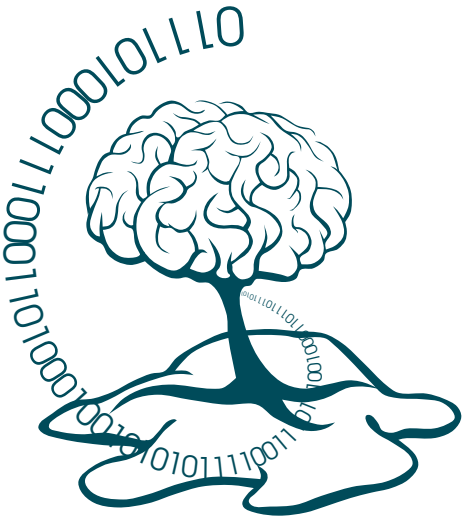

Ischemic Stroke Lesion Segmentation

www.isles-challenge.org

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Preface

Stroke is the second most frequent cause of death and a major cause of disability in industrial countries. In patients who survive, stroke is generally associated with high socioeconomic costs due to persistent disability. Its most frequent manifestation is the ischemic stroke, whose diagnosis often involves the acquisition of brain magnetic resonance (MR) scans to assess the stroke lesion's presence, location, extent, evolution and other factors. An automated method to locate, segment and quantify the lesion area would support clinicians and researchers alike, rendering their findings more robust and reproducible.

New methods for stroke segmentation are regularly proposed. But, more often than desirable, it is difficult to compare their fitness, as the reported results are obtained on private datasets. Challenges aim to overcome these shortcomings by providing (1) a public dataset that reflects the diversity of the problem and (2) a platform for a fair and direct comparison of methods with suitable evaluation measures. Thus, the scientific progress is promoted.

With ISLES, we provide such a challenge covering ischemic stroke lesion segmentation in multi-spectral MRI data. The task is backed by a well established clinical and research motivation and a large number of already existing methods. Each team may participate in either one or both of two sub-tasks:

SISS Automatic segmentation of ischemic stroke lesion volumes from multi-spectral MRI sequences acquired in the sub-acute stroke development stage.

SPES Automatic segmentation of acute ischemic stroke lesion volumes from multi-spectral MRI sequences for stroke outcome prediction.

The participants downloaded a set of training cases with associated expert segmentations of the stroke lesions to train and evaluate their approach, then submitted a short paper describing their method. After reviewing by the organizers, a total of 17 articles were accepted and compiled into this volume. At the day of the challenge, each teams' results as obtained on an independent test set of cases will be revealed and a ranking of methods established.

For the final ranking and more information, visit WWW.ISLES-CHALLENGE.ORG.

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Ischemic Stroke Lesion Segmentation Using Local Gradient and Texture Features

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Abstract. This work proposes fully automatic ischemic stroke lesion segmentation in multimodality brain MRI by extending our prior brain tumor segmentation (BTS) work [1]. The extensions of the BTS method include development of relevant MR image intensity inhomogeneity correction, several new features and feature ranking methods. We characterized brain lesions with multiple features such as piece-wise triangular prism surface area (PTPSA), multi-fractal Brownian motion (mBm), structure tensor based local gradient, regular intensities and intensity differences of MRI modalities. As in BTS, we used classical Random Forest (RF) [2] to classify the brain tissues as lesion or background.The method is evaluated on 28 patients' images having sub-acute ischemic stroke lesions from ISLES2015 SISS challenge dataset [3].

1 Methods

The success of our prior texture based BTS works[1] [4] [5] had driven the motivation of this works. Although our prior BTS work showed excellent performance in tumor segmentation, the methods needed brain lesion specific adaptation such as a new intensity inhomogeneity correction [6] technique for MR images, and introduction of a new local gradient feature information [7] and as well as a minimum redundancy maximum relevance (mRMR) feature selection [8] method. The overall flow diagram of our proposed lesion segmentation method is shown in Figure 1.

The detail description of most of the above methods can be found in our prior BTS publications[1] [4]. We briefly discuss the additional steps as follows:

Local Texture Feature Extraction: In our prior works we extract the local texture (PTPSA, mBm) features after the preprocessing. However, the preprocessing (skull-stripping and slice co-registration) step is skipped in this work since the images are already preprocessed. Note the local texture features are extracted before intensity inhomogeneity correction. As described in [9], the multi-scale wavelets do not require these corrections.

Intensity Inhomogeneity correction: It comprises of two steps. In the first step we perform 10 point histogram matching, where the reference images of four modalities are arbitrarily set from a single patient (in this case, the first patient pat001) data. Next step is normalizing all the intensity values around the

mean intensity value of cerebrospinal fluid (CSF). The method is described in [6]. However, instead of performing a two-class classification (e.g., CSF vs. Rest), we simply threshold the intensity differences among the modalities and obtain the CSF mask. We consider the histogram matched images, the normalized image differences among the modalities and the CSF mask as features for subsequent processing.

Structure Tensor based Local Gradient feature: Eigen value decomposition of the 2D structure tensor matrix [7] is performed to capture the local gradient information. From all four modalities Eigen values (λ_1, λ_2) are used as additional new features which allow a more precise description of the local gradient characteristics.

