Using principal components analysis to reduce the effect of streaking artefacts in dynamic PR-TRICKS images of the breast

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Introduction. Dynamic contrast-enhanced MRI has been shown to be valuable in the diagnosis of breast lesions and a combination of both kinetic and structural information is required to improve specificity. With conventional imaging techniques there is a trade-off between spatial and temporal resolution but more recently adaptive reconstruction techniques have been developed that allow images with either a high temporal resolution or a high spatial resolution to be obtained from data acquired in a single examination. We have adapted a PR-TRICKS sequence, which uses radial trajectories in the kx-ky plane and time ordered Cartesian sampling in the kz direction, for bilateral breast imaging and have previously shown that this approach is feasible for use in clinical studies [1]. High temporal resolution images are reconstructed using a small number of projections and the central kz planes. Higher spatial resolution images are obtained by including more projections and all of the kz regions.

The main problem with the high temporal resolution images is that the number of views used to reconstruct each image is not sufficient to satisfy the Nyquist criterion causing streaking artefacts to corrupt the images. The signal to noise ratio of each image is also decreased. We propose a method for reducing the streak artefacts and for improving signal to noise ratio in the high temporal resolution images by using principal components analysis (PCA) to filter the data in the spatial domain. By excluding components which are dominated by artefact and reconstructing the study using a limited number of components the appearance of the images is significantly improved.

Methods: 6 patients were imaged on a 1.5 GE Signa scanner in accordance with local REB guidelines. These patients were all part of an ongoing screening study and had enhancing lesions that had been identified on previous screening scans as benign. The PR-TRICKS sequence was a modified 3D SPGR with 256 projections in the kx-ky plane divided into 4 dither groups of 64 projections and 36 partitions in the kz direction organised into 3 "frames", A,B and C where frame A was closest to the centre of k space. The high temporal resolution images were reconstructed using data from frame A only and each study comprised 32 images reconstructed from the 4 different dither groups with an effective temporal resolution of 24 seconds. Principal components analysis (PCA) allows us to decompose the 32 images into an ordered sequence of component images and component time series. As figure 1 illustrates, some of these components clearly reflect the repeating pattern of dither groups used to reconstruct the data. We used a Fourier decomposition of the component time series to identify which components were dominated by reconstruction artefact. We also used the power spectrum to determine which components were dominated by white noise [2]. We then reconstructed the dynamic sequence by recombining the remaining principal components ie those that did not correspond to artefact or white noise. In order to assess the effect of this PCA filtering we generated contrast enhancement images from the raw and the filtered images. Contrast enhancement images were generated using the expression
CE = 100% x (maximum post-contrast SI – pre-contrast SI) / (pre-contrast SI)

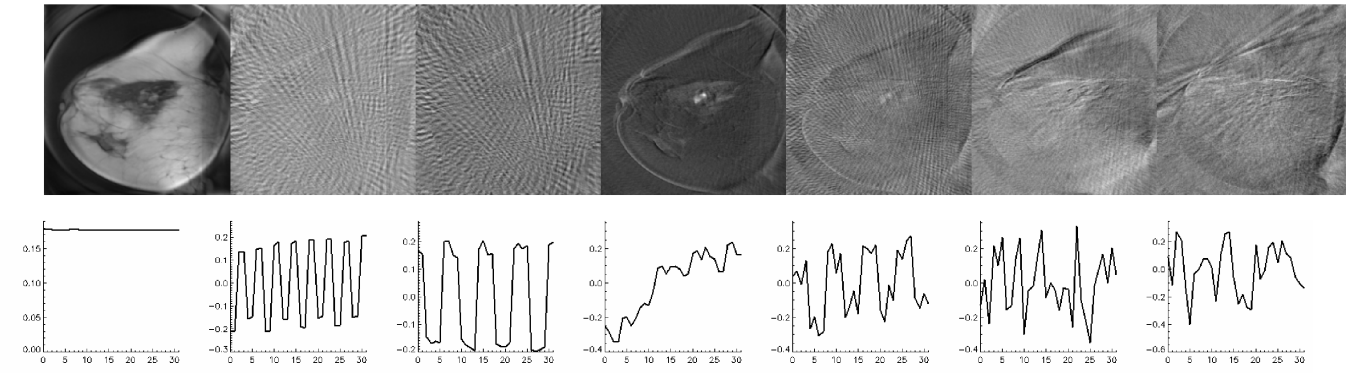

Figure 1. The first 8 PCs extracted from a sequence of 32 3D volumes (only the 7th slice is shown). Gd-DTPA was injected after the 8th time point. The Fourier decomposition of the component time series was used to determine that the 2nd and 3rd PCs were dominated by reconstruction artefact.

Results: In 5 patients we found that 2 of the principal components were clearly dominated by artefact. In the remaining patient only one of the components was dominated by artefact. The number of components dominated by white noise ranged from 19 to 26. The PCA filtering was found to have 2 effects on the parametric images. The streak artefact was significantly decreased after PCA filtering and the images had a smoother appearance. Figure 2 shows the contrast enhancement images before and after PCA filtering.

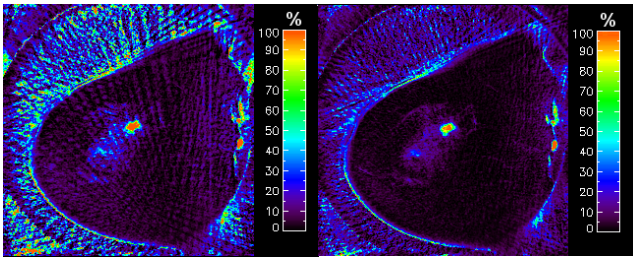

Figure 2. Parametric images of contrast enhancement generated from the original data (left) and the PCA filtered data (right).

Conclusions: The PCA filtering technique exploits the fact that the time course of the contrast enhancement is uncorrelated with the dither pattern. This means that some PCs correspond to artefact and can be excluded without removing information related to contrast enhancement. Further work is needed to determine what the effect of filtering is on quantitative parameters extracted from the images

References: [1] E. Ramsay, D. Plewes, "Adaptive Bilateral Breast Imaging Using PR-TRICKS", *Proc. Intl. Soc. Mag. Reson. Med.* 11 (2004), p247
[2] C.G.Thomas et al. "Noise reduction in BOLD-based fMRI using component analysis", 2002, NeuroImage, 17, 1521-1537