PULSAR Version 1.00

Parallel Imaging Utilizing Localized Surface-coil Acquisition and Reconstruction

USER MANUAL for GRAPPA

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USER MANUAL

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1. Introduction

This manual is written in order to explain how to use this software tool. This software package allows the user to simulate the parallel magnetic resonance imaging technique, GRAPPA(**G**ene**R**alized **A**utocalibrating **P**artially **P**arallel **A**cquisition). For specific information on this technique, please refer to the papers:

▪ Generalized Autocalibrating Partially Parallel Acquisitions (GRAPPA), M. Griswold, Magnetic Resonance in Medicne, 47:1202-1210 (2002)

User can learn how to run the software package easily through the quick-start guide.

2. System Requirements

The software package requires:
▪ **MATLAB 6.5** or higher
▪ **WinZip 8.1 SR1** or higher

It requires equivalent system requirements of MATLAB 6.5 or higher version. For specific information, see the requirements, platforms and operating systems in the MathWorks website, www.mathworks.com/support.

3. Installing PULSAR for GRAPPA

Installing PULSR for GRAPPA is very simple. Just extract 'PULSAR.zip' on your local folder. The subfolder, 'c:\PULSAR,' is automatically generated and all the files are installed there.

4. Getting Started

The software package has built-in 4-channel spine and 8-channel brain in-vivo images for demo. In order to try the demo, please follow the steps:

a. Start MATLAB 6.5 or higher.

b. Move to the 'c:\PULSAR\source\grappa' directory

c. Type 'recon' on a command window.

d. With a GUI, we select a MATLAB data-file(.mat extension), which is used for the data-input of 'PULSAR for GRAPPA.' Please select 'data_spine' or 'data_brain' and press the 'Open' button.

Note: The dimension of k-space data matrix in the file is [PE× FE×COIL]. The file should include only one matrix and the name of matrix in the file can be arbitrary.

e. For the question, 'Subsampling factor? [default: 2]' please enter your acceleration factor. The default value is '2' when there is no user-input.

Note: Input range is 2 ≤ Subsampling factor ≤ Number of coil.

f. For the next question, 'Block size? [default: 4]' please enter the number of block, which is used for GRAPPA reconstruction. The block size of '4' is used when user does not input any value for it.

Note: Input range is $1 \le \text{Block size} \le \frac{\text{Full phase-encoding lines}}{\text{Subsampling factor}}$.

g. For the question, 'Number of ACS lines? [default: 32],' please enter the number of additionally acquired k-space lines required for GRAPPA reconstruction.

Note: Input range is Block size × Number of coils ≤ Subsampling factor ≤ Full phase-encoding lines.

h. The next question is 'Number of coils for GRAPPA reconstruction? [default :4].' We select the number of coils for GRAPPA reconstruction.

Note: Input range is 1 ≤ Subsampling factor ≤ Number of coils.

i. We need to select the coil-type of geometric distribution for the question of 'Type of coil distribution? 1: Linear, 2:circularly symmetric coils [default: 1].' The 4-

channel spine demo has linear distribution of coils. On the other hands, the 8-channel brain demo has circularly symmetric coils.

j. For the last question, the way of applying Fourier transform is determined. 'PULSAR for GRAPPA' supports two options for it.

Option 1: 1D IFFT along FE -> GRAPPA Reconstruction -> 1D IFFT along PE
Option 2: GRAPPA Reconstruction -> 2D IFFT

k. After processing, reconstructed image is displayed on the screen. The left image is the reconstructed image with PULSAR for GRAPPA and the right image shows the sum-of-square image for reference, composed by full k-space data.

