Robust Arterial Input and Venous Output Function Detection for Automatic Processing in DSC-MRI

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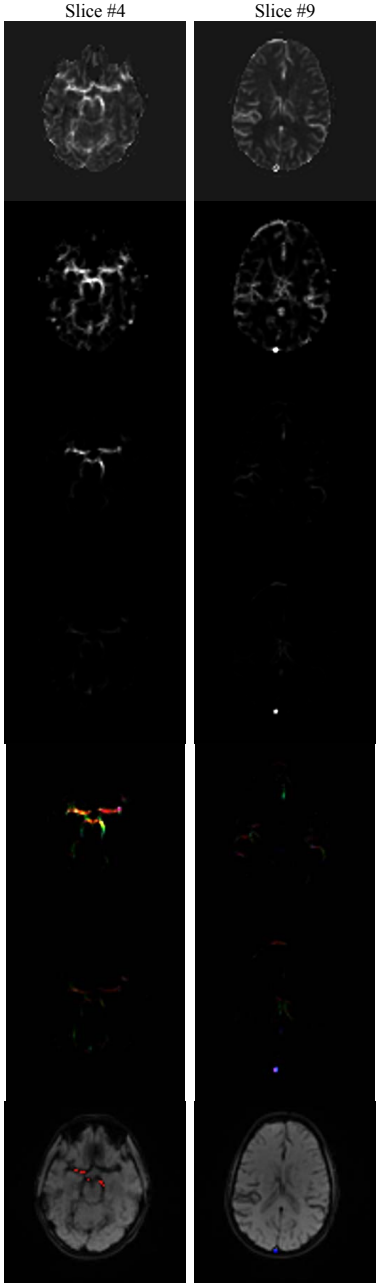
Purpose: Routine acquisition of DSC-MRI brain perfusion datasets highly benefits from fully automated algorithms because manual processing is lengthy and subject to operator preference. Unsupervised computation can deliver results can in very short time and thus can provide perfusion measurements in emergency settings (e.g. in acute stroke, [1]). To deliver quantitative perfusion maps, deconvolution is typically applied what requires selection of arterial input (AIF) and venous output (VOF) functions. Automated selection of AIF and VOF has been addressed by several groups in the past but robustness of the proposed methods in presence of patient motion and noise remains questionable. The robustness is very important for reliable unsupervised application. Existing methods evaluate properties of the temporally resolved signals (amplitude, width, delay) and do not inherently ensure that the AIF/VOF location will be chosen in anatomically meaningful location, i.e. inside or nearby a large feeding artery. Selection of VOF is especially difficult, because only delay and anatomical location can segregate arteries from veins. Additionally, due to susceptibility effects and bulk flow, the DSC-MRI signals might differ depending on orientation of the vessel in question versus main B_0 and vs. slice orientation. We hypothesize that robust detection of AIF and VOF must take into account actual location of the intracranial vessels and their orientation, not only the temporal information. **Methods:** DSC-MRI data, when gadolinium is present can be seen as a 'poor-man's 3D angiography'. Applying tubular filter [2] to such data, cylindrical structures will be enhanced. To separate arterial and venous signals, following analysis is performed: First, signal representing ΔR2* averaged over the whole brain is determined (Figure 1, green line). Arterial locations will manifest strong signals very early before the peak of the average signal (typically 4-5s earlier); whereas venous signals will show very strong signals even 6-7s after the peak. Therefore, when the tubular filter is applied in an early frame it will deliver weighting factors that favor AIF, whereas filter applied in a late frame will favor VOF locations. Additionally, the filter can deliver information about vessel orientation and thus factors that can prefer certain vessel orientation **Results:** Achieved results are presented in Fig. 2. By application of the tubular filter, non-vascular structures are suppressed, and vessel orientation is detected. By averaging over multiple points a good representation of AIF and VOF was achieved (Fig.1). **Discussion:** A novel method for robust detection of AIF and VOF in automated processing of DSC-MRI data was proposed. The approach is inherently robust in presence of noise and forces selection of AIF and VOF inside a large vessel, while promoting regions with strong signals and high contrast. By simple time criteria, selection of either arterial or venous signals can be achieved. Additionally, weighting terms with respect to vessel orientation are determined and can be used to improve accuracy of AIF and VOF signals. With advanced processing it is possible to detect vessel center (maximum of tubular filter response in plane perpendicular to the vessel orientation) and thus enforce selection of AIF and VOF several voxels outside of the vessel, as suggested in [3]. **References:** [1] Straka, M.: ISMRM 2009, [2] Frangi, A. et al: Multiscale Vessel Enhancement Filtering, Proceedings of MICCAI 1998, [3] Bleeker at al.: Journal of Cer Blood Flow & Met (2009) 29, 840–852. **Acknowledgements:** Supported in part by NIH (1R01EB008706, 1R01EB008706S1, 5R01EB002711, 1R01EB006526, 1R21EB006860, 2R01NS039325-04A2), Center of Advanced MR Technology at Stanford (P41RR09784), Lucas Foundation, Oak Foundation and an anonymous philanthropist.

Figure 2:



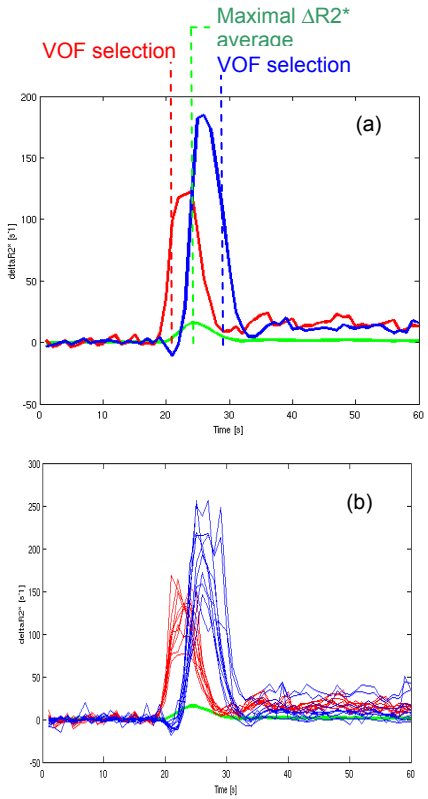


Figure 1: (a) Average signals obtained from points selected in locations as displayed on Fig.1. Red is the AIF signal, blue is the VOF signal and green is the mean ΔR2* averaged over the whole brain area. Lines indicate where AIF and VOF selection phase was chosen and this selection vs. the mean signal change. (b) signals in individual AIF and VOF points; averaging of (b) results in (a).