is calculated in terms of training performance and computational time. Two approaches are specified in their work for brain tumor detection, identification and classification. The first approach is based on an integrated

arrangement of image processing applications and the second approach is artificial neural network based on modified and improved network structure.

Bhima et al [4] has published a study in the same area that defines the analysis of MRI brain tumor prediction using various segmentation approaches. Their work focuses on the accuracy attribute for brain tumor prediction. It demonstrates the possible outcomes of predicting the brain regions with potential disorders. With the help of watershed segmentation algorithm, important value of experiments have been performed on brain MRI images. Their work defines the tumor detection possible on brain tumor with high efficiency of MRI image and also studies the combination of k-means and fuzzy means.

Benson et al [5] have presented an approach for segmenting tumor from MRI brain images with the assistance of improved Fuzzy-c means clustering and watershed algorithm. In the initial part, histogram is applied which increases the efficiency. With this algorithms an efficiency of 88.91 and 81.56 of dice and tanimoto values respectively were obtained. An additional method known as atlas based marker detection method helped to achieve an efficiency of 93.13 and 88.64 of dice and tanimoto values respectively.

Joshi et al [6] have exhibited a review of brain tumor detection techniques through brain MRI images. Their review introduced a survey of strategies and techniques utilized during tumor detection through brain MRI image segmentation. Advantages and limitations of various segmentation algorithm is examined.

Ghare et al [7] have presented the possibility of detection of brain tumor using image segmentation. This approach consist of implementation of simple algorithm for detection and shape of tumor in brain with the help of MRI images.

Thakur et al [8] has published a study with the assistance of watershed segmentation and morphological operations for brain tumor segmentation and detection. Watershed segmentation gives very good results, and meets the criteria of less computational complexity. This research work not only detects tumor, but also calculates the area of tumor in pixels. This will help the physician in surgery.

3. METHODOLOGY

The image processing techniques are utilized to recognize tumors that includes following steps - Image preprocessing and enhancement, Image segmentation, Feature extraction and Classification.

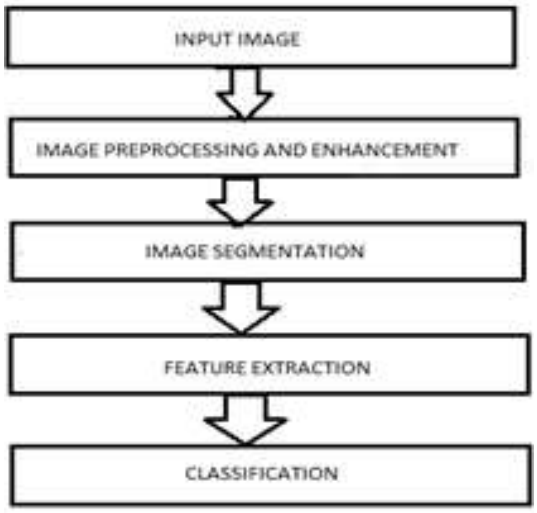

Figure 1 Overview of the research work

1. Image Preprocessing and Enhancement

This is the initial step of image processing which is used to improve the progressions made on an image and detects the different regions. This method is mainly focused on the removal of noise from an image. Various filters are utilized to remove noise.

a. Median Filter

In median filtering, the estimation of an resultant pixel is controlled by the central value of the neighboring pixels [10]. The median filter is additionally a sliding-window spatial filter, however it replaces the central value of an image with the median of all the pixel values in an image. Figure 2 shows the working of median filter.

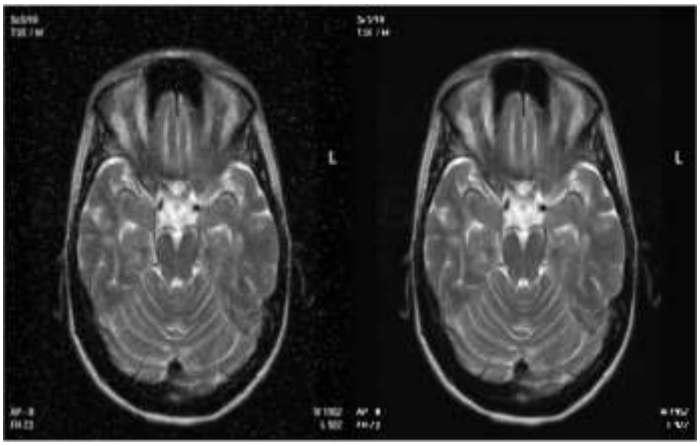

Figure 2 Application of Median Filter on brain MRI image.

b. Gaussian Filter

Gaussian Filter can be used as blurring the image and sharpening the image. Image sharpening is a powerful tool for emphasis shape and drawing focus. It refers to any enhancing technique that specifies edges and fine details in an image. The Gaussian smoothing operator is utilized to blur images and remove unwanted edges and noise. In image processing, Gaussian smoothing is the outcome of blurring an image by the assistance of Gaussian function. Gaussian function depends on mean value and variance [11]. Figure 3 shows the working of Gaussian filter.

