rtQC: An open-source collaborative framework for quality control methods in real-time functional magnetic resonance imaging.

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http://github.com/rtQC-group/rtQC

Interest in real-time fMRI (rt-fMRI) has seen a significant increase in recent years. At the same time, concerns over the validity of functional neuroimaging practices have intensified [1]. Due to the additional complexities of rt-fMRI laboratory setups (over normal offline fMRI), a user-friendly, reliable procedure for fundamental quality assurance is urgently needed. Real-time fMRI studies involve a particularly complex series of imaging manipulations and a user-friendly method to make comparisons, either between offline and online data/analyses or between different real-time implementations, would be a boon to the field. However, although many offline quality control tools exist, to date no user-friendly, open-source toolkit for the quality control of rt-fMRI has been made publicly available.

We introduce the rtQC initiative, a collaborative development framework for the establishment of standardized quality control practices to assess real-time image quality and experimental setup, with a focus on ensuring an intuitive user interface. We demonstrate use of rtQC by testing on gathered data from 1.5T, 3T and 7T scanners, from the 3 main vendors (Siemens, Philips and GE). Using rtQC as an interface to a suite of standard neuroscientific software packages (e.g. MRIcroGL, AQUA, FSL, SPM, ANTs, LIPSIA, etc) we assessed the correspondence between real-time and offline versions of the data acquired using a variety of scanning protocols with regards to: a) the orientation of the data, b) the scaling of the data within volumes across slices and c) the scaling of the data across acquired volumes. We then implemented a procedure that can convert the real-time data to the standard NIfTI format while ensuring voxelwise correspondence with the equivalent offline versions of the data across all volumes.

Initial findings confirm the fact that the online data can deviate from their offline homologues in scaling, orientation and overall positioning, in some cases affecting standard image registration and statistical inference procedures; overtly in the case of misregistration or tacitly in the case of suboptimal scaling. We also demonstrate the following features: a) An online field motion and distortion correction FSL wrapper script that can be inserted into any real-time pipeline (processing load < 0.5s); b) a “function development check” function, based on mutual information, to be utilized for comparing between different implementations of processing steps, such as different variants of motion correction or first level statistics. Inconsistencies in file formats and header information across data from different scanners and manufacturers are being documented, with the aim of communicating them to the vendors and increasing coherency of adopted conventions (e.g. with regards to DICOM fields, slice-time information and transformation matrices).

The project is open to contributions from further interested parties and it is our goal that this package will comprise a suite of user-friendly meta-functions that can be selectively inserted into any processing pipeline as well as integrated into larger open-source projects such as OpenNFT.org [2].

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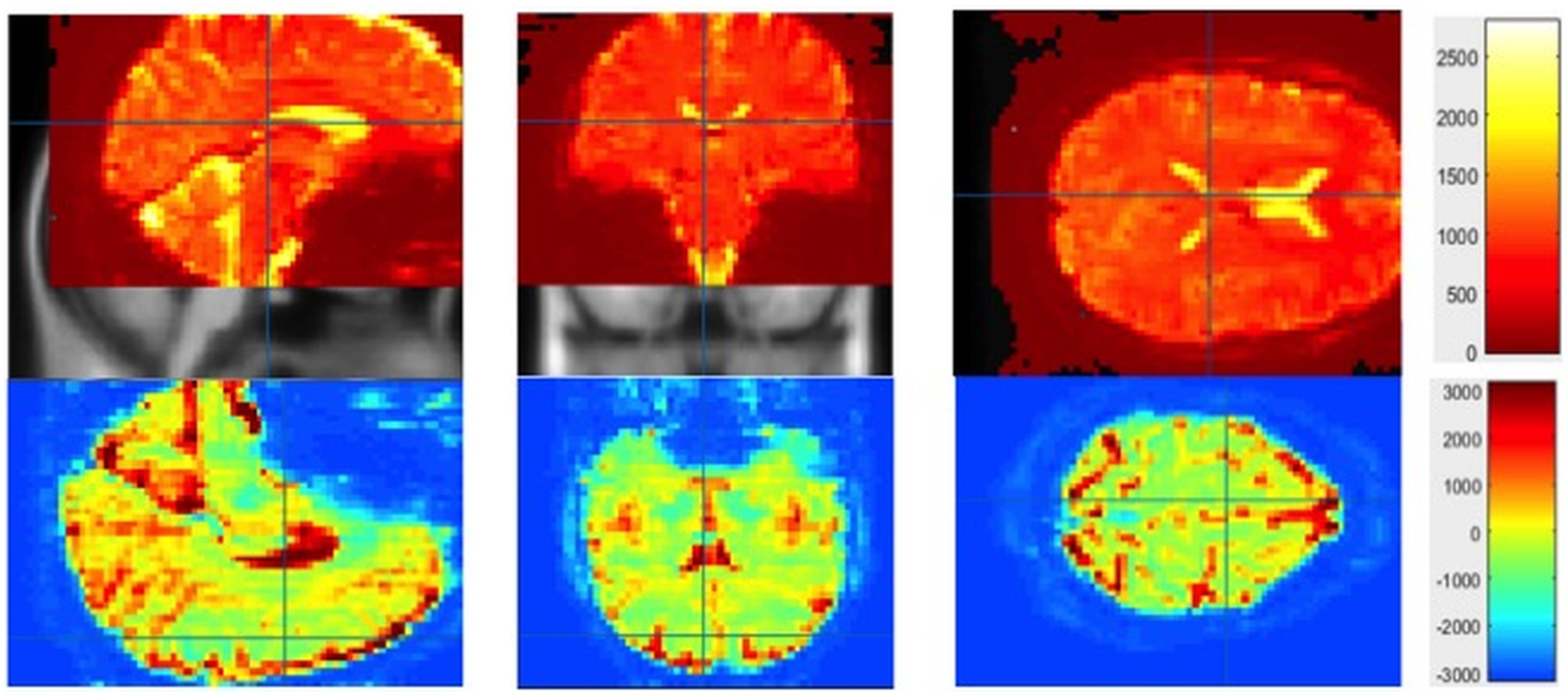

