CMBI - Coursework 1 - Figures

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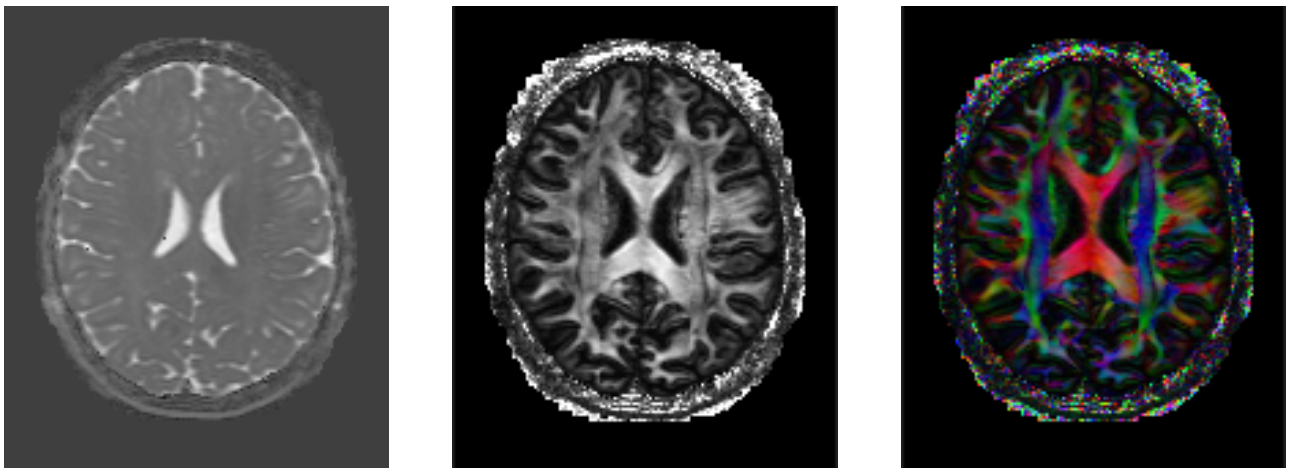
Question 1.1.1



(a) (b) (c)

Figure 1: Image mappings computed using diffusion tensor estimation. (a) Mean diffusivity map (b) Fractional Anisotropy (c) Directionally encoded color map, computed using principal eigenvector of diffusion tensor D, modulated using the fractional anisotropy value.