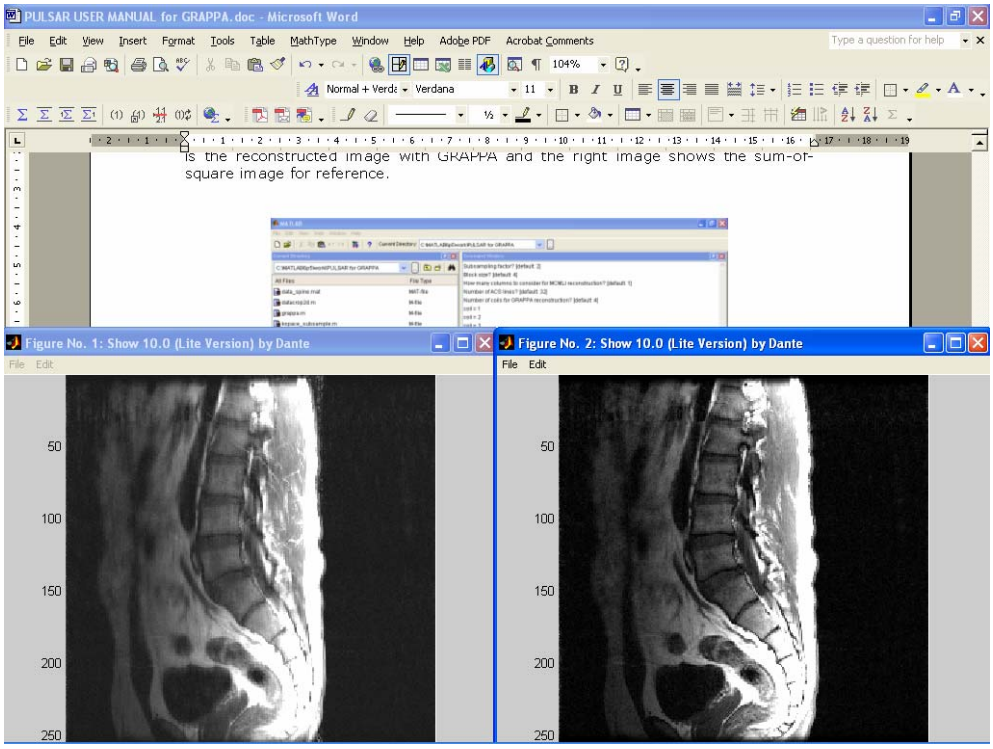
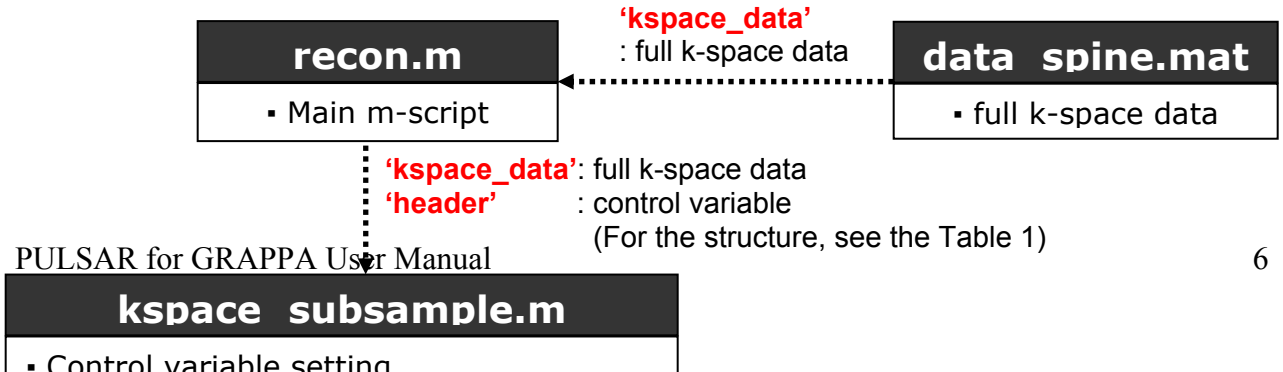


Figure 1. Getting Started Demo

5. Tutorial

(1) Overview

The entire procedure of 'PULSAR for GRAPPA' consists of two steps: k-space subsampling and image reconstruction with GRAPPA. Each step is implemented in an independent function for easy customization.



