

Hands-on with vendor-agnostic MRI data: conversion to MRD (ISMRMRD)

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MRI Together A2 Caribbean - Tuesday 14th December 2021

https://github.com/rajramasawmy/mri_together_mrd

MRI Together

A global workshop on Open Science and Reproducibility
December 2021

Speaker name:

Dr Ahsan Javed, National Heart Lung and Blood Institute, National Institutes of Health, USA.

Conflicts of interest regarding this presentation:

Nothing to disclose

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ESMRMB
European Society for Magnetic Resonance in Medicine and Biology

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Follow along!

https://github.com/rajramasawmy/mri_together_mrd

Contents

- MRD/ISMRMD structure
- MRD viewer
- SIEMENS data conversion
- GE data conversion
- Bruker data conversion
- Python Cartesian reconstruction
- Matlab spiral reconstruction

The screenshot shows a GitHub repository page for 'mri_together_mrd'. The repository is public and has 1 branch and 0 tags. The main branch is 'main'. There are 9 commits from the user 'rajramasawmy' made 6 days ago. The commits are:

- update python for smaller example (9de02c1, 6 days ago)
- added spiral data and matlab example (6 days ago)
- github noob (6 days ago)
- update python for smaller example (6 days ago)
- update python for smaller example (6 days ago)
- update python for smaller example (6 days ago)

The 'README.md' file contains the following text:

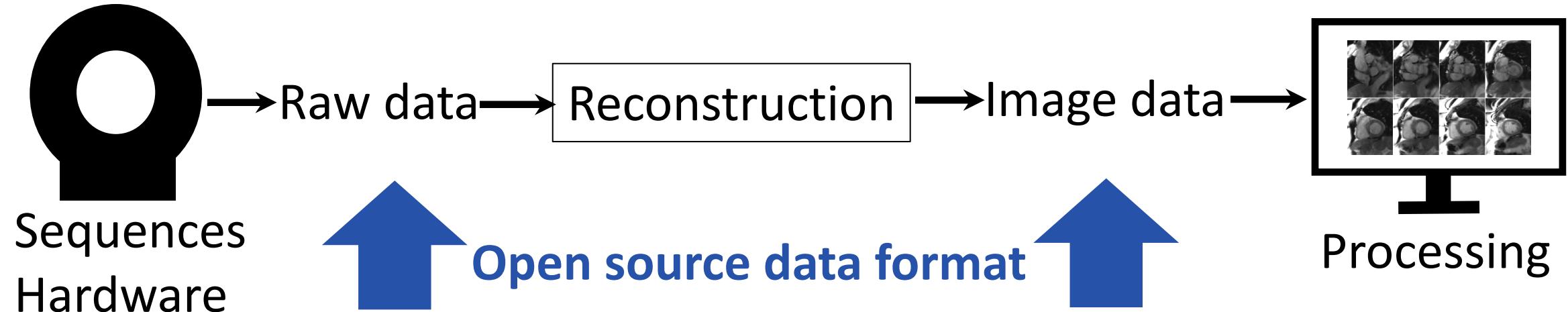
```
mri_together_mrd

MRD data conversion tutorial @ MRI TOGETHER

https://mritogether.github.io/

Raj Ramasawmy @ NHLBI, NIH. Ahsan Javed @ NHLBI, NIH. Adrienne Campbell-Washburn @ NHLBI, NIH.
```

What is vendor-agnostic MRI data?



