

Automatic Brain Tumor Detection in MRI Using Image Processing Techniques

Mariam Saii, Zaid Kraitem

Department of Computer Engineering, Faculty of Electronic and Electrical Engineering, Tishreen University, Latakia, Syria

Email address:

sc.hmk@tishreen.edu.sy (M. Saii), zydcretem@yahoo.com (Z. Kraitem)

To cite this article:

Mariam Saii, Zaid Kraitem. Automatic Brain Tumor Detection in MRI Using Image Processing Techniques. *Biomedical Statistics and Informatics*. Vol. 2, No. 2, 2017, pp. 73-76. doi: 10.11648/j.bsi.20170202.16

Received: January 6, 2017; **Accepted:** February 13, 2017; **Published:** March 1, 2017

Abstract: The research offers a fully automatic method for tumor segmentation on Magnetic Resonance Images MRI. In this method, at first in the preprocessing level, anisotropic diffusion filter is applied to the image by 8-connected neighborhood for removing noise from it. In the second step, using Support Vector Machine SVM Classifier for tumor detection accurately. After creating the appropriate mask image, based on the symmetry property in axial and coronary magnetic resonance images. The tumor detected and segmented (Dice coefficient > 0.90) in a few seconds. The method applied on several MR images with different types regardless of the degree of complexity in those images.

Keywords: MR Images, Support Vector Machine (SVM), Anisotropic Diffusion Filter, Brain Tumor Detection

1. Introduction

The brain tumor segmentation on MRI images is an important task which is used in surgical and medical planning and assessments. If experts do the segmentation manually with their own medical knowledge, it will be time-consuming. Therefore, researchers propose methods and systems which can do the segmentation automatically and without any interference. Medical image segmentation plays an important role in clinical diagnosis. An ideal medical image segmentation scheme should handle with the most preferred properties such as minimum user interaction, fast computation, and accurate and robust segmentation results [1] [2]. There are many proposed techniques for automatic and semi-automatic detection and segmentation of brain tumors. The proposed techniques can be mainly divided into two groups; Intelligent based and non-intelligent based. Most of the leading intelligent based systems are artificial neural networks [3], fuzzy c-means (FCM) [4, 5, 6], fuzzy connectedness [2], support vector machine (SVM) [7, 8], particle swarm optimization (PSO) [9], genetic algorithm [10] and hybrid methods. On the other hand, the leading non-intelligent techniques include thresholding [11, 12] and region growing [13, 14] and etc. Usually the combination of these algorithms are used to achieve better results [15, 16]. Purpose of image segmentation is Magnetic Resonance Imaging (MRI) has become a widely high quality medical imaging nowadays in the field of tumor detection. Brain tissue and tumor segmentation in MR images have become a vital area of discussion.

2. Research Objectives and Its Methods

Many of segmentation algorithms applied to detect brain tumors. MR brain images contain several segments or regions which that maybe have the similar grayscale density with tumor's area. Research benefited from the symmetry feature in MRIs, and it applied series of steps to detect the tumor accurately and quickly. The highlighted algorithms used to enclose the boundary of tumor are:

2.1. Anisotropic Diffusion Filter

Anisotropic diffusion filtering ADF is widely used for MR image enhancement. But it is non-optimal for those images with spatially varying noise levels, such as images reconstructed from sensitivity-encoded data and intensity inhomogeneity-corrected images [23]. Linear Diffusion is a traditional way to smooth an image in a controlled way via convolving it with a Gaussian kernel [21]. Non-Linear Diffusion Reduces noise and enhances contours in images, and the diffusion coefficient is locally adapted, becoming negligible as object boundaries are approached. A discrete form of ADF is given by:

$$I_s^{t+1} = I_s^t + \frac{\lambda}{|\eta_s|} \sum_{p \in \eta_s} g(|\nabla I_{s,p}^t|, \gamma) \nabla I_{s,p}^t \quad (1)$$

where I_s^t is the intensity of a pixel s from image I at instant t , λ is a scalar related to the diffusion rate, γ is a positive constant selected according to the desired smoothing level,

η_s stands for the set of adjacent pixels of s , $g(\cdot)$ is an edge-stopping function (ESF), and $\nabla I_{s,p}^t$ is the magnitude of the image directional gradient from pixel s to p at instant t [22].

