New data processing pathway for automatic detection of vascular territories and source vessel locations using random VEASL

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Purpose:

Random vessel encoded arterial spin labeling (R-VEASL) was proposed to simultaneously measure perfusion territories and detect feeding arteries without prior knowledge of their positions [1-2]. However, the source location of a territory is often blurred so that it is difficult to be manually identified and consistent results are hard to obtain. In addition, mixed supply in one territory may lead to incorrect vessel detection and decoding of perfusion territories. In the present study, we propose a new data processing pathway for R-VEASL based on region growing (RG) and matching pursuit (MP) for automatic detection of vascular territories and source vessel locations. This RG-MP method also can resolve mixed supplies.

Methods:

Five healthy subjects were studied in a General Electric MR750 3T scanner, using a commercial 8-channel head RF coil, under a protocol approved by the local IRB, and described in [2]. To maximize the SNR of the source vessel detection, a seeded region growing (SRG) algorithm [3-4] was applied to detect contiguous regions with highly correlated encoding patterns. This produces candidate perfusion territories. Seeds for SRG were distributed on a grid with a spacing of 2 pixels. The pixel labeling procedure starts from all the selected seeds by including neighboring voxels that exceed a correlation threshold with the current region averaged encoding pattern. Small regions that do not belong to any region after this procedure were reseeded. The correlation threshold is estimated based on a CCself histogram, which was generated by calculating the correlation between each voxel with all its neighbors. The average correlation value was assigned to this voxel. From segmentation of anatomical images, the fraction of gray matter in our MRI images was approximately 35%. The cut-off correlation value for the top 35% voxels in the CCself histogram was used as the correlation threshold in our SRG procedure. For source vessel location detection, Matching Pursuit (MP) was used to search all possible locations for the best matches. In our study, the iteration number was set to be 3 so that at most three source vessels can be resolved per territory.

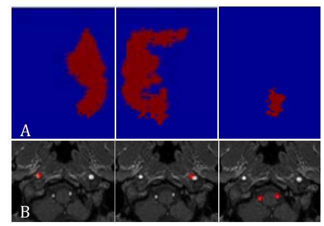

Figure 1. A, Individual perfusion territory obtained using SRG procedure; B, The corresponding source vessel detection result of each territory using MP method

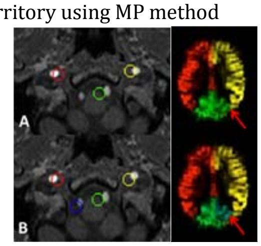

Figure 2. Two vertebral arteries cannot be correctly distinguished using the original R-VEASL data processing method (A) and are resolved using RG-MP (B).

Results:

Clustered perfusion territories using SRG of one subject is shown in Figure 1A. MP was applied for each individual territory. A correlation threshold of 0.8 was used forMP. The corresponding detection result of each territory is shown in Figure 1B. Major suppliers of each perfusion territory were detected correctly, including the basilar perfusion territory with mixed supply.

In the original R-VEASL data processing, feeding arteries for perfusion territories with two or more suppliers were sometimes detected incorrectly. As illustrated in Figure 2A, two vertebral arteries were not distinguished using the original data processing method. However, two major suppliers are resolved using RG-MP (Figure 2B). In this example, the right vertebral artery does supply the basilar territory, though this contribution is small (red arrows).

Our new RG-MP procedure fully automates the vessel detection and mapping process. Figure 3 shows the vascular territories of the intracranial arterials for the same five subjects scanned in [2]. The detection result of vessel locations is more accurate (yellow arrows). For each subject, we processed R-VEASL data collected by five different random encodings and the detection results were the same each time.

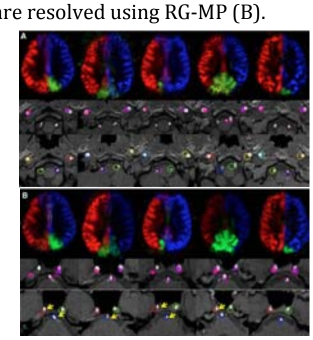

Figure 3. The source vessels and vascular territories for five subjects. A and B show different tagging planes. Vascular territories for each tagging plane are shown in the 1st and 4th rows. The corresponding source vessels detected using original and our new method are shown in 2nd, 5th and 3rd, 6th line, respectively. The color of vessels is only related to vessel detection order.

Conclusion and Discussion:

The result demonstrates that RG-MP can automatic detection of vascular territories and source vessel locations. Region growing in raw data space has been demonstrated as an effective way of obtaining individual perfusion territories. In the future, additional information (e.g. anatomical information) may be used to obtain further robustness using SRG. In the MP step, a correlation threshold of 0.8 was found to reliably detect vessels. This MP threshold may vary across subjects, and we are currently working on adaptive methods for setting the thresholds for both RG and MP portions of the algorithm.

References:

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