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Error minimization in Brain tissue extraction for T1 weighted MR images

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ABSTRACT: In the current paper, a simple algorithm is proposed that employs an efficient and unique histogram analysis. A fundamental component of this analysis is an algorithm that partitions a histogram based on the position of the maximum deviation from a Gaussian fit. In the first step, the proposed partitioning algorithm is applied to delimit the highest peak in the gray-level histogram, aiming at identifying and discarding the background region. In the second step, Gaussian distribution is applied twice to the histogram of the head. The goal is to find two thresholds that encompass the gray-level range of the brain tissues and partition the histogram into two regions. A rough binary mask is then generated. Finally, a sequence of binary morphological operations is applied to the mask in order to completely isolate the brain. The significance of the work lies in the fact that it can successfully remove the unwanted regions found in Otsu's method.

I. INTRODUCTION

Ever since the technological development started, efforts were always made towards bringing these developments into day to day life. Many algorithms were designed which can make the analysis of real life problems such that solutions can be easily derived. Several modalities were defined and developed in the field of medical imaging particularly. Magnetic Resonance imaging (MRI) is one of the powerful imaging techniques developed to study the structural features and functional characteristics of internal body parts. One of the most important stages in medical image analysis is segmentation of the object of interest or definition of their contours. Accurate segmentation of human brain MR image serves a key role in clinical diagnosis. It is very much useful in brain tissue classification, detection of tumors, identification of anatomical structures as well as identification of various cognitive disorders. Manual segmentation is time consuming and is not accurate due to human errors. Further manual segmentation suffers from inter as well as intra rater variability. To reduce the work and increase reproducibility, several semi or fully automated methods were developed. Even though much research has been carried out in this regard, no method has established itself universal for various applications.

Over the decades, brain extraction has been one of the major preprocessing phases in brain imaging applications and for further analysis of MR brain images. Brain extraction, most famously referred as skull stripping refers to the removal of non cerebral tissues such as skull,scalp,vein or meninges. Brain extraction, is generally a difficult task, as the boundaries between brain and non brain tissues, especially those between the gray matter and the dura matter, are not clear in MR images. This preprocessing step necessitates manual intervention as any error introduced in this step will propagate to further analysis steps. Any brain extraction algorithm should be robust in regard to variability of imaging characteristics. Thus, the choice of a skull stripping technique should be determined based on the subsequent processing requirements of the data. Unfortunately, there are no studies detailing how a raters or algorithms bias may influence a Neurological Image Processing.

In this paper, a new algorithm is proposed based on the probability distribution of pixels with reduced morphological operations. In section II a brief overview of existing methods is presented.The proposed algorithm was

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elaborated with an emphasis on theoretical background in section III.The test images along with step wise results obtained were explained in section IV.The paper ends with concluding about the significance of the work.

II. Related work

Till date, the brain/non brain segmentation techniques are broadly grouped into four fundamental classes Morphometry based, Atlas based, Deformable surface based as well as Hybrid approaches. The problem of brain/non-brain segmentation, referred as brain extraction, can be a subset of structural segmentation. It is an image-processing problem where a semi global understanding of the image is required as well as a local understanding. In clean images with clean sharp corners, a good solution may be found by applying small locally acting operators to the image. In the presence of large amounts of noise, or if it is required to find less sharp corners, however, a larger-scale view must be taken.

Morphological based methods [9][10] particularly region based methods, generally require manual intervention to define initial thresholds. These methods directly explore the spatial coherence of the images. White matter andgray matter tissues form a compact block in the centre of the volume: the brain. Normally, no other block of tissue in the head is larger than the brain. Considering this, region-based methods first create a rough binary mask, attempting to set most of the brain's voxels as foreground. To carry this out, usually gray- level thresholding and edge-detection are used. In the sequence, the region of the brain is separated from surrounding structures using binary mathematical morphology. Automatic identification of two seed regions using a mask produced by morphological operations is done in [1].The seed regions are further expanded with 2 D region growing algorithm based on brain Anatomy. A single 3D water shed transform based method which is simple and robust is described in [2]

Atlas-based (i.e., template-based) methods use an expert defined segmentation on an atlas space as a prior for extracting the brain on the target image. Some methods use an affine registration while other methods use elastic registration techniques. A voxel analysis of training data from Atlas was performed in [3] to produce better result for given voxel. The constraints of different acquisition protocols as well as various algorithms not yielding unique results were better handled by this algorithm. A study specific template selection strategy is proposed in [4], where the set of templates are so selected that they represent the anatomical variations in the data set. It suffers from the drawback that the masks generated must be carefully inspected and corrected. Further it requires updating of final post processing steps.

