Segmentation of Tumor/Stroke Section from Brain MRI with Hybrid Imaging Technique

G. Balaji
Student, Department of Electronics and Communication Engineering,
Sreenivasa Institute of Technology and Management Studies, Chittoor 517127, Andhra Pradesh, India

Dr. M. Saravanan
Professor, Department of Electronics and Communication Engineering,
Sreenivasa Institute of Technology and Management Studies, Chittoor 517127, Andhra Pradesh, India

ABSTRACT

In medical field, image based disease examination plays a vital role in the assessment of the infection in various internal organs. If the disease is appropriately examined, then it is possible by the doctor to plan for an efficient treatment procedure to cure or control the disease. In this paper, a hybrid image processing technique is proposed to assess the disease in brain, such as the tumor and the stroke using the pictures recorded with Magnetic-Resonance-Imaging (MRI) technique. This work implements the integration of a pre-processing technique to enhance the tumor/stroke section and a post-processing technique to extract the tumor/stroke region. In this work, Cuckoo-Search-Algorithm (CSA) and Kapur's Entropy based thresholding is initially implemented to enhance the tumor section and later, the Active-Contour (AC) segmentation is implemented to extract the tumor/stroke section for the chosen brain MRI. In this work, the datasets, such as Brats2015 and ISLES2015 is considered for the study. All the experimental work is implemented using the Matlab software and the two-dimensional (2D) brain slices are adopted for the examination. Finally, a relative study between the extracted tumor/stroke section and the Ground-Truth (GT) is implemented and the essential Image-Similarity-Parameters (ISP) is then computed. The average value of the ISP with the proposed work is better on the Brats2015 (>93.29%) and ISLES2015 (>93.71%). Hence, in future, this hybrid technique can be adopted to examine the brain MRI collected from hospitals.

Keywords—Brain MRI; stroke; tumor; Cuckoo-Search-Algorithm; Kapur's Entropy, active-contour.

I. INTRODUCTION

Medical imaging procedures are usually adopted to record the interior organs of the body with a selection of imaging events. The recorded pictures are then scrutinized with manual, semi-automated and automated procedures to recognize the accessible abnormalities and injuries in the internal body parts.

In literature, a number of imaging based evaluation procedures are existing to examine the brain MRI recorded with various modalities, such as T1, T2, T1C and Flair. In which the visibility of T1 modality is poor compared to the T2 and Flair. In which the T2 and Flair will provide the exact availability of the tumor core and the edema section. The T1C will give details regarding the tumor core [1-3]. Based on the requirement, the radiologist will record the brain section based on a hosen modality and it is then considered for the examination process. Similar image recording scheme is to be followed to record the brain abnormality called the stroke [4,5]. Because of its importance, in recent years, considerable image examination procedures are proposed by the researchers to examine the brain MRI to evaluate the stroke/tumor section using the two-dimensional (2D) MRI slices [6].

From the recent literature, it can be noted that, the brain MRI examination based on the hybrid-imaging approach will provide enhanced result [7-14] compared to the traditional single stage procedures.
The recent works also reveals that, brain image examination with and without the skull section plays a vital role in the analysis of the disease existing in the various parts of the brain. Normally, the radiologist will offer the pre-opinion regarding the disease after executing the necessary initial test with the clinical level. The opinion of the radiologist will further be examined in hospitals along with the patient's brain MRI recorded using a chosen picture modality. In hospitals, most of the brain MRI assessment is done with the experienced doctor. The doctor will have the hardcopy of the 2D brain MRI slice of the chosen region and will perform a visual check to identify the rate and the region of the infection. Due to the availability of the modern equipments and also the accessibility of the image examination software tools reduced the burden of doctors. If the digital brain MRI (3D or 2D) is fed into the examination software, the software will perform all the preliminary analysis regarding the disease and it will provide the necessary suggestion to the doctor, who involved in the process of treatment planning to cure or limit the disease impact. If the pre-opinion and the software tools evaluation report is available to the doctor, necessary decision for treatment planning can be easily reached.

