ISSN: 0976-9102 (ONLINE)
DOI: 10.21917/ijivp.2021.0362

ANALYSIS OF MORPHOLOGICAL OPERATIONS ON IMAGE SEGMENTATION TECHNIQUES

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Abstract

Image segmentation is a process of partitioning an image into different subregions based on edge detection, area based or clustering based methods. Segmentation of brain MRI images is a challenging task. This paper provides a thorough analysis of different segmentation techniques with morphological operators for brain tumor detection. After segmenting the image, morphological operators are used to eliminate and add some pixels from tumor boundaries and to improve the performance of segmentation algorithm. Manual segmentation is used to construct the gold standard for comparing the segmented image. Comparison is performed using performance parameters such as dice, Jaccard coefficient, selectivity, recall and precision. The experimental results show that precision can be improved up to 85% in clustering-based segmentation and full selectivity can be achieved by combining segmentation techniques with morphological operation of erosion. The other performance parameters have also improved by applying erosion than dilation.

Keywords:

Segmentation, Dice Coefficient, Threshold Segmentation, Jaccard Coefficient

1. INTRODUCTION

The contribution of image processing in medical imaging is incredible. Medical image segmentation used to handle different medical modalities like Medical resonance imaging (MRI), computed tomography, ultrasound, multimodal, digital mammography, X-ray, Chest radiography etc. The achievement in accuracy and preciseness in medical images gives immense help in correct diagnosis. Segmentation is a process of subdividing the image into small subregions to identify the area of interest. The basic purpose of segmentation in medical imaging is to improve the process of visualization to handle the disease detection process [1].

The accurate detection and diagnosis in case of tumor is a very sensitive and important decision. The basic process of segmentation can be carried out under two principles, similarity and discontinuity. The objects possessing similar properties are grouped together in first category, whereas the boundaries are detected to divide the subregions in second category [2].

There are many challenges in the field of image segmentation like noise, nonuniform intensity of signal, artifacts, patient’s motion, feature fading etc. Artificial intelligence and image segmentation play an important role in coping up with these challenges. Image segmentation in the field of healthcare is used to handle different medical modalities like medical resonance imaging, computed tomography, ultrasound, multimodal, digital mammography, X-ray, Chest radiography etc.

In each modality the segmentation is performed in a different manner according to the desired feature extraction. The MRI images contains high signal to noise ratio and multiple resolutions in the single frame. The most challenging task in brain MRI images is to extract the white matter, gray matter and cerebrospinal fluid [3]. In ultrasound the segmentation becomes more difficult due to motion and variable resolution [4].

The brain MRI image segmentation includes the partitioning of basic three regions i.e. white matter, grey matter and cerebrospinal fluid. These anatomical features help the radiologist to detect the exact shape, size and appearance of tumor [5]. Brain MRI image segmentation comprised of few important steps like pre-processing of image, feature extraction, edge detection and tumor detection. The pre-processing of the image is basically the filtering stage, in which the different types of filters are employed to remove the noise present in the image [2] [4].

2. RELATED WORK

Technically Image Segmentation can be defined as the differentiating the digital image into sub-regions. Segmentation might not only used for image recognition but also image compression and image editing. Meer et al. [6] presented a feature extraction algorithm based on density gradient. Coloured image of 512×512 dimension was analyzed by considering mean shift algorithm for feature space processing.

Cooper [7] combined variance and no. of regions to reduce the NP problem. He analyzed the reconstruction of 3D from 2D image by relaxing the no range information condition. Schimdt et al. demonstrated the segmentation using alignment features. They analyzed the algorithm quantitatively by considering 4 different types of alignment-based feature encoding for supervised pixel classification [8]. In 2003, the boundary predictions were estimated by using graph-based estimation. This method preserves the low variability image regions and ignoring the details [9].

Patil et al. [10] discussed about the various image segmentation techniques like region based, threshold based, segmentation based on clustering and region merging. The detailed classification of these segmentation techniques was discussed and tabulated for the purpose of research. In 2013, Chaudhary and Kulkarni proposed local entropy-based segmentation. The entropy of the image can be determined by gray level peaks of its histogram. The gray level cooccurrence matrix was analyzed to observe the Haralick texture feature for image segmentation [11].

The clustering techniques proved a good solution for efficient image segmentation. K-mean and fuzzy C mean clustering algorithms can be used to find out the regions of similarity. In 2015, the hybrid clustering technique was proposed for image segmentation in which K-mean and Fuzzy C mean clustering algorithms were integrated [12] Morphological operators are used to process the binary image on the basis of their shape and characteristics. Different types of structuring elements can be used to encode the binary information according to the applications. In 2015, the morphological operation along with the fuzzy C mean clustering-based segmentation was implemented to improve the segmentation result [13]. The accuracy and efficiency of any segmentation technique can be evaluated by its performance parameters.

