Extraction of Parasagittal Meningioma Tumor using Skull Stripping Method and Multilevel Thresholding

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Abstract. Meningioma is a type of tumor in the Brain that emerges from the layer of tissue known as meninges and surrounds the brain and the spine inside the skull. Parasagittal Meningioma’s appears along the Superior Sagittal Sinus and are attached to the Dura that run between the left and the right sides of the brain. Growth rate for Parasagittal Meningioma’s are slow and might take years before it gets detected but due to its location and the possibility of injuring the Sinus, detection and surgery of Parasagittal Meningioma tumors are complicated. In this paper we propose a simple algorithm to extract Parasagittal Meningioma Tumor from MRI or CT Scanned images using advanced Image Processing techniques.

Keywords: Parasagittal Meningioma Tumor, Skull Stripping, Multilevel Thresholding, Gaussian High-Pass Filtering.

1 Introduction

Brain is the major organ of our body that is composed of nerve cells and tissues that control the main activities of the entire body like movement of muscles, breathing and our senses. Tumor also referred to as neoplasm, are a collection of atypical tissues or cells that can have a rapid growth than normal cells and can be life threatening. Under the skull we have three layers of membranes, Dura Mater, Arachnoid Mater and the Pia Mater, collectively called meninges, which act as a protective tissue for the brain and the spinal cord. Tumor that originates in the meninges are known as Meningioma Tumor. Depending on the location, there are different types of Meningioma. They are: Convexity Meningioma, Falcline Meningioma, Parasagittal Meningioma, Intraventricular Meningioma, Skull base Meningioma, Sphenoid wing Meningioma, Olfactory groove Meningioma, Petrous Meningioma, Suprasellar Meningioma and Recurrent Meningioma [1].

Our Main Focus in this paper is in the extraction of Parasagittal Meningioma Tumor in the Brain from images acquired from digital imaging technologies like CT scan, MRI, etc. Tumors in the brain that are adjacent to the convexity dura and the
falx and are associated with the superior sagittal sinus are known as Parasagittal Meningioma Tumor. Based on their association with sagittal sinus, the parasagittal meningioma tumors are classified into three categories: Anterior, Middle and Posterior. The anterior third spreads from the crista galli to the coronal suture, the middle third of the sinus spreads from the coronal to lambdoid suture and the posterior third spreads from the lambdoid suture to the torcula [2]. The occurrence rate for parasagittal meningioma is 16.8% to 25.6 % [3]. Familiar symptoms are headache, seizures, personality changes and motor weakness. Parasagittal Meningioma tumor can be divided into three types. Type 1, where the tumor is attached to the outer surface of the superior sagittal sinus. Type 2, where the tumor pervades the superior sagittal sinus although the lumen remains patent and type 3 where the tumor invades and cause the occlusion of superior sagittal sinus [4]. Since the superior sagittal sinus allows blood to drain and also helps in venous circulation of the cerebrospinal fluid, it is important to protect the superior sagittal sinus while operating parasagittal meningioma tumor as injuring the sinus increases the mortality rate.

The use of image processing techniques in diagnosing or analyzing biomedical issues are trending and rapidly growing due its ease, accuracy, cost effectiveness and less time requirement in detecting a disease from MRI or CT scanned images as well as other form of images gained from medical imaging technologies. In this paper we have proposed an algorithm that uses many image processing techniques in MATLAB like filtering to reduce noise and sharpen the image. The algorithm determines the threshold value from histogram and uses skull stripping method and other processing techniques in MATLAB to extract Parasagittal Meningioma tumor in Brain. We used the algorithm in 50 MRI and CT Scanned images that included both the presence and absence of parasagittal meningioma tumor. The algorithm demonstrated its efficiency in extracting the tumor accurately and plotting the region boundaries of the tumor. If the image contains any tumor other than parasagittal tumor, the algorithm efficiently delivers the result as the absence of parasagittal meningioma tumor.

