Automatic training for *k-t* BLAST reconstruction

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Introduction Acquiring dynamic cardiac images with both a high spatial and temporal resolution requires the patients to perform long series of breath-holds. Fast imaging acquisition techniques, such as *k-t* BLAST [1], allow considerable reduction in the scan time (to a single breath-hold for a dynamic 3D volume) by undersampling the collected data in *k-t*-space by factors as high as 5 or 8. However, this degree of undersampling will introduce aliasing in the reconstructed images. The *k-t* BLAST method removes this aliasing by performing an additional very fast low resolution scan (training data) that estimates the spatio-temporal correlations of the object being imaged. In this work we present a technique for the reconstruction of *k-t* undersampled data without acquiring training data, and hence with a shorter scan time. The acquired training data is replaced by automatic training data obtained from a de-aliased sliding window reconstruction of the original undersampled data set. We quantify the reconstruction errors using this automatic training technique compared to the traditional *k-t* BLAST technique on a group of volunteers.

Methods The *k-t* BLAST reconstruction uses the acquired training data as a prior to separate the aliased signals in the y-f space [1]. This prior is a very low resolution scan, spatially blurred, acquired at full temporal resolution. Because we are imaging moving objects, spatial blurring and temporal blurring are not independent operations. This is shown in figure 1, which presents relative root mean square (rms) errors for *k-t* reconstructions that use training data with variable amount of spatial blurring (number of acquired lines at the centre of *k*-space) and temporal blurring, obtained by filtering the temporal frequencies. We can see that, for a given level of spatial blurring we can find a corresponding temporal blurring that has the same reconstruction error. We therefore propose using an automatic training data set for *k-t* BLAST based on a sliding window reconstruction of the raw undersampled data, which is temporally blurred [2]. To reduce the residual amount of aliasing in the sliding window images before they are used as training data we: (1) construct a mask of the moving object using edge detection, (2) replicate this mask in the aliasing positions obtained from the sampling pattern and (3) finally temporally filter these positions to reduce the aliasing that appear as a flickering of the moving part of the FOV.

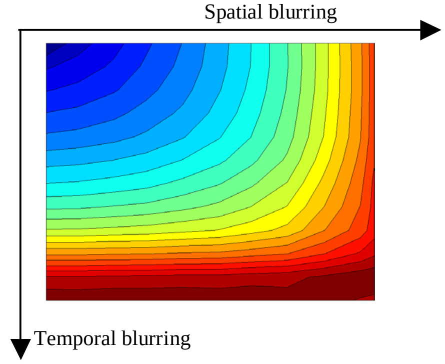

Figure 1: Root mean square error map

The automatic *k-t* training was tested on 8 healthy volunteers on a Philips Intera 1.5T scanner (Best, the Netherlands). For every volunteer, two 2D single slice SSFP scans were acquired in the short-axis orientation with 20 and 40 phases respectively. From the fully sampled *k*-space raw data, undersampled *k-t* data were simulated using an acceleration factor of 5 with the automatic training. These reconstructions were then compared to the images obtained by using spatially blurred training (11 profiles of the central *k*-space), which would be equivalent to a separate training data set.

Results and discussion Figure 2 shows one reconstructed phase with both methods from a 20 phase scan. Visually, the two solutions are very similar to each other and in both the aliasing has been strongly reduced. The bottom row displays the difference images relative to the reference fully sampled scan. We can see that the aliasing is negligible for both images and that most of the errors are located around the moving edges of the heart. This is due to the spatio-temporal filtering introduced by the *k-t* reconstruction algorithm.
There was no statistically significant difference in reconstruction errors between the automatic training and the low special resolution training for both the 20 and 40 phases scans in the 8 volunteers (p values of 0.1304 and 0.1605 respectively with a non-parametric Wilcoxon test).

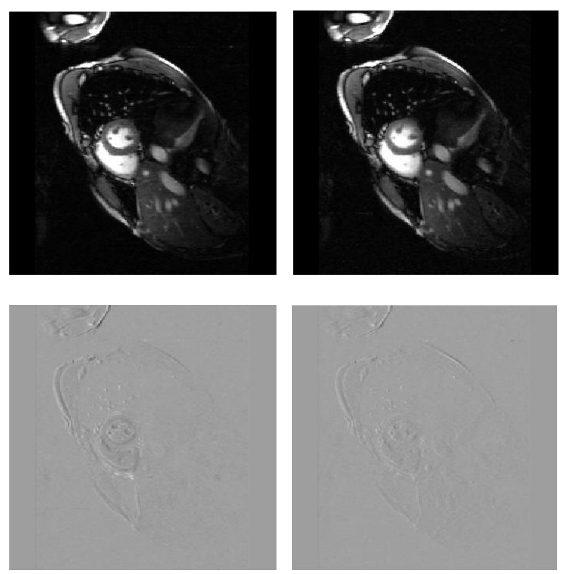

Figure 2: *k-t* reconstruction with automatic training (left) and simulated acquired training.

Conclusion
We have demonstrated that when there are enough cardiac phases to perform a sliding window reconstruction, automatic training can be used as an alternative to acquiring low resolution training data in *k-t* BLAST reconstruction. Visual assessment as well as an analysis of the reconstruction errors for 16 scans indicated that the two methods are equivalent. This allows reduction of the total acquisition time for *k-t* BLAST by saving the time needed to collect the training data (6 sec), and thus reducing the breath-hold time.

[1] Tsao et al. *MRM* 50:1031-1042 2003, [2] Boubertakh et al. *ISMRM* 2004; 342.