1. Models

1.1. Ferizi$_1$ and Ferizi$_2$

This submission uses two three-compartment models, as described in previous studies (Ferizi et al., 2014, 2013). These models consist of: 1) either a Bingham distribution of sticks or a Cylinder for the intracellular compartment; 2) a diffusion tensor for the extracellular compartment; 3) an isotropic CSF compartment. The T_2 relaxation element is fitted beforehand, to the (variable echo time) b=0 measurements. The signal model is:

$$S = \tilde{S_0}\left(f_i \exp\left(-\frac{TE}{T_2^i}\right)S_i + f_e \exp\left(-\frac{TE}{T_2^e}\right)S_e + f_c \exp\left(-\frac{TE}{T_2^c}\right)S_c\right) \quad (1)$$

where f_i, f_e and f_c are the weights of the intracellular, extracellular, and third normalised compartment signals S_{intra}, S_{extra} and S_c, respectively; the values of compartmental T_2 are indexed similarly; $\tilde{S_0}$ is the proton density signal (which is TE-independent, and obtained from fitting to the b = 0 signal). These models, as shown in the figure below, emerged from previous studies (see references below). Here, however, a single white matter T2 and separate compartmental diffusivities are additionally fitted.

There is a two-stage model fitting procedure. The first step estimates the T2 decay rate of tissue, separately in each voxel, by fitting a bi-exponential model to the b=0 intensity as a function of TE, in which one component is from tissue and the other from CSF. A preliminary analysis of voxels fully inside WM regions shows no significant departure from mono-exponential decay, equal T2 are then assumed within the intra and extracellular compartments. When fitting the bi-exponential model, the value of T2 in CSF is fixed to 1,000ms (a more precise value of CSF is unlikely to be estimated with this protocol). Thus, for each voxel, the volume fraction of CSF, the $\tilde{S_0}$ and the T2 of the tissue are estimated. These three estimates are then fixed for all the subsequent model fits. Then, each model is fitted using the Levenberg-Marquardt algorithm with an offset-Gaussian noise model.

References

Ferizi, U., Schneider, T., Panagiotaki, E., Nedjati-Gilani, G., Zhang, H., Wheeler-Kingshott, C.A., Alexander, D.C., 2014. A ranking of diffusion MRI compartment models with in vivo human brain data. Magnetic Resonance in Medicine 72, 1785–1792.

Ferizi, U., Schneider, T., Tariq, M., Wheeler-Kingshott, C., Zhang, H., Alexander, D., 2013. The importance of being dispersed: A ranking of diffusion MRI models for fibre dispersion using in vivo human brain data, in: Mori, K., Sakuma, I., Sato, Y., Barillot, C., Navab, N. (Eds.), Medical Image Computing and Computer-Assisted Intervention MICCAI 2013. Springer Berlin Heidelberg. volume 8149 of *Lecture Notes in Computer Science*, pp. 74–81.