Title: Supplemental data archive for the Multi-Channel CT Reconstruction (MCR) Toolkit

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Description:

The MCR Toolkit (https://gitlab.oit.duke.edu/dpc18/mcr-toolkit-public) has evolved over nearly a decade, first to address unique challenges associated with *in vivo* preclinical micro-CT, and now to support translation of advances in CT reconstruction between the preclinical and clinical domains. As the name suggests, the Toolkit specializes in solving "multi-channel" reconstruction problems: multi-energy (ME) CT (dual-energy, photon-counting), dynamic time-resolved (TR) CT (cardiac, perfusion), and combined multi-energy and time-resolved (METR) CT. The Toolkit strives to balance the computational demands of multi-channel reconstruction problems against the need for numerically robust denoising and reconstruction operators required to solve real-world problems. This archive contains supplemental data required to run the demos outlined in the “run_demo.m” MATLAB script included in the Toolkit’s root directory.

Files and folders:

1) ./MOBY_Phantom => Files derived from the MOBY digital mouse phantom.

   Segars, W. P., Tsui, B. M., Frey, E. C., Johnson, G. A., & Berr, S. S. (2004). Development of a 4-D digital mouse phantom for molecular imaging research. Molecular Imaging & Biology, 6(3), 149-159.

2) ./Mouse_Cardiac_ApoE_KO_180417_5 => *In vivo*, cardiac micro-CT data acquired with a photon-counting x-ray detector from Dectris, AG (0804 ME prototype).

   Mouse_Cardiac_ApoE_KO: ApoE knockout mouse model, cardiac CT scanning protocol
   Scan date: 180417 => April 17th, 2018
   Scan number on this date: 5

   ApoE knockout mouse model:
   Zhang, S. H., Reddick, R. L., Piedrahita, J. A., & Maeda, N. (1992). Spontaneous hypercholesterolemia and arterial lesions in mice lacking apolipoprotein E. Science, 258(5081), 468-471.

   See scanning protocol details in the following reference:
   Clark, D. P., Holbrook, M., Lee, C. L., & Badea, C. T. (2019). Photon-counting cine-cardiac CT in the mouse. PloS one, 14(9), e0218417. https://doi.org/10.1371/journal.pone.0218417

3) ./MOBY_Phantom/18_04_17_100516.csv, ./Mouse_Cardiac_ApoE_KO_180417_5/18_04_17_100516.csv => Identical physiological monitoring files from a single ApoE knockout mouse micro-CT scan (180417_5).

   Rows: signal readouts.
   Columns (in order from the first to last columns in the data file):
   - Time: signal readout time stamp in seconds
   - Angle: rotator angle in degrees
   - ECG: mouse ECG signal readout (arbitrary units)
   - Respiration: respiratory pillow signal (arbitrary units, respiratory gating not used)
   - Trigger 1: source trigger event (arbitrary units); a projection is subsequently acquired every 10 ms after this trigger event until 9000 projections have been acquired
   - Trigger 2: not used

4) ./Siemens_Flash_DS_DE => Raw projection data (*.nii.gz files) and metadata (*.mat files) after extraction from Siemens' proprietary projection file format. Data files are included for chains "A" and "B", referring to the two source-detector imaging chains of a SOMATOM Definition Flash commercial CT scanner.

5) ./XCAT_Phantom => XCAT phantom projection data produced with the DukeSim CT simulator. Note, several files from this folder are excluded from the archive due to licensing restrictions.

   Dynamic XCAT human phantom (https://cvit.duke.edu/)
   W. Segars, G. Sturgeon, S. Mendonca, J. Grimes, and B. M. Tsui. (2010)
   4D XCAT phantom for multimodality imaging research.
   Medical Physics 37(9), 4902-4915.

   DukeSim CT Simulator (https://cvit.duke.edu/)
   Abadi, E., Harrawood, B., Sharma, S., Kapadia, A., Segars, W. P., & Samei, E. (2018).
   DukeSim: a realistic, rapid, and scanner-specific simulation framework in computed tomography.
   IEEE transactions on medical imaging, 38(6), 1457-1465.

6) MCR_Toolkit_Public_11_28_22.zip => Archival copy of the MCR Toolkit at the time of publication submission (November 28th, 2022) and provided for reference only. The metadata included with this Duke Research Data Repository submission includes reference information for the MCR Toolkit's companion publication. If you intend to use the MCR Toolkit, download the latest version of the Toolkit from the dedicated GitLab repository: https://gitlab.oit.duke.edu/dpc18/mcr-toolkit-public.

   MCR Toolkit license information:

File formats:

*.csv => "comma-separated values" file containing physiological data (e.g. respiration, ECG signal)
*.nii => NIfTI (Neuroimaging Informatics Technology Initiative) file for storing volumetric image data
*.nii.gz => NIfTI file compressed with gzip
*.zip => platform agnostic zip file
*.mat => MATLAB file storing workspace variables
*.txt
*.pdf => PDF/A

Notes on file formats:

Opening the MATLAB *.mat files requires MATLAB version 7.0 of newer. Alternatively, *.mat files can be opened with the SciPy Python library (https://scipy.org/).

NIfTI readers can generally open *.nii.gz files directly. Alternatively, the files can first be unzipped to NIfTI files (*.nii).

In case no compatible reader is available, the NIfTI (*.nii) files of this supplemental data can be read as raw files starting from byte 352 and using the following dimension and precision information (little-endian byte ordering):

./MOBY_Phantom/X_ref2_all_t_all_th.nii: 400x400x160x10x4 voxels, single precision (4 bytes)
./ MOBY_Phantom/Yn_v2.nii: 520x264x9000x4 pixels, single precision (4 bytes)

./Mouse_Cardiac_ApoE_KO_180417_5/ApoE_KO_FBP.nii: 360x360x40x10x4 voxels, single precision (4 bytes)
./Mouse_Cardiac_ApoE_KO_180417_5/I0.nii: 515x257x200x4 pixels, uint16 (2 bytes)
./Mouse_Cardiac_ApoE_KO_180417_5/Y.nii: 515x257x9000x4 pixels, uint16 (2 bytes)

./Siemens_Flash_DS_DE/ChainA_raw.nii: 736x32x11883 pixels, single precision (4 bytes)
./Siemens_Flash_DS_DE/ChainB_raw.nii: 480x32x11883 pixels, single precision (4 bytes)

Keywords:

medical imaging

inverse problems
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multi-energy
reconstruction
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Related publications:

See the metadata included with this Duke Research Data Repository submission for updated reference information on the MCR Toolkit's companion publication**.**

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