Brain Tumor Identification Techniques using MRI: A Review

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Abstract; in the present scenario image processing is amongst those techniques that draw people from varying backgrounds together towards a common objective for the aid of mankind. One such usage of image processing is seen in the diagnosis of numerous diseases in the medical field. The uncontrolled escalation of cells inside the brain causes brain tumour. This happens due to unbalanced growth of cells within the brain. The detection of such diseases during the initial stage is important because their symptoms become significant at an advanced stage. If not detected and diagnosed at the right time, it may result in the death of the patient. Magnetic Resonance Imaging is nowadays the primary pick when it comes to the spotting of brain tumour. Manual detection of tumor by doctors is often inaccurate and consumes too much time. Multiple techniques and their respective algorithms have been unfolded by the researchers for the detection of brain tumor. This paper presents a review on all those papers that cover the several brain tumor detection algorithms.

Keywords: Image processing, brain tumor, Magnetic Resonance Imaging.

1. Introduction

A tumor is the outcome of uncontrolled development advancement of cells in the body. They are categorised as malignant or benign [1]. This generally happens with the excessive outgrowth of cells in the brain. The imbalance in the progress rate of cells results in the occurrence of tumor. Different kinds of tumors have different symptoms depending upon their size and location. A brain tumor occurs when the cell growth increases inordinately in the brain. As the skull has limited space inside, this cell growth pattern is not acceptable and it results in the outgrowth of tumor [2]. People with brain tumor may experience headache, vomiting, nausea, dizziness, fatigue, blurred vision, difficulty in walking. The detection of tumor in the beginning itself helps in its early diagnosis. The earlier it is detected, the smaller is its size and easier is the diagnosis. Magnetic Resonance Imaging (MRI) is the priority test which is being used for the detection of brain tumor. MRI scanners use the strong magnetic field, magnetic field gradients, and radio waves to attain the images of the body organs. Elaborated statistics about the structure of the body parts can be created with MRI [3]. MRI technique is preferred for brain because it is suitable for soft tissue structures.

The main organ of the human nervous system is brain and it includes soft tissues and nerve cells. The Central Nervous System (CNS) of the body comprises of the brain and spinal cord. The CNS controls all the elementary functions of the body like breathing, movement, coordination, heartbeat, hearing and especially the personality. The new cells replace the old cells once they are afflicted and detrimental. Now if these rearrangements of cells become imbalanced, it leads to the escalated growth of cells. This results in the formation of tumor in these areas. Tumors are categorized into Benign, Pre-Malignant and Malignant.

Benign Tumor: It is non-cancerous in nature. This tumor does not grow aggressively in the entire area and causes no damage to the healthy tissues around it. Moles are an example of benign tumor.
Pre-Malignant Tumors: The tumor at this stage is on the verge of becoming cancerous. If the correct treatment is not provided in time it may head towards cancer.

Malignant Tumor: This tumor grows aggressively with time and it has the capability to spread in all the regions around it. It may result in the loss of life. This stage represents the worst condition of the disease.

2. Structure of Brain

The structure of brain consists of forebrain, midbrain and hindbrain along with their multiple parts [4]. The cerebrum is the biggest segment of the human brain and it is considered under the forebrain category. It is also called as cerebral cortex. It deals with the higher order brain functions, like thought and action. It has four parts called ‘lobes’. They include frontal, parietal, occipital and temporal lobe.

The segment of the brain located in between the forebrain and hindbrain, just at the center of the brain is called the midbrain. The essential function of midbrain is to control the optical and auditory systems. It is placed in the center of the cranial cavity.

Figure 1 Structure of Brain [4]

The hindbrain consists of cerebellum. Another name for cerebellum is the “little brain”. The coordination between posture, movement, balance of the body and vasomotor centers, cardiac, respiratory is controlled by the hindbrain.

The human brain make the human beings accommodate and sustain in different kinds of environment. The overall thought process and action and reaction activities come under the control of brain. Brain tumors are primary and secondary. Primary brain tumors grow within the brain. It is either benign or malignant. One other kind is gliomas [5]. These kinds of tumors can be less wild sometimes but they put high pressure on the brain and can cause significant damage. The tumor that has a different birth location but it somehow managed to invade the brain is termed as secondary tumor. These kinds of tumors are always cancerous. The cause of secondary brain tumor is mostly lung cancer, kidney cancer, bladder cancer and more [6].

