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Segmentation of Small Veins Using 3D isotropic SW images at 7T

Narayanan Krishnamurthy[1], Yujuan Zhao[2], Rebecca Maccloud[3], Tiejun Zhao[4], Shailesh Raval[3], Junghwan Kim[3], Caterina Rosano[3], Howard Aizenstein[3], and Tamer Ibrahim[3]

1Bioengineering, University of Pittsburgh, Pittsburgh, PA, United States, 2Bioengineering, University of Pittsburgh, PA, United States, 3University of Pittsburgh, PA, United States, 4Siemens Medical Solutions, PA, United States

[Target Audience] Researchers interested in Normal and Aging Brain Morphometry using 7T SW Images

[Purpose] We took 0.5 mm^3 isotropic SW images to visualize small veins. The isotropic voxels allow for semi-automatic segmentation methods to track the vessels across slices. In addition we looked at the feasibility of using a 3D mask from isotropic images for use with high in-plane resolution 2D SW images (0.2mmx0.2mmx1.5mm) to segment structures like the hippocampus.

[Methods] High resolution 3D and 2D SWI images were obtained at 7T using parallel transmit system with a 20 channel transmit array in conjunction with a 32 channel receive-only array. Scan time of 2D without acceleration was 18min 3D with acceleration of 2 was 17min, 2D: TR=1960 ms, TE=14 ms. The 3D parameters were TR=40, TE=20, FlipAngle=24.Both acquired with Bandwith 40Hz/pixel and 150V. **Segmentation** of venous vasculature tree was done using semi-automated region growing implemented in MIPAV. Voxels within a vessel were identified and thresholding was done interactively, and restricted regionally, to track vessels across slices.

[Results and Discussions] The signal to noise ratio (SNR) in the SWI images 2D and 3D was 40 to 50 depending on regions of interest in the brain. The SNR was evaluated at deep brain structures like Hippocampus, Substantia Niagra, etc. The semi-automated region growing method was able to segment the venous vascular tree in 3D, showing tracking of the vessels across slices, as illustrated in Fig 1 Left-Bottom. The arborization localization in 3D axial, sag & cor slices are marked blue in the 3D image set. Although one can get very high in-plane resolution by increasing the slice thickness in 2D acquisition it is not suitable for tracking vessels across slices. Neighborhood based algorithms like region growing will benefit from an isotropic 3D image since these algorithms perform computations on uniformly sized neighborhoods (e.g. 3x3x3) centered on each voxel. Having higher resolution in plane will bias these algorithms towards the high resolution resulting in unexpected segmentations.

[Conclusion] Prior studies e.g. Mult Scler. 2013 Mar;19(3):316-25 & Arch Neurol. 2008 June; 65(6): 812–816., use in-plane ratings to assess venous vasculature -- with 3D imaging & isotropic voxel acquisition, this new method allows 3D processing and tracking of the veins, and thus will allow estimation of arborization metrics.

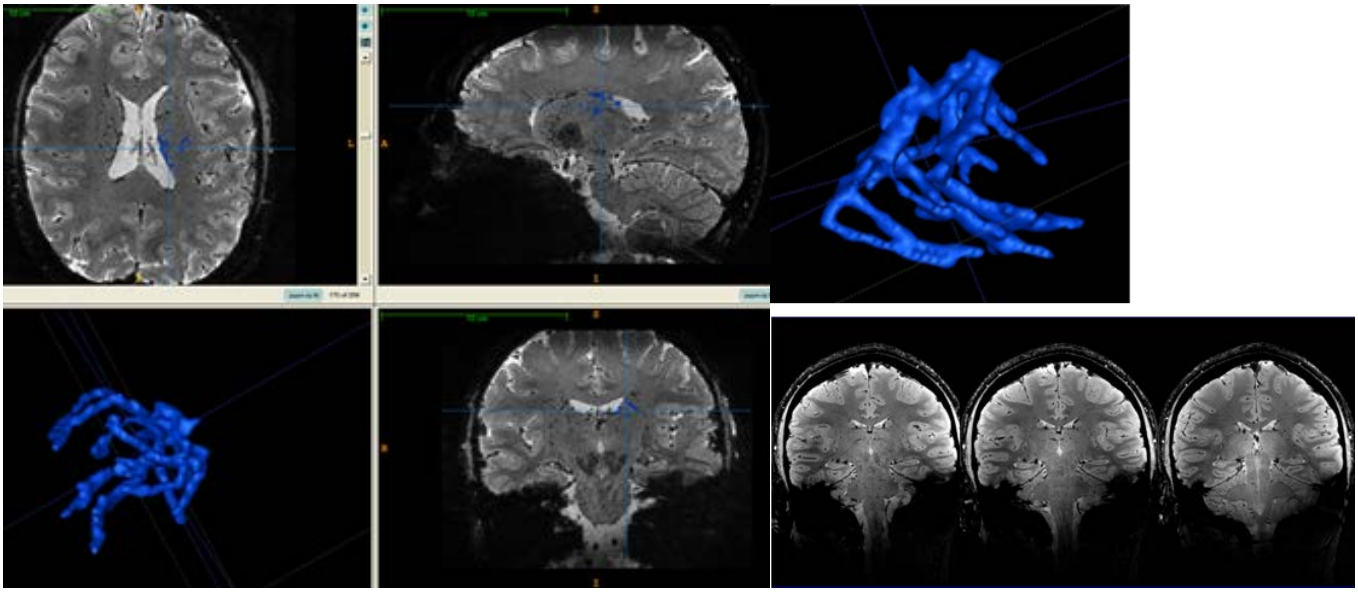

Figure 1 : (Left) A triplanar view of the relevant slices, with the vessel segmentation overlaid over isotropic 0.5mm^3 3D SWI**. Bottom-right** 2D SWI 0.2x0.2x1.5mm shows smaller veins around midbrain not seen at 3T.