2.2. Support Vector Machine (SVM)

SVM algorithm applied for binary sets separable linearly. The goal is to design hyper-plane which classify all training vectors into two classes, we can separate them by more than hyper-plane, but we choose the hyper-plane which have the maximum margin (the distance between the hyper-plane and the closest object in each class) [17]. Support vectors are the data points that lie closest to the decision surface, and they are the most difficult to classify, as the Figure 1 shows [18].

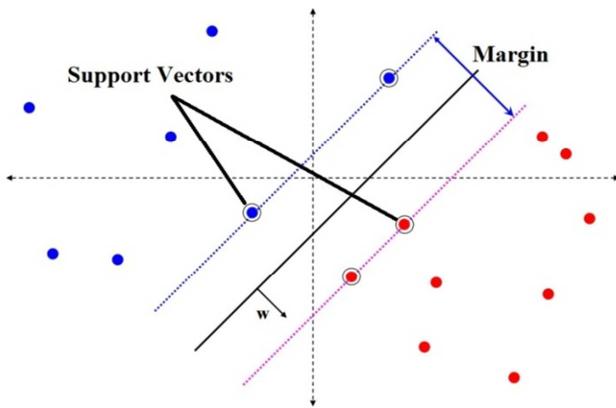


Figure 1. SVM classifier.

The decision function is fully specified by a subset of training samples. The problem of finding the optimal hyper plane is an optimization problem and can be solved by optimization techniques (use Lagrange multipliers to get into a form that can be solved analytically) [19]. Linear classifier has the form:

$$f(x_i) = w^T x_i + w_0 \tag{2}$$

Where w symbol denote to weight vector, and the distance from any class point to hyper-plane is calculated as follows:

$$z = \frac{|f(x)|}{\|w\|} \tag{3}$$

So the total margin is: $\frac{2}{\|w\|}$, and minimizing $\|w\|$ leads to

maximize the ability of separation, this can help us to separate the two classes easily [20]. To minimize w we apply Karush Kuhn Tucker (KKT) condition using λ_i multipliers as the equation (4).

$$w = \sum_{i=0}^N \lambda_i y_i x_i \tag{4}$$

3. Discussion

The proposed method apply series of steps for tumor detection in MR images. At the first step we smooth the uniform regions by using Anisotropic Diffusion Filter with remain the details of image (edges) as soon as possible. In the next step we create the mask image, which using as input to the SVM Classifier, depending on the symmetric property of brain. Finally SVM classifier surrounds the tumor region accurately depending on mask binary Image. Figure 2 illustrate the method stages.

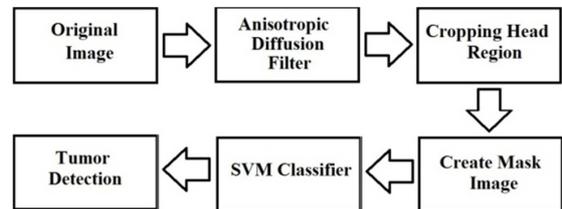


Figure 2. Box scheme for proposed method.

We applied the proposed method on several MR images. SVM algorithm uses the mask image to detect the tumor region accurately. To create the mask image we need first to crop the head region in image only without the extra black background, we do this via applying the bounding box around the biggest area in labeled image, after we convert it to binary form with low threshold. The Figure 3 shows the result of SVM algorithm.

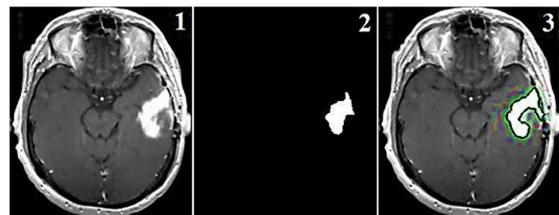


Figure 3. 1-Original cropped Image, 2-Mask Image, 3-Resulted Image (Tumor Detection).