Question 1.1.2

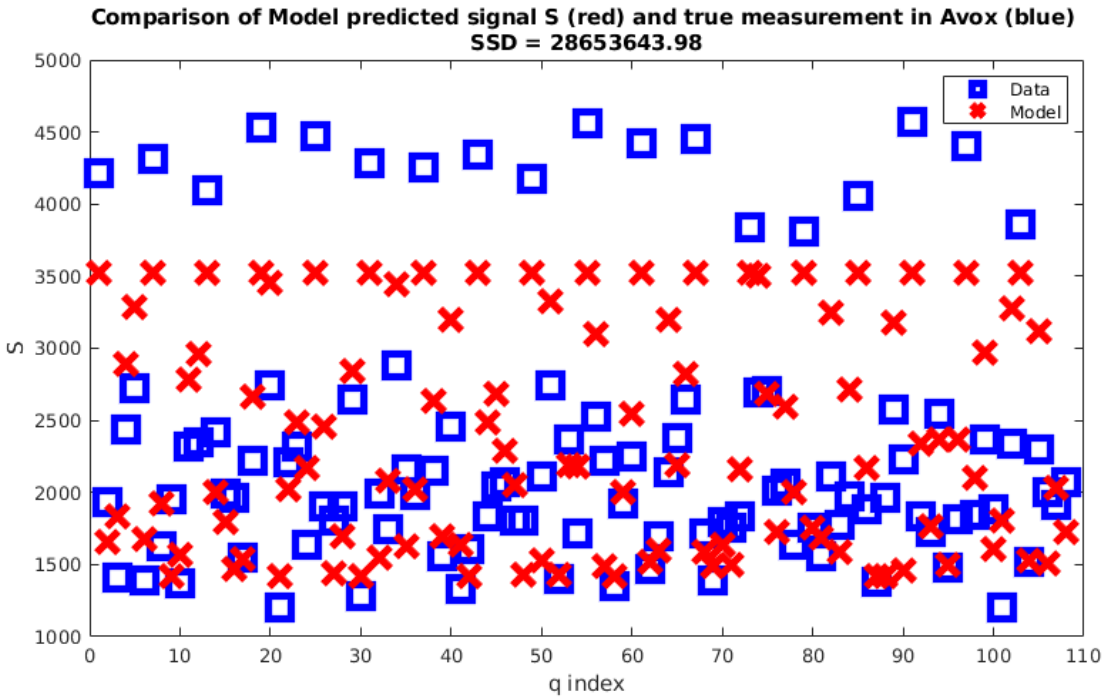


Figure 2: Evaluating quality of the basic ball-and-stick model fitting by comparing the true signal measurements for Avox=dwis(:, 92, 65, 72) with the signals S predicted using the optimal parameters. The fitting is quite poor for the b=0 voxels (blue squares) in the upper half of the image.

Question 1.1.3

Parameter	Constraint	Implementation	Inverse transform
S(0, 0)	> 0	`x(1)^2`	`sqrt(x(1))`
d	> 0	`x(2)^2`	`sqrt(x(2))`
f	[0, 1]	`exp(-x(3)^2)`	`sqrt(-log(x(3)))`

Table 1: Constraints enforced in the transformation method for each parameter. These constraints are implemented in the "BallStickSSD$_transformation.m$" $file.whenoptimizationtheSSDfunctionusingfminunc, thecorrespondinginversetransfo$

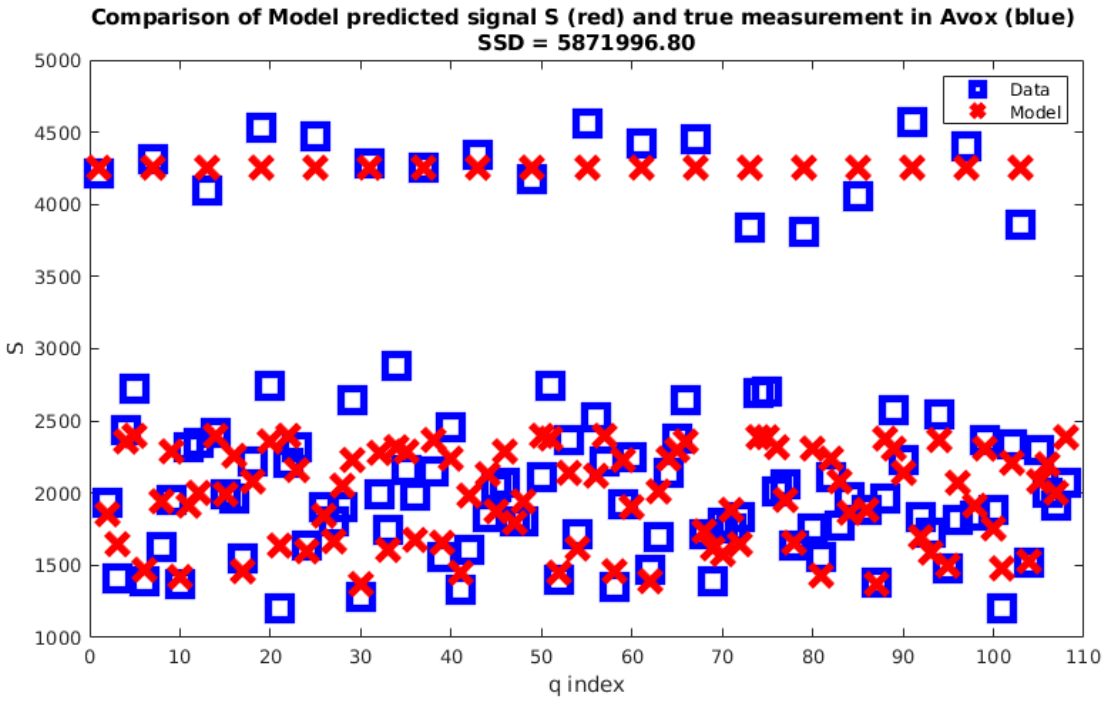


Figure 3: Evaluating quality of the transformed ball-and-stick model fitting by comparing the true signal measurements Avox with the signals S predicted using the optimal parameters for this model. A huge difference in performance is evident as the predictions for the b=0 voxels are very close to the true measurments.