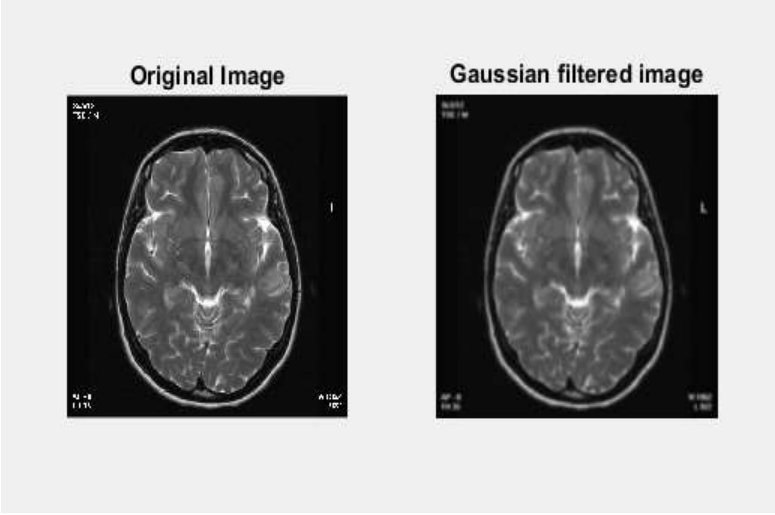

Figure 3 Application of Gaussian Filter on brain MRI image.

2. Image Segmentation

Image segmentation is the way of dividing an image into numerous parts. This is ordinarily used to recognize objects or other significant information in digital images. There are wide range of approaches to perform image segmentation. Here, we use three methods for segmenting the images that depict brain tumor.

a. Watershed Segmentation

It is one of the best strategies in grouping pixels of an image on the basis on their intensities [2]. Pixels falling under comparable intensities are gathered together. It is a better segmentation method to divide an image which can isolate the tumor from the other regions within the image. Watershed is a mathematical morphological working method. Watershed algorithm is typically utilized for checking output results rather than using an input segmentation technique. The watershed and gray-level threshold algorithm strategies are helpful for segmentation of images that depict brain tumor. Here the segmentation of brain tumor is done on the basis of similar attributes. Those attributes that are similar in nature are grouped together. The essential motivation of watershed segmentation is to extract the important features from an image to retrieve the information easily. The algorithm of watershed segmentation is fundamentally used to change the angle of gray level image in a topographic surface. Figure 4 shows the application of watershed segmentation on brain MRI image.

Figure 4 Watershed Segmentation applied on brain image.

b. Gray level Threshold Segmentation

The underlying concept of gray-level threshold segmentation is to change over a gray scale into its binary image. This is a very simple and effective segmentation strategy for images with various forces [10]. This procedure is essentially an attempt in finding a threshold value which enables the arrangement of pixels into various classifications. After gray-level threshold, the image will be segmented into two values, 0 and 1. A major issue regarding this strategy is that it produces two classes. Therefore, this technique fails to manage with multichannel images. Figure 5 shows the application of gray-level threshold segmentation on brain MRI image.

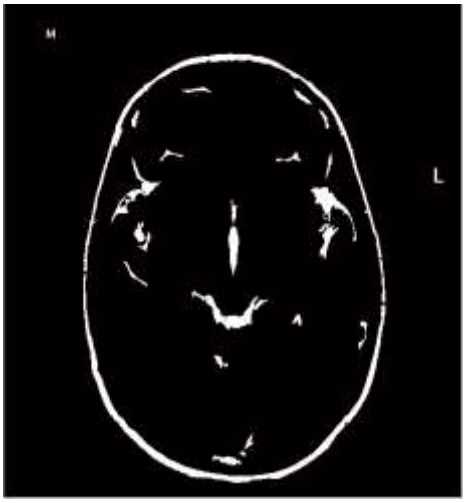

Figure 5 Gray-Level Threshold Segmentation applied on brain image.

c. Canny Edge Detection

Canny filtering is an edge detection technique used to detect the edges of an image. Here we can detect both, strong edges and weak edges of a particular image. It is a strategy to remove supportive structural information from various objects, invariably reducing the measure of information to be processed [7]. It has been broadly applied in various computer vision frameworks. Canny had discovered that the requirements for the application of edge detection on diverse vision systems are generally comparative. Accordingly, an edge detection solution to address these requirements can be executed in a extensive variety of situations. Figure 6 shows the application of edge detection on brain MRI image.

Figure 6 Canny Edge Detection applied on brain image.