One of them is dice similarity coefficient, Shamir et al. [14] discussed about continuous dice coefficient for probabilistic segmentation. To compare the segmented output with some standard image, researchers coined the term gold truth or gold standard, for that sake manual segmentation proved fruitful. In 2018, the manual segmentation for brain MRI images was discussed by Agustin and his fellow researchers [15]. By using performance parameters, different segmentation algorithms are analyzed for various Gaussian noise levels [16].

The work in this paper has analyzed morphological operations on different segmentation methods for brain MRI images. The comparisons made have proved that segmentation results can be improved by using morphological operations. These operations can add or reduce the no. of pixels at the edges of segmented image to give clear results. The following sections explain the proposed segmentation technique, experimental results and its analysis followed by conclusion.

3. SEGMENTATION TECHNIQUES

In this paper, some of the segmentation techniques are applied along with morphological operators. The morphological operators of dilation and erosion are applied and compared with Gold standard. The gold standard of the same image is created by manual segmentation.

3.1 THRESHOLD SEGMENTATION

Thresholding is suitable for images having light objects on dark backgrounds. It is used to figure out the edges or regions by reducing the noise impact in the images. it is the simplest approach to distinguish the foreground and background. Two types of thresholding methods are very common for medical images. First one is global thresholding and another is local thresholding. In global thresholding the thresholding value T is kept unique and constant for the whole image. On the contrary, in local thresholding like Otsu's thresholding, the whole image is segmented in sub images and each sub image contain its own threshold value, so the value of T keeps changing with sub images.

3.2 AREA BASED SEGMENTATION

The region-based segmentation is basically based on detection and division of areas. The area is separated according to the variation in intensities at the borders. As compared to edge detection techniques, area-based segmentation is simple and less prone to noise. The area of tumor detected by this technique is having higher accuracy rate than other segmentation techniques.

3.3 K-MEANS CLUSTERING BASED SEGMENTATION

Clustering algorithms can also be used for segmentation of images with multiple intensity variations. Clustering is mainly based on forming the classes of pixels of similar types. The quality of result depends on the measurement of similarity. K-mean, Fuzzy clustering are the most commonly used clustering techniques used for brain medical image segmentation.

3.4 ENTROPY BASED SEGMENTATION

Entropy thresholding is based on the information present in gray level histogram. The entropy of the histogram is used to extract the expected amount of information needed to specify the state of the system. The histogram for image is able to judge the complete tone distribution. In entropy thresholding the image is converted into binary to separate from the background.

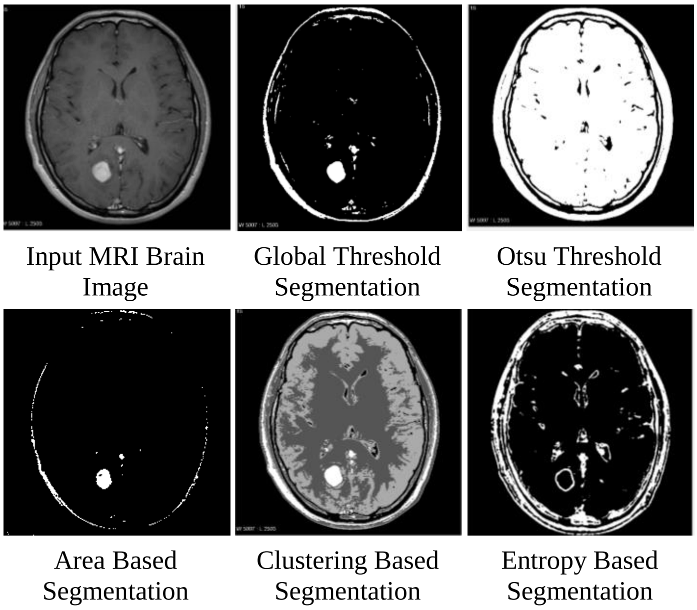

Fig.1. Output of different segmentation methods on brain MRI image

4. PERFORMANCE ANALYSIS

The sample image for implementation is taken from online open source. The effectiveness of the proposed algorithm is validated by evaluating the performance parameters. The performance parameters used for the qualitative analysis of the proposed technique are Dice, recall, precision, selectivity and Jaccard coefficient. The overview of these parameters is as follows:

$$Dice\ Coefficient = (TP + TN)/(TP+TN+FP+FN)$$

$$Recall = TP/(TP+FN)$$

$$Precision = TP/(TP+FP)$$

$$Selectivity = TN/(TN+FP)$$

$$Jaccard\ Coefficient = TP/(TP+FP+FN)$$

where,

TP - Tumor exists and it is detected correctly

TN - Tumor does not exist and it is not detected

FP - Tumor does not exist but is detected

FN - Tumor exists but is not detected.