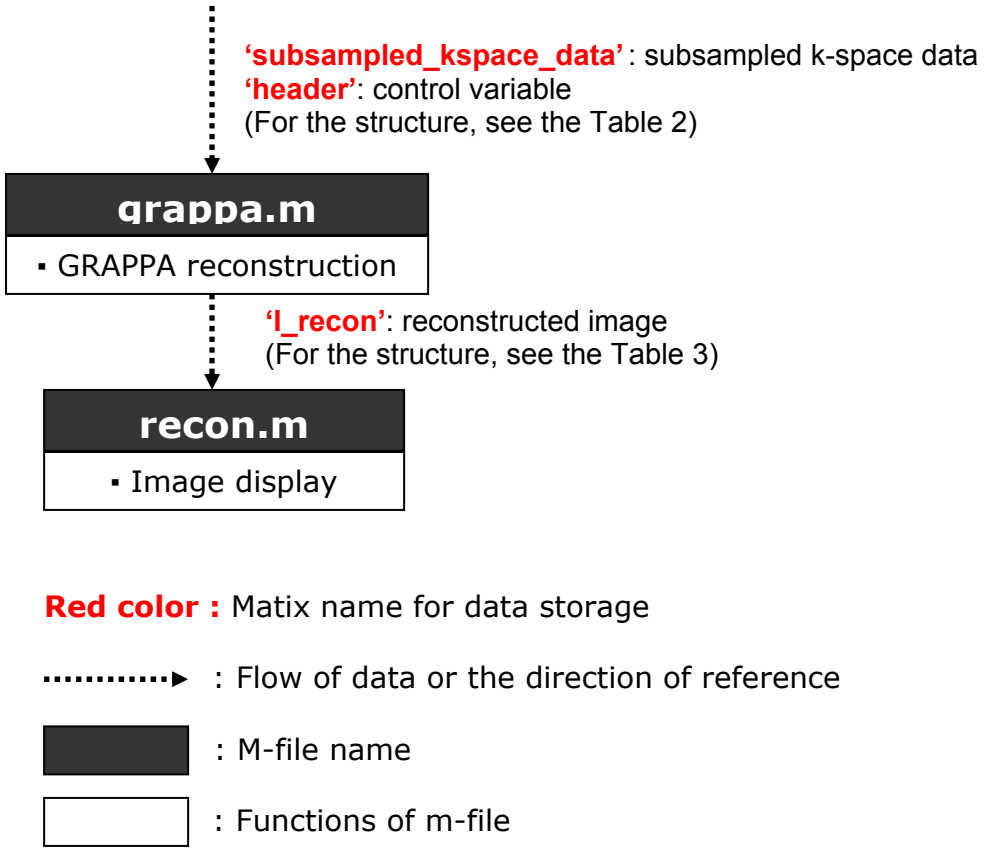


Figure 2. The overview of PULSAR for GRAPPA

(2) Specifications

A. recon.m

- Main m-script
- Initialization
- Image display

B. data_spine.mat

- Full k-space dataset for demo

Matrix Name	Structure	Description
kspace_data	N_{pe} x N_{fe} x N_{coil} N_{pe}: Number of phase encoding	Full k-space data for demo

	N_{fe}: Number of frequency encoding N_{coil}: Number of coil	

Table 1. Input/Output Specifications

C. kspace_subsample.m

▪ Control variable setting
▪ Generation of subsampled k-space data

'PULSAR for GRAPPA' basically asks users several essential control variables: 'subsampling factor,' 'block size,' 'the number of ACS lines,' and 'the number of coils,' 'type of coil,' 'the way of applying Fourier transform.' Because most of Control Variables(CV) are set-up automatically, for most cases, users do not need to set them up manually. However, if it is necessary, 'PULSAR for GRAPPA' supplies the way to customize them specifically.

Input / Output	Control Variable(CV)	Description
input	kspace_data	Full k-space data
input	header. subsampling_factor	Acceleration factor for GRAPPA reconstruction
input	header.blocks	Number of reference blocks for GRAPPA reconstruction
input	header.central_ksapce	Number of ACS lines
input	header.consider_coils	Number of coils used for GRAPPA reconstruction
input	header.coil_type	Type of coil's geometric distribution 1: Linear, 2:circularly symmetric coils
input	header.fft	The method of applying Fourier transform 1: 1D IFFT along FE -> GRAPPA Recon -> 1D IFFT along PE 2: GRAPPA Recon -> 2D IFFT
output	header.Nfe	Number of frequency encoding lines
output	header.Npe	Number of phase encoding lines
output	header.num_coil	Number of coils
output	header.sampling_location	Index of subsampled PE and ACS lines
output	subsampled_kspace_data	Subsampled k-space data in the fashion of [1: header. subsampling_factor: header.Npe]

Table 2. Input/Output Specifications

D. grappa.m

▪ GRAPPA reconstruction code consists of four parts: index calculation in order to use partial number of coils for GRAPPA reconstruction, index calculation for reference blocks, coefficient calculation using ACS lines for GRAPPA reconstruction, and the process of GRAPPA reconstruction using GRAPPA coefficients.

Input / Output	Control Variable(CV)	Description

input	subsampled_kspace_data *(structure: N_{pe} x N_{fe} x N_{coil})* *N_{fe}: Number of frequency encoding* *N_{pe}: Number of phase encoding* *N_{coil}: Number of coils* *Note: Not acquired k-space lines are filled with zero.*	Subsampled k-space data Note: The position of subampled k-space data is rearranged to be located on the full k-space domain. Moreover, ACS lines are already incorporated.
input	header	Control variables
output	I_recon *(structure: N_{pe} x N_{fe})* *N_{fe}: Number of frequency encoding* *N_{pe}: Number of phase encoding*	Reconstructed image with GRAPPA

Table 3. Input/Output Specifications

6. Contacts

Please respond for bug report and your opinions to:

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