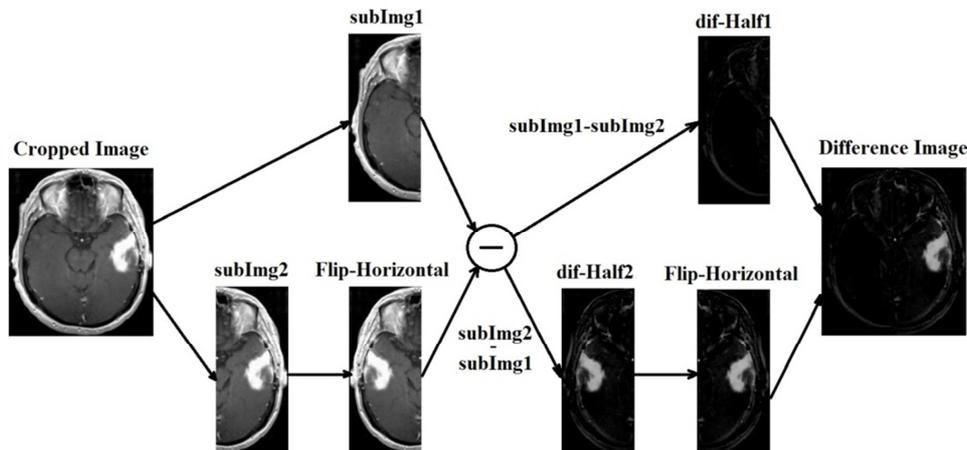


Figure 4. Creating the Difference Image depending on symmetric property.

We crop the head object and remove the unnecessary background, after that we split image into equals halves, and make flip horizontal to the second half. Finally we calculate the difference between the sub-images, and combine them to create the difference image. Figure 4 shows that tumor in MR image appear clearly.

We apply thresholding to the resulted image, and remove the small objects which appear in it using morphologic operations (Bwareaopen), as Figure 5 shows.

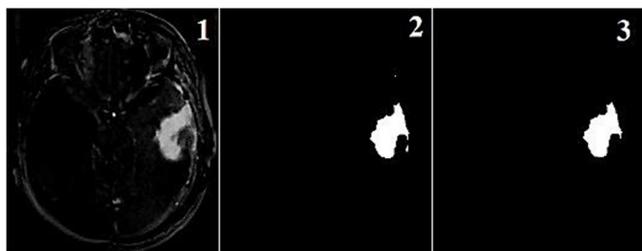


Figure 5. 1-Difference Image, 2-Thresholded Image, 3-Removing small objects.

We can simplify the box scheme as Figure 6 illustrates. The result of applying each stage in proposed method on some MR image. Note the mask image contain the region of tumor, which has white pixels, this is help SVM algorithm to detect tumor accurately.

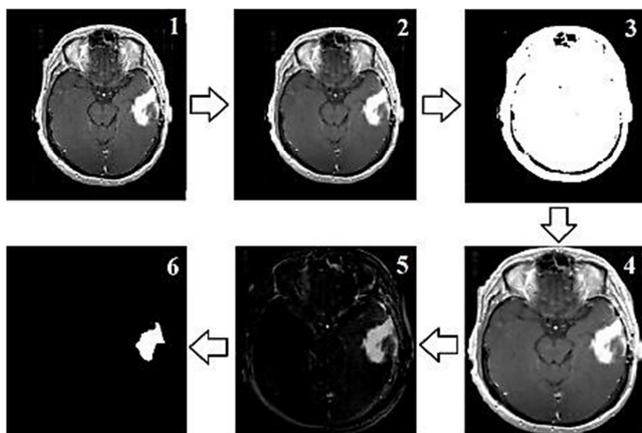


Figure 6. 1-Original Image, 2-Filtered Image, 3-Thresholded Image, 4-Cropped Image, 5-Difference Image, 6-Mask Image.

4. Results

To evaluate the segmentation process, we compute the similarity measure between the segmented image *A* and the ground truth *B* (manual segmented images) by using the dice coefficient, measured as

$$Dice = \frac{2(A \cap B)}{A + B} \tag{5}$$

Where a “good” segmentation is considered to be one with a $DC > 0.7$. We apply the proposed method on two sets of MR images with different types and sources as Figures 7, and Figure 8 show. The efficient of our tumor detection method is appeared in Table 1.

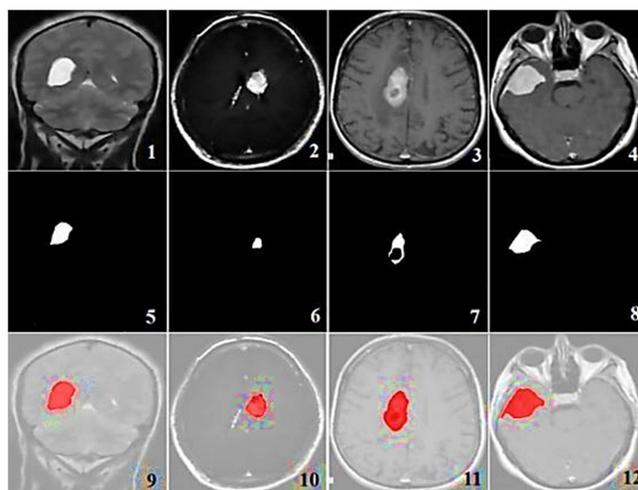


Figure 7. First set: 1, 2, 3, 4-Input Images. 5, 6, 7, 8-Mask Images. 9, 10, 11, 12-Resulted Images.

