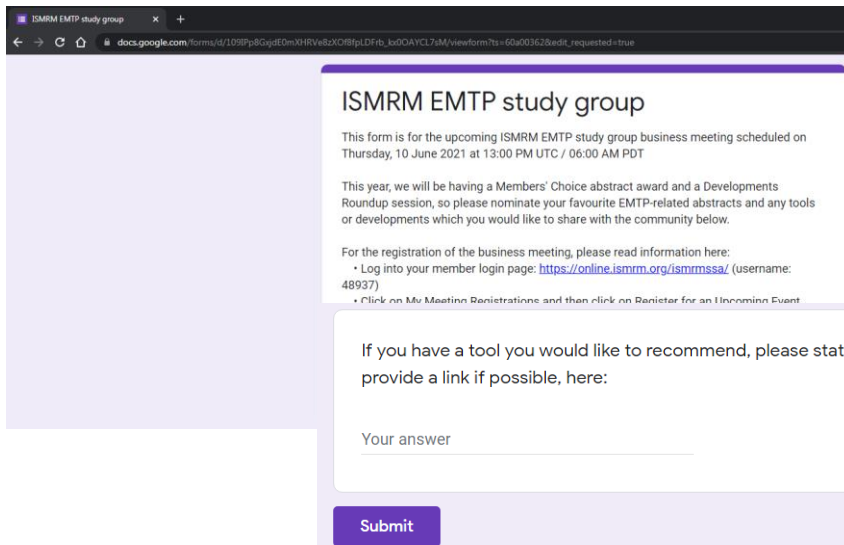


# Tools Roundup



The screenshot shows a web browser window with the address bar displaying a Google Forms URL. The form title is "ISMRM EMTP study group". The text on the form reads: "This form is for the upcoming ISMRM EMTP study group business meeting scheduled on Thursday, 10 June 2021 at 13:00 PM UTC / 06:00 AM PDT". Below this, it says: "This year, we will be having a Members' Choice abstract award and a Developments Roundup session, so please nominate your favourite EMTP-related abstracts and any tools or developments which you would like to share with the community below." It then provides registration information: "For the registration of the business meeting, please read information here: Log into your member login page: <https://online.ismrm.org/ismrmssa/> (username: 48927) Click on My Meeting Registrations and then click on Register for an Incoming Event". The main question is: "If you have a tool you would like to recommend, please state what it does and provide a link if possible, here:". Below the question is a text input field labeled "Your answer" and a blue "Submit" button.

New feature: tools roundup

These are Study Group requests in answer to the questionnaire which Jongho sent to the SG mailing list near the end of May 2021.

We received 14 methods recommendations.

# Tools Roundup

## Acquisition

3D-EPI Siemens WIP 1043A  
ASPIRE online coil combination for Siemens (C2P)

## Pre-processing

SEGUE phase unwrapping  
ROMEOPHASE phase unwrapping

## SWI

CLEAR-SWI

## QSM

SMWI (for nigrosome 1), QSMnet, QSMnet+  
AutoQSM & MoDL-QSM  
FANSI  
TKD etc  
QSMxT  
LPCNN - DL QSM for arbitrary magnetic direction  
SEPIA

## Conductivity:

UCL  
EPTlib

These are the tools we will be looking at, arranged into Acquisition, Pre-processing, SWI, QSM and ETP-related.

An abbreviated version of the authors' text appears with each slide.

Acquisition methods: 3D-EPI WIP from Siemens Australia and UQ, on-console coil combination with ASPIRE

Phase unwrapping with SEGUE from UCL, ROMEO from the Medical University of Vienna

CLEAR-SWI, a multi-echo SWI method for UHF from the Medical University of Vienna

Susceptibility Map Weighted Imaging, QSMnet and QSMnet+ from Seoul National University

AutoQSM from Shanghai Jiao Tong University

Fansi from Carlos Milovic

TKD methods from UCL

QSMxT from the University of Queensland

LPCNN QSM tool for arbitrary magnetic field direction from Johns Hopkins and the meta QSM tool

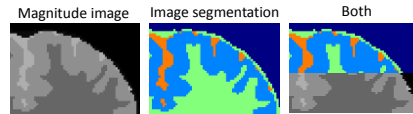
SEPIA from Kwok-shing Chan and Jose Marques from Radboud University Nijmegen

And we finish with conductivity tools from Anita Karsa and Karin Shmueli

And EPTlib from Alessandro Arduino and Ulrich Katscher

# MRI Conductivity (UCL)

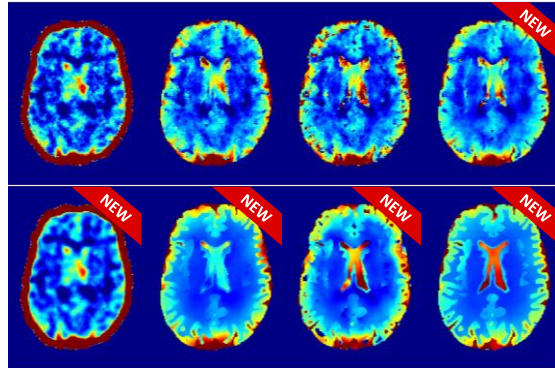
Anita Karsa and Karin Shmueli



$$\sigma = \frac{1}{\mu_0 \omega} \nabla^2 \varphi_0$$

Phase-based EPT:

$$\sigma = \frac{1}{\mu_0 \omega} \oint \nabla \varphi_0 ds$$



**Abstract:**

Karsa et al. "New Approaches for Simultaneous Noise Suppression and Edge Preservation in Quantitative Conductivity Mapping From Low-SNR Data." Proceedings of the 29th Annual Meeting of ISMRM. p.3774. 2021.

