Efficient Way of Skull Stripping in MRI to Detect Brain Tumor by Applying Morphological Operations, after Detection of False Background

Sajjad Mohsin, Sadaf Sajjad, Zeeshan Malik, and Abdul Hanan Abdullah

***Abstract*—Brain MRI is used to get deeper view of the brain conditions. Skull stripping is a major phase sometimes refers to a pre-process in MRI brain imaging applications which refers to the removal of brain non-cerebral tissues. Various algorithms have been developed to improve the effectiveness of stripping skull from MRI. Morphological algorithms of "Erosion" and "Dilation" are recursively applied together to remove the skull. Besides the removal of skull, "erosion" distorts some cerebral tissues due to the presence of false-background. So "Dilation" process is applied for the restoration. In this study, we improved the efficiency of stripping skull in MRI using systematic application of "Erosion" with AOI (Area of Interest) approach after the detection of false-background. Before applying "Erosion", a false back ground is detected. We identified the skull boundary through Dilation and then used scan line algorithm to fill the false background area. Consequently "Erosion" algorithm will only erode the AOI, resulting in the stripping of skull without any effect on the other tissues of the brain. Results show that the accuracy rate up to 95% is obtained and 43% efficiency is increased as compared to the different morphological techniques used previously.**

***Index Terms*—Skull stripping, AOI (area of interest), erosion, false background, dilation, morphology, MRI**

I. Introduction

MRI (Magnetic Resonance Imaging) is a procedure used in hospitals to scan patients and determine the severity of certain injuries. An MRI machine uses a magnetic field and radio waves to create detailed images of the body. In MRI image processing, a lot of research has been done and still in progress for making it more effective and efficient. Whole brain segmentation is often regarded as an essential step in a neurological Image processing pipeline, because the subsequently performed steps benefit from the fact that only a small set of well known tissue types is left over (i.e. White Matter, Gray Matter, CSF and possibly tumor).Usually the major objective of these operations is to detect and extract tumor from the MRI. Besides the detection of tumor, finding accurately white matter signal abnormalities requires segmentation [2]. Numerous segmentation techniques have been developed [3-6]. However, process of segmentation is distorted by the presence of non-brain tissue [7, 8]. For brain warping techniques, that is used to perform inter-subject studies; it is as well enviable to exclude all non-brain tissue from the matching process [9].

Manuscript received May 22, 2012; revised June 15, 2012.

S. Mohsin, S. Sajjad and Z. Malik are with COMSATS Institute of Information Technology, Pakistan (smohsin@comsats.edu.pk).

S. Sajjad and A. H. Abdullah are with University Technology Malaysia, Malaysia.

Skull stripping in Brain MRI is very significant phase. Various literature upon the techniques used for brain skull stripping has been studied and written in [10].

A technique that is to be used must be effective, efficient, reliable and fully automated. Different techniques have been developed and every technique has its own pros and cons. Some techniques are effective but very inefficient and vice versa. But the morphological techniques (Erosion and Dilation) used in [1] is an effective and fully automated but inefficient way of stripping skull. Erosion and Dilation are two basic operators in the area of mathematical morphology. These typically applied to binary images, but there are versions that work on grayscale images. As erosion is a technique which uses background and the foreground for the processing. In Brain MRI there is a particular intensity of the back-ground that appears before brain image. Unfortunately in brain MRI, the same intensity is appeared as a part of the brain. And this appearance is a false background. So in this scenario that algorithm would be unable to distinguish between the original back ground and the false background. Eventually the area around the false background will also be eroded, which causes distortion in the brain tissues along with the skull as shown in Fig. 1

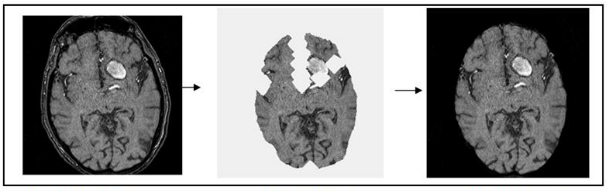

Fig. 1. Conventional MRI skull removing result

No doubt, the information that is lost during the process of "Erosion" can also be restored by applying "Dilation" recursively. An experiment shows that almost 15 to 20 iterations of "Erosion" and same iterations for the "Dilation" are required upon an MRI for skull stripping. But distortion and then restoration results in extra processing. By applying erosion along with additional technique, which differentiates the false background with the original background, can make skull stripping more efficient. The basic idea is to erode the AOI. In this way distortion of the cerebral tissue is prevented and consequently the restoration processing can also be saved. By preventing "Erosion" to be performed at regions of false background, recursive "Dilation" upon these regions will be no more required. And there are a lot of MRI images, from where the skull has to eradicate. So at each iteration (performed at a particular MRI Image) a lot of processing can be saved.

