Improved Image Quality by Noquist Acceleration of Cardiac MRI

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Introduction

The Noquist method for accelerated cardiac imaging takes advantage of the spatiotemporal redundancy whenever the field of view contains static regions [1]. Feasibility of the method for reconstruction of dynamic SSFP and velocity-encoded flow imaging has been demonstrated by reconstruction of originally conventional full-grid data sets from retrospectively selected sparse subsets [1, 2]. Notable characteristics of Noquist compared to alternative methods include full preservation of spatiotemporal resolution. The method was shown to further improve acceleration, by integrating naturally with parallel imaging [3], combining individual acceleration factors at accordingly accumulated SNR penalty.

This study reports first results of an implementation of Noquist for a prospectively gated dynamic cardiac imaging method (GE FastCARD). The objective of this investigation is to demonstrate actual improvement of image quality by accelerated acquisition using prior knowledge of spatiotemporal redundancy.

Materials and Methods

A prospectively gated, segmented *k*-space pulse sequence (GE FastCARD) on a GE scanner platform (R12M4) was modified to implement data acquisition using the Noquist accelerated *kt*-space acquisition grid by adjusting the view tables to skip acquisition of appropriate *k*-space views for each cardiac phase. The modified pulse sequence code was installed on a clinical GE Signa Horizon LX 1.5T MRI instrument at our institution. Test data were acquired with a FIESTA SSFP technique using an 8-channel cardiac array coil. For comparison, conventional fully sampled images were also obtained with identical acquisition parameters, with the exception of lower resolution for the conventional acquisition.

Data were acquired, per IRB-approved protocol, for an axial mid-heart slice of a healthy adult volunteer, showing bi-ventricular motion, and dynamics of the septum and mitral and tricuspid valves by both methods. Scan parameters were: TE=1.2 ms; TR=2.8 ms; flip angle=45°; FOV: 34 cm (readout direction) x 25.5 cm (phase encoding direction); slice thickness=10mm, vps=16; cardiac phases=20 (no view sharing); sampling grid size=192 x 96; imaging time=9 seconds. For the same acquisition time, this resulted in effective resolution of 192 x 160 for Noquist, with predicted noise amplification of 1.0 (static FOV) and 1.7 (dynamic FOV). Images were reconstructed offline using Matlab R14 (The Mathworks Inc. Natick, MA), on a PC with Pentium D 3.2GHz CPU and 2GB of RAM running Fedora Core 4 Linux.

Results

Fig 1 shows a comparison of the conventional (a) and the Noquist-accelerated image (b). Both the images are of diagnostic quality. Noquist image shows an improvement in the image resolution with a penalty of higher SNR in the dynamic region (phase encoding lines 32 to 112). The observed noise amplification at static and dynamic FOV's were found to be 1.16 and 1.897 respectively.

Discussion and Conclusions

The conventional image shows partial volume averaging and blurring near the ventricular walls. In the Noquist-accelerated acquisition we can observe clearly improved image clarity, compared to conventional image acquisition. Depiction of the mitral valve is substantially improved, as is the definition of the left and right ventricular walls. The thickening of the RV wall is clearly seen. It is possible to better delineate the endocardium and pericardial space. Image quality is good specifically in the near field. Edge detection and volume assessment is possible.

These initial results demonstrate that, with current MRI technology, the improvement in image resolution of an acceleration method like Noquist can outweigh the associated penalty in SNR, resulting in a net visual improvement in image quality. As coil technology and instrument SNR continue to improve, this net quality gain may be anticipated to also improve further. These results underscore the importance of further development of methods for accelerated imaging from sparse data using prior information.

References

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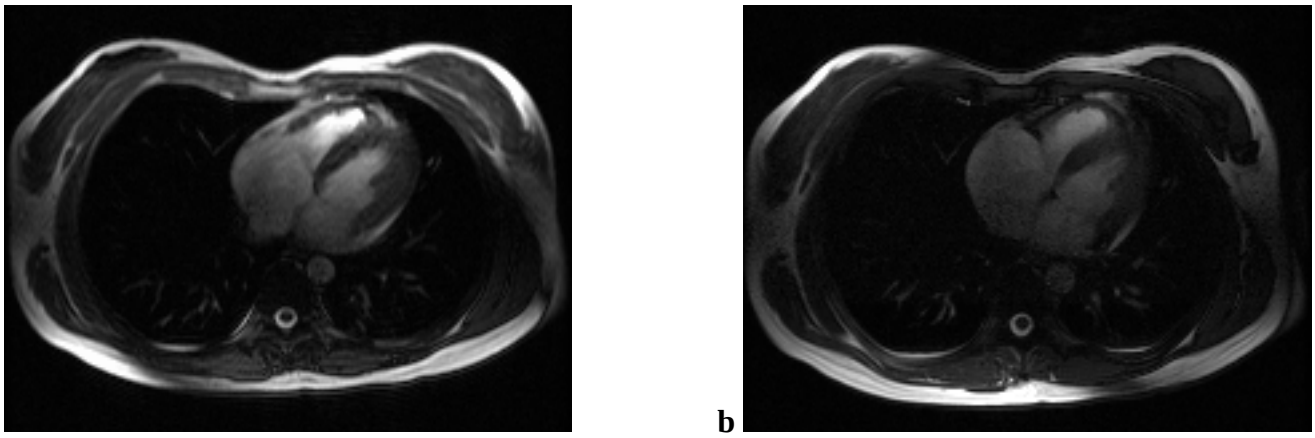

Figure 1: Comparison of conventional (a) and Noquist (b) accelerated images. The 9th cardiac phase is shown in both acquisitions. Conventional and Noquist images are shown reconstructed on a 213 X 160 image grid.