3. Magnetic Resonance Imaging (MRI)

A lot of imaging techniques are developed for the detection of tumor, for instance, MRI scan, computed tomography (CT) scan, angiography, biopsy and others. Among these techniques MRI scan is preferred particularly for the brain, as it is a suitable technique for soft tissues. These images were developed back in 1969 by Raymond V. Damadian and finally in 1977 they were produced for human beings.
An elaborated description about the soft tissues of the concerned body part can be obtained using these images. It also provides a productive comparison of the tissues [7]. The MRI scanner can give three kinds of MRI images, namely, T1 weighted, T2 weighted and Proton density (PD) images. The images can be obtained in three planes – axial plane, sagittal plane and coronal plane [5].

Figure 2 Different planes of MRI images [5]

The T1 and T2 weighted MR images are signal intensity based. All the MRI protocols include the T1 weighted sequence. It is assumed to give the most appropriate macroscopic description of the tissues. The high fat content tissues having high signal intensity are displayed by the bright areas. On the hand, dark areas are displayed by high water content tissues having low signal intensity. The echo time and repetition time are considerably long for T2 weighted sequences. The flip angle is less important in this case [8]. Here, the dark areas are represented by the high fat content tissues having very less signal intensity. The high water tissues having high signal intensity are shown by the bright areas. The dark areas with less signal intensity display the low proton density tissues in PD images. The high proton density tissues are shown by bright areas having high signal intensity [7].

4. Literature Review

The following section of the paper will present a review about the work done by various scholars to detect brain tumor. The sequence is as follows: segmentation along with other algorithms, feature extraction and classification, using GUI program and some comparative studies.

M. Sudharson et Al [9] projected tumor image processing in the following three stages: preprocessing of the image, segmentation and morphological operations. A grey scale version of the image is obtained. Any noise in the image is removed by using high pass filter. Image enhancement is achieved by using median filter. Watershed segmentation algorithm was used for the identification of tumor. Moreover morphological operations are used to calculate area, entropy, mean and standard deviation. These parameters are compared for normal as well as abnormal images. It is seen in the result that the values for abnormal conditions are high. They were able to get accurate results in short duration of time.

An adaptive technique to detect brain tumor was given by Swapnil R. Telrandhe et Al [10]. The image is first preprocessed by converting it into grey scale. Image enhancement and noise removal is attained by median filter. Skull masking is used to get rid of the non-brain tissues. They have applied some morphological operations namely dilation and then segmented it by K-means clustering algorithm. Along with K means, object labelling was used to get more fine details. Finally classification was done with the help of support vector machine. The algorithm was successful in detecting and classifying the type of tumor with its area.
Another strategy for brain tumor detection was given by Natarajan P et al [11]. They preprocessed the image by making use of the sharpening and median filters. The image enhancement was achieved by histogram equalization. They segmented the image with the help of thresholding segmentation. The resultant binary image undergoes some morphological operations. Finally they used image subtraction to detect tumor. Firstly the tumor region was obtained separately from the image and then the resulting image was subtracted from the parent image. The final image contains only the tumor. They positively identified the tumor region from the MRI images.

Anupurba Nandi [12] has also worked with K-Means clustering algorithm to detect brain tumor. She used the basic preprocessing techniques on the images. High pass filter, median filter and histogram equalization were applied for noise removal and enhancement. Watershed segmentation including thresholding and K Means clustering were compared. Then the regular morphological operations were applied. The watershed algorithm has one drawback which is its sensitivity to local minima. However along with morphological operators, this technique proved to have better results than K Means clustering.

Ramya.K et al [13] also did her research using watershed transform. The image was passed through a median filter to remove the noise. Then they have used a watershed transform technique which consists of gradient magnitude. The gradient descent defines the segmented regions. Morphological operations were used to identify the focal point of the tumor. The invisible tumor was detected by using background markers with threshold value. The segmented output gives the intensity, size and shape of the tumor. This research gives an accuracy of 99.99%.

Pranjal Jain et al [14] developed a GUI program in MATLAB to detect the brain tumor. The input in GUI is the name, patient’s age and his MRI scan. The whole procedure comprises preprocessing, segmentation, morphological operations, watershed segmentation and area calculation. Accurate results were achieved by computing watershed segmentation and ridges.