II. Design and Implementation

Contributions Due to the false background problem, extra processing takes place. But after merging some additional techniques we can make this process works correctly. This algorithm can produce required results very efficiently, if it could differentiate between the real back ground and the false background.

Let *U* = set of all pixel values of the Original Image at [*x*, *y*]

O = set of all pixel values of brain object at [*x*, *y*]

Back = set of all pixel values Original background

As it is discussed that the value similar to the background with in the Boundary of the skull is a false background. Now if these values can be changed before the process of erosion then our goal can be achieved. The first thing is to identify the area where the false background is appeared. This is done by applying the "Dilation" only at once. It will detect the boundary as shown in Fig. 2

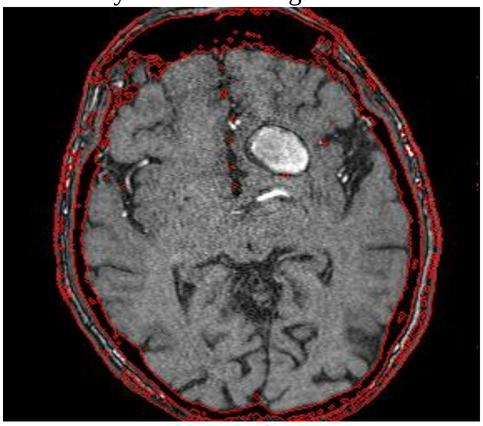

Fig. 2. Dialation

Now we fill those false points with the help of scan-line algorithm as shown in Fig. 3

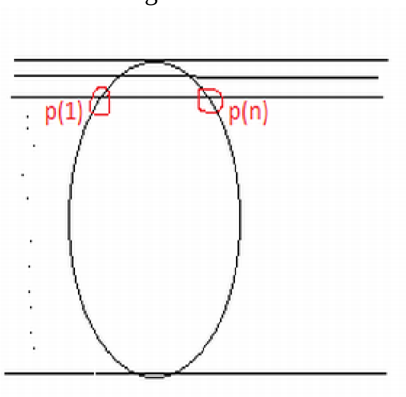

Fig. 3. Scan line

Let c be the color that is not a part of the brain MRI image and b is the color that is appeared as a boundary (i-e in Fig 3, it is red), As it is seen in fig, there are some spots of the color "b" (red), which shows the presence of false back ground, also the area between the skull and the brain is also a false background. Using the algorithm below, we will be able to fill those false points with the color which is not present in the MRI Image.

For a given pair of intersection points

p(*1*) = (X_i, *Y*) i.e. the first point of intersection

p(*n*) = (X_i, *Y*) i.e. the last point of intersection

let f_b=background-color

For $y = y_{min}$ to y_{max}

{

Intersect scan-line *y* with each edge

for *x* = p(*1*) to p(*n*)

Pix=Getpixel(*x*,*y*)

IF (pix== f_b)

Putpixel at that point of line *pf* color b

Else

Leave the original pixel as it is

}

In this way all points of false the value of false back ground changed from "f_b" to "b". Eventually the original background and false background are distinctive. Now we need to just apply "Erosion". The last step is to restore the original value of "f_b" by replacing it with "b" and results as shown in Fig. 4 can be produced.

III. Results

No doubt the desired results can be achieved with the morphological processes of "Erosion" and "Dilation" to remove skull [1], but cost and processing time is not efficient, which can be minimized by adopting the approach discussed in this paper.

Fig (1) shows the image having skull stripped after the process of "Erosion" and "Dilation". To remove skull two processes are involved, which are recursively performed, taking much time.

If going with the approach of differentiating the false background with the help of scan line algorithm similar results can be achieved with significant improvement in efficiency. After detecting the brain object by applying the "Dilation" process just at once as shown in Fig (2) and false background detection with the help of altered scan-line algorithm, the "Erosion" can produce the result as shown in fig (3), where no information is lost. And in this way recursive "Dilation" on an image is certainly not required, which is 50 percent of the total processing in stripping skull [1].Single iteration of "Dilation" for detecting boundary and scan-line algorithm for the detection of false-background combines together to take 14 percent of the total time as compared to the process of recursive "Dilation" in [1]. In this way of skull stripping, 43 percent efficiency is increased with accuracy up to 95 percent. (Table I and II), as well as there is no lost of information as shown in fig. 4.

