

Image Registration and Segmentation for the Quantitative Evaluation of Complex Medical Imaging and Diagnosis over Head – A Systematic Review

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ABSTRACT

In medical imaging and diagnosis, the complex shape of the ventricular system makes accurate visual comparison of CT scans difficult. The current research developed a quantitative method to measure the change in cerebral ventricular volume over time. Key elements of the proposed work are: adaptive image registration based on mutual information and wavelet multi resolution analysis; adaptive segmentation with novel feature extraction based on the Dual-Tree Complex Wavelet Transform; volume calculation. This new approach has potential for development as a tool in the evaluation of medical diagnosis such as hydrocephalus.

Keywords : Hydrocephalus, DT-CWT, Image Registration, Image Segmentation

INTRODUCTION

Example disease over Head: Hydrocephalus,[3,4] also known as "water on the brain," is a medical condition in which there is an abnormal accumulation of cerebrospinal fluid (CSF) in the ventricles, or cavities, of the brain. This may cause increased intracranial pressure inside the skull and progressive enlargement of the head, convulsion, and mental disability. Hydrocephalus can also cause death.

EXISTING WORK – LITERATURE SURVEY

The medical imaging and diagnosis over the head are commonly evaluated by visual comparison of serial CT scans of the head. However, the complex shape of the ventricular system[1] and the differences in the angulations of slices combined with slight differences in positioning of the head from one CT study to the next can make direct visual comparisons of serial imaging studies difficult and of limited accuracy. This makes the quantitative assessment of the volume change desirable.

Existing methods for quantitatively assessing ventricular volume [2] have included the diagonal ventricular dimension the frontal and occipital horn ratio, the ventricular brain ratio, the Evans ratio, Huckman's measurement, and the minimal lateral ventricular width, among others. The previous attempts to quantitatively assess ventricular volume have focused on linear, ratio, or surface area estimates of ventricular size, and as such, have been limited by the fact that they try to estimate volume dimensional construct using 1- or 2-dimensional measurements. In many cases the estimates are based solely on measurements taken from a single axial slice, and may leave potential volumetric changes in the 3rd or 4th ventricles unaccounted for. The previous techniques that have tried to assess volumetric changes 3dimensionally have been time consuming, limiting their clinical applicability.

Furthermore, often measurements appropriate for adults are not appropriate for pediatric patients.

IMAGE REGISTRATION AND SEGMENTATION – METHODOLOGY

This research work describes a new methodology to measure the change in the volume of the ventricles using CT scans taken at two separate times. The method involves registering the two CT image sequences to be compared, automatically segmenting the ventricles in all the image slices, and calculating a volume change from the results. Image registration [11] is used to align the second set of CT images with the first, thus making the volume calculations consistent, reducing the error caused by the partial volume effect and improving the accuracy of the calculated change in volume. The differences in angulation of the slices combined with the slight differences in positioning of the head from one CT to the next are referred to in this paper as the displacement of the human head. A number of image registration techniques have been described previously, including landmark techniques; point-based and thin-spline based methods; mutual information-based methods [6].

The current research required a rigid registration technique to compensate for the rigid displacement of the head between the CT scans, while maintaining the differences in ventricular volume and shape. Both in-plane and out-of plane displacements needed to be considered. The new approach includes an adaptive rigid registration method[10] based on mutual information combined with image gradient information, and wavelet multiresolution analysis. Image segmentation[8] is the process of separating out mutually exclusive homogeneous regions of interest and in this research is used to isolate the ventricles in preparation for the volume calculation. This research work focus on a variation of the watershed automated segmentation method. The

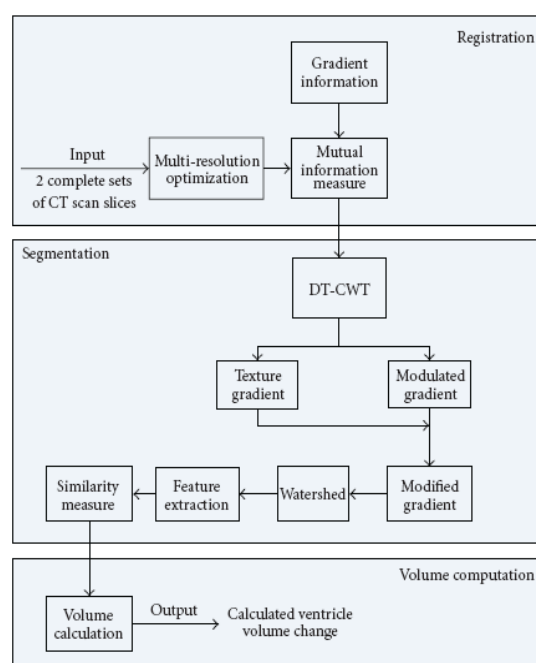
watershed method [9] suffers from an over segmentation problem, and a number of methods proposed in the literature to overcome the problem have had varying success.

In the current research, the Dual-Tree Complex Wavelet Transform [13] (DT-CWT) is proposed to detect the texture boundaries and a novel feature extraction method used to optimize the segmentation results. Once the images are registered and the ventricles are segmented, it calculates the change in volume. To validate the method developed in this study, the simulate brain tissue can be used as well as realistic medical lab data set can be used.

Methodology:

1. Registration Process
 - a. Optimization
 - b. Change in Volume Error
 - c. Modified Mutual Information
2. Adaptive Segmentation
 - a. Preliminary Segmentation
 - b. Texture Classification and feature Extraction
3. Volume Calculation

Framework Model:



CONCLUSION

- Future work will include a more rigorous determination of the predictor value.
- The validation of the new approach can be made by collecting and testing a larger set of clinical data to examine the algorithm's performance on a wider range of clinically significant volume changes, particularly small clinically relevant changes.
- The performance optimization can be done by modifying the parameters involved in the framework developed.

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