Question 1.1.4

Parameter	STD of Gaussian
S0	1e+03
d	1e-03
f	1e-01
θ	1e-01
ϕ	1e-01

Table 2: STD Values chosen for the Gaussian noise added to each parameter value when performing multiple runs of the Ball-and-Stick model.

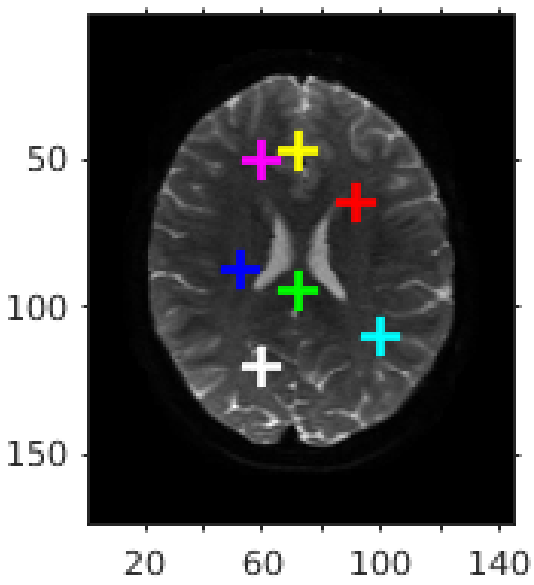
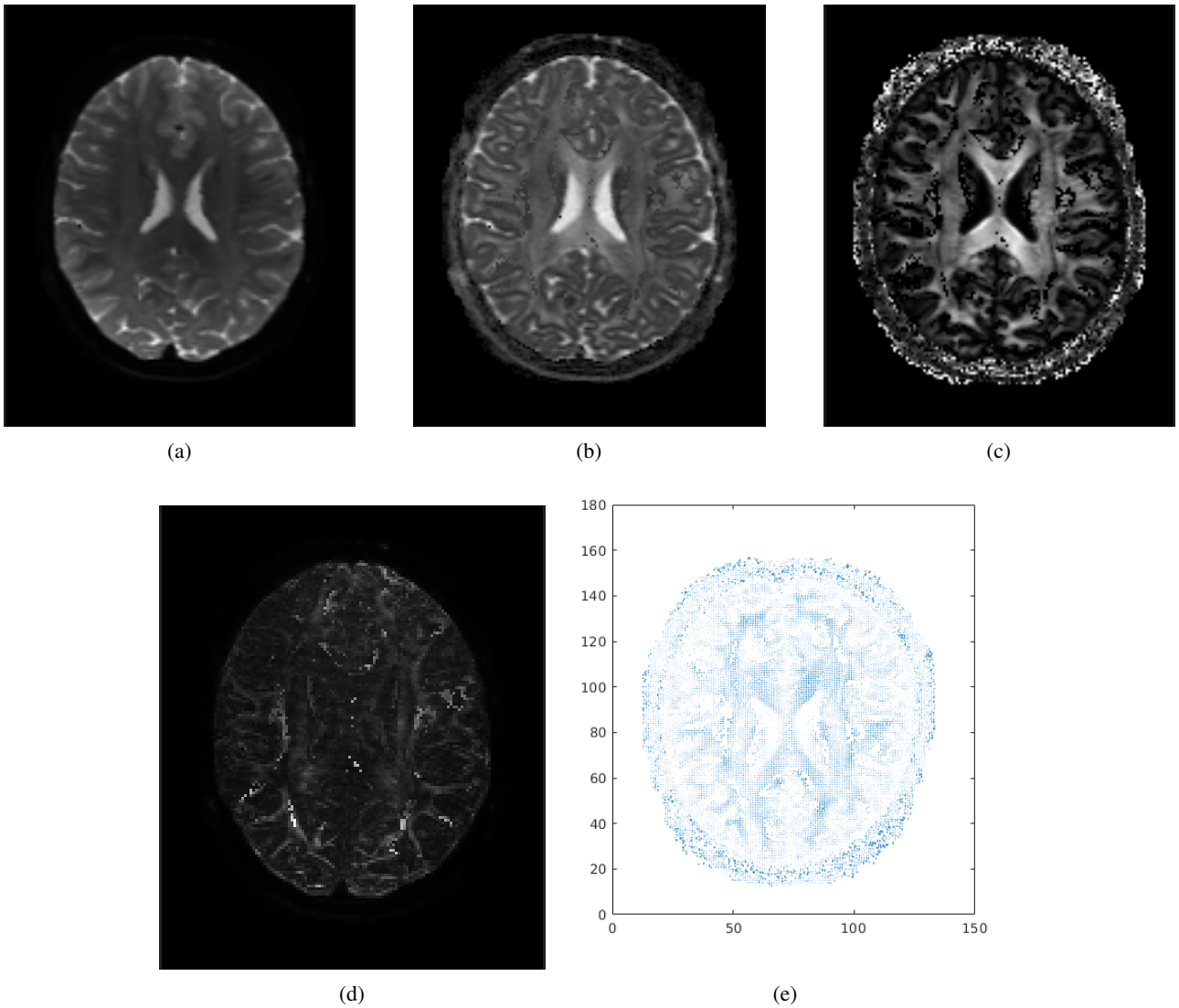