Table 1. Evaluation Segmentation Process using Dice Criteria.

First set of MR images		Second set of MR images	
Img1	0.942	Img5	0.932
Img2	0.927	Img6	0.913
Img3	0.901	Img7	0.941
Img4	0.962	Img8	0.883

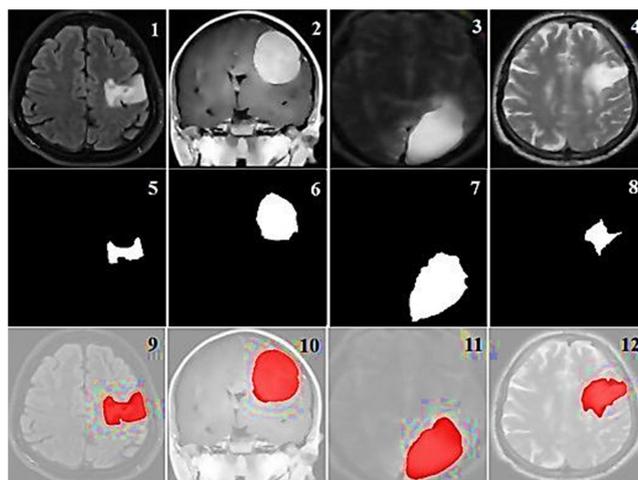


Figure 8. Second set: 1, 2, 3, 4-Input Images. 5, 6, 7, 8-Mask Images. 9, 10, 11, 12-Resulted Images.

5. Conclusion

In this paper, the proposed approach based on several steps has demonstrated great potential and usefulness in MRI tumor segmentation. We apply Anisotropic Diffusion Filter for smoothing with remaining the details of image. After that we create mask image depending on Symmetric property of brain MR images. Finally we use SVM for tumor detection accurately. The proposed segmentation method able to detect of brain tumors in database contains 40 MR images, and accuracy rate is 95.5% depending on Dice criteria.

Acknowledgements

We acknowledge the help extended by Dr. Hussam

Hassoun, Al-Basel Hospital, for providing various MR Images to conduct this study.

