**Advanced MRI 2022**

MATLAB Session 4: **Quantitative MRI**

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Start by adding the ‘Material’-directory to your MATLAB search path. Also include the “nifty” toolbox.

**1a)** Review the Matlab script ‘quantitative\_MRI\_1.m’.

This script reads in real MRI data from data.nii.gz and mask.nii.gz. The nifty format with its “.nii”-extension, is a common way of saving medical data for processing. Once loaded, the nifty structure will contain a header “data.hdr” containing all relevant imaging parameters, as well as a 4D image “data.img”. If you are unfamiliar with this format, take some time to explore the “.hdr” and “.img” fields.

The data.nii.gz file contains the data of a DWI acquisition whereas the mask.nii.gz contains a binary mask of the liver. The script defines the b-values are which the MRI was obtained.

To minimize computational demand, we subsequently select a single slice from the dataset (slice 10). Furthermore, we have averaged the signal of the repeated measurements per b-value to reduce the amount of data further (but retain the gain of improved SNR of the repeated measures)

Run the script such that it plots a mono-exponential fit to the mean of the data from within the ROI (note the plot is on a logarithmic scale). Also, add a plot of the residuals (=data-fitted estimate). What do you think of the fit? Does it capture the data well?

**1b)** As learnt in the class today, there are several models for DWI data. The provided fit is the conventional model. Now, implement the Intravoxel Incoherent Motion model discussed in the lecture. Fit this model to the mean data and explain the difference with the conventional fit.

* Does this model fit the data well? Note that typically, D is in the order of 0.001, f in the order of 0.2 and D\* in the order of 0.05. These are important as initial guess parameters. S0 is in arbitrary units and we will keep them similar to the ADC model (S0 initial=1)

**1c)** For most of you, your fit will still not be completely satisfactory. This is a result of the initial guess being “poor”. If you examine the data, the baseline signal (S0) is in fact in the order of 200. Try to rectify the fit by taking an initial S0 guess of 200 and explain why the results are so different.

* How could this be an issue in MRI?
* Changing the initial guess worked for this example, but in practical use that is not an option. How could you find a general solution to this? **TIP:** there is a simple way of estimating S0 from your data

**1d)** So far, we have taken the mean signal value from within a region of interest and fitted two DWI models to the data. However, often, clinicians want to see the DWI parameter maps, instead. This requires fitting the DWI model to all individual voxels. Produce parameter maps for D, f and D\*.

* Perform a fit for each voxel
* Show the parameter maps per IVIM parameter
* **Bonus**: fitting can last long; if you are only interested in values from within the liver (mask/ROI) you could choose to only fit these voxels. Try implementing the fit only to the relevant voxels and generate parameter maps only in the ROI.

**1e)** -Are the mean (from within the liver) of D, f and D\* (1d) identical to the fitted D, f and D\* to the mean liver signal (1c)?

* Explain why you may expect identical/different numbers here?
* What would you expect is the best approach?

**1f)** (**Bonus**): Add Rician noise to the data, redo the fits and study the parameter maps under the influence of Rician noise. Rician noise can be added by adding Gaussian noise to the real and complex domain of the signal and then taking the absolute again (assume the data given is the real value and the initial complex value is 0). In MRI, the noise magnitude is often identical, whereas the signal decreases for the b-value images. So you will need to define the SNR for b=0.

At what SNR (SD of the noise) do you start seeing contrast changes in the parameter maps (we suggest testing SNR=[100, 50, 20,10,7,5]? This can be done by repeating exercise 1d with different levels of added noise. Was this SNR expected?