The QSM 2016 Reconstruction Challenge

4th International QSM Workshop,
September 26th-28th 2016, Graz, Austria
www.qsm2016.com

The Challenge: Motivation

- Early concepts for QSM reconstruction date back to a decade ago, while more refined methods have been continuously developed from single orientation, in a clinical setup, with low recon artefacts

- This allowed QSM to attract a high number of researchers (300 members in the Electro-Magnetic Tissue Properties study group)

- QSM is utilized in clinical studies of neurological disorders and is increasingly becoming a topic of research outside the brain

The Challenge: Aims

- To test the ability of various QSM algorithms to faithfully recover the underlying susceptibility from noisy phase data acquired *in vivo*

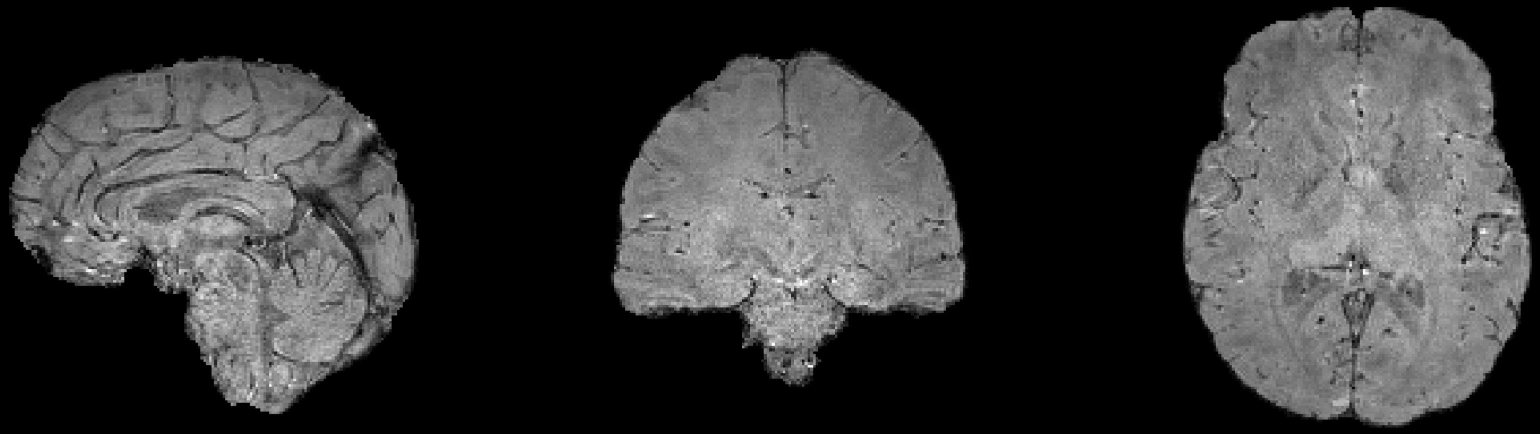
- To provide a common ground-truth dataset that would help benchmark not only existing QSM algorithms, but also the methods that will be developed in the future

- To disseminate the results and lessons learned in the challenge in a participant-driven paper

Data Acquisition

- Healthy female age 30 @ 3T Siemens Tim Trio
- 3D-GRE with Wave-CAIPI acquisition
- 12 orientations sampled @ 1.06 mm iso
- TE / TR = 25 / 35 ms, @ BW = 100 Hz/pixel
- T_{acq} = 94 sec / orientation @ R=15-fold acceleration
- Roemer/SENSE coil combine with sensitivities estimated from additional reference acquisitions with head/body coil reception
- Details: B Bilgic et al NIMG’16

Magnitude transversal orientation



will be made available

Raw phase: BET brain mask [1]

