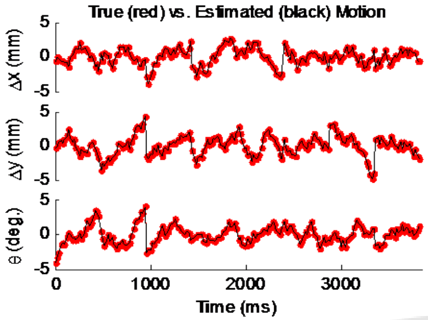
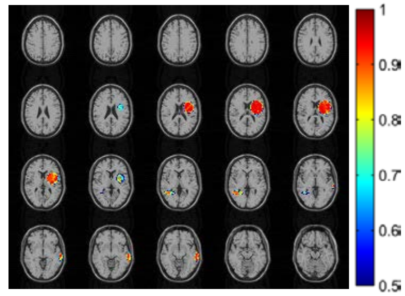
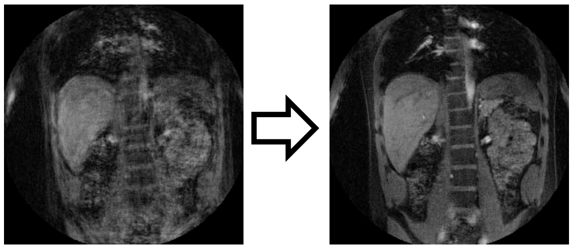
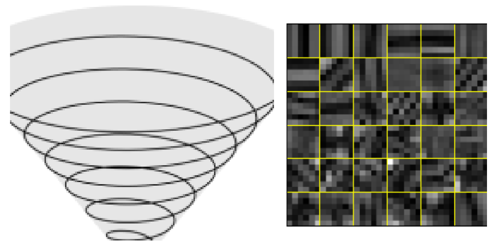
Virginia Imaging Theory and Algorithms Laboratory



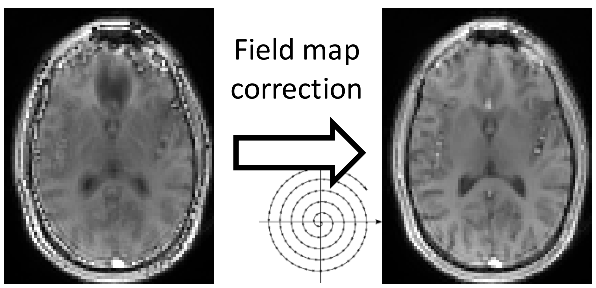


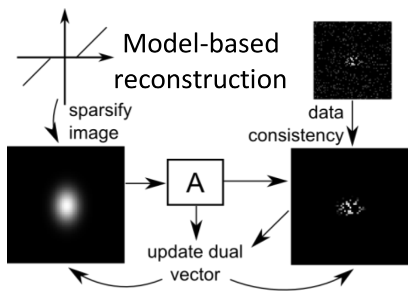


Body magnetic resonance imaging with motion correction



Reconstruction for fast magnetic resonance imaging





New signal processing theory, models, and algorithms are needed to address growing demand for new scientific and biomedical imaging capabilities that exceed physical limits due to wavelength or acquisition speed. Doctors will be able to study and diagnose diseases in living subjects at greater levels of detail, revealing new insights and improving accuracy. Microscopes will be able to locate and track molecules and cells in three dimensions with unprecedented precision. Our research focuses on driving the field forward by constructing image and measurement models and combining these models with new, computationally efficient reconstruction algorithms suitable for practical use.

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“Reconstructing high quality images using models and algorithms.”

University of Virginia Engineering

Automatic Image Quality Comparison for Image Processing

While humans are generally capable of assessing the quality (e.g., noise level, sharpness) of a series of images, perceptual valuations of image quality remain challenging for a computer, especially without access to a "perfect" reference image. This research has produced an innovative approach for automatically comparing two or more images of the same object to determine which has the better quality, distinguishing noise and blur from salient image content. This approach results in improved image reconstructions and other forms of processing, like denoising, by enabling algorithms to be tuned or adjusted to produce the best possible quality image according to the automatic metric. We are investigating new approaches for improving image models and algorithms like dictionary-learning using this framework. We are also extending the framework to automatically identify artifacts introduced by typical image acquisition and reconstruction schemes in magnetic resonance imaging and other domains.

Motion-Robust, Rapid Magnetic Resonance Imaging

More powerful magnets, parallel imaging coils, and fast imaging protocols have made acquiring time-series of magnetic resonance images viable for the study of physiology in the brain, heart, liver, kidneys, and other organs, advancing both scientific research, and medical diagnostics and treatment. Coupling these exciting acquisition technologies with novel model-based reconstruction algorithms promises to increase spatial and temporal resolution, mitigate the presence of acquisition-related artifacts, and make imaging more comfortable for research subjects and patients. With greater resolution, such imaging can better localize activity in the multiple layers of the brain. Similarly, motion-robust, high-resolution cardiac imaging will enable detailed assessment of cardiac function while no longer requiring patients to hold their breath during scans. Dynamic imaging is also valuable for following progression of liver cancer and assessing kidney function. In all these cases, our lab is applying new model-based reconstructions featuring models for motion, structure, and dynamic variations. Future work on data-adaptive models, optimization techniques, and image quality metrics will continue to push the state-of-the-art. Working closely with clinicians in the University of Virginia Health System, these algorithms will be evaluated and applied in real clinical imaging applications, enabling our research to have significant immediate impact.

RECENT RESEARCH DEVELOPMENTS

- A new perceptual image quality comparison framework enables more robust image reconstruction and processing algorithms, automatically.
- Rapid, motion-robust acquisition and reconstruction strategies aim to transform the use of magnetic resonance imaging in young children, in heart patients, and in subjects for brain research.

RECENT GRANTS

- NIH Ruth L. Kirschstein National Research Service Award Postdoctoral Fellowship -- Adaptive Techniques for Robust High-Resolution Functional Magnetic Resonance Imaging (2012-2014)

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