MRI Brain study simulation

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Introduction

✓ Measurement of accuracy of segmentation methods needs an a priori voxel classification.

✓ A phantom simulating tissue morphology, topology, texture and MRI characteristics is mandatory.

✓ Currently, physical phantoms do not meet these requirements.
Current digital phantoms do not include inhomogeneity of tissues.

Our aim was the implementation of a software tool allowing the simulation of MRI brain studies to validate segmentation algorithms.
It was obtained from a 150 slices (5 sets, 1mm apart, 3mm thick) spin-echo study (T1w + PD-T2w) on a NV.

After registration, reslicing at 1mm and averaging, a volume of low noise isotropic data was obtained.

R1 and R2 relaxation rates and proton density 3D maps were derived.

A multi-parametric segmentation was applied and interactively refined according to the topology model.
The Model

Tissue model

$R_1$ model
Mean tissue rates calculation

Rate maps calculation

Acquisition simulation

Model (maps and compartments)

Segmentation and mean signal values calculation

B0, Mean signal values for each known tissue, TR, TE, Flip angle, Inversion angle, Noise on air, slice thickness, Z inhomogeneity, K-space filter, K-space lines, K-space quantization.

Manual input

Phantom

AND / OR

Target study
Results

MS patient
1 T
CSE TR/TE 2200/90

NV
1.5 T
CSE TR/TE
1867/90
Results

MS patient
1 T
CSE TR/TE 640/30

NV
1.5 T
CSE TR/TE 510/15
Results

Target study

BrainWeb

Our digital phantom
Conclusions

✓ A software procedure to generate digital brain phantoms from real acquisitions or user defined parameters has been developed.

✓ Phantoms are composed by 17 compartments representing normal tissues and an other optional compartment modelling MS white matter lesions.

✓ The procedure has been extended to gradient-echo sequences allowing validation and comparison among most segmentation algorithms.

✓ Phantoms are available at the web site: http://lab.ibb.cnr.it