1. SM Smith HBM'02

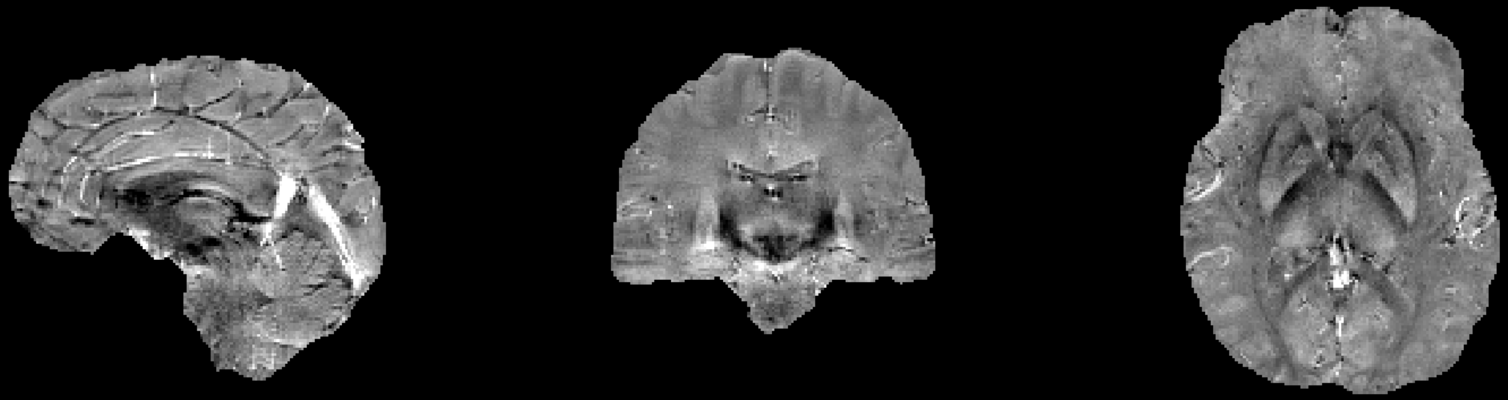
Laplacian unwrapping [2]

2. W Li et al NIMG’11

Laplacian Boundary Value (LBV) background removal [3]

3. D Zhou et al NMR in Biomed’14

3D polynomial fit 4th order: remove Tx phase



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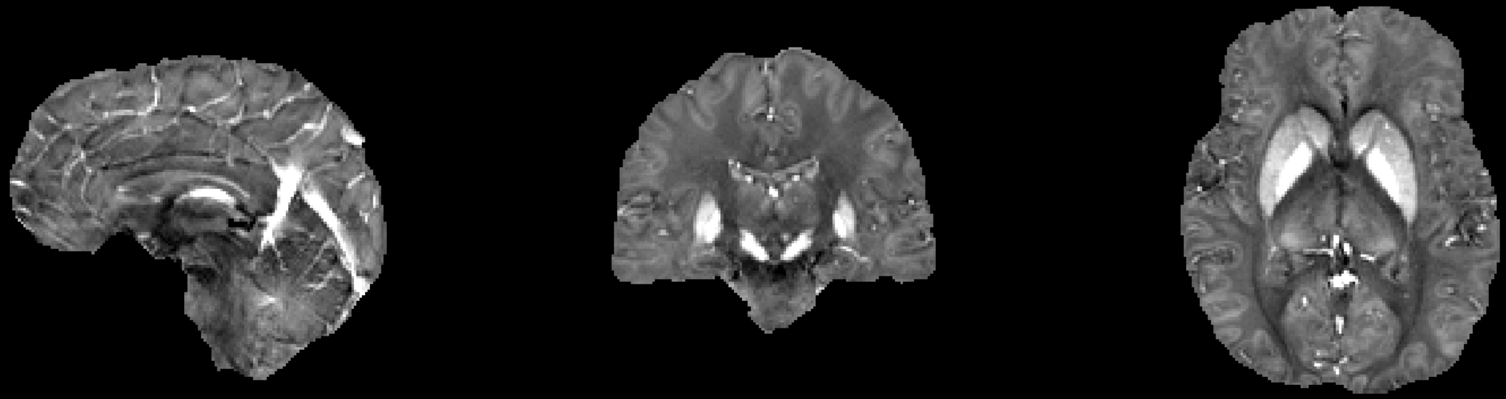
in ppm, normalized by $(\gamma \cdot TE \cdot B_0)$

