Expanded Design of Web-Distributed Software fMRI Phantoms

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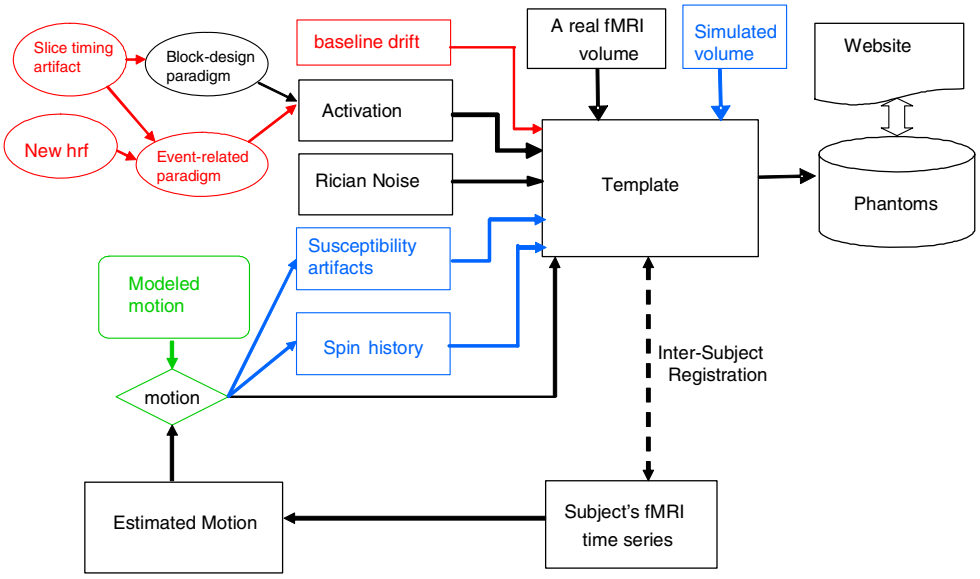
Introduction: Computer-generated phantoms can provide a way of evaluating new processing algorithms for functional magnetic resonance (fMRI) data analysis, provide test sets for teaching personnel how to use unfamiliar FMRI software processing systems, and enable experimenters to simulate the results of a possible FMRI study without having to take up valuable magnetic resonance imager time. We have reported on a methodology for constructing phantoms that are able to simulate some of the characteristics of real fMRI experiments [1]. These phantoms are pre-constructed and are available via a web-site for those who would like to use them [2]. Our goal in this ongoing work is the establishment of a fully interactive web site that permits the user to build a phantom that meets his/her needs, incorporating a greatly expanded set of simulation capabilities for evaluating increasingly more sophisticated fMRI image processing software.



Methods: We have taken the design reported last year [2] and refined it by adding additional capabilities to the phantom generation process. Our currently available phantoms are able to simulate a range of real subject motion characteristics, different signal-to-noise ratios, and different activation levels. Since there are many more effects from the data collection process that need to be included in any simulated study, we have expanded the design to include the capabilities to specify slice timing artifacts, differences in hemodynamic response functions, baseline drifts, and spin history effects. In addition, by using a unique MR simulator [3] we are able to model motion-induced susceptibility artifacts that can be incorporated into the phantom as well. Furthermore, we have developed a technique to parametrically model motion that greatly expands our capability to simulate a wide variety of motion effects beyond the original classes in our earlier configurations. Our design permits the user to specify phantoms based on real subject data or phantoms derived from highly accurate simulated data. The diagram to the left shows the capabilities that we have designed into the phantom. Those boxes in black are the original configuration, while the colored boxes represent the added capabilities. A revised web-based distribution site is under development that will add each of these characteristics as they are incorporated into the phantom construction process. When a requestor selects a custom phantom, the web site will gather the information and pass it to a semi-automated construction process that will result in the selected phantoms. These will be placed into a secure area on the server where the requestor can retrieve them using password access. The phantom sets will also be incorporated into a database for future download, if requested.

Results: The current version of the web site (www.vuiis.vanderbilt.edu/fmriphantoms) provides a set of 40 different pre-built phantoms with different levels of activation that are available for immediate download. The expanded website, when complete, will incorporate the more interactive design that permits the user to select either customized phantoms or one of the pre-computed data sets. The picture at the left is of the screen that will be used in the selection of the pre-constructed phantoms. This is one of two paths that a user can take through the web site. The other path will produce the customized phantoms according the requirements of the user as the characteristics illustrated in the diagram are added. The process of generating the phantoms is based on the originally reported framework that exhibits the flexibility to include additional simulations as required. Likewise the web site is being constructed with web portal software that provides the framework for our distribution system.

Conclusions: We have taken a methodology for producing phantoms for testing fMRI image processing software and have incorporated it into a new design that will permit us to produce greatly expanded software phantoms. The capabilities of these phantoms will permit users to evaluate more elaborate processing algorithms that the current versions of the phantom cannot study. Moreover, the expanded design for producing new phantoms will be accessed through a redesigned and expanded web site that offers the potential user of these phantoms an easy way to specify exactly the characteristics needed for a particular application.

References: [1] Pickens DR, Li Y, Morgan VL, Dawant BM. 2005. *Mag Res Imaging* 23:653-663. [2] Li Y, Morgan VL, Dawant B, Pickens DR. Presented at the ISMRM Annual Meeting, Miami, May 7-13, 2005. Poster presentation. [3] Yoder DA, Zhao Y,Paschal CY, Fitzpatrick JM. 2004. *Mag Res Imaging*, 22, 315-328.

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