2 Literature Review

Meningioma’s are slowest growing tumor and can be divided into three grades. Grade 1 which is benign and has the slowest growth rate, grade 2- atypical which are aggressive and has the risk of recurrence and grade 3 malignant or cancerous which are the most aggressive ones but also the rarest as medical history says only 1% of meningioma’s are malignant [5]. Mostly they are benign. Treatment required for Parasagittal Meningioma Tumors are mostly surgeries and radiation and in less cases when the tumor size is excessively small, it can be treated with medication.

There have been research going on in creating algorithms that could simplify the detection of meningioma’s or any form of tumor in the brain using advanced image processing techniques, artificial intelligence and machine learning. G. B. Praveen and Anita Agarwal in their paper used multi stage classification method and segmentation method for diagnosing brain tumor [6]. Hammad A. Qureshimentioned that there are advantages in histopathological image data than in non-invasive mechanism such as MRI and PET, as histopathology are still more accurate and are available at very high
resolution and have great spatial information. But at the same time Hammad A. Qureshi has mentioned the challenges in meningioma subtype classification as different areas in histological images may have different textural properties which in turn may represent different patterns and hence textural analysis and recognition is not straightforward [7]. In the thesis Hammad A. Qureshi classified Meningioma’s using an adaptive discriminant wavelet packet transformation [7].

O. Wirjadi, Y. –J. Kim, F. Stech, L. Bonfert and M. Wagner developed a Bayesian model for detection and classification of meningioma nuclei in microscopic images. They mentioned in the paper that determining the proliferative potential of the tumor cell nuclei are helpful and algorithms must be adaptable to changing imaging situations and also to changing domains of application without changing the actual algorithm [8].

Robert G. Ojemann wrote that 43 patients with parasagittal meningioma tumor were experimented. In 27 patients only the edge of the sinus was involved but the other 16 patients had extensive involvement of the sinus. Among the 16 patients, 6 patients who had tumor in the anterior third were recovered easily. Among the other 10 patients who had tumor in the middle third, for 2 of them moderate paralysis persisted due to the extreme involvement of the sinus making the operation more complicated [2].

3 Proposed Methodology

In our algorithm we have used Gaussian High Pass Filtering, Histogram, Skull Stripping Method, Multilevel Thresholding, Tracing region boundaries or edge detection and few other image processing techniques to extract Parasagittal Meningioma Tumor in the Brain from MRI or CT Scanned Images.

3.1 Proposed Algorithm

Step 1: Start
Step 2: Read input image (MRI or CT Scanned images)
Step 3: Conversion of original image into Gray Scale Image
Step 4: Gray Scale Image is passed through Gaussian High-Pass Filtering
Step 5: Display the histogram of the non-black pixels
Step 6: Implement Skull Stripping Method using Threshold value from histogram
Step 7: Implement Multilevel Thresholding
Step 8: Plot and extract the shape and the region boundaries of the tumor in the original image
Step 9: According to the Region of Interest (location of Parasagittal Meningioma Tumor)
   Step 9.1: If Parasagittal Meningioma Tumor present
   Step 9.1.1: Display in the message box “Parasagittal Meningioma Tumor Present”
   Else
   Step 9.2: Display in the message box “Absence of Parasagittal Meningioma Tumor”
Step 10: Stop
4 Analysis of the Algorithm

4.1 Read Input image and conversion into gray scale image

Original images like MRI images and CT scanned images are taken as input image (as shown in Fig.1.) with the use of uigetfile function in MATLAB and then these images are converted into gray scale images with the help of rgb2gray function in MATLAB (Fig.2 shows an example). We convert original image to gray scale image to reduce the complexity and work with easier 1D pixel value of a gray scale image.

![Fig. 1. Read input image](image1)

![Fig. 2. Conversion into gray scale image](image2)
4.2 Gaussian High-Pass Filtering

When we subtract the low pass filtering image from the original image we get high-pass filtering image. Gaussian high-pass filtering provides intricate information from the image by sharpening the image (as shown in Fig.3.) and enhancing minute details of the image. On the other hand we don’t receive this information using low pass filtering. Hence Gaussian high-pass filtering helps in extracting the boundaries of the tumor region and to get accurate results.