COSMOS QSM [5] from 12 orientations



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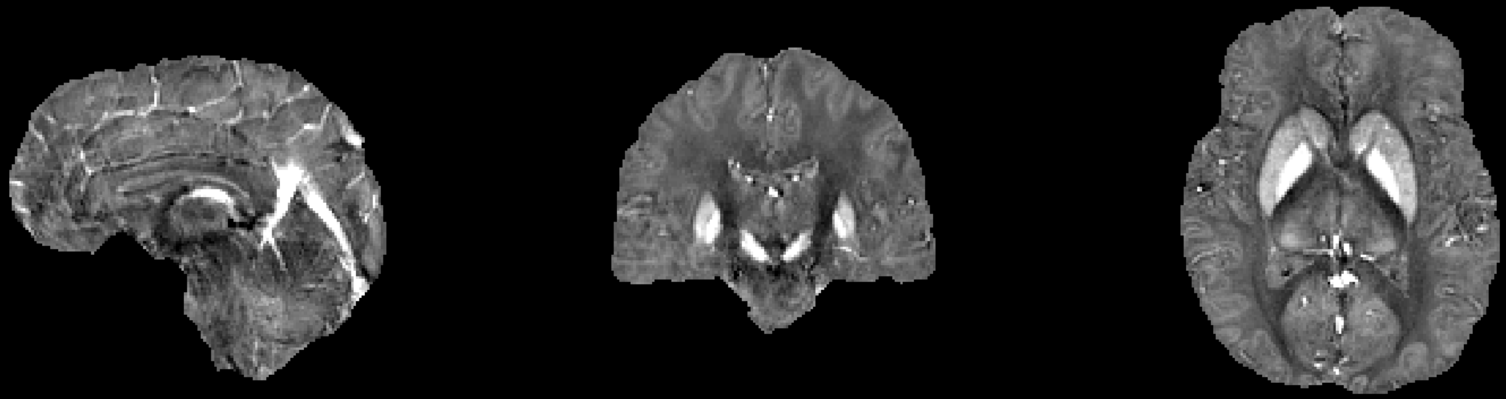
-0.10 ppm 0.14 ppm

5. T Liu et al MRM’09

χ_{33} from 12 orientation STI solution [6]



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6. C Liu MRM'10

χ_{33} as ground truth

- Observed phase in subject frame of reference:

$$\theta(k) = \frac{1}{3} H' \bullet \chi(k) \bullet H \; - \; H \bullet k \frac{k' \bullet \chi(k) \bullet H}{k^2}$$

χ_{33} as ground truth

- For the transversal acquisition where H = [0,0,1]:

$$\theta(k) = \frac{1}{3}\chi_{33}(k) - k_z \frac{k_z\ \chi_{33}(k)}{k^2}$$

χ_{33} as ground truth

- For the transversal acquisition where H = [0,0,1]:

$$\theta(k) = \left(\frac{1}{3} - \frac{k_z^{\,2}}{k^2}\right) \chi_{33}(k)$$

Evaluation Metrics

- Susceptibility maps calculated from the single orientation scan provided will be tested against the gold-standard χ_{33} using the global metrics:

i. RMSE – root mean squared error (lower the better, best possible RMSE=0%)

ii. HFEN – high frequency error norm (lower the better, best possible HFEN=0%)

iii. SSIM – structure similarity index (in the range [0, 1], best possible SSIM=1)

- Quantitative comparison within major Deep Gray Matter nuclei and White Matter regions of interest

Data and Source Code

- Data provided:
    i. Single axial oriented GRE (preprocessed by LBV and 4^{th}-order TX phase removal)
    ii. χ_{33} (will serve as ground truth for the QSM recon challenge)
    iii. COSMOS QSM
    iv. MPRAGE and GRE magnitude to serve as structural prior if needed