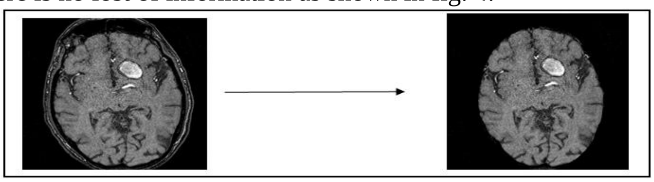

Fig. 4. Proposed technique result.

Following tables are showing the time of the skull stripping upon 32 bit images

TABLE I: SHOWING THE PROCESS FOR SKULL STRIPPING USED IN [1]

Process	Time per iteration(sec)	Iterations (i)	Number of images n	Time for n images (let n=100)
Erosion	.7	15	100	1050
Dilation	.7	15	100	1050
Skull stripping	1.5	30	100	2100

TABLE (2) REPRESENTS THE RESULTS AFTER APPLYING THE PROPOSED METHOD

Process	Time per iteration(sec) t	Iteration i	Number of images n	Total=n*i*t (sec)
Dilation	.7	1	100	70
Filling false background	.8	1	100	80
Erosion	.7	15	100	1050
Skull stripping	2.2	17	100	1200

These tables clearly shows that almost 43 percent optimization can be achieved.

IV. CONCLUSION AND FUTURE DIRECTIONS

Applying erosion at AOI brings out significant results. This technique produces robust, accurate and fully automated skull stripping as compared to other techniques. Being a preprocess, it will increase the performance of Medical MRI imaging. Future work involves symmetric way of stripping the skull by altering some existing algorithms and finding more efficient and effective approaches for stripping skull.

ACKNOWLEDGEMENTS

The authors acknowledge ICT R and D Funds, Ministry of IT, Government of Pakistan for generously funding the project “3D Graphical Imagery Therapy for Healing Brain Tumor in Children”. This paper is among the series of researches being done under this project. The authors will also like to acknowledge the Higher Education Commission (HEC) of Pakistan for the funding provided to the authors for registering and presenting this paper to the conference.

REFERENCES

[1] M. M. Ahmed and D. B. Mohammad, *Segmentation of Brain MR Images for Tumor Extraction by Combining K-means Clustering and Perona-Malik Anisotropic Diffusion Model*.

[2] Comprehensive Brain MRI Segmentation in High Risk Preterm Newborns http: plosone. [Online]. Available::/www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0013874

[3] S. Koompairojn, A. Petkova, K. A. Hua, and P. Metarugcheep, Semi-Automatic Segmentation and Volume Determination of Brain Mass-Like Lesion , 2008.

[4] M. Sezgin and B. Sankur, “Survey over image thresholding techniques and quantitative performance evaluation," J. *Electron. Imaging*, vol. 13, no. 1, pp. 146-165, 2004.

[5] P. Zhigeng and L. Jianfeng, "A Bayes-Based Region-Growing Algorithm for Medical Image Segmentation," *Computing in Science and Engineering*, vol. 9, no. 4, 2007.

[6] H. Khotanlou, O. Colliot, J. Atif, I. Bloch, 3D brain tumor segmentation in MRI using fuzzy classification, symmetry analysis and spatially constrained deformable models, 2008.

[7] W. M. Wells, W. E. L. Grimson, R. Kikinis, and F. A. Jolesz, “Adaptive Segmentation of MRI data,” *IEEE Trans. Med. Imaging* vol. 15: pp. 429-443, 1996.

[8] F. Maes, K. V. Leemput, L. E. DeLisi, D. Vandermeulen, and P. Suetens, “Quantification of Cerebral Gray and White Matter Asymmetry from MRI” Proc. Medical Image Computing and Compter-Assisted Intervention MICCAI '99, Cambridge. Springer LNCS, vol. 1679, pp. 348-357, 1999.

[9] T. AW, *Brain Warping*, Academic Press, San Diego

[10] R. Kikinis, M. E. Shenton, G. Gerig, J. Martin, M. Anderson, D. Metcalf, C. R. G. Guttmann, R. W. M. Carley, W. Lorensen, H. Cline, and F. A. Jolesz , “Routine Quantitative Analysis of Brain and Cerebrospinal Fluid Spaces with MR Imaging,” *J. Magnetic Resonance Imaging*, vol. 2, pp. 619-629, 1992.