Fig. 3. Gaussian High-Pass Filtering

4.3 Histogram and Skull Stripping Method

Histograms group data’s into bins and then plot the numeric data. We can modify the aspects of the histogram by changing its property values. Imhist (I,n) in MATLAB calculates the histogram where I specifies the number of bins used in the histogram and n defines the number of color bar displayed at the bottom of the histogram plot [9]. We have displayed the histogram (Fig.4. shows an example) to understand we need to threshold it at what gray level. We have ignored the black pixels to get the histogram of just the non-zero pixels.

Brain contains Cerebral as well as the non-Cerebral Tissues. Non-Cerebral Tissues are the Skull, Cerebrospinal Fluid and the Meninges. Since Meningioma’s or the Parasagittal Meningioma Tumor originates from the Meninges we have developed our algorithm to remove the non-cerebral tissues that are the Skull and the Cerebrospinal Fluid and keep the meninges with the help of the threshold value obtained from the histogram. This helps in the accuracy of detecting whether the tumor is originating from the meninges or not. The process of removing the non-cerebral part from the MRI or CT scanned images is known as Skull Stripping (Fig.4. contains an example).
4.4 Extraction and Displaying the Presence or absence of Parasagittal Meningioma Tumor

Multilevel Thresholding (shown in Fig.5.) has been used where the best threshold is obtained by minimizing or maximizing the criterion and the number of threshold is predefined [10]. Multilevel Thresholding and Threshold Segmentation help in analyzing accurate information by grouping together elements of same characteristics and by extracting the required region of interest.

We have traced the region boundaries and plotted (Fig.6. shows an example) the edges and superimposed it with red color to identify the tumor part in the original image and in the last part we have identified and extracted the location where parasagittal meningioma tumor are situated in and have traced and developed our algorithm to identify whether there is a presence or absence of parasagittal meningioma tumor (as shown in Fig.7.).
5 Analysis of the Result

Table 1 shows an overview of the result acquired from the simple algorithm and the time required to extract the Parasagittal Meningioma Tumor from the MRI or CT Scanned Images. In the below table there are four types of results. First and second shows the presence of Parasagittal Meningioma Tumor. The Third case shows the presence of tumor but the tumor present is not Parasagittal Meningioma Tumor. The Fourth case shows absence of any tumor.
Table 1. Estimated time and analysis of the result

<table>
<thead>
<tr>
<th>Type</th>
<th>Image</th>
<th>Required Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presence of Parasagittal Meningioma Tumor</td>
<td><img src="image1.png" alt="Image" /></td>
<td>14s 38ms</td>
</tr>
<tr>
<td>Presence of Parasagittal Meningioma Tumor</td>
<td><img src="image2.png" alt="Image" /></td>
<td>14s 10ms</td>
</tr>
<tr>
<td>Presence of Tumor but not Parasagittal Meningioma Tumor</td>
<td><img src="image3.png" alt="Image" /></td>
<td>14s 18ms</td>
</tr>
<tr>
<td>Absence of Tumor</td>
<td><img src="image4.png" alt="Image" /></td>
<td>15s</td>
</tr>
</tbody>
</table>

6 Conclusion

Above proposed algorithm could accurately extract the information about the presence or absence of Parasagittal Meningioma Tumor according to the location. The algorithm is cost effective and less time consuming and efficient to display the desired output. Future work would involve the classification of every type of Meningioma Tumor and its related sizes and to display the exact location of these types of Tumor. Future work would also include the rate of involvement of the parasagittal meningioma tumor with the superior sagittal sinus. This could ease the preoperative assumptions and help during the operative period.
References

2. Robert G. Ojemann, M. D.: Congress of Neurological Surgeons Honored Guest Presentation