BrainWeb:
Online Interface to a 3D MRI Simulated Brain Database[†]

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Introduction

The increased importance of automated computer techniques for anatomical brain mapping from MR images and quantitative brain image analysis methods leads to an increased need for validation and evaluation of the effect of image acquisition parameters on performance of these procedures. Validation of analysis techniques of in-vivo acquired images is complicated due to the lack of reference data ("ground truth"). Also, optimal selection of the MR imaging parameters is difficult due to the large parameter space. BrainWeb makes available to the neuroimaging community, on-line on WWW, a set of realistic simulated brain MR image volumes (Simulated Brain Database, SBD) that allows the above issues to be examined in a controlled, systematic way.

Features

The SBD was generated by varying specific imaging parameters in an MRI simulator, which starts from a digital phantom, and performs a realistic, first-principles modeling of the imaging process based on the Bloch equations [1]. The range of parameters was chosen according to the values typically encountered in modern MRI systems [2]. As an example of the generality of this approach, MS lesions (extracted from real MRI-s) were added to the normal brain phantom and the generation process was repeated. For each anatomical model (phantom), three imaging sequences are available online (T_1, T_2, PD), each with a fixed set of parameters: typical values of slice thickness, noise and intensity non-uniformity (INU) levels. All 3D image volumes are in stereotaxic space, and can be interactively explored online in 3 simultaneous orthogonal views. In addition, BrainWeb allows a remote user to run their own MRI simulation through the WWW interface. Each simulated brain image, as well as the source digital phantoms, can be downloaded in a variety of file and data compression formats.

Applications

SBD can be used to study the performance of anatomical brain mapping techniques, such as: non-linear co-registration [3], cortical surface extraction, or tissue classification algorithms [2]. Also, it can help the validation of quantitative analyses of neuropathology (e.g. MS lesion quantification), or of other medical pattern recognition and image processing techniques. The main advantages of using this database are: (i) the answer is known a priori in the experiment, and (ii) imaging parameters can be independently controlled (see Fig. 1). Since the source for all simulations is the same digital phantom, one has a systematic means of establishing the sensitivity of any particular procedure with respect to any imaging parameter or artifact.
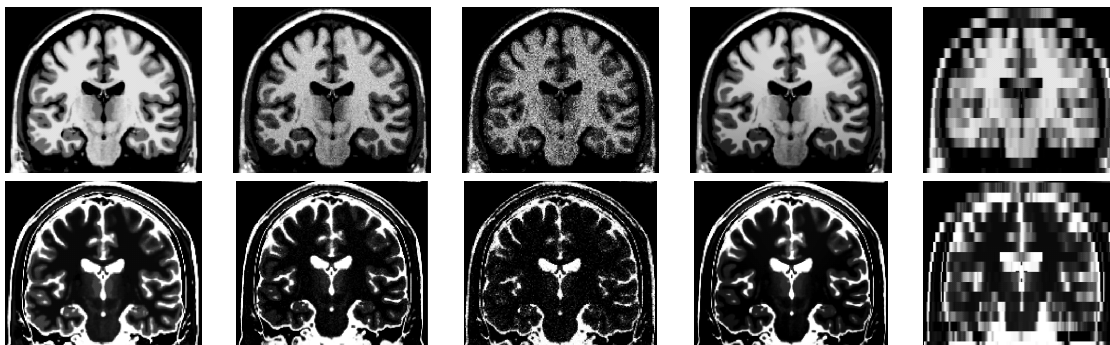

Figure 1: T_1(top) & T_2 (bottom): (left to right) ideal, typical, large noise, large INU, very thick slice

Conclusions

BrainWeb, containing the full SBD as well as the anatomical model (phantom) used as input to the MR simulator, are available on WWW at "`http://www.bic.mni.mcgill.ca/brainweb/`". We are currently working on extending SBD to include fMRI and PET simulated data.

References

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[3] Collins, D.L., Holmes, C.J., Peters, T.M., Evans, A.C. *Human Brain Mapping*. 3(3):190–208, 1996.