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fastMRI Breast: A publicly available radial k-space dataset of breast dynamic contrast-enhanced MRI

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Synopsis

Keywords: Machine Learning/Artificial Intelligence, Cancer

Motivation: There is a lack of publicly available k-space data of breast dynamic contrast-enhanced (DCE) MRI that can be used for development of image reconstruction and machine learning methods for breast MRI.

Goal(s): We aim to make a publicly available radial k-space dataset of breast DCE-MRI which will promote development of fast and quantitative breast imaging methods.

Approach: Data of women undergoing routine diagnostic breast DCE-MRI exams have been acquired using a stack-of-stars radial imaging at 3T.

Results: Our fastMRI breast dataset includes radial k-space data and case-level labels for 275 cases (70 malignant, 158 benign and 47 no-lesion cases).

Impact: This work introduces the first large-scale dataset of radial k-space data for breast DCE-MRI acquired in diagnostic breast MRI exams. Having this dataset and accompanying reconstruction code publicly available, will support research and development of fast and quantitative breast DCE-MRI.

Introduction

Recently, a number of publicly available MRI datasets have been released, such as RNet (1), HCP (2), and ADNI (3). However, these datasets are limited to reconstructed images and do not include raw k-space data. Due to the limited availability of k-space datasets, the fastMRI initiative has recently been taken to make the raw k-space data of brain, knee (4) and prostate (5) publicly available. The current fastMRI datasets are all cartesian sequences. fastMRI+ (6) also include labels for various pathologies, enabling the development of clinically relevant reconstruction and detection methods. In this abstract, we present a new dataset for breast MRI, particularly with radial k-space data of Dynamic Contrast-Enhanced (DCE)-MRI acquired during diagnostic MRI exams. Breast DCE-MRI is widely used for detecting increased risk screening (7), cancer staging (8), and prognosis with chemotherapy (9,10). However, it presents significant challenges in image reconstruction, given the inherent trade-off between temporal resolution and image quality. To address this challenge, acquisition of radial DCE-MRI with a golden-angle has been proposed combined with compressed sensing and parallel imaging, offering high spatial resolution and flexible temporal resolution, while maintaining comparable diagnostic performance to conventional DCE (11). By making the fastMRI Breast dataset publicly available, we aim to facilitate the development of fast and quantitative breast DCE-MRI methods.

Description of dataset and code

Patient population: The dataset includes raw k-space data for 275 breast cancer patients scheduled for clinical breast MRI. The patients were scanned between Dec-2018 and June-2022. 70 cases were found to have a malignant lesion, 158 benign and 47 cases had no suspicious lesions. The mean age of subjects is 43±11. The data was acquired with approval from the Institutional Review Board.

Breast DCE-MRI study: All subjects underwent a diagnostic breast MRI exam on a whole-body 3T scanner (MAGNETOM TimTrio, Siemens Healthcare, Erlangen, Germany) with a 16-channel breast coil. The DCE-MRI was conducted with a golden-angle radial stack-of-stars 3D gradient echo sequence known has GRASP (Golden-angle RAdial Sparse Parallel imaging) (12). A total of 288 spokes were acquired continuously with 83 partitions for 2.5 min, resulting in 192 slices after partial Fourier (see scan parameters in Table 1). Spectrally selective Adiabatic Inversion Recovery (SPAIR) was used for fat suppression. A GRASP scan of 2.5 min was first acquired before the administration of contrast (Seg 1) and a second scan was acquired during contrast injection (Seg 2). For the second GRASP scan, a single dose of Gadobutrol (Gadavist, Bayer Healthcare Pharmaceuticals) at 0.1 mM/kg body weight was injected at 2 mL/s intravenously at the 1-min mark into the scan. Both scans can be used for image reconstruction or the second one alone as an ultrafast breast MRI scan.

Raw k-space dataset: We provide the raw k-space data for Seg 1 and Seg 2, along with GRASP reconstructions for all 275 cases. Raw data were exported from the scanners, anonymized, and saved into a Hierarchical Data Format (HDF5) file which can be easily manipulated in Python. The corresponding reconstructed images are also included in these files. Our dataset also includes case-level labels describing, for each case, whether it is malignant, benign, or has no lesion. Dataset will be hosted at: https://fastmri.med.nyu.edu/.

Reconstruction code: With this dataset, we provide a GPU-based GRASP reconstruction code implemented in python. The reconstruction code uses SigPy implementations of NUFFT (13), coil sensitivity estimation(14) and iterative reconstruction with temporal total variation (TV) regularization. Radial data can be used to reconstruct dynamic images with a flexible temporal resolution (aka, number of radial views per frame). Representative reconstructed images of malignant, benign and healthy datasets are shown in Fig. 1. In the presence of a cancer lesion, one can appreciate rapid time to enhancement following contrast injection using the provided DCE-MRI data (Fig.2).

Discussion

To our knowledge this is the first large-scale publicly available radial k-space data of breast DCE-MRI from a clinical patient population. While public breast DCE datasets do exist, they are generally focused on testing particular research question such as segmentation and classification (15) or machine learning performance (16). The fastMRI breast data can serve not only for qualitative examination of the post-contrast images, but also for the calculation of quantitative pharmacokinetic kinetic parameters to improve the diagnostic performance of breast DCE-MRI. It can also be used independently as a dataset for reconstruction of static images without contrast change. The availability of this dataset will further promote research of breast DCE image reconstruction and quantification of breast lesions.

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Figures

Table1: Breast data scanning parameters	
Sequence	T1 weighted radial stack-of-stars 3D gradient echo
FOV	320 × 320 × 212 mm^3
Matrix size	320 × 320
Slice Thickness	1.1mm
TR	4.87ms
TE	1.8ms
Number of slices	192
Radial views	288
spatial resolution	1 × 1 × 1.1mm^3

Table 1. Breast data scanning parameters

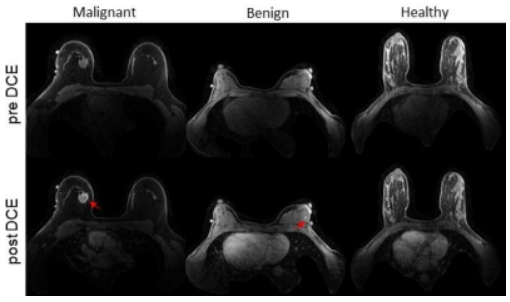

Fig. 1: Reconstruction results of representative malignant, benign and healthy datasets during pre and post contrast injection, with 5.3 Sec temporal frame.

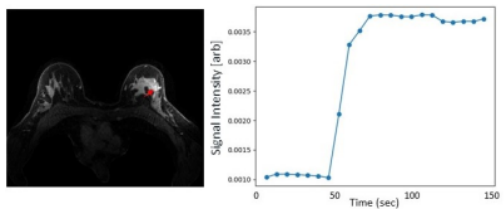

Fig. 2: Signal enhancement of a malignant lesion during injection of contrast material.

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