Miss Shrutika Santosh et al [15] used the thresholding technique for brain tumor detection. They used the basic preprocessing operations for image enhancement. Then by using threshold point, dilation and erosion the tumor was detected. They managed to calculate tumor area and display the stage of tumor accurately in approximately 9.14 seconds.

As a skull stripping method with modified morphological process was taken into account by Ms. T. K. Sreeja et al [16]. They have used wiener filter with thresholding technique. To remove the unwanted edges, they used a skeletonization algorithm. Then to finally get the wanted region they would use morphological with connected operators. Their modified method gave improved results than the existing method.

Ahmed Kharrat et al [17] followed a three step process: enhancement, segmentation and classification. The segmentation was accompanied by an enhancement process to refine the image quality. They would use mathematical morphology for contrast enhancement. K means algorithm pooled with wavelet transform gave the extracted tumor region. The PSNR value was found to be 21.6272, which is acceptable.

Two different approaches were compared by M. Monica Subashini et al [18]. The first approach involved thresholding, edge detection, filtration, feature extraction and classification. It gave accuracy up to 92.5%. The second approach made use of histogram equalization, thresholding, segmentation by using K mean clustering and error analysis by SVD. The results were accurate up to 87.5%.
Sayd Tahri Yassine et al. [19] utilized the expectation maximization algorithm in their work. For preprocessing they have used N1 means filter. The image is categorized into ‘tumor class’ or ‘no tumor class’ using EM algorithm. They compared their results with seven tumor extraction methods. This method demonstrated accurate results with a simulation time of just 30 seconds.

To reduce the mathematical intricacy of the classification process Nilesh B. Bahadure et al. [20] uses feature extraction method. The extracted features were optimization to detect brain tumor. Tumor classification is accomplished by comparing the calculated area. The dice index similarity coefficient was computed and found to be 0.73, which shows high accuracy of this method.

Nilesh Bhaskarrao Bahadure et al. [21] did another research on the basis of Berkeley wavelet transform (BWT) with support vector machine (SVM) classifier for improved tumor detection performance. The outer areas in the brain scans were extracted using morphological operations. First order statistical and second order textural features were calculated. They compared their results with ANFIS, Back propagation and K-NN. The proposed classifier gave exclusive results than other techniques, with 96.51% accuracy.

SANDABAD Sara et al. [22] made use of the histogram analysis of MRI scans for tumor identification. Expectation Maximization algorithm was taken into account for tumor extraction. They did histogram analysis based on a threshold value. This method handles a broad spectrum of lesions. The method was found to be easy, simple and fast with simulation time of 5-8 seconds.

Esmail Hassan et al. [23] used the GUI interface approach in MATLAB to identify brain tumor from the MRI scans of the patients. The interface was designed to use any arrangements of image processing algorithms to give the best results. They, in particular used the Prewitt horizontal edge emphasizing filter and watershed pixels. The results were far more accurate with this technique.

A relative analysis of different algorithms to detect brain tumor was done by Nailah Afshan et al. [24]. They have compared Fuzzy C-Means clustering, K-Means clustering and histogram thresholding. The results were matched based on area, shape and location of tumor. According to their study the combination of K-Means clustering and Fuzzy C-Means segmentation gave the best results. Histogram thresholding was found to be the most inefficient of all the three methods.

Another comparative approach was adopted by Shobana G et al. [25] for brain tumor diagnosis and detection. They have taken transform techniques, namely, discrete cosine transform (DCT), discrete wavelet transform (DWT) and both independently combined with probabilistic neural network (PNN). Preprocessing of image was done using histogram equalization.

B. Suneetha et al. [26] did an assessment of image processing techniques to identify brain tumor. Their proposed technique uses optimized Kernel Possibilistic C-Means algorithm, Adaptive DW-MTM filter and Repression Neural Network. Their technique has been contrasted with several segmentation and feature extraction techniques. Their method was found to be more effective.
5. Conclusion and Future Work

The finest outcome of tumor detection is achieved by using a proper segmentation and classification technique. This paper gives a review on multiple techniques and their respective algorithms used to detect brain tumor using MRI images. Some automatic detection algorithms came into light, providing better and faster detection. K- Means clustering, Fuzzy C-Mean clustering, neural networks, wavelet transforms and various other methods are discussed. The majority of the techniques gave better accuracy results. The key emphasis in the future should be on developing a lot more precise automatic techniques for brain tumor detection. It saves great amount of time and effort which can be directed towards other productive work.

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