# View-sharing PROPELLER with pixel-based optimal blade selection (POBS) for dynamic contrast-enhanced MRI

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## Introduction

View-sharing techniques [1] have been proposed to increase the frame rate for dynamic imaging. View-sharing PROPELLER (VS-Prop) [2,3] updates the central k-space continuously by using rotating blades, whereas the outer k-space data are provided by adjacent blades acquired at lower frame rates to achieve high effective spatial resolution. Image reconstruction of fine structures contributed more from the high-spatial-frequency components is thus sensitive to the priority decision [2] or neighboring assignment [3] of blades. Since the dynamic signal response can be spatially varying, manipulation of the composing blades in VS-Prop does not have to be identical for different regions. In this study, therefore, we propose a novel method termed pixel-based optimal blade selection (POBS) to minimize reconstruction artifacts due to under-sampled outer k-space data.

## Materials and Methods

VS-Prop [3] reconstructs each image frame using a minimal number ($N_b$) of consecutive blades that cover a circular k-space, while the central polygonal region was filled only by one $k$-th ($1 \leqq k \leqq N_b$) target blade. In other words, given the target blade, there are $N_b$ choices to select the composing blades. In the original VS-Prop method, $k$ is around $N_b/2$. The basic idea of POBS is to search for one (out of $N_b$) set of neighboring blades exhibiting the closest image contrast with the target blade, on a pixel-by-pixel basis by least square error estimation, to prevent from artifacts caused by inconsistencies of outer k-space data. The VS-Prop image with $k = N_b/2$ was used as the initial estimates of signal intensity. After the first optimal set of blades was determined, each pixel was refreshed by the new value to yield the second estimates of signal intensity, with which the selection of blades was repeated to find a new optimal set of blade composition for each of the pixels. This process was iterated until convergence.

Computer simulation was performed by generating a series of 24 full-sampled dynamic Shepp-Logan phantom images (one shown in Fig.1). Two circular regions of interest (ROIs) with diameters of 7.0% and 4.4% FOV (Figs.1 and 2a) were added to simulate signal enhancements (signal increase/decrease as a step function). Rotating blades in size of 256*52 ($N_b$=8) were then obtained to generate VS-Prop images using the original method ($k$=5 for all pixels) and POBS. Dynamic contrast-enhanced MRI (DCE-MRI) on rabbits was also performed on a 3T scanner (Siemens Trio, Erlangen, Germany) using the turbo-FLASH sequence (TI/TE=74/1.5ms, FOV 140 mm, matrix 128*26, 100 frames with ECG gating, 112 ms per slice, 3 slices) to image the pre- and post-contrast dynamics with bolus injection of 2ml Gd-DTPA (0.1 mmol/kg).

## Results

Figure 2 demonstrated six consecutive frames (13th to 18th) in cropped views from the 24 dynamics for the original full-sampled images (Fig.2a), low-resolution blade images (Fig.2b), VS-Prop images at $k$=5 (Fig.2c), VS-Prop with POBS after three iterations (Fig.2d), and maps of POBS target index ($k$, Fig.2e), respectively. Errors in POBS VS-Prop were less than 15%, with reduction of artifacts visually perceivable (yellow arrows in Fig.2d vs. Fig.2c). Figure 3 showed results of animal experiments in six dynamic frames (21-26 of 100) for the low-resolution blade images (left), VS-Prop images (middle), and VS-Prop images with POBS (right). With POBS, not only the dark band artifact in the left ventricle disappeared (yellow arrows), but the blood vessels also showed improved conspicuity (red arrows).

## Discussion

VS-Prop exhibits strong potential in DCE-MRI with increased temporal resolution (by a factor of 5 in this study). In the example of rabbits, the acquisition time of 112ms for 128*26 allows 3~4 slices to cover the heart within a <500ms cardiac cycle, hence also provides advantages in spatial coverage. With POBS, reconstruction artifacts are minimized. In Fig.2e, it can be found that the $k$-values at or near ROI1 in the 17th frame are mostly one, which means that the data points were provided by VS-Prop reconstruction using the 17th blade (target) and the 18th-24th blades (neighboring). Consequently, artifacts were largely suppressed since the template for all composing blades is the same (i.e., no enhancement in ROI1). Similarly, $k$-values for ROI1 in the 16th frame are mostly 8 (16th blade as target and 9th-15th blades as neighboring, all enhanced in ROI1), resulting in its superior performance in DCE MRI reconstruction. We therefore conclude that POBS is an effective adjunct for VS-Prop in DCE-MRI.

## References:

1. Oesterle C et al., JMRI 2000;11:312-323.
2. Pipe JG, ISMRM 1999; abst. 157.
3. Chuang TC et al., ISMRM 2006; abst. 2954.

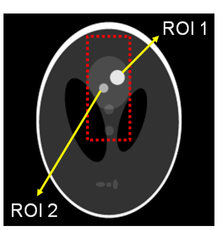


**Fig.1** The 16th full-sampled frame of 24 dynamics. ROI 1 and 2 were enhanced from frame no. 9-16 and 15-24, respectively. The red dotted rectangle was cropped for demo in Fig.2.

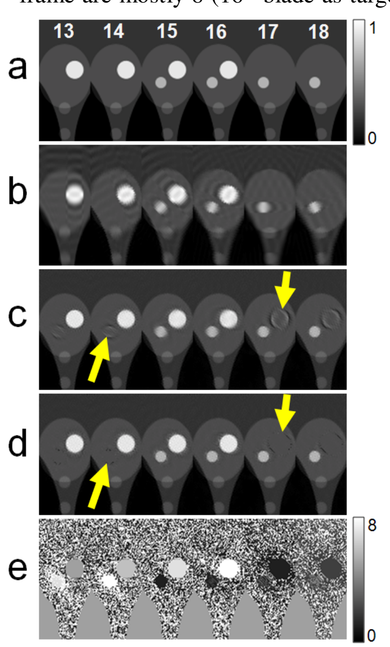


**Fig.2** Six cropped frames of 24 dynamics were shown in full-sampled templates (a), low-resolution blade images (b), default VS-Prop images at $k$=4 (c), VS-Prop with POBS (d), and the map of target index $k$ (e).

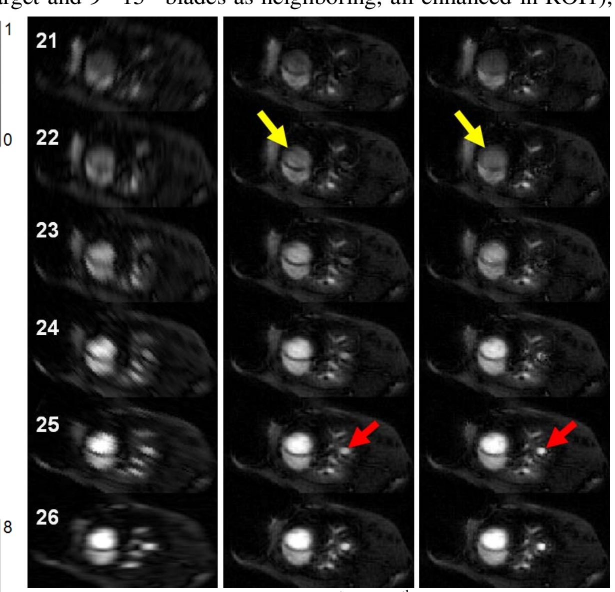


**Fig.3** Six successive frames (21st to 26th) of the animal DCE experiment: blade images (left), VS-Prop (middle) and POBS VS-Prop (right).