Figure 4: The Locations of voxels that are described in Table 2

Coordinate	Proportion of global minima (in 100 runs)	N (number of runs required)
+	0.96	1
+	0.29	9
+	0.97	1
+	0.32	8
+	1	1
+	0.99	1
+	0.90	1

Table 3: Proportions of global minima and number of runs required to be 95% sure that there is at least 1 global minimum is found within those runs. This is found for different coordinates around the brain slice, for which the location on the brain is color coded using the brain map in Figure 4 as a guide.

Question 1.1.5

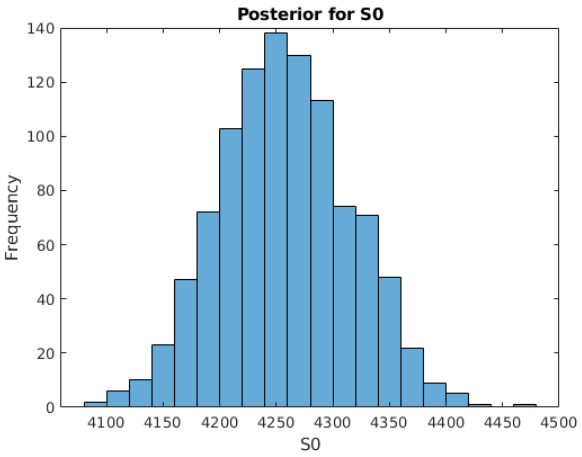


(a) (b) (c)

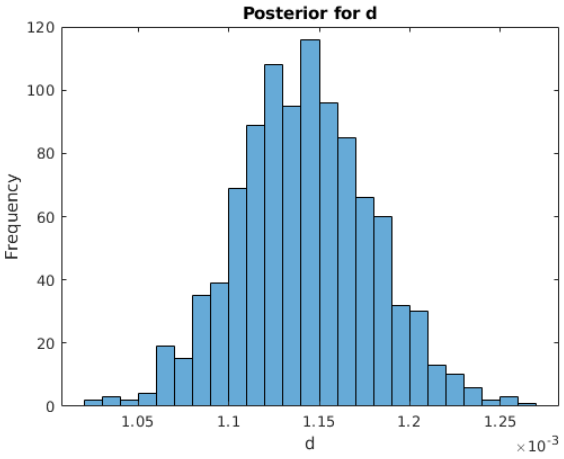
(d) (e)

Figure 5: Parameter maps generated from the transformed ball-and-stick model. (a) S0 Map (b) d Map (c) f Map (d) RESNORM Map (e) Fibre Direction Map computed using θ and ϕ parameters in model.