These parameters can be evaluated with the help of considering true positive (*TP*), true negative (*TN*), False positive (*FP*) and false negative (*FN*). Dice similarity coefficient is the most frequent evaluation index used for medical image segmentation, which gives the ratio of the area where the two objects intersect to the total area. The maximum value for Dice is 1. Recall can be given by ratio of TPs to all positives, which is the sum of TPs and false negatives (FNs). Precision gives the ratio of TPs to the sum of both the positives, whereas selectivity is the ratio of TNs to the sum of TN and FP. Jaccard coefficient is another frequently used qualitative factor for image segmentation. It is the ratio of TP to all the other three factors [16]-[18].

4.1 MANUAL SEGMENTATION

To validate the segmentation algorithm, a standard image has to be taken for comparison and also to evaluate the performance parameters. In clinical process, the brain tumor segmentation can broadly be classified in three categories. Manual segmentation, Semi-automatic and automatic segmentation. In the proposed method, manual segmentation is considered for validation. The user involvement is there to find out the segmented region. The manual segmented image is taken as reference image to compare the other automatic segmented images.

4.2 IMPLEMENTATION OF MORPHOLOGICAL OPERATORS

Morphological operators can be treated as data processing methods that are useful in image processing. It can be used in many fields like texture analysis, boundary extraction, noise elimination etc. The objective of morphological image processing is to eliminate the defects along with maintaining the structure of the image.

The image is verified with the help of morphological operators that are the structuring elements which introduced in the image to create an output image of same size having the pixel formed by the comparison of original image pixel with its neighbour pixels. There are various types of structuring elements for verification like diamond shaped, square shaped, cross shaped.

Two basic operations of morphological operators are erosion and dilation in which we add or remove the pixels from the boundary of object.

In this paper the impact of these two morphological operators has been analysed by observing the values of few performance parameters. The four different segmentation techniques are taken into account for analysing the effect of morphological operations. The observed values for performance parameters like Dice, Recall, Precision, Selectivity and Jaccard coefficient for every segmentation technique before and after application of morphological operator helps judge the improvement.

In global threshold the value the value of T (Threshold coefficient) is kept 110 and then both the morphological operations i.e. dilation and erosion are applied on it, the set of three readings are observed for performance parameters. The structuring element disc is selected with radius of 3 for validation of image. On the contrary, in Otsu's local threshold the value of coefficient changes with the position.

The whole image is categorized in small sub-images, the threshold coefficient keeps on changing its value with these sub-images. Local threshold segmentation is preferred over global thresholding, if the image is having high contrast variation. The three set of observations are taken for observing the variation in values of performance parameters.

In region segmentation the image is again subdivided in small patches or regions depending upon the pixel density. The morphological operations helps to redefine the boundaries of those sub-regions. Region or area-based segmentation is appropriate for the images having less types of aerial variation. If the image is segmented on the basis of groups of pixels having same characteristics then it is said to be clustering based segmentation. The morphological function improves the edge detection and helps in identify the foreground and background.

Table.1. Observed values of performance parameters on different segmentation techniques

Performance Parameter	Value	After Erosion	After Dilation
Global Threshold Segmentation			
Dice	0.1834	0.6176	0.0778
Recall	0.7277	0.7854	0.661
Precision	0.1049	0.5796	0.0409
Selectivity	0.042	0.4142	0.00115
Jaccard Coefficient	0.0996	0.4468	0.0405
Otsu's Local Threshold Segmentation			
Dice	0.0188	0.0363	0.0211
Recall	0.7214	1	0.823
Precision	0.015	0.0185	0.0107
Selectivity	0.1	0.14	0.05
Jaccard Coefficient	0.02	0.028	0.0107
Tumor area /Region segmentation			
Dice	0.4082	0.3535	0.1832
Recall	0.8143	0.8439	0.2147
Precision	0.2723	1	0.1027
Selectivity	0.0786	1	0.0207
Jaccard Coefficient	0.2564	0.2147	0.1008
K-Mean Segmentation			
Dice	0.2884	0.612	0.1957
Recall	0.8771	0.9275	0.5957
Precision	0.1726	0.8528	0.1074
Selectivity	0.0284	0.5352	0.0096
Jaccard Coefficient	0.1685	0.4409	0.1085

On the basis of above observations, all the five performance parameters can be analysed separately to judge the effect of erosion and dilation. On an average if the graphs are analysed, the application of erosion shows improved results in case of global thresholding, Otsu's thresholding, area-based segmentation and K-mean clustering-based segmentation. If we analyse the patterns generated in Jaccard coefficient, again for global threshold, Otsu's threshold and clustering based segmentation the improvement is visible. So, it can be concluded that the morphological operation erosion gives improved results for above analysed segmentation methods.