References

- [1] M. C. Clark, L. O. Hall, D. B. Goldgof, R. Velthuizen, F. R. Murtagh, and M. S. Silbiger, "Automatic tumor segmentation using knowledgebased techniques". *IEEE Trans. on Medical Imaging*, vol. 17, no. 2, pp. 238-251, April 1998.
- [2] S. D. Olabarriaga and A. W. M. Smeulders, "Interaction in the segmentation in medical images: A survey. *Medical Image Analysis*", vol. 5, no. 2, pp. 127-142, June 2001.
- [3] M Sharma, S Mukharjee, "Brain Tumor Segmentation Using Genetic Algorithm and Artificial Neural Network Fuzzy Inference System", *Advances in Computing and Information Advances in Intelligent Systems and Computing Volume 177*, pp. 329-339, 2013.
- [4] M. Rakesh, T. Ravi, "Image Segmentation and Detection of Tumor Objects in MR Brain Images Using FUZZY C-MEANS (FCM) Algorithm", *International Journal of Engineering Research and Applications*, Vol. 2, Issue 3, May-Jun 2012, pp. 2088-2094.
- [5] J. selvakumar, A. Lakshmi, T. Arivoli, "Brain Tumor Segmentation and Its Area Calculation in Brain MR Images using K-Mean Clustering and Fuzzy C-Mean Algorithm", *IEEE-International Conference On Advances In Engineering, Science And Management*, pp. 186-190, 2012.
- [6] A Ravi, A Suvarna, A D'Souza, GRM Reddy and Megha, "A Parallel Fuzzy C Means Algorithm for Brain Tumor Segmentation on Multiple MRI Images", *Proceedings of International Conference on Advances in Computing Advances in Intelligent Systems and Computing Volume 174*, pp. 787-794, 2012.
- [7] J. Zhou1, K. L. Chan1, V. F. H. Chong, S. M. Krishnan, "Extraction of Brain Tumor from MR Images Using One-Class Support Vector Machine", *Proceedings of the 2005 IEEE, Engineering in Medicine and Biology 27th Annual Conference*, pp. 6411-6414, 2005.
- [8] L Guo, L Zhao, Y Wu, Y Li, G Xu, Q Yan, "Tumor Detection in MR Images Using One-Class Immune Feature Weighted SVMs", *IEEE TRANSACTIONS ON MAGNETICS*, VOL. 47, NO. 10, pp. 3849-3852, OCTOBER 2011.
- [9] S Chandra, R Bhat, H Singh, "A PSO Based method for Detection of Brain Tumors from MRI", *2009 World Congress on Nature & Biologically Inspired Computing (NaBIC 2009)*, pp 666-671, 2009.
- [10] M Sharma, S Mukharjee, "Brain Tumor Segmentation Using Genetic Algorithm and Artificial Neural Network Fuzzy Inference System (ANFIS)", *Advances in Computing and Information, Springer-Verlag Berlin Heidelberg, AISC 177*, pp. 329-339, 2013.
- [11] MK Kowar, S Yadav, "Brain Tumor Detection and Segmentation Using Histogram Thresholding", *International Journal of Engineering and Advanced Technology*, Volume-1, Issue-4, pp 16-20, April 2012.
- [12] Mandeep Kaur, Dr. V. K. Banga "Thresholding And Level Set Based Brain Tumor Detection Using Bounding Box As Seed", *International Journal of Engineering Research & Technology*, vol. 2, issue 4, pp 2503-2507, April – 2013.
- [13] S Tiwari, A Bansal, R Sagar, "Identification of brain tumors in 2D MRI using automatic seeded region growing method", *ISSN: 2249-5517 & E-ISSN: 2249-5525, Volume 2, Issue 1*, pp.-41-43, 2012.
- [14] N Behzadfar, H Soltanian-Zadeh, "Automatic segmentation of brain tumors in magnetic resonance Images", *Proceedings of the IEEEEMBS International Conference on Biomedical and Health Informatics*, pp 329-332, 2012.
- [15] Mehdi Jafari and Reza Shafaghi, "A hybrid approach for automatic tumor detection of brain MRI using support vector machine and genetic algorithm", *Global journal of science, engineering and technology*, Issue 3, pp 1-8, 2012.
- [16] Mehdi Jafari, Javad Mahmoodi, Reza Shafaghi, " A Neural Network-based Approach for Brain Tissues Classification Using GA", *Global journal of science, engineering and technology*, Issue 7, pp 1-7, 20.
- [17] Saeid Fazli, Parisa Nadirkhanlou, "A Novel Method for Automatic Segmentation of Brain Tumors in MRI Images", *Research Institute of Modern Biological Techniques University of Zanjan, Iran*, 2015.
- [18] P. Shantha Kumar and P. Ganesh Kumar, "PERFORMANCE ANALYSIS OF BRAIN TUMOR DIAGNOSIS BASED ON SOFT COMPUTING TECHNIQUES", *American Journal of Applied Sciences* 11 (2): 329-336, 2014.
- [19] M. Madheswaran and D. Anto Sahaya Dhas, "Classification of brain MRI images using support vector machine with various Kernels". *Biomedical Research*, Volume 26 Issue 3, 2015.
- [20] Jianguo Zhang, Kai-Kuang Ma, Meng Hwa Er, "TUMOR SEGMENTATION FROM MAGNETIC RESONANCE IMAGING BY LEARNING VIA ONE-CLASS SUPPORT VECTOR MACHINE", *School of Electrical & Electronic Engineering Nanyang Technological University, Singapore*, 2009.
- [21] J. Weickert. *Anisotropic diffusion in image processing*, ECMI Series, Teubner, Stuttgart, ISBN 3-519-02606-6, 1998.
- [22] Caio A. Palma, Fabio A. M. Cappabianco, Jaime S. Ide Paulo A. V. Miranda. "Anisotropic Diffusion Filtering Operation and Limitations-Magnetic Resonance Imaging Evaluation". *Preprints of the 19th World Congress. The International Federation of Automatic Control. Cape Town, South Africa. PP. 3887-3892*, 2014.
- [23] Alexei A. Samsonov and Chris R. Johnson. "Noise-Adaptive Nonlinear Diffusion Filtering of MR Images With Spatially Varying Noise Levels". *Magnetic Resonance in Medicine* 52: 798-806, PP. 798-806, 2004.