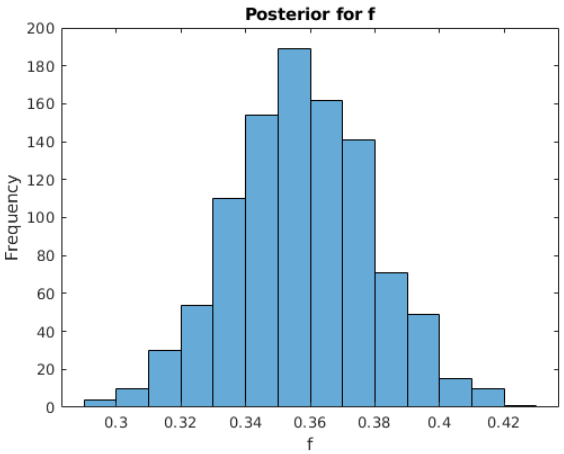
Question 1.2.1



(a)



(b)



(c)

Figure 6: Posterior distributions of the parameters from ball-and-stick model for Avox=dwis(:, 92, 65, 72) (a) S0 posterior (b) d posterior and (c) f posterior. These distributions were determined using 1000 iterations of parametric bootstrapping, where on each iteration, Gaussian noise was added to each signal and optimization was performed to obtain a new parameter sample.

Parameter	2-sigma range	95% range
S(0, 0)	[4.1409e+03, 4.3734e+03]	[4.1453e+03, 4.3700e+03]
d	[1.0670e-03, 1.2169e-03]	[1.0689e-03, 1.2170e-03]
f	[3.1395e-01, 4.0134e-01]	[3.1426e-01, 4.0024e-01]

Table 4: 2-sigma range and 95% range for the parameters S0, d and f.

