QIBA Newsletter

March 2011 • Volume 3, Number 1

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IN MY OPINION

Industry Needs a More Quantitative Approach to fMRI

By CATHY ELSINGER, PhD

Recent advances in functional neuroimaging techniques have revolutionized the approach to surgical planning. Blood oxygen level dependent (BOLD) functional MRI (fMRI) is a noninvasive imaging tool with enormous potential in the field of brain mapping, combining high-resolution anatomical images and physiological information. Functional imaging data provides critical information to the neurosurgeon in terms of deciding which therapy to employ and in considering therapeutic approaches that might otherwise be dismissed due to perceived procedural risk. Adopting fMRI technology for clinical brain mapping has increased not only due to improved outcomes but also in part to the introduction of Current Procedural Terminology (CPT) codes which provide a mechanism for insurance reimbursement.

During the early years of BOLD imaging, software for stimulus delivery and analysis of BOLD imaging data was developed by researchers and available as freeware.

Peripheral equipment for stimulus presentation, response collection, synchronization of stimulus delivery and image acquisition were not provided by the MR vendor, but were available through third-party vendors or developed in-house. Multidisciplinary teams of researchers (biophysicists, neuropsychologists, statisticians, etc.) were required to integrate and implement solutions, resulting in significant variability in methodology and workflow. FDA-cleared, commercially available turnkey fMRI systems that could be implemented by a single radiologist or clinician did not exist. This has now changed.

Barriers to widespread clinical adoption and a more quantitative approach still exist because the model of integration across data acquisition systems, MR platforms and data analysis software solutions remains. The challenge is improving functionality and integration capabilities where there is variability in methodologies and protocols employed across vendors and sites. Advancing the field of fMRI requires that those of us in industry be willing to address improvements in functionality to satisfy the growing need for a quantitative approach, to better meet the needs of the end user. To remain compatible with the installed base of equipment and multiple vendors providing alternative component solutions, industry must invest what resources we can in support of the groundwork required to reach this goal.

QIBA's mission is to improve the value and practicality of quantitative imaging biomarkers by reducing variability across devices, patients and time. QIBA's fMRI Technical Committee is tasked with developing best practices guidelines for implementing and optimizing fMRI protocols and associated outcomes measures and defining quantitative outcome measures for each specific use-case. We see our current groundwork requirements as threefold: describe the biomarker and establish performance expectations in terms of readout measures; understand what is achievable in terms of accuracy, reproducibility, sensitivity and specificity; and describe the system (required infrastructure, quality control measures, etc.), required to transition the biomarker into practice, as well as provide guidance to clinicians, industry and standards group regarding implementation and test guidelines. We ultimately envision a need to establish recommendations within the DICOM standard for full realization of this goal.

Industry is in the unique position to greatly influence this effort if we maintain dedication to the ultimate goals and are willing to invest available resources in support of QIBA's ongoing efforts.

Cathy Elsinger, PhD, is Chief Scientific Officer at NordicNeuroLab AS, an adjunct instructor in the Department of Neurology at the Medical College of Wisconsin and a co-chair of the QIBA fMRI Technical Committee. With a background in cognitive neuroscience and psychobiology, Dr. Elsinger has executed experimental design for functional imaging studies of neurological disorders with special interest in assessing disease state, therapeutic response and monitoring recovery in movement disorders, traumatic brain injury and stroke.

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ANALYSIS TOOLS & TECHNIQUES

The Need for Open Imaging Archives: How Open Imaging Archives Benefit Algorithm Development

By RICARDO S. AVILA, MS

Over the last decade, numerous quantitative imaging biomarker conferences and workshops have made recommendations to increase the number, size, and quality of open image archives. This highly consistent call for action is motivated by the many benefits likely to be achieved if access to high-quality imaging data was much less of a barrier to imaging biomarker development. While the benefits of open image archives are often difficult to objectively measure, it is nevertheless worthwhile to briefly review them so as to help clarify the importance of the recommendations.

We will do so here in the context of early algorithm development, where the open availability of data can have a profound impact on scientific progress.

It is important to recognize that benefits can be obtained from open archives of all sizes. While clear goals, large collections, and high quality datasets are hallmarks of successful image archives, smaller data contributions with little or no metadata can still impart a great deal of benefit to many algorithm researchers and developers. For example, a collection of CT lung datasets without further information on the location of abnormalities or conditions can be helpful to many algorithm developers. The development of a lung segmentation algorithm, often a necessary and critical component of a computer-aided detection or diagnosis algorithm, must support a wide range of patient lung presentations. The availability of additional public datasets helps provide researchers with needed resources.

To better understand the critical need for even modestly sized datasets, it is instructive to examine research into algorithms for MR imaging bias field correction, an important processing component of many potential quantitative imaging biomarker algorithms. A 2007 review article summarizing the state of the field using 60 bias field correction algorithm publications over a 20-year period found that the median number of datasets used for the evaluation of algorithms, per publication, increased from less than 5 to approximately 10 datasets, with the growth owing largely to the open availability of simulated datasets[1]. Of additional concern was that only 10% of publications used 5 or more real patient datasets for the latter decade studied. As more open MR imaging archives become available and are embraced by researchers, we hope to see further improvements in these numbers and a corresponding rise in the collective statistical significance of findings in the field.

