QSM: Susceptibility Calculation Methods

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- Toolbox for MRI susceptibility (χ) calculation step written in both MATLAB and Python
- Three χ calculation techniques:
  - Truncated k-space division (**TKD**)[1]
  - Closed-form k-space inversion with Tikhonov regularisation (**dirTik**)[2]
  - Iterative fitting with Tikhonov regularisation (**iterTik**)[2]

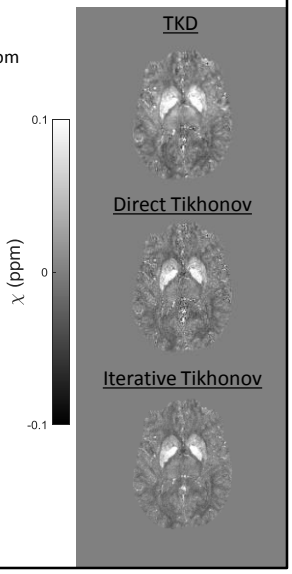
$$\arg\min_{\chi} \|MW(B_{local} - B_0(d * \chi)\|_2^2 + \alpha\|M\chi\|_2^2$$

Binary tissue mask

Weighting term accounting for spatially varying noise

Regularisation term (default $\alpha = 0.05$)

- Note all three methods have default PSF-based correction for χ underestimation[3]



- This tool is a set of three MRI susceptibility calculation methods written in both MATLAB and Python for easy implementation as the last step in your QSM processing pipelines.
- The methods include TKD, k-space inversion with Tikhonov regularisation also known as Direct Tikhonov, and iterative fitting with Tikhonov regularisation.
- For the iterative Tikhonov regularisation method, explained in more detail in Anita Karsa's paper on Optimised QSM for the Head and Neck, the solution is found by solving this least-squares minimisation problem with a Tikhonov regularisation term, using a conjugate gradient method. It is very quick and accurate for many applications including neuroimaging and head-and-neck imaging.

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How to access:

- Request download as either:

  Free Academic licence: 24 month term

  Other use licence: Negotiable

Example use (MATLAB):

```
Parameters.FieldMap = FieldMap;
Parameters.Noise = NoiseMap;
Parameters.Mask = Mask;
Parameters.Resolution = [1 1 1];
Parameters.B0direction = [0 0 1];
Parameters.Alpha = 0.05;

QSM = iterTik(Parameters);
```

From N_std output of Fit_ppm_complex.m or Fit_ppm_complex_TE.m from MEDI Toolbox

Download: https://xip.uclb.com/product/mri_qsm_tkd

[1]: Shmueli, K et al. (2009). Magnetic susceptibility mapping of brain tissue in vivo using MRI phase data, Magnetic Resonance in Medicine vol 62 issue 6, 1510-1522

[2]: Karsa, A., Punwani, S., & Shmueli, K. (2020). An optimized and highly repeatable MRI acquisition and processing pipeline for quantitative susceptibility mapping in the head-and-neck region. Magnetic Resonance in Medicine, 84(6), 3206-3222

[3]: Schweser, F et al. (2013). Toward online reconstruction of quantitative susceptibility maps: superfast dipole inversion, Magnetic Resonance in Medicine vol 69 issue 6, 1581-1593

- To download this toolbox simply request a download and provide an academic email address for the academic licence, or we would be happy to negotiate a licence for non-academic or commercial use.
- An example use of the iterTik function in MATLAB is shown here, where the Noise input to the Parameter struct is obtained from one of the Fit_ppm_complex functions in the MEDI toolbox.
- You can download this tool at the link shown here.