Generalized Magnetic Resonance Image Reconstruction using
The Berkeley Advanced Reconstruction Toolbox
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Target Audience: Image reconstruction researchers and developers

Introduction: There is a strong need for tools to flexibly compare, prototype, and deploy new MRI reconstruction algorithms. We present the Berkeley Advanced Reconstruction Toolbox (BART) 1,2, a framework for iterative image reconstruction which aims to address these needs. BART is a programming library and collection of command-line tools to simulate, analyze, and perform MR image reconstruction. Table 1 lists BART availability and resources. The library provides generic implementations of several iterative optimization algorithms and supports parallel computation using multiple CPUs and GPUs. The command-line tools provide direct access to a wide range of functionality from basic operations to complete implementations of advanced calibration and reconstruction algorithms. A tool is included to perform generalized Parallel Imaging and Compressed Sensing (PICS) 3 for arbitrary sampling trajectories and regularization.

Functionality: The use of BART is twofold: firstly, to rapidly test and prototype advanced algorithms; and secondly, to integrate these algorithms into the data acquisition and reconstruction pipeline. The programming library provides interfaces for operations on multi-dimensional arrays (e.g. to access slices of an array or to apply a transformation along an arbitrary subset of the dimensions) as well as initial support for common file types (e.g. Siemens data, ISMRMRD, DICOM). The command-line tools operate on memory-mapped input and output using a simple data format. Interoperability with Python and Matlab (Mathworks, Natick, NA) is included, as well as third-party integration with GPI Lab 4 (gpilab.com).

Demonstration: As a proof of concept, we show in Figure 1 a Bash script that was used to reconstruct a Dynamic Contrast Enhanced (DCE) MRI data. Using BART, we coil-compressed the data, estimated ESPIRiT maps 5, and applied a parallel imaging and compressed sensing reconstruction 5. The reconstructed output was then converted to DICOM. Figure 2a shows a reformatted reconstruction from the DCE data using the PICS tool with locally low rank 6 (LLR) regularization. Figure 2b shows a GRASP 7 reconstruction of radially under-sampled data using the PICS tool.

Summary: We present BART, a toolbox for image reconstruction which includes many advanced algorithms and is freely available to the MRI community. State-of-the-art reconstruction methods can be developed using BART and integrated into a clinical reconstruction environment.

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