A technique for warping MR images to histological sections based on thin-plate splines with homologous points optimization by minimizing bending energy

Y. Liu[1,2], M. Uberti[1,2], H. Dou[2,3], H. Gendelman[2,3], and M. Boska[1,2]

[1]Radiology, University of Nebraska Medical Center, Omaha, NE, United States, [2]Center for Neurovirology and Neurdegenerative Disorders, University of Nebraska Medical Center, Omaha, NE, United States, [3]Pharmacology and Experimental Neuroscience, University of Nebraska Medical Center, Omaha, NE, United States

Introduction: Thin-plate splines have been used extensively in the registration of MR images to histological sections[1-3]. Landmark extraction for thin-plate splines is always prone to error. Previous techniques have been developed to optimize the landmark extraction using mutual information (MI). We proposed a technique to optimize the landmark extraction by minimizing bending energy of the landmarks[4].

Methods and Applications: The proposed technique is described in the following chart in Fig.1. Its application in a HIV-1 encephalitis study using a mouse model is demonstrated in the same figure. Superparamagnetic Iron Oxide (SPIO) labeled monocyte-derived macrophages (BMM) were injected intravenously and tracked across the blood-brain barrier using T2*-wt MRI in five mice at a Bruker 7T scanner[5]. Brains were removed and fixed for histological analysis. Histological sections were stained by Prussian blue. MRI volumes were first registered to the 3D histology (stacked histological sections) using affine transformation. MRI volumes were then re-sliced to match histological sections. These slices were then warped to histological sections using the proposed technique.

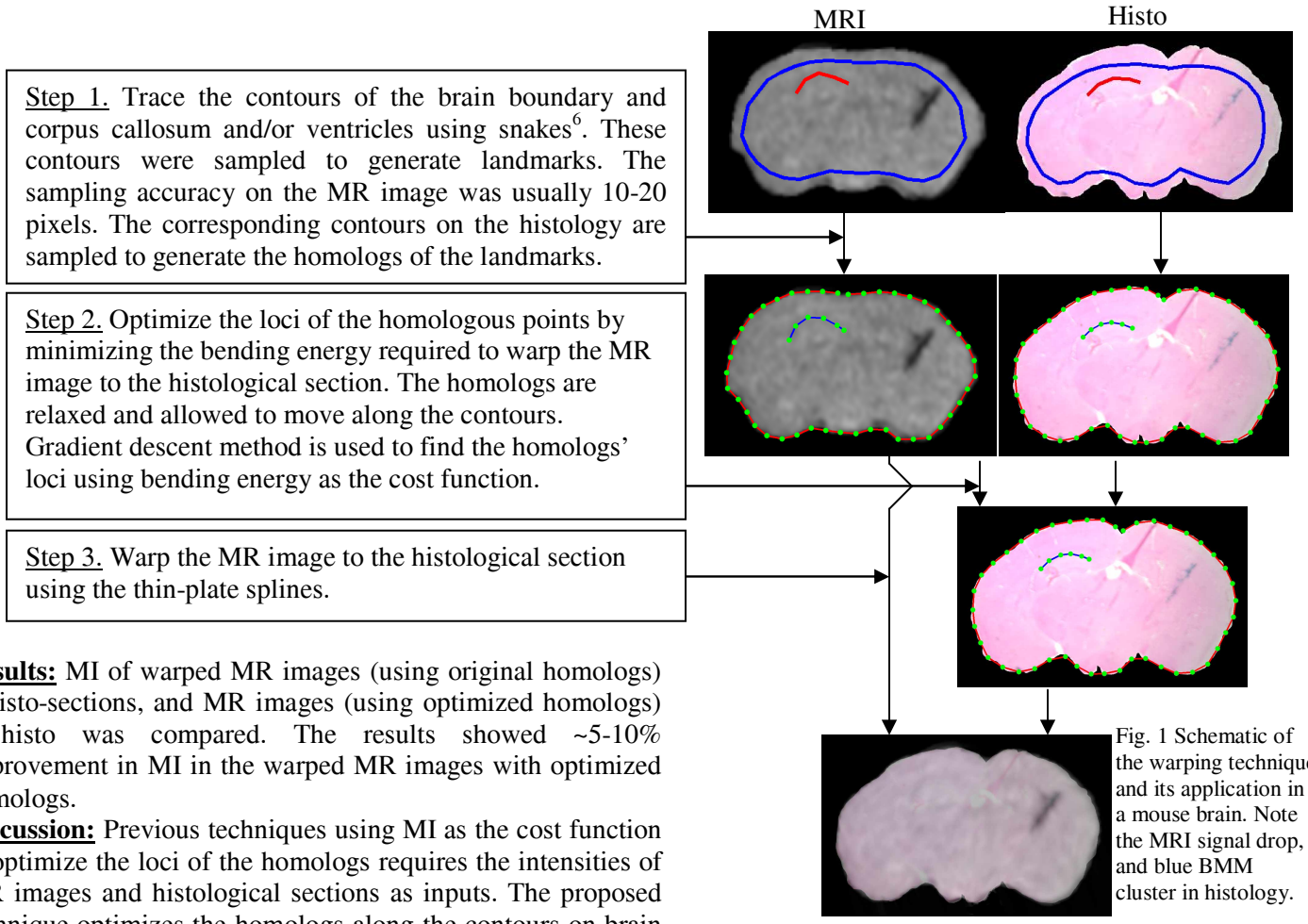

Fig. 1 Schematic of the warping technique and its application in a mouse brain. Note the MRI signal drop, and blue BMM cluster in histology.

Results: MI of warped MR images (using original homologs) – histo-sections, and MR images (using optimized homologs) – histo was compared. The results showed ~5-10% improvement in MI in the warped MR images with optimized homologs.

Discussion: Previous techniques using MI as the cost function to optimize the loci of the homologs requires the intensities of MR images and histological sections as inputs. The proposed technique optimizes the homologs along the contours on brain structures. This procedure is more efficient than methods using MI. Its accuracy needs to be further studied.

Reference:

1. Kim B, Boes JL, et al. *Neuroimage*. 1997; 2. Jacobs MA, Windham JP, et al. *Med Phys*. 1999; 3. Meyer CR, Moffat BA, et al. *Mol Imaging*. 2006; 4. Bookstein FL. *IEEE Trans Pattern Anal Mach Intell*. 1989; 6. Dou H, Liu Y, et al. *14th Conference on Retroviruses and Opportunistic Infections* 2007; 6. Xu C, Prince J. *IEEE trans. on image processing*. 1998.