Differentiating Multiple Sclerosis from Cerebral Microangiopathy based on Modern Pattern Recognition Techniques on Magnetic Resonance Images

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Abstract

The diagnosis of Multiple Sclerosis (MS) is primarily based on the clinical examination, while it is supported by Magnetic Resonance (MR) imaging evaluated by experienced radiologists. Although, the typical imaging characteristics of MS follow well documented patterns, there are other pathologies affecting the Central Nervous System (CNS) that resemble the imaging characteristics of MS and vice versa. Cerebral Microangiopathy (CM) belongs to such pathologies that may puzzle the radiologist regarding his/her final decision. The differential diagnosis problem usually arises at the onset of the disease, when there is no spread of the signs and symptoms in space and time. The early diagnosis of both diseases is of great importance for the beginning of the right treatment.

The aim of the present thesis was to evaluate whether textural features may help in discriminating MS from CM. This was achieved by designing, implementing, and evaluating a pattern recognition system on MR images employing textural features.

The clinical material consisted of 29 patients all scanned with the same MR protocol. The MS group comprised of 11 patients diagnosed with clinically definite MS. On the other hand, the CM group included 18 patients with verified CM. Every patient was scanned on a MAGNETOM Sonata MR modality of 1.5 Tesla with the Fluid Attenuated Inversion Recovery (FLAIR) protocol at the ‘251 General Airforce Hospital, in Athens, Greece. Twenty-three textural features were calculated, 4 from the image histogram, 14 from the co-occurrence matrices and 5 from the run-length matrices. The regions used included MS and CM lesions in addition to the Normal Appearing White Matter (NAWM) adjacent to each lesion.

The classification methods utilized in the present thesis included a/ the Probabilistic Neural Network (PNN) classifier used to estimate the capability of textural features in discriminating MS from CM and b/ the combination of the PNN classifier, the Support Vector Machines (SVM) classifier and the k-Nearest Neighbor classifier (k-NN) evaluated each one separately and as a whole in a Multi-Classifier (MC) system. Additionally, the Least-Square Feature Transformation (LSFT) technique was applied to improve the accuracy of the classification system by clustering the textural features, for each pathology, around arbitrary pre-selected points rendering them more separable. The performance evaluation of the designed classification schemes was based on the External Cross Validation (ECV) process, which is considered indicative for the generalization of the designed classification system to 'unseen' cases.

It was found that the textural features calculated from MS and CM lesions contain useful clinical information regarding the texture of MS and CM as depicted on MR images. The classification accuracy attained was 73% in correctly discriminating MS from CM utilizing the ECV method. In addition, the utilization of the adjacent NAWM to each lesion and the LSFT technique in the classification scheme boosted the classification accuracy by 10% resulting in 83% overall classification accuracy in the MC system.

The textural features that participated in the optimum feature vector were related to the degree of homogeneity, the amount of randomness and the dispersion of the gray-tone intensity values within the texture of the MS and CM. These textural characteristics are related to textural parameters that physicians employ in diagnosis and they were proportional to the textural imprint of MS and CM lesions i.e.. MS-regions were darker, of higher contrast, less homogeneous, and rougher as compared to CM.

Finally, the proposed system might be of value as an assisting tool in lesion characterization when MS differential diagnosis issues arise.