"TopUp Docker", an SPM extension for EPI distortion correction

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Introduction

EPI images, used in functional and diffusion MRI, present geometric distortions due to the susceptibility distribution. These deformations prevents a good match with other non-affected modalities and accurate anatomical localisation. To address this issue, two approaches have been proposed: the **"field mapping"** and **"top-up"** approaches [1,2]:

- “Field mapping” requires the acquisition of specific "field map" images, to derive the field inhomogeneity and the distortion through a physical model.
- “Top-up" only requires the acquisition of a few EPI images with an opposite phase encoding direction thus leading to a distortion in the opposite direction. With these 2 sets of images, one then estimates the field that when applied to the two sets of volumes will maximise the similarity of the unwarped volumes.

Both approaches are available in widely used open-source packages, "field map" in SPM [3] and "top-up" in FSL [4]. Nevertheless **either approaches cannot easily be integrated in the same processing pipeline**, e.g. for a direct comparison of their performances, because of their respective eco-systems.

Methods

Here we propose a lightweight Docker containerized version of the FSL’s TopUp tool directly interfaced in Matlab. On top of this, we providethe MatlabBatch GUI to integrate the "top-up" correction into SPM's batching system. The Docker installation simply requires to

1. install Docker Desktop [5],
2. download the "TopUp_Docker" container [6],
3. load it into Docker.

Then the Matlab code should be placed in a folder on Matlab's path and the MatlabBatch "config" files in a folder named "TopUpDocker" in SPM's "toolbox" subfolder. See figure

Discussion

The code and container allow to directly use FSL’s TopUp correction with SPM, without the need to install a full FSL distribution. The container weights only about 350MB, compared to the ~15GB of a full FSL distribution, and is available on ULiège's *dataverse* server [6], while the Matlab code is openly available on GitHub [7].

The approach proposed, interfacing Docker with Matlab, also opens the door to using other non-Matlab based tools in Matlab.

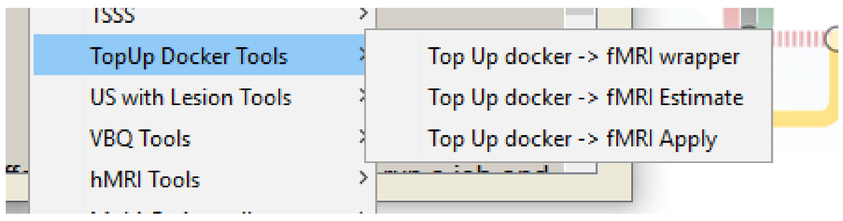
Results

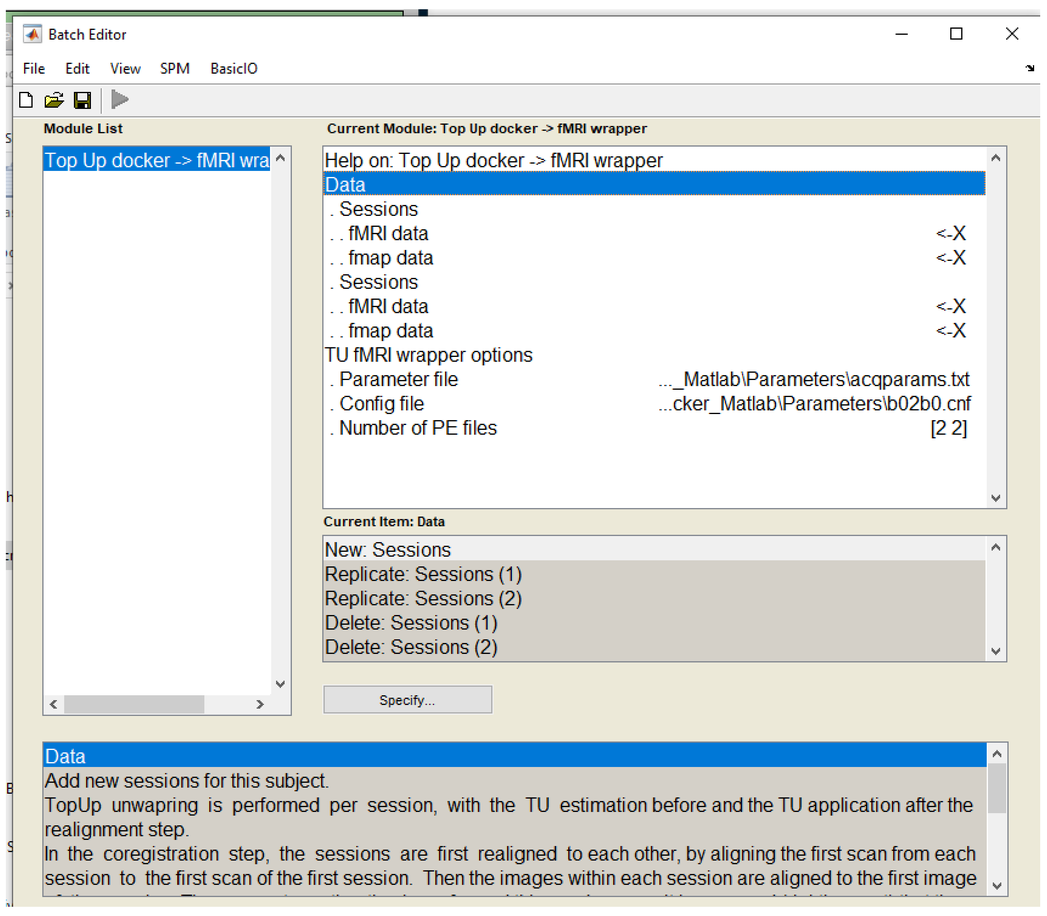
The Matlab code, which will only work if Docker is installed and loaded with the right container, is organized in 3 levels:

- "low level" functions talk directly to Docker and activate the container, through 'system' commands;
- "intermediate level" functions deal with the images to parameters to perform the calculation, moving things around as necessary to work with Docker;
- "high level" functions integrate the tool in SPM and provide a "wrapper" for the end user.

The tool can be used with a script and is interfaced in SPM. A function can test if Docker and the TopUp container are behaving as expected when actioned from Matlab

Since the core of the processing is the original FSL TopUp tool, the results of obtained on a dataset with an FSL installation or the Matlab-interfaced docker-ized version are exactly the same.





References & acknowledgments

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[2] J.L.R. Andersson, et al. . How to correct susceptibility distortions in spin-echo echo-planar images: application to diffusion tensor imaging. NeuroImage, 20(2):870-888, 2003. https://doi.org/10.1016/s1053-8119(03)00336-7

[3] SPM, https://www.fil.ion.ucl.ac.uk/spm/

[4] FSL, https://fsl.fmrib.ox.ac.uk/fsl/fslwiki/FSL

[5] Docker desktop, https://www.docker.com/products/docker-desktop/

[6] Docker TopUp container, https://doi.org/10.58119/ULG/ADYEJF

[7] Matlab code, https://github.com/CyclotronResearchCentre/TopUp_docker_Matlab/

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