Clustering based Segmentation of MR Images for the Delineation and Monitoring of Multiple Sclerosis Progression

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Abstract— **This paper presents a clustering-based method for the detection of Multiple Sclerosis (MS) lesions, by including anatomical information, brain geometry and lesion features, while volume quantification is performed. The proposed method utilizes Fluid Attenuated Inversion Recovery (FLAIR) images for the delineation of the plaques and brain atrophy estimation. The methodology includes five steps: (i) image preprocessing, (ii) image segmentation utilizing the K-means clustering algorithm, (iii) post processing for elimination of false positives, (iv) delineation and visualization of the MS lesions, and (v) brain atrophy estimation. It is implemented in two different datasets; (a) a dataset of 3D FLAIR MR Images, acquired in 30 MS patients, and (b) a dataset of 15 FLAIR MR Images, provided by the MICCAI Challenge 2016. A sensitivity 73.80%, and 71.52% was achieved for the two datasets, respectively. Brain atrophy was determined only on the first dataset, since follow up scans are available.**

Keywords—Multiple Sclerosis, Brain MRI, Brain atrophy estimation

I. Introduction

Multiple Sclerosis (MS) is an autoimmune demyelinating disease affecting the Central Nervous System, causing loss of myelin sheaths of neuronal axons in the brain and in the spinal cord. This damage in myelin sheaths disrupts the ability of signal transmission in different parts of the nervous system, resulting to physical and psychological problems, such as loss of balance or memory, muscle or walking problems among others [1]. The demyelination creates scars, known as plaques, mostly in the white matter of the brain or in the spinal cord, and for that reason lesion detection plays an important role in studying the disease's progression over time. Until now, Magnetic Resonance Imaging (MRI) is considered the most common, accurate and non-invasive method for diagnosing and monitoring MS. In addition, MRI scans allow the evaluation of the response to treatment and determination of the disease pattern and its disability [2].

During the past years, several studies have been examined MRI segmentation of MS lesions in brain. A brief description of the state-of-the-art methods used so far, is presented in the study of Danelakis *et al.* [3], where supervised and unsupervised methods based on different features are described. Also, different methods presented in the MICCAI challenge 2016 for MS lesion image segmentation are given by Commowick *et al.* [4]. Furthermore, many state-of-the art methods for MS segmentation utilizing MR Images are described by Kaur *et al.* [5], proposing the need of developing the specific area in terms of MRI scanner, MRI protocol and a further improvement of the proposed techniques.

The proposed technique in this paper is a semi-supervised, statistic, lesion-based method, aiming at the detection of MS plaques and the monitoring the progression of the disease. As a semi-automated method, the procedure seems less time consuming, while its most important feature is that plaques are detected by the implementation of rules, exploiting geometrical, texture, intensity and other lesion features, employing knowledge obtained by the experts.

II. Materials and Methods

A. Dataset

For the evaluation of the proposed method, two datasets are utilized. A dataset of 3D MRI FLAIR images is acquired from 30 MS patients, within the ProMiSi project [6] aiming at the development of a tool for the delineation of MS lesions and brain atrophy.

The recruitment of the patients was performed in the Neurology Clinic of University Hospital of Ioannina, while the acquisition of the MRI images was performed in the Ippokratio Ioanninon S.A. Beforehand, written informed consent was signed by the patients the approval by the ethical committees has been obtained.

The 3D MRI FLAIR images were manually annotated by an expert radiologist. All brain images were acquired on MRI scanner, 1.5 Tesla Siemens Achieva Nova. The 3D FLAIR MRI consists of 180 contiguous sagittal 2 mm slices. In order to compare the proposed method with other methods reported in the literature, the MICCAI Challenge 2016 [2] data was used. The MICCAI dataset [4] consists of 15 3D FLAIR MRIs, acquired on three different MRI scanners. All images were manually delineated by 7 different experts.

B. MS Lesion Segmentation

The pipeline of the proposed method is depicted in Fig. 1.

Preprocessing

The preprocessing step includes the following three modules.