USING WATERSHED AND MULTIMODAL DATA FOR VESSEL SEGMENTATION: APPLICATION TO THE SUPERIOR SAGITTAL SINUS

N. Passat[1,2], C. Ronse[1], J. Baruthio[2], J.-P. Armspach[2] and J. Foucher[3]

[1]*LSIIT, UMR 7005 CNRS-ULP, Strasbourg I University, France*

[2]*IPB, UMR 7004 CNRS-ULP, Strasbourg I University, France*

[3]*U405 INSERM Strasbourg I University, France*

Abstract   Magnetic resonance angiography (MRA) provides 3-dimensional data of vascular structures by finding the flowing blood signal. Classically, algorithms dedicated to vessel segmentation detect the cerebral vascular tree by only seeking the high intensity blood signal in MRA. We propose here to use both cerebral MRA and MRI and to integrate a priori anatomical knowledge to guide the segmentation process. The algorithm presented here uses mathematical morphology tools (watershed segmentation and grey-level operators) to carry out a simultaneous segmentation of both blood signal in MRA and blood and wall signal in MRI. It is dedicated to the superior sagittal sinus segmentation but similar strategies could be considered for segmentation of other vascular structures. The method has been performed on 6 cases composed of both MRA and MRI. The results have been validated and compared to other results obtained with a region growing algorithm. They tend to prove that this method is reliable even when the vascular signal is inhomogeneous or contains artefacts.

Keywords: vessel segmentation, watershed segmentation, a priori knowledge, MRA, MRI

1.   Introduction

Magnetic resonance angiography (MRA) is a technique [5] frequently used to provide 3D images of cerebral vascular structures. The availability of precise information about brain vascular networks is fundamental for planning and performing neurosurgical procedures, but also for detecting pathologies such as aneurysms and stenoses. Since all classical image processing tools have been applied more or less successfully to the case of vessel segmentation, it might be interesting to explore new kinds of algorithms involving a priori knowledge. In a previous paper [8] we proposed a first attempt to use anatomical knowledge as a way to guide a segmentation algorithm. A major

breakthrough of this work was the creation of an atlas dividing the head into different areas presenting homogeneous vessel properties. The use of this atlas enables to store a priori knowledge concerning the vessels located in each area and then to propose ad hoc segmentation algorithms. In this paper, we propose an algorithm dedicated to one of these areas, containing a main vessel of the venous tree: the superior sagittal sinus (SSS). This algorithm is based on mathematical morphology tools (watershed segmentation and grey-level operators). It also integrates a priori anatomical knowledge and uses both MRA and MRI data in order to take advantage of both acquisition techniques. It uses a multi-resolution slice by slice process, simultaneously segmenting the flowing blood signal in MRA and the blood and vessel wall in MRI. This paper is organized as follows. In Section 2, we review previous approaches concerning vessel segmentation. In Section 3, we describe the way to use anatomical knowlege. In Section 4, the proposed algorithm is described. In Section 5, technical details concerning the method and the database used for validation are provided. In Section 6, the method is tested and compared to a region growing algorithm. Discussion and projects are presented in Section 7.

2.   **Related work**

The vessel segmentation methods can be divided into several categories, corresponding to the main strategies used to carry out the segmentation. The first proposed strategies were based on filtering [4]. Method based on mathematical morphology (hysteresis thresholding in [7], grey level erosions and dilations in [3] or grey-scale skeletonization in [10]) and region growing [11] have also been proposed. More recently, methods based on vessel tracking [6], and crest line detection [1] have also been proposed.

It has to be noticed that very few vessel segmentation methods have been designed to process multimodal data. A method proposed in [9] for cerebral vascular structures visualization, uses both 3D MRA and 2D X-ray images. A method has been proposed by us in [8], where angiographic and non angiographic data are involved in an atlas-based region growing algorithm. Nevertheless, the simultaneous use of images from different modalities is quite unusual. The algorithm presented here, based on watershed [2] segmentation and mathematical morphology operators, proposes to uses both MRA and MRI to take advantage of anatomical knowledge concerning the brain superficial venous structures.

3.   **A priori knowledge integration**

The SSS presents many invariant properties (i.e. properties being identical for every subjects) which can be useful for guiding a segmentation process. These properties and a way to use them are described as follows.