Due to its significance, in recent years, a number of brain MRI evaluation procedures are proposed and implemented by the researchers to assess the brain sickness. In the proposed work, a soft-computing based image examination procedure is implemented to examine the brain abnormalities, such as tumor/stroke from the brain MRI. This work proposes a hybrid tool based on the Cuckoo-Search (CS) and Kapur's-Entropy (KE) multi-level-thresholding (MLT) and Active-Contour (AC) segmentation. Later, an examination among the ground-truth (GT) and segmented brain section is implemented and essential values like Jaccard (JI), Dice (DI), sensitivity (SE), specificity (SP), accuracy (AC) and precision (PR) are computed for both the Brats2015 and ISLES2015 datasets. In this work, for each dataset, 50 numbers of Flair modality images are considered for the examination and the experimental outcome confirms that, proposed technique offered better average values of performance measures.

II. METHODOLOGY

This part of the paper describes the methodology implemented in the proposed work to analyze the brain MRI database. The work implemented in this paper is depicted in Figure 1.

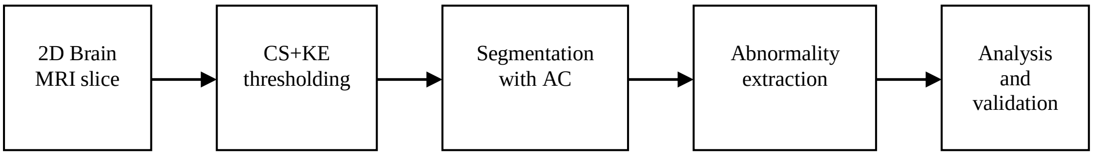


Figure 1. The overview of proposed hybrid image examination tool

Figure 1 presents the arrangement of the proposed image examination tool. Initially, the 2D brain MRI to be analyzed is enhanced with the CS+KE thresholding. Later, the tumor/stroke section is extracted using the AC technique and finally the extracted region is compared against the GT and based on the result, the proposed technique is validated.

A. **Dataset**

In this work, two benchmark MRI datasets, such as the Brats2015 and ISLES2015 are adopted for the examination. The main advantage of this dataset is, the existing brain pictures are free from the skull section and these images will not require any skull-stripping procedures [14]. Further, these datasets are recorded with various modalities and every 2D slice of the picture is associated with its own GT offered by an expert member. The related research works on Brats2015 and ISLES2015 can be found in [15-17].

B. **Pre-Processing**

Thresholding is a common pre-processing approach widely adapted to enhance the conventional and medical pictures. Here, the thresholding procedure is implemented using the Cuckoo-Search (CS) algorithm and the Kapur's-Entropy (KE) procedure. During this process, the multi-level thresholding with a chosen threshold value of three is employed to enhance the MRI picture.

CS algorithm is originally developed by Yang and Deb (2009) to find the optimal solution for engineering optimization problems [18].

The mathematical expression for this approach is as follows:

$$X_i^{(t+1)} = X_i^{(t)} + \alpha \oplus BW \qquad (1)$$

where $X_i^{(t+1)}$ =updated location, $X_i^{(t)}$ =initial location,

α = search parameter and BW=Brownian walk [19].

Image thresholding by Kapur method maximizes the entropy criterion to determine the optimal threshold value. The Entropy of the image measures compatibility and separability among classes. In this sense, when the optimal threshold value appropriately separates the classes, the Entropy has the maximum value. Initially Kapur has derived the entropy method for bi-level thresholding. Later it is extended to multilevel thresholding. For the bi-level example the objective function of Kapur's problem can be defined as [19];

$$J(th) = H_1^c + H_2^c \qquad (2)$$

Where C = 1 for Grayscale image.

Where the Entropies H_1 and H_2 are computed by the following model

$$H_1^c = \sum_{i=1}^{th} \frac{Ph_i^c}{\omega_0^c} \ln\left(\frac{Ph_i^c}{\omega_0^c}\right), \qquad (3)$$

$$H_2^c = \sum_{i=th+1}^{L} \frac{Ph_i^c}{\omega_1^c} \ln\left(\frac{Ph_i^c}{\omega_1^c}\right)$$

Similar to Otsu's method Entropy-based approach can be extended for multiple threshold values; for such a case it is necessary to divide the image into K classes using the similar number of thresholds. Under such condition the new objective function is defined as follows:

$$J(TH) = \max\left(\sum_{i=1}^{k} H_i^c\right) \qquad (4)$$

Where *TH* is a vector that contains multiple thresholds.

