VOP_compression_iterative_Hybrid_tri

Compression Algorithm for specific absorption rate compression

by Stephan Orzada (stephan.orzada@dkfz.de)

Syntax

```
VOP_compression_iterative_Hybrid_tri(filename_in,eps_G,R,options)
```

Description

This function compresses a set of SAR matrices loaded from "`filename_in`" into a VOP file. The algorithm is a new algorithm using the iterative algorithm by Orzada et al.(1) with the CC criterion by Lee et al.(2) and the CO criterion by Gras et al.(3). The paper from which this work resulted is currently under review at Magnetic Resonance in Medicine.

Input arguments

`filename_in` – Character array containing filename and path pointing to a full set of SAR matrices.

The file must contain an array with the name "matrices", either in the form N_{ch} by N_{ch} by number of SAR matrices, or in triangular format (use function `format_sq2tri(matrices)` to get the right format). If you want to use a GPU, it is recommended to use `single` format.

`eps_G` – Scalar factor for overestimation.

This factor is the multiplied with the worst case SAR of the original file to determine the maximum allowed overestimation at the start of the algorithm. For example: 0.4 means 40% of SAR_{wc}.

`R` – Reduction factor.

This factor is multiplied with eps_G after each iteration to reduce the overestimation.

`options` – Struct with options for compression

There are many options to influence the behavior of the algorithm. The following table shows the available options. Example: `options.name_save = 'Test_8ch'`. There are default values for all options if you do not explicitly specify them.

`name_save`	Name for the save file(s) which will contain the results from the compression. There will be one file for each iteration, each containing a complete set of VOPs. Default is `['VOP_SOR_' filename_in]`
`max_iter`	Maximum number of iterations. Default is 3.

max_number_VOPs	Maximum number of VOPs. Default is 60. The algorithm will try to achieve exactly this number of VOPs by adjusting the reduction factor in in the last iteration(s).
useGPU	Default is FALSE. Set to TRUE if you want to use your GPU. If no usable GPU is detected, the algorithm reverts to FALSE. The GPU is only used for the speed enhancement of the CC criterion as proposed by Kuehne et al. (4). If no GPU is used, the speed enhancement uses pageeig on CPU, which is also very fast.
OverestimationMatrixType	'Diagonal' (Default), 'Global', 'User'. 'Diagonal' uses a diagonal matrix with the entries on the main diagonal all equal to . 'Global' calculates the mean of all SAR matrices from the full set and normalizes the lowest eigenvalue of this to eps_g * SAR_{wc}. 'User' lets you specify your own matrix with the OverestimationMatrix option.
OverestimationMatrix	A user provided overestimation matrix in the form N_{ch} by N_{ch}. Default is [] and reverts to a diagonal matrix.
continueFile	Lets you specify a filename (and path) of a VOP file to continue compression. This uses the value of eps_G from the specified file, but the R value you provide to the function. If this option is not present, or the file can't be loaded, the function will start a normal compression with the provided parameters.
numMat4GPU	Number of matrices send to GPU as a batch. Depending on the size of your GPU memory, you can adjust this number. Default is 1e5.
numMat4Pageeig	Number of matrices sent to Matlab's pageeig function to be calculated in parallel. Default is 50,000.
N_vop_switch	Number of VOPs at which the algorithm starts using the CO criterion instead of the CC criterion. Default is 30.
block_size_max	Number of matrices send to rQstar function as a block. Default is 10,000. This number is also dynamically changed when running the algorithm.
block_size_2	Number of matrices sent to rQstar function as a block during the second step of each iteration. Default is 50,000. Larger numbers increase RAM use, but might be faster with very high CPU core counts. (>100).

Output

After each iteration a file is saved containing:

eps_G – overestimation factor

Sglobal – Overestimation matrix (Nch by Nch)

VOP – The VOPs (including overestimation)

VOPID – The ID of each VOP (position of the corresponding SAR matrix in the array of the full set)

overestimation_max – the upper bound for the overestimation.

`timings` – timings for this iteration. `timings(1,:)` contains the calculation time in seconds, while `timings(2,:)` contains the number of remaining matrices at this time point.

`elapsed_time` – total calculation time since start of the algorithm in seconds.

References

1. Orzada S, Fiedler TM, Quick HH, Ladd ME. Local SAR compression algorithm with improved compression, speed, and flexibility. Magn Reson Med 2021;86(1):561-568.
2. Lee J, Gebhardt M, Wald LL, Adalsteinsson E. Local SAR in parallel transmission pulse design. Magn Reson Med 2012;67(6):1566-1578.
3. Gras V, Boulant N, Luong M, Morel L, Le Touz N, Adam JP, Joly JC. A mathematical analysis of clustering-free local SAR compression algorithms for MRI safety in parallel transmission. IEEE Trans Med Imaging 2023;PP.
4. Kuehne A, Waiczies H, Niendorf T. Massively accelerated VOP compression for population-scale RF safety models. Proc Intl Soc Mag Reson Med 26 2017:478.