Open Image Archives Accelerate Innovation, Build Consensus
Another benefit associated with open image archives is the acceleration of innovation when more researchers are allowed to investigate and undertake a project in a research area. When an open image archive is made publicly available, researchers around the world are able to instantly access this information and explore algorithmic ideas as well as reproduce published observations and findings. This can help increase the number of researchers performing investigations as well as shorten the time for research groups to commence a research project. Related to this is the fact that

commonly available datasets can help build scientific consensus on the performance of different classes of algorithmic methods. This has been successfully employed in evaluating image registration algorithms by the RIRE project for over a decade [2] [3]. There is also benefit to enabling scientists and engineers from other fields to investigate a research area. Given that the study of quantitative imaging biomarkers is increasingly relying on cross-disciplinary knowledge, this is also a potentially large benefit.

Some of the greatest benefits of open image archives can be obtained when a research community fully supports and embraces the effort and builds data resources that not even the largest institutions or groups could possibly attain on their own. For over a decade, the scientific communities supporting the Protein Data Bank (PDB) [4] and GenBank [5] initiatives have required the submission of supporting data to an open repository as a requirement for publication. As a result, each of these repositories has experienced decades-long periods of exponential data growth, with GenBank currently doubling in size every 18 months. This now vast scientific resource is being utilized for a wide range of research projects that would have not otherwise been possible. If the medical imaging community was to adopt a similar approach, routinely publishing the wide diversity of patient presentations with structural, functional, and molecular imaging, we would be able to contemplate a new set of population-based investigations and algorithms, particularly if we were to establish links to the open and now fairly mature genetic and macromolecule databases.

These are some of the more important benefits associated with the expanded adoption and support of open image archives. As a research community, we must work to increase the number, size, and quality of open image archives for the development and evaluation of imaging biomarker algorithms.

References:
[1] RA Review of Methods for Correction of Intensity Inhomogeneity in MRI. *IEEE Transactions on Medical Imaging,* March 2007; 26(3):405â€"421.Vovk, U., et al.
[2] Comparison and Evaluation of Retrospective Intermodality Brain Image Registration Techniques. *Journal of Computer Assisted Tomography*, 1997; Vol. 21, No. 4, 554-566. West, J., et al.
[3] www.insight-journal.org/rire
[4] The Protein Data Bank: A Historical Perspective. *Acta Cryst.*, 2008; A64, 88-95. Berman, H.M.
[5] www.ncbi.nlm.nih.gov/genbank

Ricardo S. Avila, MS, is the senior director of Healthcare Solutions at Kitware Inc., and co-chair of RSNA's Imaging Biomarker Roundtable Ad Hoc Committee on Open Image Archives. He has been leading the development of quantitative imaging biomarkers and computer-aided diagnosis algorithms for nearly two decades with a particular emphasis on the development of algorithms for the quantitative measurement of lung lesions with high-resolution CT.

QIBA Steering Committee Discusses Funding

The QIBA Steering Committee met in January in
Washington, D.C., to work toward finalizing
decisions on the first round of project funding. As a
result, it is anticipated that approximately $600,000
will be awarded to fund projects closely aligned with
QIBA goals, almost equally distributed across
volumetric CT, DCE-MR and FDG-PET modalities.

SAVE THE DATE
QIBA Fourth Annual Meeting

May 24-25, 2011
Renaissance Arlington Capital View Hotel, Arlington, Va.

The Quantitative Imaging Biomarkers Alliance (QIBA) was established late in 2007 with
representatives from pharmaceutical companies, imaging equipment manufacturers,
imaging informatics companies, government agencies, imaging societies, RSNA
leadership and clinical trialists. Since then, QIBA working meetings have been held
each year in May.

Efforts are under way to improve the accuracy and reproducibility of quantitative
imaging biomarkers. Through the work of its five Technical Committees, QIBA is
engaged in understanding and reducing measurement variability across imaging
devices, patients and time.

The ongoing work of the Technical Committees is posted on the QIBA wiki.

Additional details about QIBA's 4th Annual Meeting will be posted as they become
available at www.rsna.org/QIBA.

New participants in QIBA Technical Committees are always welcome; please contact
QIBA@rsna.org for more information.

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QI/IMAGING BIOMARKERS IN THE LITERATURE

PubMed Search on the Importance of a Quantitative Approach to fMRI

The December 2010 issue of QIBA Quarterly contains a related article, "The Challenges of Making fMRI Reproducible," by James Voyvodic, PhD. To view the article, please click here.

Each issue of QIBA Quarterly will feature a link to a dynamic search in PubMed, the National Library of Medicine's interface to its MEDLINE database. Click here to view a PubMed search on the Importance of a Quantitative Approach to fMRI in radiology.

Take advantage of the My NCBI feature of PubMed that allows you to save searches and results and includes an option to automatically update and e-mail search results from your saved searches. My NCBI includes additional features for highlighting search terms, storing an e-mail address, filtering search results and setting LinkOut, document delivery service and outside tool preferences.

QIBA in the Literature
Two QIBA-related articles by Andrew J. Buckler, M.S., and colleagues have been accepted for publication by *Radiology*:

- A Collaborative Enterprise for Multi-Stakeholder Participation in the Advancement of Quantitative Imaging," appears in the March issue. (MS 10-0799)
- "Quantitative Imaging Test Approval and Biomarker Qualification: Inter-related but Distinct Activities," is scheduled to appear in the May issue. (MS 10-0800)

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