A specific surface is evolved using various forces to find the brain in deformable approaches. This approach is basically data driven with the complexity of guessing the initial surface.A fast as well as robust brain extraction algorithm using this approach was proposed in [5].It uses a model that applies a set of locally adaptive forces to accurately estimate brain tissues. Deformation of triangular tessellation of a sphere's surfaced is involved to achieve the required task. Control processes such as sensing, proactive planning, reactive behaviour, and knowledge representation are used in [6]. It further uses machine learning method to make the process more accurate.

Hybrid approaches are combination of other approaches by incorporating additional elements based on the necessity. Localization of a single white matter voxel and creating a global minimum using it in the white matter before applying a watershed algorithm with a preflooding height is proposed in [7].Building an initial estimate performs well to deal with impact of intensity non uniformities and noise, it may remove parts of cerebellum. A surface deformation process corrects these inaccuracies.

III. Proposed algorithm

It is known that histogram can be considered as a graphical representation of tonal distribution in digital images. Various objects or sub structures in an image can be distributed at various levels in a given histogram. If the distribution as well as the location of separation is known, objects can be easily discriminated and extracted. This fundamental concept is taken and further modified in the current algorithm. The proposed algorithm is largely depends on the probability distribution of brain tissues and simple morphological operations. Various processes involved are briefly explained in the subsections given below.

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A.Threshold selection

The significance of this step is to separate the desired region from unwanted portions. Either it can be back ground including noise or the brain tissues, proper selection of threshold plays key role. The concept is not new [8], but it's greatness lies in the fact that it can effectively remove the portions that were extracted in other methods et.al Otsu's method. It involves obtaining the peak difference between probability distribution and normal distribution fit of the given image. This is required as there is need to find the location of separation between both the peaks. The normal distribution fit to the Histogram can be defined as

$$H'(x) = \frac{1}{\sqrt{2\pi\sigma^2}} exp(\frac{-(x - \mu)2}{2\sigma^2})$$

Where is the mean and σ^2 is the variance. This step of selection of threshold and isolating the regions of interest is carried out at multiple levels.Once the noise as well as background are removed, the brain tissues are derived by iteratively choosing the upper and lower limits that encompasses the desired region. This can also be done by approximately considering a fraction of area under the distribution curve for upper limit and remaining portion for the lower limit[8].The area or the range of pixels that exist between the two thresholds is the rough binary mask of the brain tissues.

B.Holefilling :

A holemay be defined as a background region surrounded by a connected border of foreground pixels. Let A be a set whose elements are 8-connected boundaries with each boundary enclosing a background region (a hole). Given a point in each hole, the objective is to fill all the holes with ones (for binary images). Initially, an array X_0 of zeros is formed having same size as the array containing A, except at the locations in X_0corresponding to the given point in each hole, which is set to one. The hole filling process is carried out as given below.

$$X_k= (X_{k-1} \oplus B) \cap A^c$$

The algorithm terminates at the iteration step k if $X_k = X_{k-1}$. The set $X_k$then contains all the filled holes; the union of $X_k$and A contains all the filled holes and their boundaries. The dilation would fill the entire area if left unchecked. However, the intersection at each step with the complement of Alimits the result to inside the region of interest. This is an example of how a morphological process can be conditionedto meet a desired property.

C.Morphological image processing:

It is a collection of non-linear operations related to the shape or morphology of features in an image. Morphological operations rely only on the relative ordering of pixel values, not on their numerical values, and therefore are especially suited to the processing of binary images. Morphological operations can also be applied to grayscale images such that their light transfer functions are unknown and therefore their absolute pixel values are of no or minor interest.

Morphological techniques probe an image with a small shape or template called a structuring element. The structuring element is positioned at all possible locations in the image and it is compared with the corresponding neighborhood of pixels. Some operations test whether the element "fits" within the neighborhood, while others test whether it "hits" or intersects the neighborhood

1) Erosion and dilation:

The erosion of a binary image f by a structuring element s (denoted f $\ominus$ s) produces a new binary image g = f $\ominus$ s with ones in all locations (x,y) of a structuring element's origin at which that structuring element s fits the input image f, i.e. g(x,y) = 1 is s fits f and 0 otherwise, repeating for all pixel coordinates (x,y).

Erosion with small (e.g. 2×2 - 5×5) square structuring elements shrinks an image by stripping away a layer of pixels from both the inner and outer boundaries of regions. The holes and gaps between different regions become larger, and small details are eliminated. Larger structuring elements have a more pronounced effect, the result of erosion with a large structuring element being similar to the result obtained by iterated erosion using a smaller

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structuring element of the same shape. If s_1 and s_2 are a pair of structuring elements identical in shape, with s_2 twice the size of s_1, then

$$f \ominus s_2 \approx (f \ominus s_1) \ominus s_1.$$

Erosion removes small-scale details from a binary image but simultaneously reduces the size of regions of interest, too. By subtracting the eroded image from the original image, boundaries of each region can be found: $b = f - (f \ominus s)$ where f is an image of the regions, s is a 3×3 structuring element, and b is an image of the region boundaries.