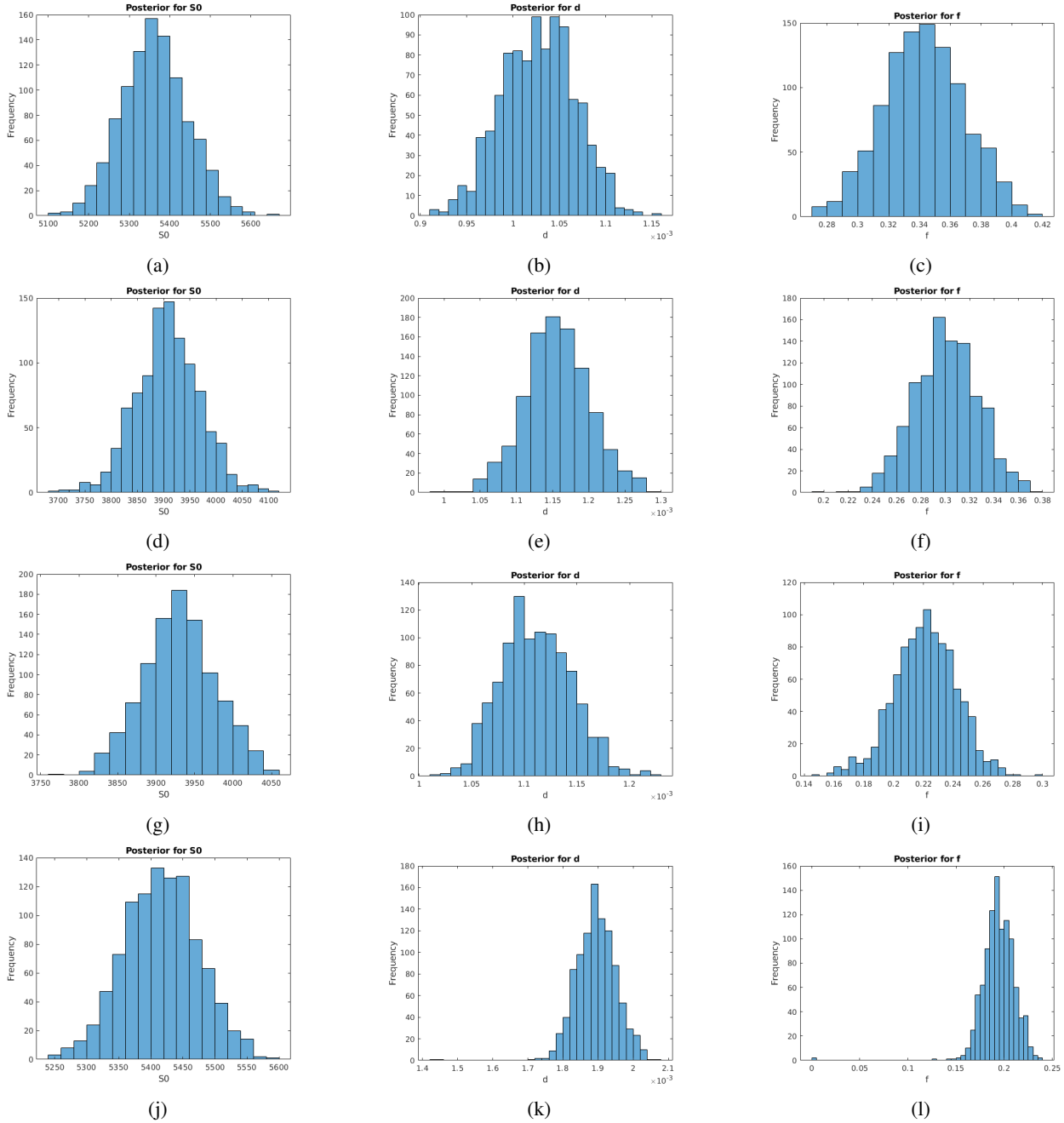


Figure 7: Posterior distributions of the S0, d and f parameters of the Ball-and-Stick model for 4 other voxels. Each row contains the posteriors S0, d and f for the voxels. The voxels positions are in the order dwis(:, 60, 50, 72), dwis(:, 50, 80, 72), dwis(:, 60, 120, 72) and dwis(:, 70, 90, 72).

Parameter	2-sigma range	95% range
S(0, 0)	[5.1995e+03, 5.5239e+03]	[5.2031e+03, 5.5205e+03]
d	[9.4790e-04, 1.1063e-03]	[9.4544e-04, 1.1015e-03]
f	[2.9027e-01, 3.9536e-01]	[2.9423e-01, 3.9424e-01]

Table 5: 2-sigma range and 95% range for the parameters S0, d and f of voxel (:, 60, 50, 72).

Parameter	2-sigma range	95% range
S(0, 0)	[3.7861+03, 4.0298e+03]	[3.7888e+02, 4.0253e+03]
d	[1.0664e-03, 1.2470e-03]	[1.067e-03, 1.2479e-03]
f	[2.4839e-01, 3.5308e-01]	[2.4942e-01, 3.5185e-01]

Table 6: 2-sigma range and 95% range for the parameters S0, d and f of voxel (:, 50, 80, 72).

Parameter	2-sigma range	95% range
S(0, 0)	[3.8373e+02, 4.0235e+03]	[3.8360e+03, 4.0213e+03]
d	[1.0448e-03, 1.1779e-03]	[1.0515e-03, 1.1753e-03]
f	[1.7932e-01, 2.3611e-01]	[1.7493e-01, 2.6044e-01]

Table 7: 2-sigma range and 95% range for the parameters S0, d and f of voxel (:, 60, 120, 72).

