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A Survey on Methods of Skull Stripping in MR Images

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***Abstract:** The magnetic resonance (MR) brain images are considered as most informative images which contain tissue details compared to other methods of imaging. Along with brain, the presence of non-brain tissues is required to be considered for automatic brain image segmentation and analysis techniques. Skull stripping involves this process of removing skull area from brain MR images for quantitative and morphological operable outcomes. Variety of techniques are available for skull stripping purpose. Some of them are discussed in this paper.*

***Keywords:** Brain segmentation, Skull stripping, MRI brain, Brain Extraction, Brain structure segmentation.*

I. INTRODUCTION

The quantitative analysis in digital image processing has increased the scope of diagnosis due to better visualization capabilities. To find applications in medical image processing the computerized medical image analysis and computer-aided diagnosis has promoted many imaging techniques. Among the various imaging techniques, MRI (magnetic resonance image) is the most widely used imaging technique in the medical field. The spatial resolution in images provide more information on the anatomical structures.

To get high degree of anatomical structures in brain MR imaging of brain is the best option, which provides better visualization of both interior and exterior structures. Due to such capability it is possible to detect even the minute changes in these structures that develop over a time period. By specific directivity such as top to bottom, side to side, or front to back can be obtained through MRI scans. The research related to diagnosis, treatment, surgical planning, and image-guided surgeries have become more popular with the three dimensional MR brain images.

Based on different contrast characteristics of the brain tissues, T1-weighted, T2-weighted, and PD-weighted, are primarily three types of MR brain images [2]. Out of various medical imaging techniques MRI has the ability to image the brain in any plane also without physically moving the patient.

II. SKULL STRIPPING OF MR BRAIN IMAGES

For exploring brain images several image processing methods are required. Segmentation is an essential process in medical image processing and analysis [6]. There are variety of algorithms, being proposed in the field of medical image segmentation which required to be analyzed with respect to their applicability [7]. These algorithms and techniques can be categorized based on their methodology as: gray level features based methods, texture features based methods, model-based segmentation methods, and atlas-based segmentation methods [8–13].

To eliminate non brain tissues from brain MR images skull stripping is a preliminary step, required for many clinical applications and analysis. Depending on factors such as accuracy and speed the best suitable method can be selected.

For the sake of improvement in speed and accuracy of prognostic and diagnostic procedures in medical applications automated skull stripping is considered as most helpful strategy.

Based on performances using commonly available datasets, various automated skull stripping methods can be comparatively studied and analyzed. Based on merits and limitations of individual method of automated skull stripping suitable method can be chosen.

III.SKULL STRIPPING METHODS:

To separate skull region from brain, these methods involve the morphological erosion and dilation operations. Using the combination of thresholding and edge detection methods initial region of interest (ROI) can be detected. The development of mask for non region of interest is main drawback of these methods which varies randomly in accordance with shape and sizes of areas to be masked. The final output of these methods mainly depend on empirical experimentation and finalizing the parameters.

Brummer et al. [4] suggested the method, automatic detection of brain contours in MRI datasets This is one of the commonly used methods for skull stripping. Histogram based thresholding and morphological operations is the process involved in this method. With respect to various experimentations and their performance evaluations discrimination in the desired and undesired structures is feasible. With the use of sequence of conventional and morphological operations this method is implemented, along with 2D and 3D operations. In third dimension to propagate coherent 2D brain masks overlap tests are performed on candidate's brain regions of interest in the neighboring slice images. mathematical morphology is used in some existing methods are sometimes sensitive to small data variations. To separate brain tissues from non-brain tissues the task becomes difficult in this scenarios.

In third dimension to find and label the cortical surface of MR brain images and to detect anatomical brain boundaries, Sandor and Leahy [5] used 3D Marr–Hildreth edge detector and morphological operation as a preprocessing procedure.

Lemieux G et.al, [6] Suggested the methods called as exbrain. It is a fully automatic algorithm that segments T1-weighted MR head scans. The process involves thresholding based increments in unit steps until there is a significant change in the volume found after a set of morphological and connected component operations. As processing capability is fully 3-dimensional scan orientation is not the obstacle for this method. Shattuck et al. [7] have proposed method for the brain surface extraction (BSE) for T1 and T2-weighted brain images. Anisotropic diffusion filtering is used in this method. A 2D Marr–Hildreth edge detection technique is used to detect edges in the image. TO remove Gaussian noise, low pass filtering with a Gaussian kernel s used. Localization of zero crossings in the laplacian of the filtered image. To break connection between brain and other non-brain tissues, BSE along with morphological erosion operation outperforms. To fills small pits and holes that may occur in the brain surface a morphological closing operation is used as final step of BSE. BSE depends on fixed parameters such as diffusion iteration, diffusion constant, edge constant, and erosion size. BSE shows less performance and failures when image contrast is too week.

Shanthi and Sasikumar [8] shown a method based on seed growing and thresholding for automatic segmentation of brain MRI.

Mikheev et al. [9] described method based on intensity threshold followed by removal of narrow connections. The Bridge Burner method is used for the purpose. Morphologically closing the output along with filling the holes in the mask, the algorithm can be modified to produce an output similar to the other skull stripping methods. But as original method fails to strip skull automatically.

Park and Lee [10] developed 2D region growing based skull stripping method for T1-weighted MR brain images. Mask produced by morphological operations two seed regions of the brain and non-brain are identified and a mask is produced. Based on the general brain anatomy information, the seed regions were expanded using 2D region growing algorithm. Gao and Xie [11] described anisotropic diffusion filtering and morphological processing for skull stripping MR brain images.

