REDUCING DATA HANDLING ISSUES IN LARGE COIL ARRAYS BY 'IF' UNDERSAMPLING

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INTRODUCTION:

Parallel imaging systems with large number of receiver channels are becoming increasingly popular. As the channel count rises, so does the amount of data that must be handled. This is a particular problem for real-time imaging and narrow-bandwidth sequences such as used for MR microscopy. In an earlier meeting, our research group presented a real-time 64 channel data acquisition and reconstruction system assembled in a single computer [1]. The system uses state of the art 32-channel digitizer (ICS-645) and DSP (Transtech TS-P36N) boards connected via a dedicated high speed FPDP (Front Panel Data Port) bus to support data throughput rates of upto 160 Mbytes/sec. A dedicated bus is needed to avoid the shared PCI bus which is only capable of 80MBytes/sec. However, the latest digitizers available can generate 2GigaSamples/sec (NI PXI 5152) which would require buses much faster than the FPDP bus to allow any real-time processing. While our system may not be as robust as commercial systems, it has the advantage of being a relatively inexpensive approach that can be readily implemented by many research groups. Of interest are the capabilities, or more appropriately, the constraints placed on parallel imaging applications by the use of this system. The real-time digital demodulation and image reconstruction techniques were limited to applications involving large bandwidths (eg. 100 KHz) and lower number of frequency encodes (eg. 128) due to the constraints presented by maximum throughput of the data buses (PCI and FPDP). Additionally, multiple receiver channels generate data handling and storage problems in applications such 3D MR microscopy[2,3]. For example, to generate a 2048x2048x64x32 microscopy data set, the total data that needs be collected is 16000 (samples) x 2(bytes/sample) x 256(phase encodes) x 64(channels) x 32 (3D slices) = 16GB per average. Such large amounts of data create issues with storage, moving and processing the data. To address these two issues, we investigated the option of reducing the amount of data that was being digitized, by undersampling the IF signal. Undersampling the MRI signal has been studied before and it has been reported that the images can be reconstructed without loss of information [4].

METHOD:

A fully-encoded data set was collected using the 64 channel receiver system [5]. The MR signal from each channel was mixed down to an Intermediate Frequency (IF) of 500 KHz before digitization. In this example, the signal bandwidth from each coil was only 50 kHz, centered at 500KHz IF, the signal was sent to a single digitizer card capable of digitizing 32 channels at 2.5MHz per channel. The digitized data was then sent to the DSP board also assembled in the same computer (see Figure 1). The reconstructed sum of squares image from all the 64 channels is shown in Figure 2(a). However, the MR signal being band-limited, digitization at frequencies lower than twice the IF (Nyquist criterion) is possible without loss of information. We chose an undersampling factor of 16, centering the aliased signals at 156.25KHz. The image reconstructed using the undersampled data is shown in Figure 2(b).

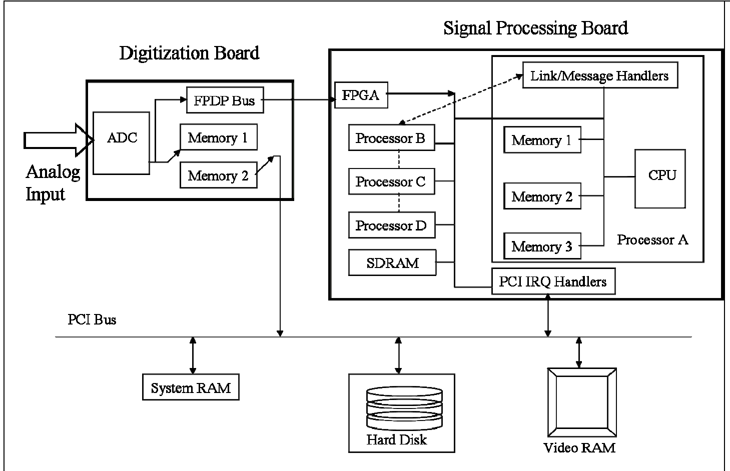

Figure 1: Schematic of the rapid imaging setup used to acquire and process the data.

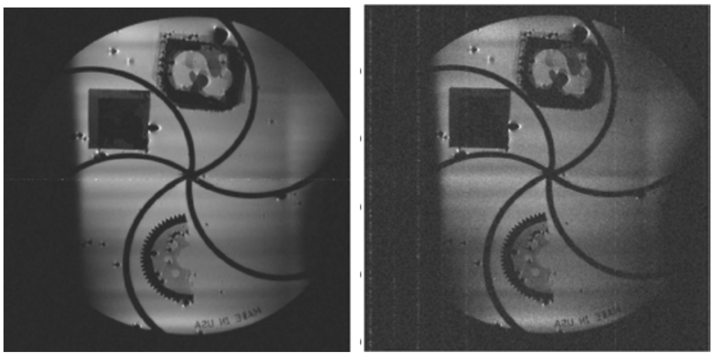

Figure: 2(a) Figure: 2(b)

Shown are the sum of squares images from 64 channels. 2(a) is from the data sampled at 2.5MHz and 2(b) is from data sampled at 156.25KHz

RESULTS & DISCUSSION:

In this example, we used an undersampling factor of 16, making real-time reconstruction of small bandwidth signals possible and makes the handling of data in 3D microscopy easier. However, the SNR of the images from the undersampled data is low the absence of bandpass filters, as mentioned in [4]. To improve the SNR, we are in the process of modifying the system to include fixed analog filters right after IF mixing and before digitization. Commercially available 455 KHz filters with 12 KHz BW are very cheap but restrictive in terms of the pulse sequences. A better solution which we are investigating is the use of active filters. The abstract presents a design for rapid parallel imaging systems, which will continue to improve with improving computational technologies.

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