- Matlab code provided:
    i. Compute TKD and Closed-form L2 recons as example
    ii. Evaluate performance metrics

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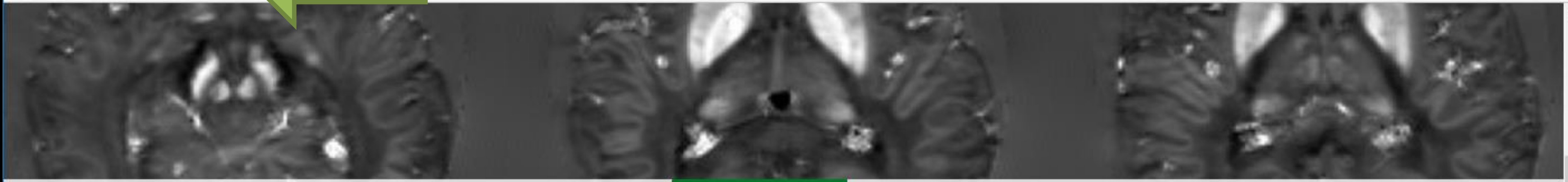

WELCOME | PROGRAM | REGISTRATION | ABSTRACTS | QSM CHALLENGE | VENUE | ACCOMMODATION | ABOUT GRAZ | CONTACT

THE QSM 2016 RECONSTRUCTION CHALLENGE

Quantitative susceptibility mapping allows the determination of a basic physical property in vivo. Early concepts for QSM were introduced a decade ago and more refined methods have been proposed recently to allow the calculation of magnetic susceptibility from a single orientation, in a clinical setup, and with low reconstruction artefacts. Therefore, QSM has attracted a high number of researchers (there are currently around 300 members in the ISMRM Electro-Magnetic Tissue Properties (EMTP) study group), it is utilized in clinical studies of neurological disorders and is increasingly becoming a topic of research outside the brain.

AIM

The aim of this QSM 2016 reconstruction challenge is to test the ability of various QSM algorithms to faithfully recover the underlying susceptibility from noisy phase data acquired from a healthy volunteer.

GOLD STANDARD REFERENCE DATA SET AND MAGNETIC SUSCEPTIBILITY MAP

GRE data with 1mm isotropic resolution acquired with a 32-channel receive coil array from a healthy human brain in 12 different head orientations.

TEST DATA SET PROVIDED

A single orientation (transversal) GRE data as well as the "ground truth" data set (x_{33} of the STI).

EVALUATION AND ERROR METRICS

Susceptibility maps calculated from the single orientation scan provided will be tested against the "gold-standard" reference x_{33}. Deviations from the gold standard will be quantified using (i) RMSE – root mean squared error, (ii) SSIM - structure similarity index, (iii) HFEN – high frequency error norm, and (iv) quantitative errors in selected white and gray matter ROIs.

TIMELINE AND DATA

1. *The QSM2016 challenge will be presented at the EMTP study group at the ISMRM in Si pore*
2. *Data and instructions can be downloaded here (__qsm_recon_challenge_2016.zip__)*
3. *Deadline for submission of QSM results: September 3rd, 2016*
4. *Results will be presented at the 4th QSM workshop in Graz at September 27th, 2016 .*

EMAIL MAILING LIST

If you would like to receive updates and additional information concerning the recon challenge please send us an email to **qsm@neuroimaging.at**.

www.qsm2016.com

Timetable

- Timetable:
  - Kickoff today (MRI data can be downloaded at www.qsm.rocks)
  - Please join mailing list at qsm@neuroimaging.at (for updates and info)
  - Deadline for submission of QSM results:

    September 4th, 2016
  - Results will be presented at the 4th QSM workshop in Graz (September 27th 2016).

- **Thanks to Christian Langkammer and Ferdinand Schweser!**