Detection of Abnormal Human Brain Structure from MRI using Symmetry Features

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Introduction

Brain magnetic resonance images (MRI) and X-ray computed tomography scans are crucial in modern medical diagnoses. Detection of abnormal human brain structure in MRI is important in medical diagnosis because it provides information associated to anatomical structures as well as potential abnormal tissues necessary for treatment planning and follow-up of patients. However, there is usually a time delay between images acquisition and interpretation of radiologists and/or doctors who prescribe the images, which may contribute to clinical exacerbation of the patients.

Alarm through electronic medical record (EMR) [1] has been proved to be effective in reducing medical malpractices; nonetheless, the auto-alarm within EMR is limited to simple laboratory data due to technical challenges. Despite numerous efforts and promising results in the medical imaging community, accurate and reproducible segmentation and characterization of abnormalities are still a challenging and difficult task because of the variety of the possible shapes, locations and image intensities of various types of tumors. Existing methods leave significant room for increased automation, applicability and accuracy.

Computerized strategies for distinguish a standard of asymmetry, considered as normal, from abnormal asymmetry have been very elusive, because that human brains are not perfectly symmetric [2]. In order to detect and quantify the complex regional changes which occur under a variety of normal and pathological conditions, we propose a unifying, local phase-based approach for brain anatomy structure symmetry detection. This algorithm generates a symmetric index for MR brain images that is based on the analysis of orientation map information by using histogram comparison. A histogram comparison of the orientation map between the right and left hemispheres, based on local-phase algorithm, is then developed to reflect the observed variability of shape and color in anatomical structure of the pixels whose correspondences are found by the symmetric algorithm.

Experimental results of the proposed algorithm on 24 MR brain images (11 pathological, 13 healthy), show that the symmetric index can help differentiate between normal brain structures and intracranial pathologies with promising performance. We expect that this symmetric index can provide clinical and formulary information to physicians.

Materials and Methods

A. Data Acquisition

The MR brain images were acquired by a Bruker 3T Biospec MRI machine and a 1.5T Siemens MRI machine respectively in the college and hospital. The main reason to use this sequence was the ideal balance of imaging quality and scanning time (delete). Images performed in the college were examined carefully to exclude possible pathologies.

B. Our Proposed Algorithm

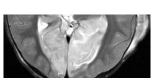
Phase congruency [3] is an illumination and contrast invariant measure of symmetry in an image. An indication of the orientation of the feature is obtained from the minimization of the moments of phase congruency. A step further towards measuring the similarity between the left and right hemispheres can be done by comparing the histograms of its orientation map. The idea behind histogram-based approaches is that two hemispheres with the same morphology will have little difference in their histograms. In addition, histograms are invariant to hemispheric asymmetry appearing to be present at birth. An abnormal detection is declared if the absolute sum of histogram differences between two hemispheres is greater than a threshold T. In this procedure, the threshold is chosen 0.0136, which was obtained after experimenting on enough number of samples as described in table 1. Receiver operating characteristic (ROC) curve [4] analysis was done to evaluate the performance of the symmetric index in differentiating between normal brain structures and intracranial pathologies. The area under the ROC curve (Az) was calculated to summarize the performance of symmetric index in the task of differentiation. We calculated sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) by using symmetric index of the cutoff value. When any value of symmetric index was larger than its cutoff value, we regarded it as an abnormal case. Afterward, diagnostic accuracy, sensitivity, specificity, PPV, and NPV, including 95% confidence interval (CI), were also calculated and compared.

Results and Discussions

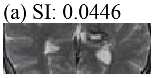
In this experiment, the MR brain images database contains 24 MR images which are used to test our experiment. All of the MR brain images are assigned a symmetric index depend on the similarity with the right and left hemispheres through our algorithm. Figure (a)~(c) are axial MR images of three abnormal cases from [5][6][7], and figure (d) and (e) are normal cases from the database. SI (Similarity Index) represents the similarity between the left and right hemispheres. Fig. (a)~(e) demonstrate the efficacy of our algorithm under different conditions: (a) symmetric large lesions; (b) minor lesion hidden beside symmetric normal structures; (c) small symmetric lesions. Furthermore, our algorithm does not over-response to asymmetric but structures (Fig. d-e). In the evaluation of the performance difference of the symmetric index in the differentiation between normal brain structures and intracranial pathologies by using ROC analysis, the ROC curve and the Az value are shown in Fig 2. Az value area under the ROC curve is 0.97. Cutoff value of the symmetric index was 0.0136. Diagnostic accuracy, sensitivity, specificity, PPV, and NPV, including 95% CIs of symmetric index for differentiating between normal brain structures and intracranial pathologies, are given in Table 1.

Conclusions

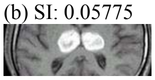
In this preliminary study, we use symmetry index, anatomical landmarks, and specific shapes and colors of each neuroimage to discriminate between normal brain structures and intracranial pathologies, and to provide a feasible foundation for images auto-alarm system in the future. Significant differences were found in the symmetric index between normal brain structures and intracranial pathologies. Early detection of abnormal neuroimages using symmetric index as a criterion may construct an intelligent image auto-alarm system in the near future.



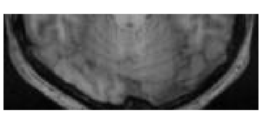
(a) SI: 0.0446



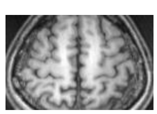
(b) SI: 0.05775



(c) SI: 0.04814



(d) SI: 0.0123



(e) SI: 0.0065

Fig. 1. Examples of calculating the symmetric indices to differentiate the normal cases (d-e) from abnormal cases (a-c)[5][6][7]. SI represents a symmetric index.

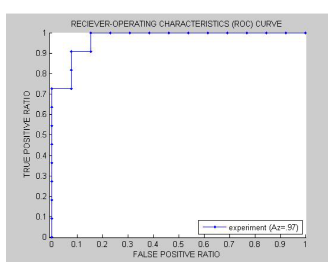


Table 1: Diagnostic accuracies of symmetric index for differentiation between normal brain structures and intracranial pathologies

Variable	Accuracy, %	Sensitivity, %
SI> 0.0136	78.9(75-82.9)	70.2(57.7-82.7)
Specificity, %	PPV, %	NPV, %
86.3(79.3-93.3)	88(82.6-93.5)	82.8(76.4-89)

Fig. 2. Graph shows the ROC curve of our experiment for differentiation between normal brain structures and intracranial pathologies. Az value area under the ROC curve is 0.97.

References

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