Computer aided diagnosis of epilepsy lesions based on multivariate and multi-modality data analysis

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Introduction

One third of patients suffering from epilepsy are resistant to medication. For these patients, surgical removal of the epileptogenic zone offers the possibility of a cure. Surgery success relies heavily on the accurate localization of the epileptogenic zone. The analysis of neuroimaging data such as magnetic resonance imaging (MRI) and positron emission tomography (PET) is increasingly used in the pre-surgical work-up of patients and may offer an alternative to the invasive reference of Stereo-electro-encephalography (SEEG) monitoring. To assist clinicians in screening these lesions, we develop computer aided diagnosis systems (CAD) based on a multivariate and multi-modality data analysis approach. Fig.1 gives a schematic overview of the proposed framework.

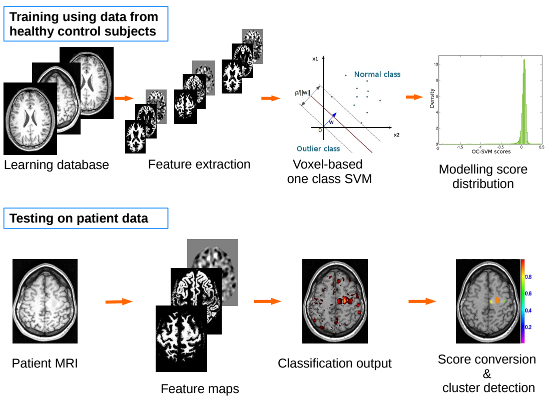

***Fig.1**: overview of the proposed CAD system.*

Material and Methods

Data: A first CAD system was constructed using T1-weighted, FLAIR and diffusion (DTI) MR images of 40 healthy control subjects. The system was tested using both realistic simulations and clinical data.

Feature extraction: Six features capturing image patterns associated with epileptogenic lesions were extracted from T1-weighted images. The FLAIR image was intensity scaled. Mean diffusivity and fractional anisotropy maps were extracted from the DTI image. All extracted features were spatially registered to the MNI (Montreal neurological institute) reference space and smoothed using a Gaussian kernel of 6 mm width.

Classifier: A OC-SVM classifier was associated with each voxel from the 3D volume. To take into account the multi-modal nature of the extracted features, each single modality was associated with a base OC-SVM classifier. Majority voting was then used to combine the three base classifier outputs [2]. Two approaches have been proposed to convert OC-SVM scores into calibrated probabilities. The first approach constructs a normative score distribution using leave-one-control-out [1]. The second is a global reformulation of the OC-SVM problem to estimate nested probability level-sets [3]. Based on the converted scores, the score map is thresholded to highlight suspicious voxels at a given p-value.

Results

Fig.2 illustrates an example case of a good correlation between the activated SEEG contacts and the detection map obtained for a given patient.

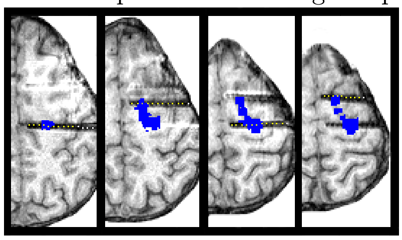

***Fig.2**: A patient post-SEEG implantation MRI axial slices overlaid with the activated SEEG electrodes (yellow dots) and the detection map (blue).*

Our results show that multi-modal fusion can improve the CAD system performance. The best performances were obtained with our novel late fusion approach. The proposed CAD system also outperforms univariate statistical analyses (SPM) and compares favourably with recent state-of-the-art approaches in terms of sensitivity and specificity.

Discussion

The proposed CAD system combines multi-modality images with machine learning algorithms for the detection of lesions associated with intractable epilepsy. The initial formulation of the OC-SVM classifier was adapted to take into account the specificity of this detection task by proposing 1) a voxel-level classification scheme, 2) an ensemble learning strategy for handling multi-modal data and 3) a conversion of classification scores into calibrated probabilities. The CAD system was validated using both realistic simulations and clinical data.

References

[1] M. El Azami et al. PRNI'2013, Philadelphia.
[2] M. El Azami et al., ISBI'2015, New York.
[3] M. EL Azami et al., ESANN'2016, Bruges.

Acknowledgements

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