In this work, CS will adjust the threshold of the picture till the KE reaches its maximal value. The detailed expression on the KE adopted in this paper can be found in [14].

C. **Validation**

The performance of the proposed technique is validated based on a comparative analysis between the ground-truth (GT) and segmented brain section is implemented and essential values like Jaccard (JI), Dice (DI), sensitivity (SE), specificity (SP), accuracy (AC) and precision (PR) [6,14,20].

III. RESULTS and DISCUSSION

This section of paper highlights the results and discussions. All the works are realized by means of Matlab7 software. Primarily, the flair modality brain-image obtained from the image database is considered for the assessment. Here, the 2D view of the MRI is evaluated. The brats2015 will have the dimension of 216x160 pixels and the ISLES2015 will have the dimension of 512x512 pixels.

Initially, the Brats2015 is considered for the examination and the sample image considered for the demonstration is depicted in Figure 2.

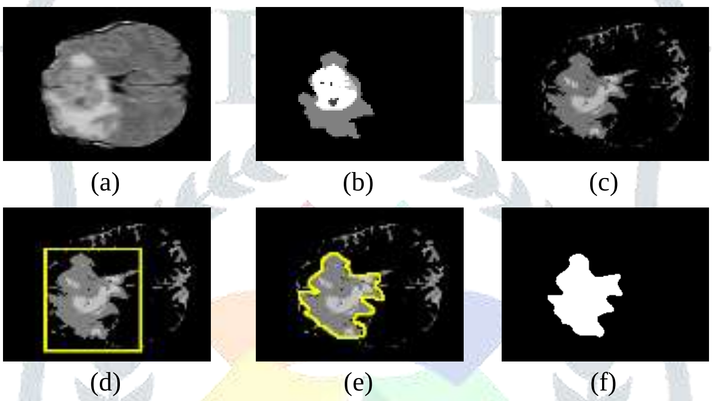
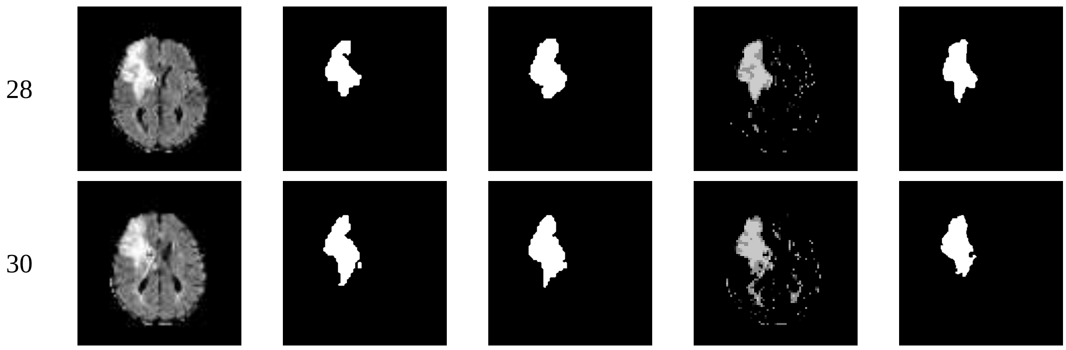


Figure 2. Results obtained for sample Brats2015 picture. (a) and (b) depicts the test picture and the GT respectively. (c) Outcome of CS+KE thresholding, (d) and (e) Initial and converged bounding box of AC, (f) Extracted tumor section

Fig 2 presents the outcome attained with the sample test picture of the Brats2015 dataset. For this image, following values are attained during the comparison of the GT with the tumor; JI=0.8452, DI=0.9018, SE=0.9728, SP=0.9473, AC=0.9916 and PR=0.9019. Similar procedure is implemented on other test pictures of the Brats2015 and the average similarity values obtained from the proposed technique is around 93.30%.

Later, this procedure is implemented on the ISLES2015 database. Fig 3 depicts the sample test pictures considered for the examination. The results of the image confirms that, proposed technique is efficient in providing better extracted stroke alike to the GTs available in Fig 4 (b) and (c). Table 1 presents the image performance measures obtained for the considered sample images with GT1. The Results with the GT2 is also similar. This procedure is executed on all the considered images (50 numbers) and the mean of JI, DI, SE, SP, AC and PR will offered the valued of 93.72%.