3. Feature Extraction

The feature extraction technique is utilized to get the most essential features in an image, to decrease the processing time and complexity in the image analysis [1]. Extracting the exact part of the image that contains the tumor is a task that can be very unpredictable in the account of brain tumors, as a result of the complex structure of the brain. Certain features such as area, major axis, minor axis and eccentricity are extracted. According to the outcomes got from the feature extraction, the classifications of the tumor is finished.

4. Classification

The image classification is the final stage of MRI image processing. It is the process of categorizing all of the pixels in a digital image into several set of classes. Depending on the features selected from the feature extraction technique, the output of the classification varies. K-nearest neighbor (KNN) classification algorithm is used in this experiment.

- K-Nearest Neighbor(KNN)

The main objective of the k- nearest neighbor algorithm is to find the nearest neighbor of an unknown data point. This algorithm works depending on the value of k. If the value of k=n, then we can predict n-nearest neighbor. This paper includes two classes: a normal class and an abnormal class. Using the features from the previous method, KNN classifies the given input. In this algorithm, we have to find in which class the tumor is identified, in which of the two classes or which is the nearest neighbor of a particular input image. In this research, we take 100 normal images and 100 abnormal images for classification. After classifying all of the features, the algorithm produced an accuracy of 92.35 %.

4. EXPERIMENTAL RESULT

This section presents the details of the dataset used for experiments in this paper and the results are analyzed.

1. Dataset

A set of MRI gray-scale image database is used in this experiment with each image being of size 220x220 pixels. There are 38 patients brain MRI images taken from website of the laboratory of eHealth of the university of Cyprus, at: http://www.medinfo.cs.ucy.ac.cy/. This database is a collective outcome of 38 patients. For every patient, we have two types of files,

- MRI. TIFF image files represents the first and second examination (0 months, 6-12 months).
- plq files represents lesion segmentation. It can be loaded into MATLAB software. The delineations can be loaded into MATLAB ie, load(file.plq, '-mat'); Then the points can be drawn on the image.

Figure 7 and 8 shows, Normal MRI brain image and Abnormal MRI brain image respectively.

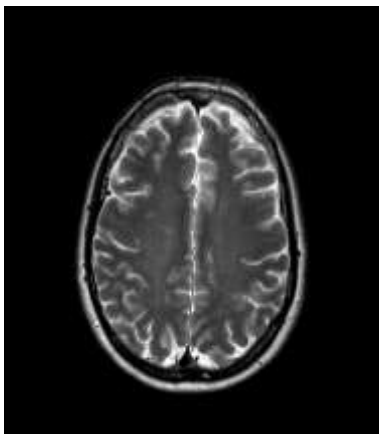

Figure 7 Normal Image

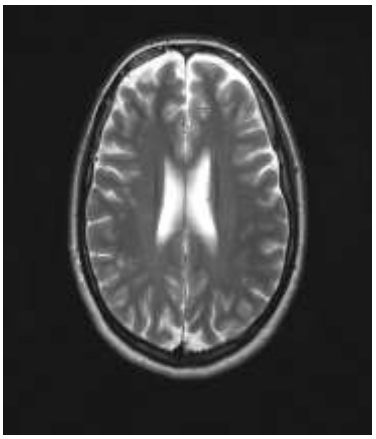

Figure 8 Abnormal Image

2. Implementation in MATLAB

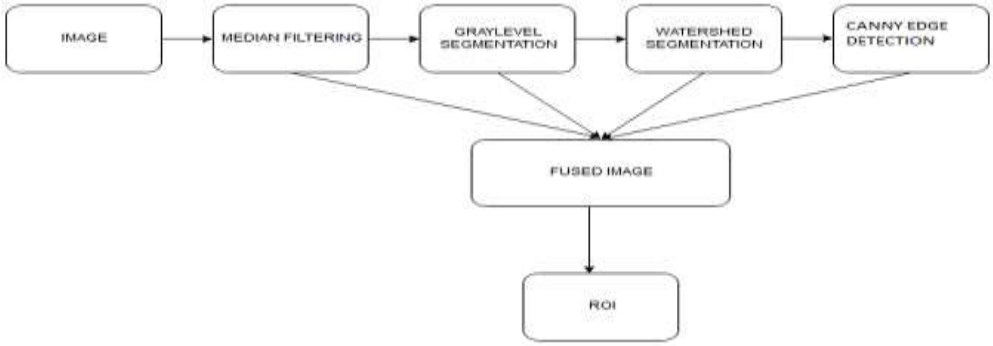

Figure 8 Methods applied in the research work.

To demonstrate the discoveries proposed in this work, we provide the MATLAB implementation of this framework in figure 8 to test the visual advantages of different filtering and segmentation techniques for brain tumor detection using MRI images. MATLAB is a multipurpose numeric programming language which includes different built-in library functions ranging from image processing to higher order numeric calculation.

