Spatiotemporal Filtering of Myocardial ASL Data: Implications in Detection and Diagnosis of Coronary Artery Disease

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Introduction: Myocardial arterial spin labeling (ASL) perfusion imaging is a promising tool for the diagnosis and assessment of coronary artery disease (CAD) in humans [1,2]. Registration and spatiotemporal averaging is a necessary step in order to achieve diagnostically useful myocardial blood flow (MBF) and MBF reserve measurements [1-3], which are indicators of CAD severity. The post-processing filter parameters impact the SNR and resolution of MBF reserve maps and ultimately the sensitivity and specificity to CAD. We present a systematic approach for optimizing these parameters using receiver operating characteristic (ROC) curves.

Methods: Patient Data: Twenty-nine patients suspected of having CAD were recruited from those scheduled for routine rest-stress cardiac MR. Myocardial ASL was performed at rest and stress during adenosine infusion (dosage: 0.14 mg/kg/min) using an ASL sequence composed of FAIR tagging and balanced SSFP imaging as described in Ref. [1,2], at a single mid-short-axis slice. Patients showing perfusion defects on stress first-pass MRI imaging had follow-up coronary angiography performed to confirm the presence of CAD and to locate stenotic vessels.

ASL Data Processing: ASL perfusion reserve maps were generated for each patient after resampling and filtering ASL data in a polar coordinate frame using rectangular, Gaussian, Hamming, Kaiser, and Tukey windows with filter widths of π, π/2, π/3, π/4, π/6, π/8, π/10, π/12, and π/18 [3].

Evaluation: ROC curves were generated for each combination of filter type and filter width using stenotic vessels identified on X-ray angiography as the ground truth. The area under the ROC curve (AUC) was calculated to evaluate the filter parameters that provided best identification and localization of CAD.

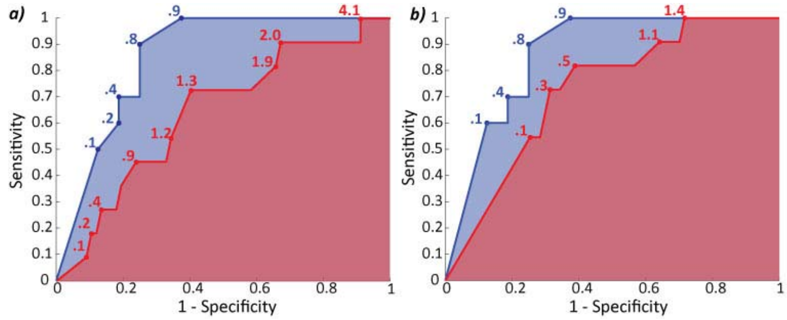

*Figure 1: Representative ROC curves for (blue) detecting presence of CAD, and (red) identification of the most ischemic segment(s). **(a)** Gaussian filter, width π/3 (detection and localization), **(b)** Kaiser filter width π/3(detection) and width π/18 (localization). Perfusion reserve threshold values are listed at each point along the ROC.*

Results: Figure 1 contains representative ROC curves for a Gaussian and Kaiser filter. The AUC for the ROC curves was calculated for each filter type and width and is shown in Figure 2. Overall, the AUC for CAD detection was greater than the AUC for CAD localization regardless of the choice of filter or filter width. The maximum AUC for detecting angiographic CAD was **0.839 ± 0.012** and occurred at filter widths of 0.361π ± 0.083π while the maximum AUC for locating ischemic segments was **0.711 ± 0.009** and occurred at filter widths of 0.092π ± 0.037π. The Kaiser filter was the best at detecting and localizing CAD with a maximum AUC of 0.863 and 0.724 respectively. Table 1 summarizes the maximum AUC and the corresponding filter widths.

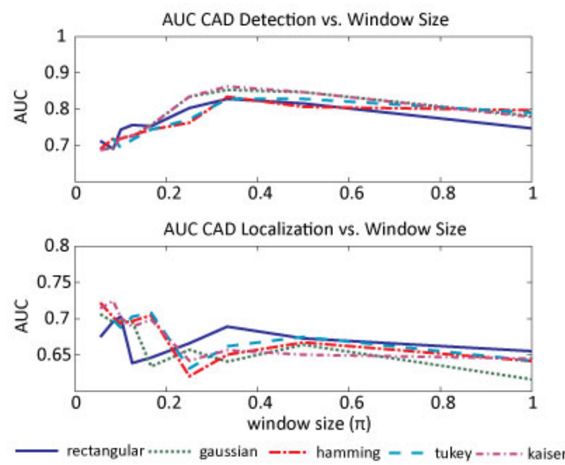

Figure 2: Area under the ROC curve as a function of filter type (color) and filter size (horizontal axis). (top) Detection of CAD and (bottom) Localization of most ischemic segment(s).

Discussion: ROC analysis is a powerful tool used in medicine to measure the performance of a diagnostic test. By tuning the myocardial ASL filter parameters to maximize AUC, a measure of diagnostic accuracy, we avoided the ambiguity involved in finding a balance between SNR and resolution. ROC analysis shows that ASL myocardial perfusion reserve is better at detecting CAD than locating the most ischemic segments, regardless of filter parameters. ROC analysis also demonstrated that localizing ischemic segments requires a smaller filter width (~0.092π) compared to detecting CAD (~0.361π), which is intuitive, given the higher resolution generally required for localization. While the Kaiser filter was shown to best detect CAD and localize ischemic segments, no concrete conclusion can be drawn due to the small cohort size. Recruitment is ongoing, and we expect to have datasets from 150 patients with suspected CAD by August 2012.

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References: [1] Zun Z et al, MRM 62: 975, 2009 [2] Zun Z et al, JACC Imaging (*in press*) [3] Jao T et al, ISMRM 2011

	Rectangular	Hamming	Tukey (0.2)	Tukey (0.4)	Kaiser (2)	Kaiser (4)	Kaiser (8)	Gaussian (2)	Gaussian (4)	Gaussian (8)
Max AUC Det ; Loc	.828; .701	.834; .722	.828; .708	.825; .696	.844; .708	.863; .710	.838; .725	.725; .610	.853; .706	.838; .655
Width Det ; Loc	π/3; π/10	π/3; π/18	π/2; π/6	π/3; π/10	π/4; π/8	π/3; π/18	π/3; π/12	π; π	π/3; π/18	π; π

Table 1: AUC and corresponding filter widths for (Det) CAD detection and (Loc) CAD localization.