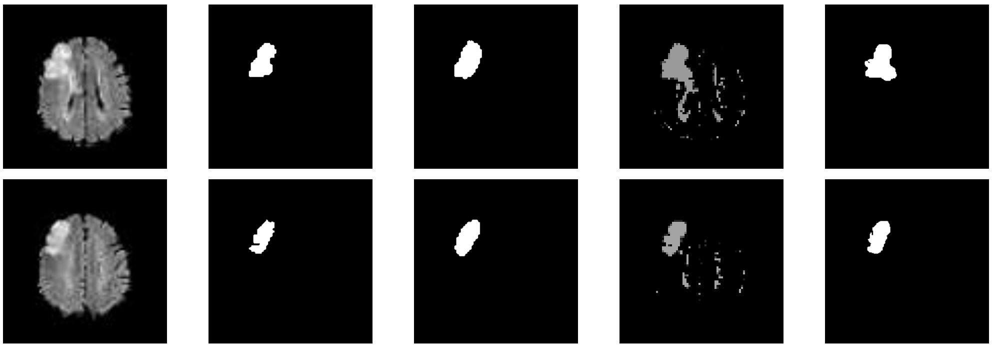


Figure 3. Results obtained for the ISLES2015 database. (a) Pseudo name, (b) Test image, (c) and (d) GTs available in the database, (e) Thresholded picture, and (f) Extracted stroke section

Table 1: Performance values for ISLES2015 database

Slice	JI	DI	SE	SP	AC	PR
28	0.8749	0.9037	0.9522	0.9911	0.9901	0.9122
30	0.8816	0.9082	0.9324	0.9903	0.9903	0.9131
32	0.8932	0.9216	0.9662	0.9914	0.9915	0.9153
34	0.8847	0.9173	0.9816	0.9922	0.9901	0.9078

From above results, it can be confirmed that, proposed technique works well on the considered datasets. In future, the performance of the tool can be improved by considering other pre-processing and post-processing available in the literature.

IV. CONCLUSION

In this study, an image examination procedure based on the CS+KE and AC is proposed to examine the flair modality brain MRIs of the Brats2015 and ISLES2015 dataset. During this study, 50 2D slices of each dataset is considered for the evaluation and the results are recorded. An assessment between the extracted tumor/stroke and its related GT is then performed to compute the performance of the proposed tool based on its similarity parameters. The average value of the ISP with the proposed work is better on the Brats2015 (>93.29%) and ISLES2015 (>93.71%). Hence, in future, this hybrid technique can be adopted to examine the brain MRI collected from hospitals.

REFERENCES

[1] K.T. Palani, and B. Parvathavarthini. "Automated EEG seizure detection based on S-transform," In. proc of International Conference on Computational Intelligence and Computing Research (ICCIC), IEEE, pp. 1-5, 2016. Doi: 10.1109/ICCIC.2016.7919558.

[2] K.T. Palani, B. Parvathavarthini, and K. Chitra. "Evaluation of joint analysis of multiple interictal events for spike extraction and source imaging," International Journal of Biomedical Engineering and Technology. vol. 25, no.1, pp.77-102, 2017.

[3] N. Dey, V. Rajinikanth, A.S. Ashour, and J.M.R.S. Tavares, "Social group optimization supported segmentation and evaluation of skin melanoma images," Symmetry, vol.10, no.2, pp.51, 2018. doi:10.3390/sym10020051.

[4] N.S.M. Raja, S.L. Fernandes, N. Dey, S.C. Satapathy, and V. Rajinikanth, "Contrast enhanced medical MRI evaluation using Tsallis entropy and region growing segmentation," Journal of Ambient Intelligence and Humanized Computing, pp.1-12, 2018. Doi: 10.1007/s12652-018-0854-8.

[5] N.S.M. Raja, V. Rajinikanth and K. Latha, "Otsu based optimal multilevel image thresholding using firefly algorithm," Modelling and Simulation in Engineering, vol.2014, paper id.794574, 2014.