Figure 1: Raw fMRI data superimposed on the SPM MNI template, without registration. The top row shows offline data that were exported in classic dicom format and were then converted to NIfTI format using the dcm2nii program from the MRIcro software. The bottom row shows the exact same dataset as exported in real-time. Note the difference in scale and orientation. Such inconsistencies are to some extent expected and readily observable by experts but may be ignored by real-time novices, unless standard quality assurance procedures are established. The rtQC toolbox proposes procedures and includes implementations that ensure absolute correspondence between real-time datasets and their offline equivalents.

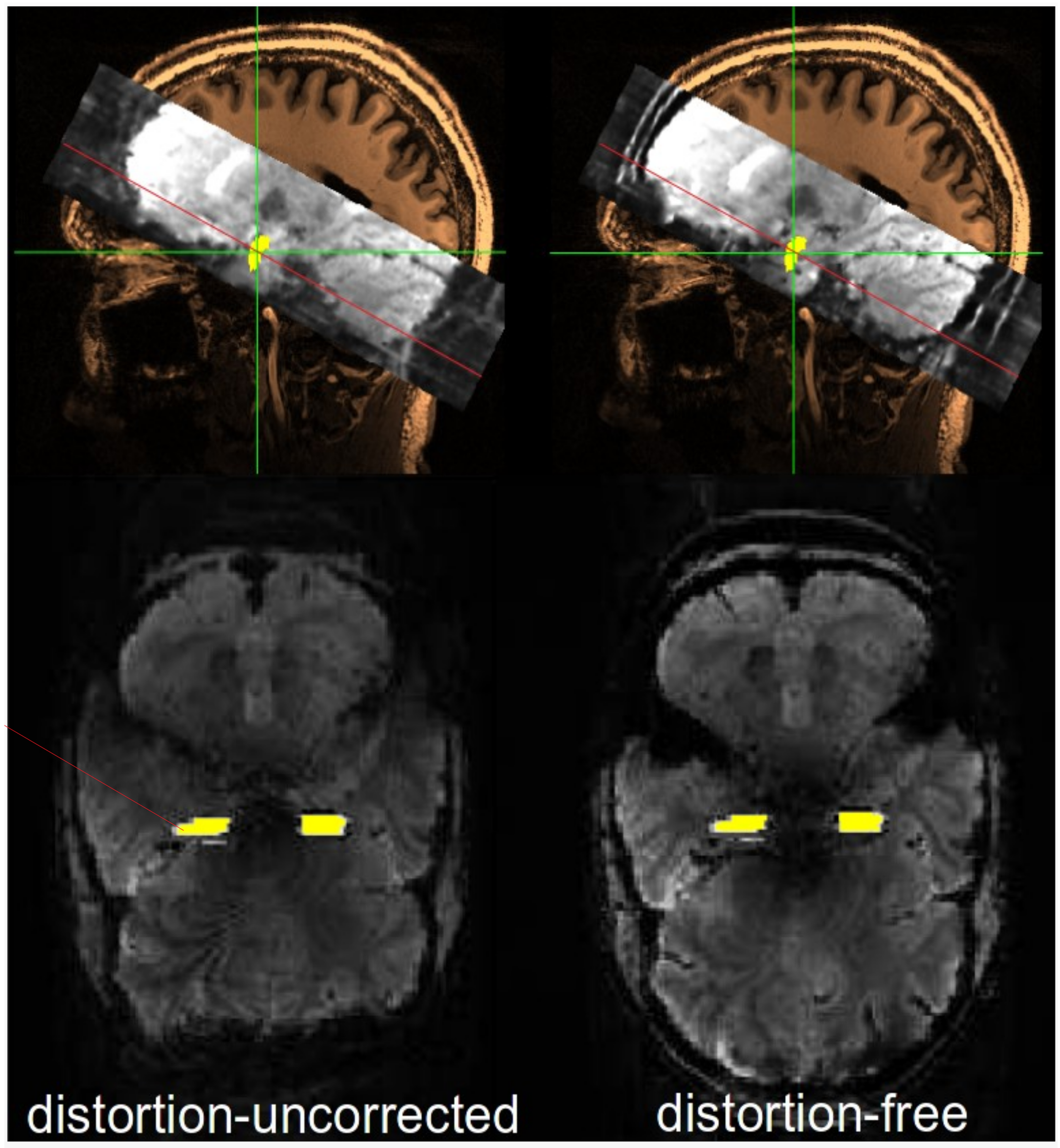

Figure 2: Distortion correction can lead to significant improvements in data quality. The rtQC toolbox includes scripts that facilitate adding distortion correction to real-time analysis pipelines.