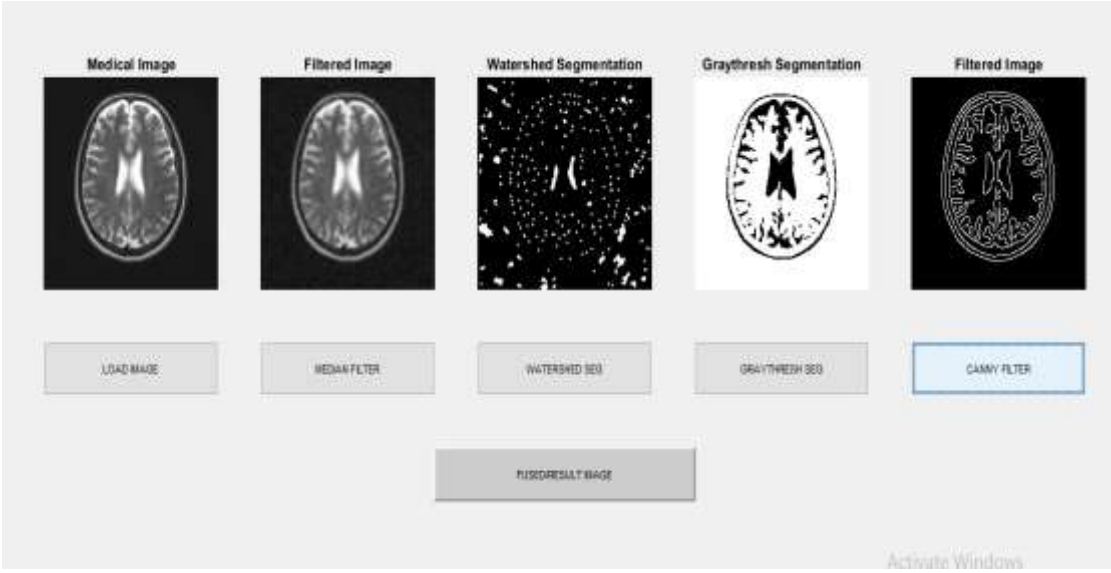

Figure 9 Graphical User Interface (GUI) in MATLAB

In the first stage, we apply two pre-processing methods for noise removal and contrast enhancement on the MRI brain scan images that we use as input data. Filtering methods are mainly used for noise removal operations. In this experiment, we mainly use two filtering methods i.e. Median filter and Canny filter. The Median filter is also a spatial filter; however it replaces the middle value in the image with the median of all the pixel values in the image. Canny edge detection is an edge detection strategy to remove supportive structural information from various objects, invariably reducing the measure of information to be processed.

After pre-processing, we perform tumor segmentation by using Watershed segmentation and Gray-Level threshold segmentation techniques. The idea of watershed strategy is to change the gradient of gray-level image in a topographic surface where the qualities are translated as heights and each local minima in an image is referred to as catchments [6]. In gray-level threshold segmentation, a gray scale image is turned into a binary file or a black and white image by initial selection a gray level threshold value in the input MRI image and

then rotating every pixel black and white according to whether its gray value is greater than or lesser than the threshold value[7].

After completing image segmentation, fuse all of the preprocessing and segmentation methods and then calculate the Region of Interest (ROI) from which we can find the area, eccentricity, major axis and minor axis. The expected output image after fusing all of the methods would be as given below (figure 10).

Figure 10 Fused Result of MATLAB GUI

From this result we can find the features (area, eccentricity, major axis, minor axis) of an image. Certain features of the images are taken for Feature Extraction. According to the outcomes from feature extraction, the type of tumor is classified. Classification is the process of categorizing the input image into several sets of classes. The classification process is done based on the features selected from the feature extraction. K-Nearest Neighbor (KNN) classification algorithm is used in this procedure. In this algorithm, we have to predict in which of the two classes the tumor occurs in or is a part of. In this experiment, we take 100 normal images and 100 abnormal images for classification. After classifying all the features, the algorithm produced an accuracy rate of 92.35 %.

5. CONCLUSION

In this work, several algorithms are referred, to define the various stages of MRI image processing and it has also specifies different filtering and segmentation approaches. Different methodologies proposed by various researchers are considered, all of which show that image processing have major role in brain tumor detection and classification, along with possible segmentation approaches. This research study describes Brain tumor detection using MRI images by means of segmentation using watershed, gray level threshold and canny edge detection algorithms. The achieved outcomes are appeared in feature extraction which demonstrates the efficient tumor detection by using K-Nearest Neighbor (KNN) algorithm. Depending on the features selected from the feature extraction technique, the output of the K-Nearest Neighbor classification algorithm may vary.

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