[6] V. Rajinikanth, and S.C. Satapathy. "Segmentation of ischemic stroke lesion in brain MRI based on social group optimization and Fuzzy-Tsallis entropy," Arabian Journal for Science and Engineering. pp.1-14, 2018. Doi: 10.1007/s13369-017-3053-6.

[7] N.S.M.Raja, V. Rajinikanth, S.L. Fernandes, S.C. Satapathy, "Segmentation of breast thermal images using Kapur's entropy and hidden Markov random field," Journal of Medical Imaging and Health Informatics, vol.7, no.8, pp. 1825-1829, 2017. doi: https://doi.org/10.1166/jmihi.2017.2267.

[8] R. Vishnupriya, N.S.M. Raja, and V.Rajinikanth, "An efficient clustering technique and analysis of infrared thermograms," Third International Conference onBiosignals, Images and Instrumentation (ICBSII), IEEE, pp.1-5, 2017. DOI: 10.1109/ICBSII.2017.8082275.

[9] S.C. Satapathy, N.S.M. Raja, V. Rajinikanth, A.S. Ashour and N. Dey, "Multi-level image thresholding using Otsu and chaotic bat algorithm," Neural Computing and Applications, 2016. doi:10.1007/s00521-016-2645-5.

[10] T.D.V. Shree, K. Revanth, N.S.M.Raja, Raja, V. Rajinikanth, "A hybrid image processing approach to examine abnormality in retinal optic disc," Procedia Computer Science, vol.125, pp. 157-164, 2018. DOI: 10.1016/j.procs.2017.12.022.

[11] V. Rajinikanth, N. Dey, S.C. Satapathy, and A.S. Ashour. "An approach to examine magnetic resonance angiography based on Tsallis entropy and deformable snake model," Future Generation Computer Systems, vol.85, pp. 160-172, 2018. Doi: 10.1016/j.future.2018.03.025.

[12] S. Suganthi, and S. Ramakrishnan, "Semiautomatic segmentation of breast thermograms using variational level set method, IFMBE Proceedings," vol.43, pp.231–234, 2014. doi: 10.1007/978-3-319-02913-9_59.

[13] V. Rajinikanth, N.S.M. Raja, and K. Kamalanand. "Firefly algorithm assisted segmentation of tumor from brain MRI using Tsallis function and Markov random field," Journal of Control Engineering and Applied Informatics. vol.19, no.3, pp.97-106, 2017.

[14] V. Rajinikanth, S.C. Satapathy, S.L. Fernandes, and S. Nachiappan. "Entropy based segmentation of tumor from brain MR images–A study with teaching learning based optimization," Pattern Recognition Letters. vol.94, pp.87-95, 2017. Doi: 10.1016/j.patrec.2017.05.028.\

[15] Maier et al. " ISLES 2015 - A public evaluation benchmark for ischemic stroke lesion segmentation from multispectral MRI," Medical Image Analysis. Vol.35, pp.250–269, 2017.

[16] Menze et al. (2015) The multimodal brain tumour image segmentation benchmark (BRATS). IEEE T Med Imag 34(10):1993-2024. https://doi.org/10.1109/TMI.2014.2377694

[17] Brain Tumour Database (BraTS-MICCAI), http://hal.inria.fr/hal-00935640.

[18] X.S.Yang and S.Deb, Cuckoo search via Lévy flights. In: Proceedings of World Congress on Nature and Biologically Inspired Computing (NaBIC 2009), pp. 210–214. IEEE Publications, USA, 2009.

[19] V.S. Lakshmi, S.G. Tebby, D. Shriranjani and V. Rajinikanth, "Chaotic cuckoo search and Kapur/Tsallis approach in segmentation of T.cruzi from blood smear images," Int. J. Comp. Sci. Infor. Sec. (IJCSIS), vol.14, no.CIC2016, pp.51-56, 2016.

[20] I.T. Roopini, M. Vasanthi, V. Rajinikanth, M. Rekha, and M. Sangeetha, "Segmentation of tumor from brain MRI using fuzzy entropy and distance regularised level set," LNEE, vol.490, pp.297-304, 2018. Doi: 10.1007/978-981-10-8354-9_27.