Pre-Processing Technique for Brain Tumor Detection and Segmentation

Sheela.V.K [1] Dr. S. Suresh Babu,[2]

[1]Research Scholar, Department of Computer Science, Noorul Islam University, Tamilnadu, India

[2]Professor, Department of Electronics and Communication TKM college of Engineering , Kerala, India

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Abstract- Magnetic Resonance Imaging (MRI) is one of the power full visualization techniques, which is mainly used for the treatment of cancer. Magnetic Resonance Imaging is a radiation-based technique which represents the internal structure of the body in terms of intensity variation of radiated wave generated by the biological system when it is exposed to radio frequency pulses. Magnetic resonance imaging is used for the diagnosis of diseases related to soft tissues. When we interpret or inspect brain images, we should be aware of the image contrast, because all the information about the brain is mapped into intensity variation. The presences of materials which can affect the strong magnetic field can produce artifacts and intensity variation in the image. Artifacts are some extra features that are not related to original image. These features are introduced in the image during image acquisition. Artifacts and intensity variation affect the quality of analysis. So we need an efficient rectifying methodology for the removal of artifacts and intensity variation present in the image. Pre-processing techniques makes the image suitable for further processing; it enhances the quality of the image and finally removes the noise present in the Image. Pre-Processing techniques aim the enhancement of the image without altering the information content. Here we discuss most relevant and important pre-processing techniques for MRI images before dealing with brain tumour detection and segmentation.

Keywords: Brain Tumor, Pre-processing, Segmentation, Image re-sampling, Skull Stripping, Contrast Enhancement, Noise Removal, Histogram Equalization

1. INTRODUCTION

Magnetic Resonance Imaging (MRI) is one of the power full visualization techniques, which is mainly used for the treatment of cancer. Using MRI image technology, the internal structure of the body can be acquired in a safe and invasive way. Magnetic Resonance Imaging is a radiation-based technique; it represents the internal structure of the body in terms of intensity variation of radiated wave generated by the biological system, when it is exposed to radio frequency pulses. Magnetic Resonance Imaging is a very useful medical modality for the detection of brain abnormalities and tumor. It does not produce any damage to healthy tissue with its radiation, it provides high tissue information. Brain imaging allows a look into the brain and providing a detailed map of brain connectivity. Other major brain imaging methods are Diffusion Tensor Imaging (DTI), Position Emission Tomography (PET) and Event-Related Potential.

Mainly MRI is used for identify the structural feature of the brain with high spatial resolution. The brain consists of cortical lobes, Sub-cortical structure and different tissues like Gray matter (GM), White matter (WM) and Cerebrospinal Fluid (CSF).

When we interpret or inspect brain image, require careful consideration of the contrast, because all the information about the brain mapped into intensity variation. So we need pre-processing to remove extra marks and labels present in the image. Pre-processing techniques makes the image suitable for further processing, to enhance the image quality and finally pre –processing removes the noise present in the Image.

2. REVIEW ON PRE-PROCESSING TECHNIQUES

The main causes of image imperfections are as follows

1. Low resolution
2. Simulation
3. Presence of image artifacts
4. Geometric Distortion
5. Low contrast
6. High level of noise

The imperfections due to these are normally reduced through pre –processing methodologies.

2.1. Image Re-sampling

Re-sampling is the process which converts the original image to a new image, by projecting, to a new coordinate system or altering the pixel dimensions. By applying geometric correction and translation, the net effect is that resulting redistribution of pixels involves their spatial displacements to new, more accurate relative positions.

Re-sampling is commonly used to produce better estimates of the intensity values for individual pixels. An estimate of the new brightness value that is closer to the new location is made by some mathematical re-sampling technique. Three sampling algorithms are commonly used are, Nearest Neighbor technique, the transformed pixel takes the value of the closest pixel in the pre-shifted array. In the Bilinear Interpolation approach, the average of the intensity values for the 4 pixels surrounding the transformed output pixel is used. The Cubic Convolution technique averages the 16 closest input pixels; this usually leads to the sharpest image.

2.2. Gray Scale Contrast Enhancement

The aim of contrast enhancement is to improve the interpretability or perception of information in images for preparing the image suitable for further processing like image understanding and interpretation.

Contrast enhancement process is used to make the image brighter, to improve the visual details in the image. Contrast Enhancement is mainly categorized into two groups; they are direct methods and indirect methods. In the case of the direct method of contrast enhancement, a contrast measure is first defined, which is then modified by a mapping function to generate the pixel value of the enhanced image. On the other hand, indirect methods improve the contrast by exploiting the under-utilized regions of the dynamic range without defining the image contrast term.

Indirect methods can further be divided into several subgroups

1. Decompose an image into high and low-frequency signal e.g., homomorphic filtering,
2. Histogram modification techniques.
3. Transform-based techniques.

Contrast stretching also known as normalization is a simple image enhancement technique that attempts to improve the contrast in an image by `stretching' the range of intensity values.

