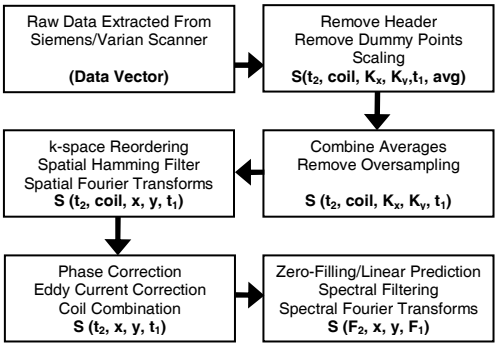
A MATLAB-Based Program for Post-Processing Across Multiple Platforms

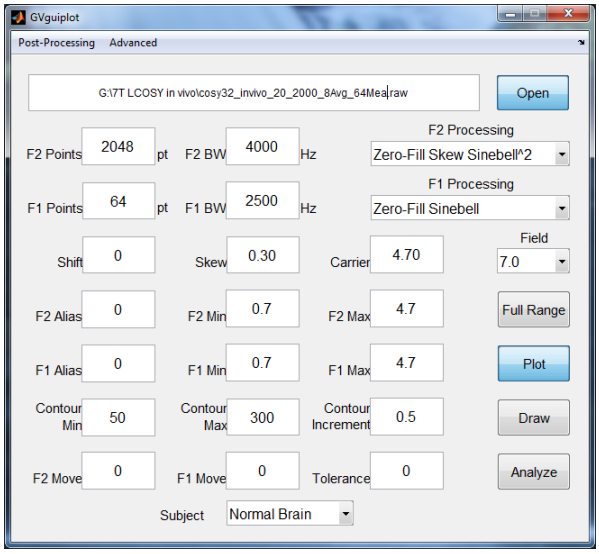
Gaurav Verma[1], Michael Albert Thomas[2], and Harish Poptani[1]
[1]*Radiology, University of Pennsylvania, Philadelphia, PA, United States,* [2]*Radiological Sciences, University of California Los Angeles, Los Angeles, CA, United States*

Introduction: The post-processing programs implemented by various magnetic resonance (MR) hardware manufacturers can often be proprietary closed-box systems, making it difficult to implement new sequences whose processing differs significantly from more mainstream sequences. For example, when two-dimensional (2D) MR spectroscopy (MRS) studies are acquired with phased-array coils, the default coil combination technique on the Siemens platform performs zero-phasing of each t_1 increment, resulting in artificial "parallel diagonals" (1) . To avoid this, post-processing must add coil data while preserving t_1 phase information (2). Moving data analysis offline to more flexible platforms like MATLAB allows increased transparency and customizability in developing post-processing schemes and provides access to MATLAB's library of native functions. The main purpose of this study was to develop an offline technique for extracting, processing and analyzing advanced spectroscopy and imaging sequences across various platforms.

Materials & Methods: The post-processing program was developed by extracting raw measurement data into MATLAB as a long vector of unsigned integers. Figure 1 shows the processing steps involved in reconstructing spectroscopic data from this initial step. Scan parameters used for data reconstruction were extracted using a simple text search of the main and measurement headers. Processing steps were empirically tested on Siemens sequences where offline reconstruction involved the same post-processing steps as Siemens Image Calculation Environment (ICE) such as, scans acquired with circularly-polarized coils. The processing was refined until the MATLAB-generated processed data matched the analogously ICE-processed data to within machine precision.

Further processing steps were then added to improve the quality of data processing including the implementation of 1D/2D spectral and spectral filters, with user-adjustable parameters like shift and skew. The option for DC offset removal was implemented by subtracting the average value of the tail end of long free induction decay (FID) signals from the full acquisition. Volume integral regions (3) based on chemical shifts of known metabolite resonances were added for signal quantification. These regions could be adjusted depending on the scanned anatomy to identify, for example, metabolites from human brain, rat brain, brain tumors or healthy calf muscle (4). Regions could be placed manually by using a reference chemical shift, for example NAA at 2.0 ppm or automatically by finding local maxima within a user-selectable tolerance in ppm range (default = 0.1 ppm).





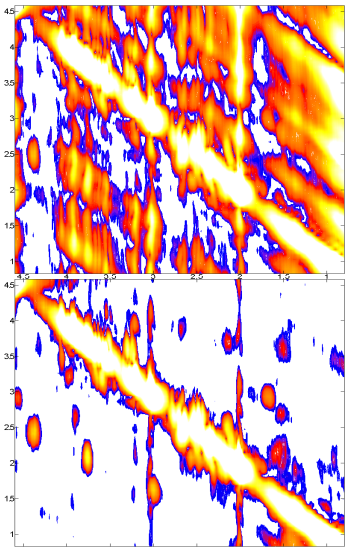


Figure 1 (top): Schematic showing processing steps in reconstructing raw 2D MRS data.
Figure 2 (right): GUI of GVguiplot showing various processing and plotting options.
Figure 3 (far right): 2D MRS data processed with conventional coil combination (top) and the phase-preserving method in GVguiplot (bottom).

Results & Discussion: The developed post-processing program can read Siemens raw measurement or RDA files (VB15, VB17 and VD11 platforms), SID files generated from the EPSI (5) sequence, Varian fid files and header-less RAW files. Spectra can be plotted in 1D or 2D and resulting in data stored in header-less RAW format, independent of the original platform. Figure 1 shows the graphical user interface (GUI) of the program, which allows various options including plotting, zero-filling, 1D and 2D filtering and integral/volume quantification. Variables like spectral points, bandwidth, field strength and center frequency can be adjusted to accommodate a variety of scan parameters. Data can be extracted, plotted and quantified, with and the resulting peak integrals are output as plain text and as spreadsheets in Microsoft Excel.

Figure 3 shows an example 2D MRS brain phantom spectrum acquired with a 32-channel phased-array coil as processed by ICE (top) and processed offline (bottom). 2D MRS data preserving t_1 phase information resulted in data free of parallel diagonals where resonances from each metabolite in the phantom were clearly detectable. An executable version of the program will be made available in future, and the source code can be provided to interested collaborators by contacting the authors.

Conclusion: The MATLAB-based post-processing program could potentially aid in the development of new advanced MRS techniques by providing robust, highly customizable post-processing methods. An example of this utility is the implementation of phase-preserving coil combination for reconstructing 2D MRS data without the introduction of parallel diagonals.

References: 1. Brown MA. Magn Reson Med 2004; 52:1207-1213. 2. Verma G. et al. Proc. ISMRM 17 (2009) 4264. 3. Costa et al. Crit rev Neurobiol 2004;16(1-2):1-23 4. Velan S., Magn reson Med 2007; 26:405-409. 5. Ebel A. et al. Magn Reson Med 2001; 46:1072-1078.