The dilation of an image f by a structuring element s (denoted $f \oplus s$) produces a new binary image $g = f \oplus s$ with ones in all locations (x,y) of a structuring element's origin at which that structuring element s hits the input image f, i.e. g(x,y) = 1 if s hits f and 0 otherwise, repeating for all pixel coordinates (x,y). Dilation has the opposite effect to erosion -- it adds a layer of pixels to both the inner and outer boundaries of regions.

IV. SIMULATION RESULTS

The efficiency of the algorithm was initially validated on Sagittal section of T1 weighted MR image as shown in Fig 1. At first, histogram partitioning technique is applied on the input image from which a threshold is obtained to remove the back ground. This is helpful in removal of noise if any from the MR image and also to know the pixel values of the Head.

After extracting the Head portion, next step is to remove non brain tissues like skull , eyes etc…This step is achieved by considering the significant portions of Head Histogram.

Histogram partitioning is again applied to obtain two thresholds that encompasses the brain region.Various morphological operations as per our algorithm, are applied to obtain the mask. The results obtained in various steps are as shown in the Figures below. The maskrequired to for eliminating non brain tissues is shown in fig 2(a).In addition, this encompasses all the processes involved. Once the mask is obtained, the brain can be extracted easily as shown in figure 2(b).This extracted brain can be used for further analysis like diagnosing different diseases like Brain tumours, Alzheimer's, epilepsy, schizophrenia, multiple sclerosis (MS) etc. Fig 3 shows a comparison between Otsu's method and current method. . Otsu's method selects threshold by minimising the within class variance of two groups of pixels, which is not suitable for all applications. In Fig 3(a) the Head portions were wrongly included using the prominent Otsu's method. Fig 3 (b) shows how the current algorithm can successfully eliminate the erroneously classified regions. Our algorithm was later applied to Axial view of the brain MR image and results were obtained which are on par with Sagittal section. The original axial image is shown Fig.4 and various steps involved in the generation of mask are shown in Fig. 5(a). The head histogram obtained as well as peak and valley points are completely differ from those for Sagittal section. The extracted brain region obtained with the help of brain mask is shown in Fig.5 (b).Any way the current work is restricted to comparing the results with Otsu's method for Sagittal section only.

Fig 1

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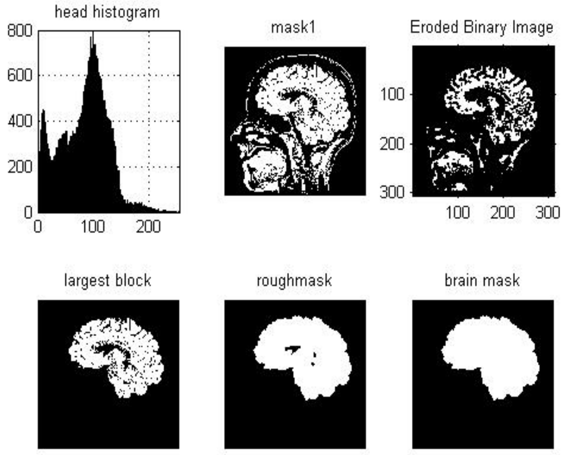

Fig 2.(a)Various steps involved in the mask generation (b)Extracted brain from the Sagittal section