2.3 Noise Removal

Each imaging modality has many physical parameters that determine the visibility and sharpness of image. These are determined by spatial resolution and the clarity of boundaries. Both spatial resolution and contrast rendition are affected by noise.

There are several de-noising algorithms exists for noise removal each algorithm have its own advantage and disadvantage. Linear filters like Gaussian and wiener filters are conceptually simple, but I they degrade the details and the edges of the images. Therefore the de-noised image would be blurred. Markov Random Field method is robust against noise and preserves the fine details in the image, but Markov random field algorithm implementation is complex and time consuming. In the case of high redundancy images, using non –local methods we can remove the noise but it eliminate non-repeated details. Maximum likelihood estimation is another method of noise removal by adopting different hypothesis, but it does not retain the edge details.

2.4 Mathematical Operation

Mathematical Morphology based on set theory, which is applicable to binary images as well as grey scale images. Morphology is an image processing, technology that process images supported on shapes. There are four basic operations of mathematical morphology

1. Dilation
2. Erosion
3. Opening
4. Closing.

Dilation is defined as the maximization value in the window. Hence, the image after dilation will be brighter or increased in intensity. It also expands the image and mainly used to fill the spaces. Erosion is just opposite to dilation. It is defined as the minimization value in the window. The image after dilation will be darker than the original image. It shrinks or thins the image. Opening and closing both parameters are formed by using dilation and erosion. In opening, the firstly image will be eroded and then it will be followed by dilation. In closing, the first step will be dilated and then the result of this is followed by erosion [4].

2.4.1 Dilation Operation

Dilation operation is one of the bases of morphology processing. Dilation is the operation of "lengthening" or "thickening" in a binary image. This special way and the extent of thickening are controlled by structural elements. Mathematically, dilation is defined as set operation. A is dilated by B, written as A_B, is defined as [1] $A \oplus B = \{z \mid (\hat{B}) \cap A \neq \varphi\}$ among them, φ is for the empty set, B is for the structure element, and $\hat{B}$ is for the reflection of collection B. In short, that A is dilated by B is the set composed of the origin positions of all structural elements. After mapping and translation, B at least has one overlap with A [1][5].

2.4.2 Erosion operation

Erosion operation is also one of the bases of morphological processing. Erosion "shrinks" or "thins" the objects in the binary image. As in the dilation, the way to shrink and the extent is controlled by a structure element. The mathematical definition of erosion is similar to dilation A is eroded by B, recorded as AΘ B and defined as [1] A ΘB = {z |(B)z ⊆ A} Among them, φ is for the empty set, B is for the structural element, and Ac is in the supplement of collection A. In another word, that A is eroded by B is the set composed of the origin positions of all structural elements, in which the background of translation B does not overlay on A's [1][5].

2.4.3 Operations of opening and closing

Opening operation generally makes the contour of objects smoother and disconnects narrow, discontinuous and removes thin protrusions. Similarly with opening operation, closing operation also makes an outline smooth, but the opposite is that it usually eliminates discontinuity and narrows long, thin gap, clears up small holes, and fill the ruptures of the contour line [1]. Ao B = (AΘB)⊕ B As the same case with binary image, opening operation first using b to erode f plainly, and then using b to do dilate operation on the results obtained [1][5].

Closing and opening operation

Also, using B to do closing operation on A, expressed as

A• B definite as [1]

A• B = (A⊕ B)ΘB

A• B is a complement of all translation union of B that do not overlap A.

Pre-Processing techniques mainly aimed for the enhancement of the image without altering the information content in an image. In this paper, we implement a pre-processing method for the enhancement of brain tumor MRI image without altering image content and make suitable for further processing.

3. PROPOSED PRE-PROCESSING METHODS

The pre-processing of the input MRI image is carried out using three techniques of RGB to grey conversion, skull strip removal and histogram equalization.

3.1. Conversion to Grayscale

Image obtained after scanning, usually in RGB (Red, Green and Blue) color format. The image contain three independent planes namely Red, Green and Blue components. In the case of RGB image, pixel intensity represented by the combination of these three plane intensity values. In the case of greyscale image pixel values represented by the intensity values ranges from 0 to 256. Grey scale image ranging from black to white with different shades of grey. Light intensity at each pixel in greyscale image lies in single band of electromagnetic spectrum.

Conversion of a color image to greyscale is done with the help of different weighting to the color channels red, green and blue to effectively represent the effect of shooting black-and-white film with different-colored photographic filters on the cameras [6]. Similarity between the RGB image and greyscale image is that match between the luminance of the greyscale image and RGB image... For the conversion of the image, representation of its luminance, add with 30% of the red value, 59% of the green value, and 11% of the blue value of the RGB image.

3.2. Skull Stripping

Skull striping refers to the removal of non-brain structure and unwanted portions of image from scanned image to have the required image for tumour detection. Scanned image consists of brain area, scalp, skull and dura. The unwanted portions can be separate with the aid of rim of cerebrospinal fluid (CSF) .Skull removing can be done with the help of intensity thresholding followed by morphological operation to obtain required brain area for tumor detection. Let the input image can be represented by an array of pixels, which hold the values of intensity at corresponding positions in an image.