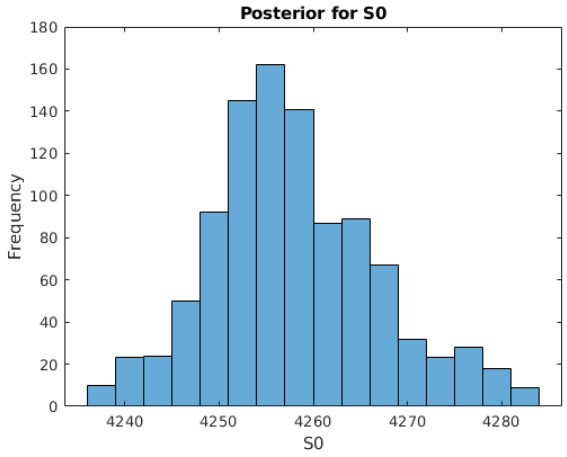
Parameter	2-sigma range	95% range
S(0, 0)	[5.2996e+03, 5.5323e+03]	[5.3002e+03, 5.5272e+03]
d	[1.7782e-03, 2.0116e-03]	[1.7897e-03, 2.0075e-03]
f	[1.5971e-01, 2.2886e-01]	[1.6574e-01, 2.2356e-01]

Table 8: 2-sigma range and 95% range for the parameters S0, d and f of voxel (:, 70, 90, 72).

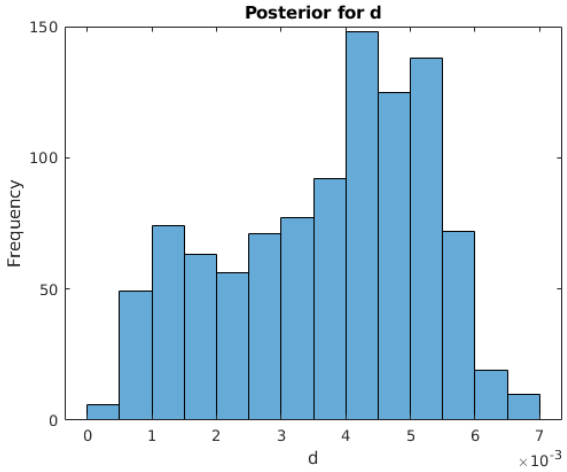
Question 1.2.2

Parameter	Value
Iterations	1000
Burn-in	0
Sampling interval	450
S0 STD	1e-01
d STD	1e-05
f STD	5e-04
θ STD	1
ϕ STD	1

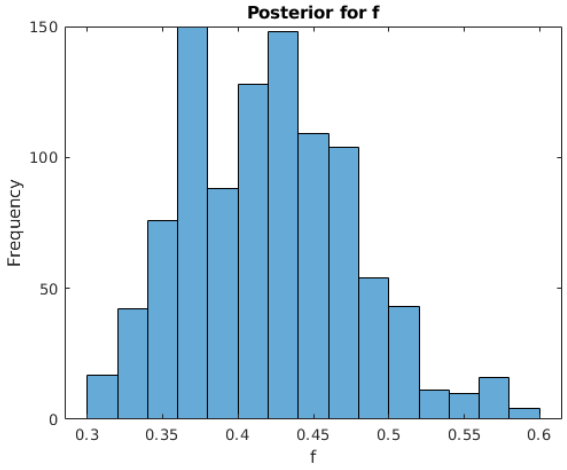
Table 9: MCMC Algorithm parameters. This includes the algorithm-specific parameters including the burn-in, sampling-interval and iterations, and the size of the perturbations to add to the parameters, defined by the STD of the Gaussians noise.



(a)



(b)



(c)

Figure 8: Posterior distributions for the Ball-and-stick model parameters (a) S0 posterior (b) d posterior and (c) f posterior. Samples where obtained using using MCMC performed on Avox=dwis(:, 92, 65, 72).

Parameter	2-sigma range	95% range
S(0, 0)	[4.2401e+03, 4.2758e+03]	[4.2408e+03, 4.2783e+03]
d	[5.9527e-04, 6.8067e-03]	[8.2042e-04, 6.0512e-03]
f	[3.0893e-01, 5.3326e-01]	[3.2618e-01, 5.5440e-01]

Table 10: 2-sigma range and 95% range for the parameters S0, d and f of voxel (:, 92, 65, 72).