Klein A et al.,[12] have shown the diffusion, morphological operations and connected component analysis to extract the brain region in axial slices in brain extraction algorithm (BEA). Wels M et.al., [14] have shown method based on morphological operation and run-length scheme for brain extraction.

IV. CHALLENGES IN SKULL STRIPPING TECHNIQUES:

Due to natural shape variations in brain sizes skull stripping is challenging task in MR images. Automated algorithms for skull stripping consist of factors satisfying robustness, efficiency, reliability, and accuracy in results even in case of large volume of datasets. Due to presence of noise and various imaging artifacts in MRI, substantial degradation in performances of automated skull stripping techniques mainly depend on distortions introduced which ultimately responsible for quality loss of images. Some of the challenges in the skull stripping techniques are as follows:

A. Target tissue type in the brain imaging process, produces images with different contrast and scan quality. this shows selective approach for datasets with their information details.
B. Non homogeneous brain structures and vary with individuals which shows common settings requirement to maintain image axial parameters during slicing operations.
C. Skull stripping automation involves common fixing of axis stripping process to get final view angles of specific brain MR images and hence performance is solely dependent on dataset image axis parameters.
D. Prior sensor noise estimation and delineation is required for automated skull stripping which may ensure the performance in terms of accuracy and retention of region of interest information.

V. CONCLUSION

To remove non-brain tissues from brain MR images automated skull stripping is a preliminary step. Speed and accuracy of skull stripping are main parameters considered for many clinical applications and neuroimaging studies.

Stupendous techniques are available for skull stripping out of which proper applicable method selection is desired. In this paper we have addressed few methods of them based on their specific performance parameters and applicability. Our approach of study have shown the development of new strategies to be considered while doing automatic skull stripping.

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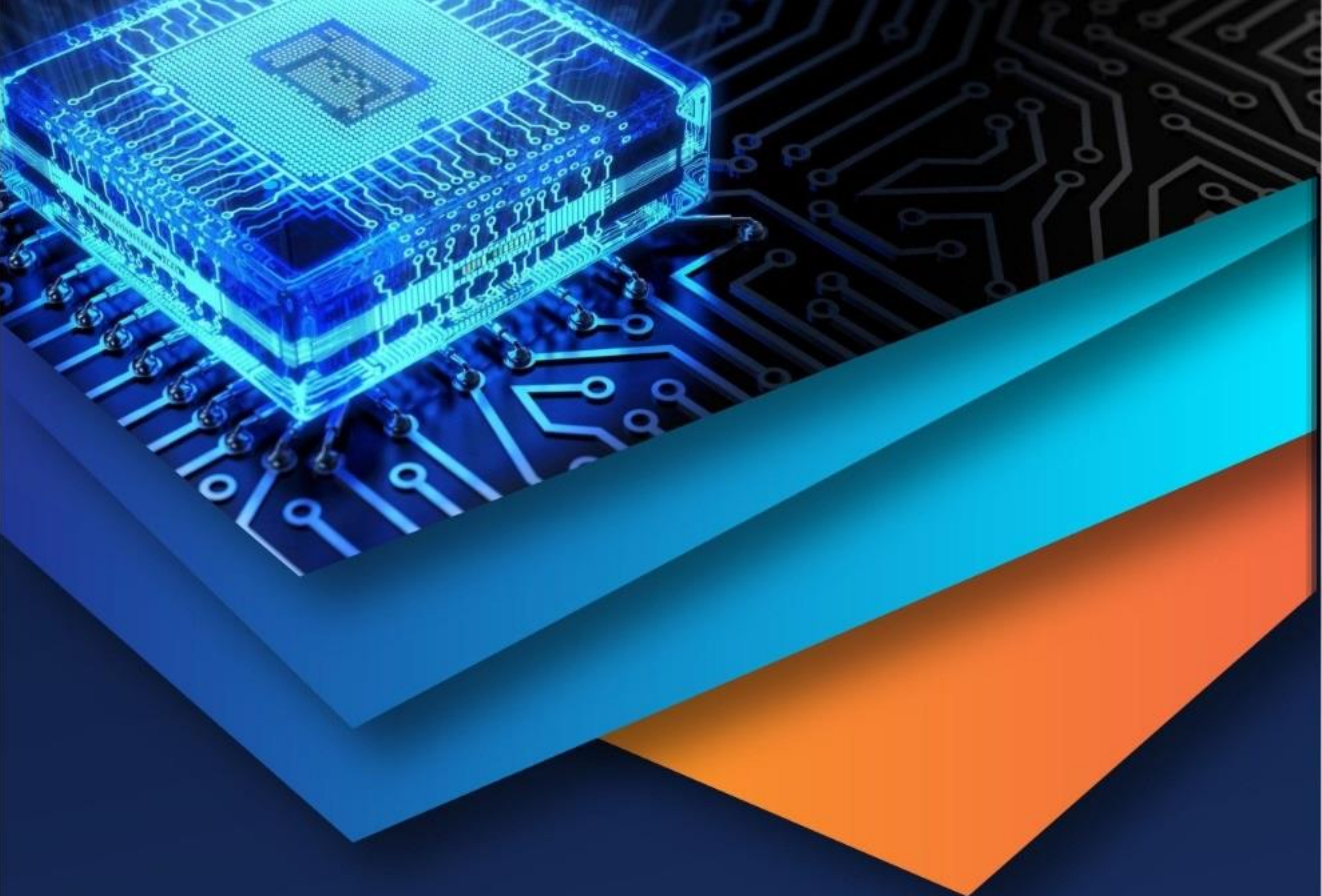

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