Let Ip={ Ip1, Ip2................................Ipn}

Where Ip1..... Ipn represents the intensity values of pixels 1 to n.. And np – represents total number of pixels in an image. Let intensity threshold set to be T, and the condition for removal of pixels from the image is that, those pixels having intensity less than threshold T. Usually those pixels satisfying this condition would represent the narrow connections. The method is such that it satisfies two conditions. One is that the brain should be weakly connected to non-brain structures. The second is that the mask produced by intensity thresholding should preserve as much brain as possible. The selection of threshold value is critical in this scenario because, if threshold values if set too low may lead to the inclusion of dura, which is not desirable. Too high threshold values can provide a clearer demarcation between the brain and non-brain structures but at the expense of brain erosion. Hence, the threshold should be set at an optimum level so as to yield good results.

After intensity thresholding, we have the required brain image, which must be enhanced so as to make it fit for tumor detection technique. For this, we make use of morphological operations. It also assists in the removal of narrow connections.

3.3. Histogram Equalization

Histogram is a graphical representation of tonal distribution in a digital image. It contains number of pixels for each tonal value. Histogram equalization refers the process to improve the dynamic range of the histogram of the image, to obtain output image with a uniform distribution of tonal values. This process improves the contrast of the image which will improve the feature extraction [7].

Let be a given image represented IM as an Imr X Imc matrix of integer pixel intensities ranging from 0 to N-1. Here, N is the number of possible intensity values and 256 in case of gray-scale images. It can be defined as

$$p_n = \frac{\text{number of pixels with intensity } n}{\text{total number of pixels}}$$

The histogram equalized image f will be defined by;

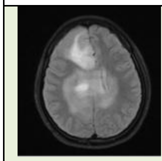
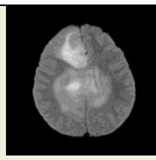
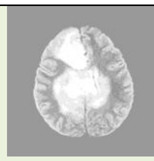
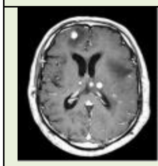
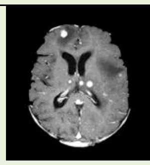
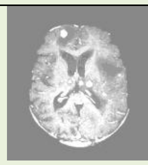
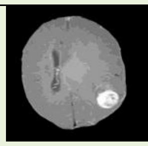
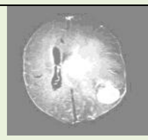
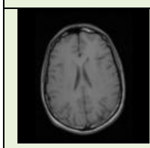
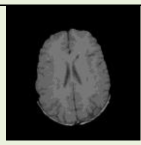
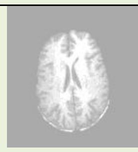
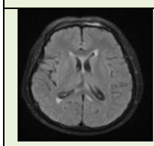
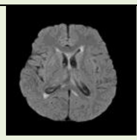
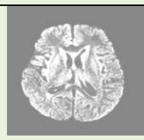
$$f_{jk} = floor\left((N-1)\sum_{n=0}^{f_{jk}} p_n\right)$$

Where, floor () rounds down to the nearest integer.

4. RESULT AND DISCUSSION

Image pre-processing makes a major role in the field of image analysis. In this section, we present experimental results from real MR brain images using Skull Stripping & Histogram Equalization. The proposed technique is designed for supporting the tumor detection in brain images with tumor and without tumor. The obtained experimental results from the proposed technique are given in the table1. Table 1 shows the original image, image after stripping skull and enhanced using histogram equalization.

Table1: Input image, image after stripping skull and enhanced using histogram equalization.

Input Image	Image after Skull stripping	Image after Histogram Equalization
		
		
		
		
		

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BIOGRAPHIES

Dr.S Suresh Babu received his B.Tech degree in Electronics & Communication Engineering from the university of Kerala. M Tech in Computer Science & Technology from IIT Roorkee and Ph.D in IT enabled services from PSG College of Technology. He has served as Principal to College of Engineering, Chengannur, College of Engineering, Munnar, T K M Institute of Technology, Kollam and T K M College of Engineering, Kollam. His research interests are in IT Enabled Services, Image Processing, and Mobile & Ad-hoc Networks. He is a reviewer and Editorial Board member of many international journals/conferences. He is a member of PG Board of Studies at various universities like MG, Kerala and Cochin University of Science & Technology (CUSAT). He is a member of various technical bodies and committees like Standing Appellate Committee (SAC) of AICT, ISTE, IEEE, Computer Society of India (CSI), Quilon Management Association (QMA), Solar Energy Society of India.

Sheela.V.K : Received her B.Tech degree in Electronics & Communication Engineering from University of Calicut in 1998, M Tech in Computer Science from Kerala university in 2007 , Research Scholar under the department of Computer Science in Noorul Islam University , Tamilnadu. India