Feature ranking and selection: Since all the features are not equally important and redundancy among the features degrades the classifier's performance, a mutual information based mRMR[8] feature ranking technique is implemented. From the feature list, we choose 19 top ranked features out of 35 total features. The feature selection method show that intensity features in Flair and DWI MRI modalities as well as mBm, intensity difference, and local gradients features extracted from Flair and DWI modalities show the most discriminative properties respectively. This observation is also confirmed in other relevant works [10].

2 Results and Discussions

We obtain 2D segmented tissues using the predicted pixel labels from RF. These 2D segments are then stacked to generate volume image. Example lesion segments using two slices are shown in Figure 2.

Quantitative evaluation: We evaluate our preliminary lesion segmentation results using 28 training patients' obtained from the ISLES-2015 SISS challenge dataset. The performance efficiency is evaluated by across patient cross-validation, where odd numbered patients are used for training while the even numbered patients' are used for testing, and vice versa. On an average 59% Dice score overlap with 23% standard deviation is obtained from across the patient cross-validation. We notice comparatively better performance for lesions with larger size. Patientwise quantitative Dice overlap are presented in Table 1.

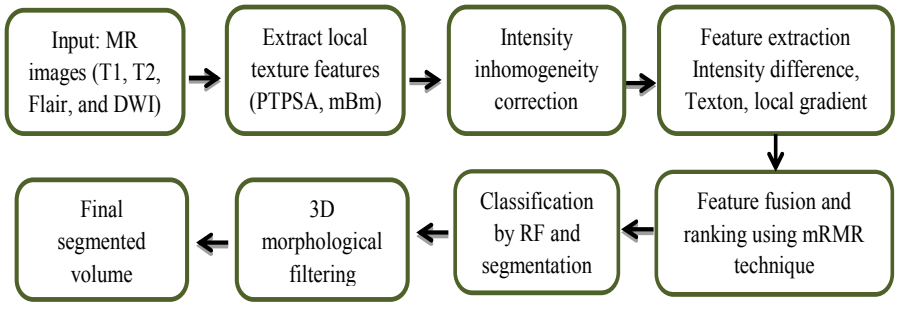

Fig. 1. Generic flow diagram of the proposed method

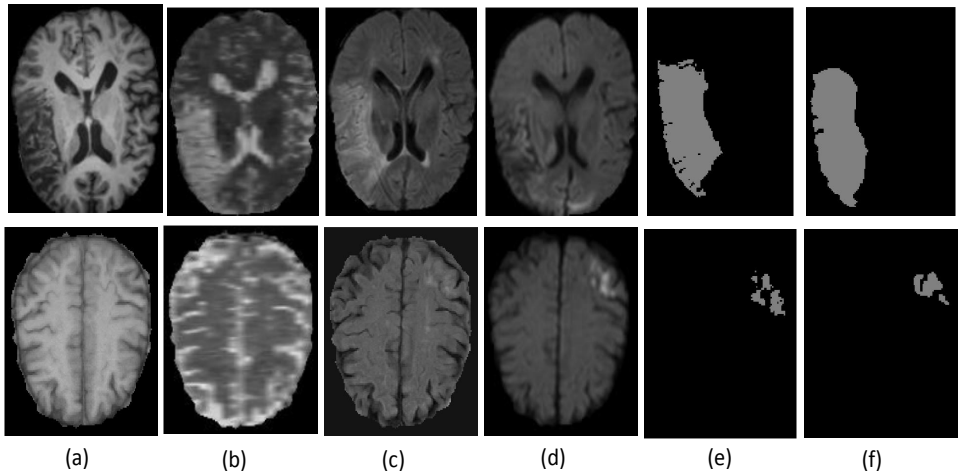

Fig. 2. Segmented lesions with corresponding input and ground-truth images. Each row represents an example set of multimodality MRI slices; Input: (a) T1, (b) T2, (c) Flair (d) DWI (e) Segmented lesion (f) ground-truth.

Pat	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	P13	P14
DC	0.89	0.75	0.35	0.75	0.81	0.89	0.81	0.77	0.83	0.53	0.60	0.65	0.13	0.80
Pat	P15	P16	P17	P18	P19	P20	P21	P22	P23	P24	P25	P26	P27	P28
DC	0.74	0.47	0.51	0.55	0.26	0.73	0.08	0.55	0.56	0.56	0.62	0.27	0.26	0.79

Table 1. Summary of quantitative Dice(DC) score for 28 patients: Avg. 59%, std. 23%

3 Conclusion

This work proposes an automatic lesion segmentation method and cross validation using ISLES-2015 SISS challenge dataset. Experimental results with 28 clinical patient data sonfirm the efficacy of our method for sub-acute ischemic stroke lesion segmentation. The training results show comparable performance when compared to other state-of-the art works posted on the VSD website[3]. Note the evaluation results reported here are obtained using the ground-truth provided on the VSD web on our local machines. We notice a considerable number of false positives in our detections that compromise the overall results. Our future works include study of more effective features and sophisticated feature selection techniques. We also plan to study deep neural network based segmentation technique to develop a generalize method for both sub-acute and acute ischemic lesion segmentation. At the time of writing this report, the evaluation process had been in-process in the online evaluation tool posted on the VSD website [3]. The cross-validation results from VSD web will be reported in the next iteration of this submission.

Acknowledgments

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