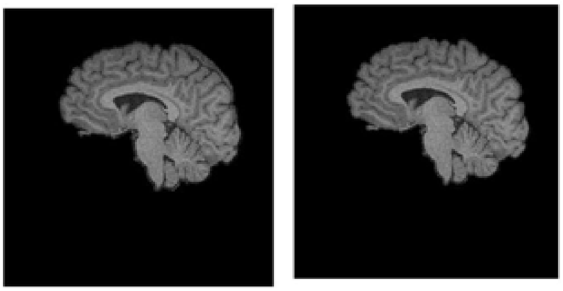

Fig3.Extracted Brain using a) Otsu’s method b) Proposed method

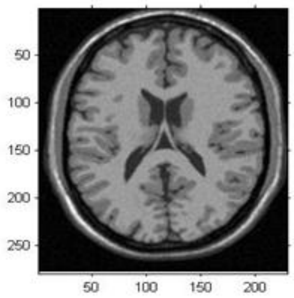

Fig4

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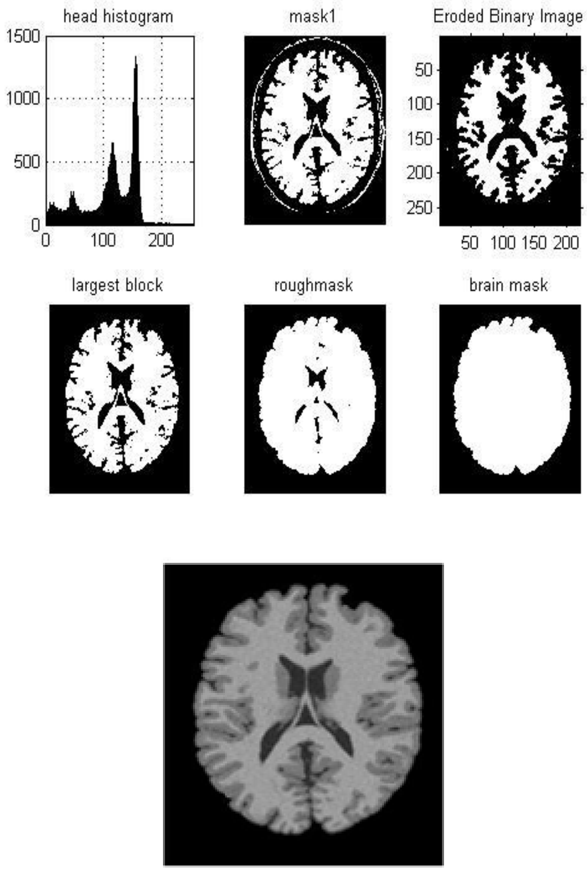

Fig.5(a) Various steps involved in the mask generation (b)Extracted brain from the Axial section

V. CONCLUSION

Skull stripping methods are designed to eliminate non-brain tissue in magnetic resonance (MR) brain images. This is a fundamental step for enabling processing of brain MR images. The aim of this project is to develop a new skull stripping method based on two steps: the first one a pre-segmentation that employs thresholds and morphological operators. This is achieved through a new technique of histogram partitioning and a new histogram analysis for finding the gray- level range of the brain tissue. An efficient method for medical image segmentation can be both a direct tool for a physician and part of a more complex image feature extraction pipeline. The importance of developing new and competitive solutions in this area arises from the ever-increasing amount of clinical data acquired daily in hospital and medical centres, and the possibility of extracting statistically relevant information from this data to be used directly in medical research. The proposed algorithm can be best used as a tissue classifier and can be a fundamental preprocessing step in MR image analysis.

REFERENCES

1. Jong Geun Park, ChulheeLee,"Skull stripping based on region growing for magnetic resonance brain images, NeuroImage,Volume 47, Issue 4, 1 October 2009, Pages 1394–1407
2. Horst K. Hahn and Heinz-Otto Peitgen,"The Skull Stripping Problem in MRI Solved by a Single 3D Watershed Transform" Proc. MICCAI, LNCS 1935: 134-143, Springer, Berlin, 2000.
3. Rex DE, Shattuck DW, Woods RP, Narr KL, Luders E, Rehm K, Stoltzner SE, Rottenberg DA, Toga AW," A meta-algorithm for brain extraction in MRI", Neuroimage. 2004 Oct; 23(2) : 625 - 37.
4. J Doshi, G Erus, Y Ou, B Gaonkar, C Davatzikos, "Multi-Atlas Skull Stripping". Academic Radiology, 20(12): 1566-1576, ,2013
5. Stephen M. Smith," Fast Robust Automated Brain Extraction", Human Brain Mapping " 17:143–155 ,2002

6. Gautam Prasad, Anand A. Joshi, Albert Feng, Arthur W. Toga, Paul M. Thompson, "Demetri Terzopoulos,Skull-stripping with machine learning deformable organisms", Journal of Neuroscience Methods 236 (2014) 114–124
7. F. Se´gonne, A.M. Dale,E. Busa,M. Glessner,D. Salat, H.K. Hahn,and B. Fischl." A hybrid approach to the skull stripping problem in MRI" , NeuroImage 22 ,2004, 1060– 1075
8. Andre´ G.R. Balan , AgmaJ.M.Traina , MarcelaX.Ribeiro, PauloM.A.Marques, CaetanoTrainaJr,, "Smart histogram analysis applied to the skull-stripping problem in T1-weighted MRI", Computers in Biology and Medicine 42 (2012) 509–522
9. Gambino O1, Daidone E, Sciortino , M, Pirrone R, Ardizzone E, Automatic skull stripping in MRI based on morphological filters and fuzzy c-means segmentation, ConfProc IEEE Eng Med Biol Soc. 2011;2011:5040-3.doi:10.1109 IEMBS . 2011.6091248.
10. Benson, C.C. ; Dept. of Comput. Sci., Univ. of Calicut, Calicut, India ; Lajish, V.L., "Morphology Based Enhancement and Skull Stripping of MRI Brain Images", International Conference on Intelligent Computing Applications (ICICA), 254 – 257, 2014