**Motion artefact reduction using non-rigid registration**

G. Leung[1], M. Froh[2], R. Bitar[1], A. Martel[2,3], A. Moody[1]

[1]Department of Medical Imaging, Sunnybrook and Women's College Health Sciences Centre, Toronto, Ontario, Canada, [2]Imaging Research, Sunnybrook and Women's College Health Sciences Centre, Toronto, Ontario, Canada, [3]Department of Medical Biophysics, University of Toronto, Toronto, Ontario, Canada

## Introduction

When high resolution images are desired, a sacrifice is made between signal to noise (SNR) or acquisition time. Increasing the number of data averages prolongs the imaging time and regains some loss in SNR. However, over the extended imaging time, patient motion between each image can degrade image quality. Many techniques have been proposed to improve image quality by retrospectively correcting for motion between the acquisition of each TR (e.g. [1]). However, many of these techniques employ a rigid deformation model to correct for the inter-acquisition motion. This paper proposes a technique for reducing the impact of inter-image motion and obtain high SNR images by non-rigidly registering individual images prior to averaging.

## Methods

The principal idea of this technique is to acquire many identical acquisitions of noisy, high resolution images with each of these images differing due to slight patient motion. Post acquisition, these images are non-rigidly registered and then averaged. This gives the desired high SNR and high spatial resolution without the interference of subtle patient motion.

Images were acquired on a GE Signa TwinSpeed (General Electric, MI) with a spoiled gradient echo sequence. A dedicated carotid array (ScanMed NE) was used as a receive only imaging coil. Imaging parameters were TR/TE/θ= 7.1/2.1/15 with a 160 squared matrix and 28 one millimeter slice, interpolated to half millimeter yielding 56 slices. An eight centimeter field of view was used, and the no phase wrap option was selected, doubling imaging time. Image resolution is 500 microns isotropic. 20 identical volumes are acquired in a multiphase acquisition producing 1120 images. Each of these phases takes 63.1 seconds to acquire for a total imaging time of 21 minutes. Images were averaged prior to registration and compared with images averaged post registration. The image gray levels were normalized to range from 0 to 1, and repeated measures of gradient steepness across vessel walls in both the registered and unregistered image sets are taken as metrics of image sharpness.

The image space based registration was performed on each of these individual 40 volumes using the algorithm proposed by [2]. This algorithm was implemented on an eight CPU cluster producing the deformation field for all of the images in four minutes. This deformation field is then applied to the Fourier transform of the raw data, prior to the modulus operation which is then added to produce the high SNR, high spatial resolution post-registered images.

## Results

Image **A** (left) shows a sagittal image of the carotid bifurcation, averaged without registration. Image **B** (middle) shows the same data set registered prior to averaging. The plot on the right **C** shows the pixel intensity gradient depicted on the line shown in **B**. Prior to registration, the gradient peaks are quite broad, indicating poor sharpness in edges. Post registration, these gradient peaks increase in intensity, and decrease in width indicating an increase in image sharpness.

## Discussion

It has been shown that by non-rigidly registering entire image sets post reconstruction, image sharpness and image quality can be improved. Since the registration algorithm interpolates the voxels in the registration process thereby smoothing the noise, SNR comparisons are unreliable to compare the image quality. The steepness of gradient metric shown provides a measure of edge crispness which simple SNR measurements do not provide.

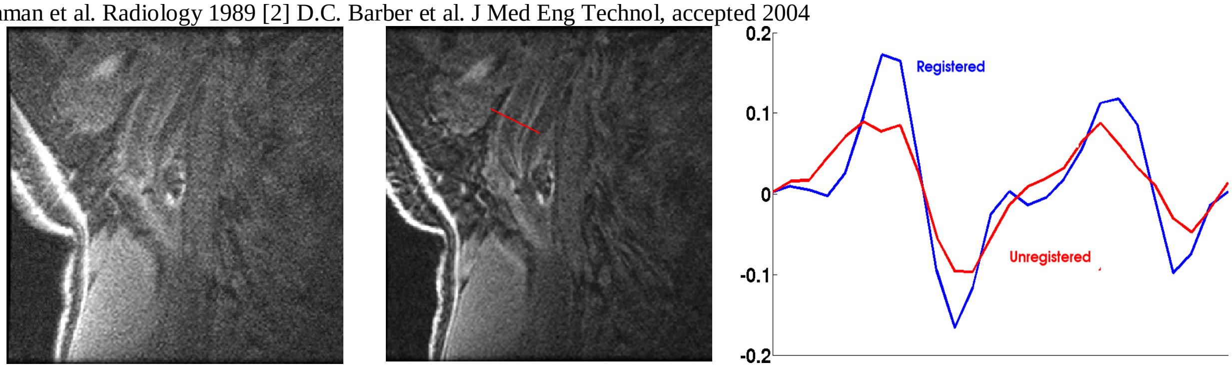
The image acquisition time of over one minute is still long to 'freeze' any motion that might occur. Thus, each individual image can be blurred by motion artefacts during the acquisition of the images. These artefacts are not corrected using this technique however can be dealt with by using other techniques of retrospective motion correction. However, by further reducing image acquisition time using strategies such as partial Fourier or parallel acquisitions, the motion within each frame is 'frozen' and the residual motion can be removed using the above outlined strategy.

## Conclusion

High resolution images with high SNR obtained using long scan times can be improved by non rigidly registering each acquisition prior to averaging. Owing to the speed of the registration algorithm, this technique can be implemented in a clinical setting producing high SNR, high resolution images free of subtle patient motion.

## References

[1] RL Ehman et al. Radiology 1989 [2] D.C. Barber et al. J Med Eng Technol, accepted 2004




A B C

Figure A shows images averaged prior to registration. Figure B shows same data, registered prior to averaging. The plot C displays the gradient of the signal intensity across the line shown in B. The blue line represents the registered signal intensity gradient, while the red line shows the unregistered signal intensity gradient.