5. CONCLUSION

Segmentation is an important step in medical image processing. In this paper the proposed algorithm uses different segmentation techniques for brain MRI images. Moreover, the impact of morphological operations: dilation and erosion are observed on these segmentation techniques by evaluating using the performance parameters. The improved values of parameters like Dice coefficient, Jaccard coefficient etc. proves the robustness of proposed algorithm. For calculating the accurate values, manual segmentation is used to construct a gold standard image. Precision improves up to 85% in clustering-based segmentation. While full selectivity has been observed in case of area-based segmentation. Based on observed results, it can be concluded that combination of segmentation with erosion improves the performance parameters than dilation in threshold-based segmentation, area-based segmentation and k-mean clustering-based segmentation. In future the impact of morphological operators can be analysed on segmentation implemented with deep learning algorithms.

REFERENCES

[1] S. Bauer, T. Fejes, J. Slotboom, R. Wiest, L.P. Nolte and M. Reyes, “Segmentation of Brain Tumor Images based on Integrated Hierarchical Classification and Regularization”, *Proceedings of International Conference on Multimodal Brain Tumor Segementation*, pp. 33-39, 2012.

[2] A. Christe, K. Malathy and A. Kandaswamy. “Improved Hybrid Segmentation of Brain MRI Tissue and Tumor using Statistical Features”, *ICTACT J Image Video Processing*, Vol. 1, No. 1, pp. 34-49, 2010.

[3] J. Vijay and J. Subhashini, “An Efficient Brain Tumor Detection Methodology using K-means Clustering Algorithm”, *Proceedings of International Conference on Communication and Signal Processing*, pp. 653-657, 2013.

[4] B.K. Bala, “Enhanced Palm Vein Recognition Algorithm with Equalizer Technique”, *International Journal of Engineering and Advanced Technology*, Vol. 8, No. 5, pp. 888-890, 2019.

[5] R.P. Joseph, C. Senthil Singh and M. Manikandan, “Brain Tumor MRI Image Segmentation and Detection in Image Processing”, *International Journal of Research in Engineering and Technology*, Vol. 3, No. 11, pp. 1-5, 2014.

[6] D. Comaniciu and Peter Meer, “Robust Analysis of Feature Spaces: Color Image Segmentation”, *Proceedings of IEEE Computer Society Conference on Computer Vision and Pattern Recognition*, pp. 750-755, 1997.

[7] M.C. Cooper, “The Tractability of Segmentation and Scene Analysis”, *International Journal of Computer Vision*, Vol. 30, No. 1, pp. 27-42, 1998.

[8] Mark Schmidt, Ilya Levner, Russell Greiner, Albert Murtha and Aalo Bistritz, “Segmenting Brain Tumors using Alignment-Based Features”, *Proceedings of 4th International Conference on Machine Learning and Applications*, pp. 1-6, 2005.

[9] Pedro F. Felzenszwalb and P. Daniel, “Efficient Graph-Based Image Segmentation”, *International Journal of Computer Vision*, Vol. 59, No. 2, pp. 167-181, 2004.

[10] Dinesh D. Patil and Sonal G. Deore, “Medical Image Segmentation: A Review”, *International Journal of Computer Science and Mobile Computing*, Vol. 2, No. 1, pp. 22-27, 2013.

[11] L.T. Mariappan, “Analysis on Cardiovascular Disease Classification using Machine Learning Framework”, *Solid State Technology*, Vol. 63, No. 6, pp. 10374-10383, 2020.

[12] Dinesh D. Patil and Sonal G. Deore, “Medical Image Segmentation: A Review”, *International Journal of Computer Science and Mobile Computing*, Vol. 2, No. 1, pp. 22-27, 2013.

[13] Diya Chudasama, Tanvi Patel, Shubham Joshi and Ghanshyam I. Prajapati, “Image Segmentation using Morphological Operations”, *International Journal of Computer Applications*, Vol.117, No. 18, pp. 1-16, 2015.

[14] R.R. Shamir, Yuval Duchin, Jinyoung Kim, Guillermo Sapiro and Noam Harel, “Continuous Dice Coefficient: A Method for Evaluating Probabilistic Segmentations”, *Proceedings of International Conference on Computer Vision and Pattern Recognition*, pp. 1-8, 2019.

[15] Hapsari Peni Agustin, “Brain Tumor Image Segmentation in MRI Image”, *Proceedings of IOP Conference Series: Materials Science and Engineering*, Vol. 336, No. 1, pp. 1-14, 2018.

[16] Chong Zhang, Xuanjing Shen, Hang Cheng and Qingji Qian, “Brain Tumor Segmentation based on Hybrid Clustering and Morphological Operations”, *International Journal of Biomedical Imaging*, Vol. 2019, pp. 1-15, 2019.