We're into the home straight now in the ETP section.

The MRI conductivity mapping tool developed at UCL contains MATLAB implementations of all methods presented in the abstract below. These methods are based on two different formulations of the phase-based Helmholtz equation and include edge preservation based on the magnitude image and/or the image segmentation.

# MRI Conductivity (UCL)

## HowToUse\_QCM.m

**XIP**  
HOME PRODUCTS

Search products

Home > All products > Healthcare Tools > MRI Conductivity

### MRI Conductivity

State-of-the-art algorithms for MRI phase-based electrical conductivity mapping

Quantitative Conductivity Mapping (QCM) is a non-invasive technique that calculates the high-frequency tissue electrical conductivity ( $\sigma$ ) from the phase ( $\phi$ ) of the MRI signal. QCM has a range of potential clinical applications including measuring sodium levels<sup>1</sup>, and distinguishing between different types of brain plaques<sup>2</sup>.

a) Laplacian-based methods

Most QCM methods are based on the following differential equation<sup>1</sup>, valid in regions with slowly varying  $\sigma$ :

$$\nabla^2 \phi = \frac{1}{\mu_0} \frac{1}{\omega^2} \nabla^2 \sigma \quad (1)$$

where  $\mu_0$  is the vacuum permeability,  $\omega$  is the proton Larmor frequency, and  $\nabla^2$  is the Laplacian operator. Applying a finite-difference approximation of  $\nabla^2$  over a kernel (Figure 1a), which is why most current methods fit a 3D quadratic function within a kernel (Figure 1b) around each voxel and calculate the Laplacian of these fitted functions<sup>3,6</sup>. This 3D quadratic fit is usually either i) weighted by the magnitude values within the kernel (Figure 1c) or ii) restricted to voxels from the same tissue type<sup>7</sup> (Figure 1d) to avoid artifacts of the conductivity boundaries where Eq. 1 is not applicable.

While these are the most commonly used methods for QCM, there is a lack of readily available implementations that could be used as a standard. Here, we have implemented a MATLAB function that performs QCM by quadratic fitting within an ellipsoidal kernel of user-defined dimensions and with options for i) magnitude- or ii) segmentation-based edge preservation. Moreover, i) and ii) can be used in combination (Figure 1e), which is a new approach that shows promise for outperforming all the other techniques (Figure 1f).

**MRI Conductivity - Academic Licence**  
Preview terms  
Term: 24 months  
Price per 1 unit: £0.00 per unit  
**REQUEST NOW**

**Licence - Other Use**  
Preview terms  
Term: 12 months  
Price per 1 unit: TBD  
**REQUEST NOW**

```
HowToUse_QCM.m
55 % Calculating the conductivity map by solving the integral equation
56
57 %-----Arguments-----
58
59 Inputs.PhaseMap = N(D array) - B1 phase map in radians (you may need to
60 multiply by 2 to get the B1 transmit phase)
61
62 Inputs.PhaseMask = N(D array) - B1 phase mask including all voxels with
63 available phase information. This is different from the MRI mask which is
64 a just a portion of the Tissue Mask.
65
66 Inputs.Method = {'string'} - 'full', 'mag', 'seg', or 'magseg' specifies the
67 edge preservation method (see abstracts and paper for more details). 'all'
68 specifies a 3D quadratic fit within an ellipsoid around each voxel to cal-
69 culate the first derivatives followed by surface integration on another
70 ellipsoid. 'mag', 'seg', and 'magseg' include magnitude- and/or segmen-
71 tation-based edge preservation for both steps.
72
73 Inputs.KernelRadialDiff = V(vector) - Radial (along x,y,z) in mm of the ellipsoid
74
75 Note: the 3D quadratic fit to calculate the first derivatives is performed.
76 We have found the optimal kernel radius in an image with magnitude SNR = 16
77 and 1 mm isotropic resolution to be:
78 k 'mag' - [10 10 10]
79 k 'seg' - [5 5 5]
80 k 'magseg' - [10 10 10]
81
82 Inputs.KernelRadialInt = V(vector) - Radial (along x,y,z) in mm of the ellipsoid
83
84 Note: the surface integral is performed. We have found the optimal kernel
85 radius in an image with magnitude SNR = 16 and 1 mm isotropic resolution to
86 be:
87 k 'full' - [6 6 6]
88 k 'mag' - [14 14 14]
89 k 'seg' - [10 10 10]
90 k 'magseg' - [20 20 20]
```

### Links:

[https://xip.uclb.com/product/MRI\\_conductivity](https://xip.uclb.com/product/MRI_conductivity)  
([https://xip.uclb.com/i/software/MRI\\_conductivity.html](https://xip.uclb.com/i/software/MRI_conductivity.html) also redirects here)

Email: [anita.karsa.14@ucl.ac.uk](mailto:anita.karsa.14@ucl.ac.uk) or [segueUCL@gmail.com](mailto:segueUCL@gmail.com)

The MATLAB functions are licenced for free for academic use and can be downloaded from the UCL XIP website. The HowToUse\_QCM.m file contains a detailed list of all the necessary inputs and their descriptions.



# Tools Roundup



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I'd like to thank all the authors who contributed their slides and methods. With their permission, we'll be including these slides in the software section of the emtphub.org website