- Algorithm sharing
- Data repositories
- Reproducible research
- Standardization across research community

Open source raw data options:
.ra <https://github.com/davidssmith/ra>
MRD (gadgetron, fastMRI)
.cfl (BART)
<https://github.com/mrirecon/bart/blob/master/README#L316>

Open image formats: NIFTII, BIDS, DICOM

MRI Raw Data (MRD/ISMRMRD)

MRD (rebranded from “ISMRMRRMRDMRMRDD”)

- Community effort to standardize raw data format
- Hierarchical standard data format HDF5



Full Paper

ISMRM Raw data format: A proposed standard for MRI raw datasets

Souheil J. Inati, Joseph D. Naegle, Nicholas R. Zwart, Vinai Roopchansingh, Martin J. Lizak, David C. Hansen, Chia-Ying Liu, David Atkinson, Peter Kellman, Sebastian Kozerke, Hui Xue, Adrienne E. Campbell-Washburn, Thomas S. Sørensen, Michael S. Hansen✉

Vendor translations in MRD/ISMRMRD

ISMRMRD	Bruker	GE	Philips	Siemens
kspace_encode_step_1	encode step 1	Frame	e1	Line
kspace_encode_step_2	encode step 2	–	e2	Partition
Average	–	–	Measurement	Acquisition
Slice	Slice	Slice	Location	Slice
Contrast	Echo	Echo	Echo	Echo
Phase	–	–	Cardiac phase	Phase
Repetition	Repetition	Repetition	Dynamic scan	Repetition
Set	–	–	Row	Set
Segment	–	–	–	Segment

<https://github.com/ismrmrd>

- Community effort!

[siemens_to_ismrmrd](#)

Siemens ISMRMRD converter

● XSLT 27 11 13 2 Updated 11 days ago

[ismrmrd-python](#)

Python API for the ISMRMRD file format

● Python 13 15 6 0 Updated on May 28

[ismrmrd](#)

ISMRM Raw Data Format

● C++ 60 54 39 2 Updated 24 days ago

[ismrmrd-python-tools](#)

ISMRMRD Python Toolbox

● Python 28 25 6 1 Updated on Apr 22

[ismrmrdviewer](#)

● Python MIT 6 4 2 0 Updated 25 days ago

[ge_to_ismrmrd](#)

GE to ISMRMRD converter

● C++ 6 5 0 0 Updated on Jan 14

[philips_to_ismrmrd](#)

Philips to ISMRMRD converter

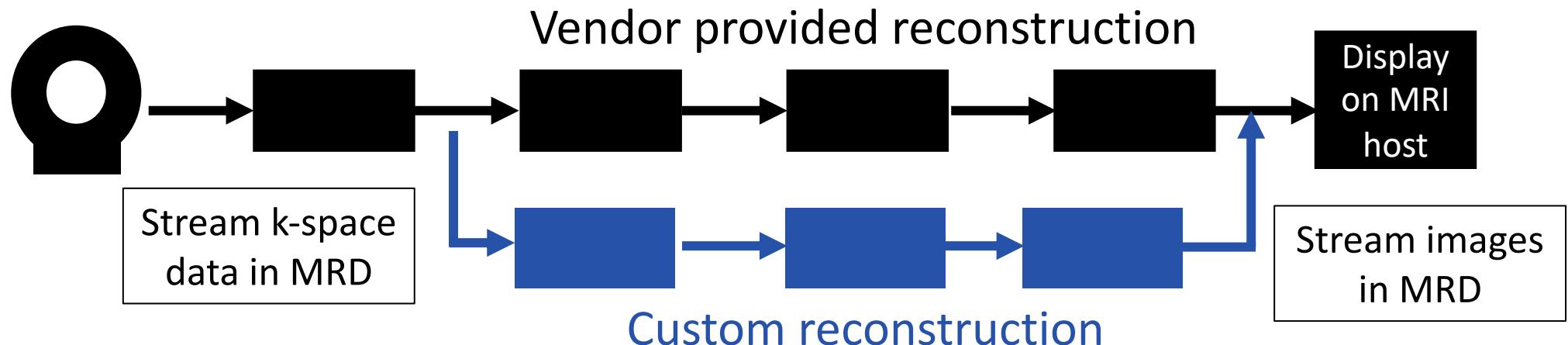
● C++ 10 8 4 1 Updated 27 days ago

[bruker_to_ismrmrd](#)

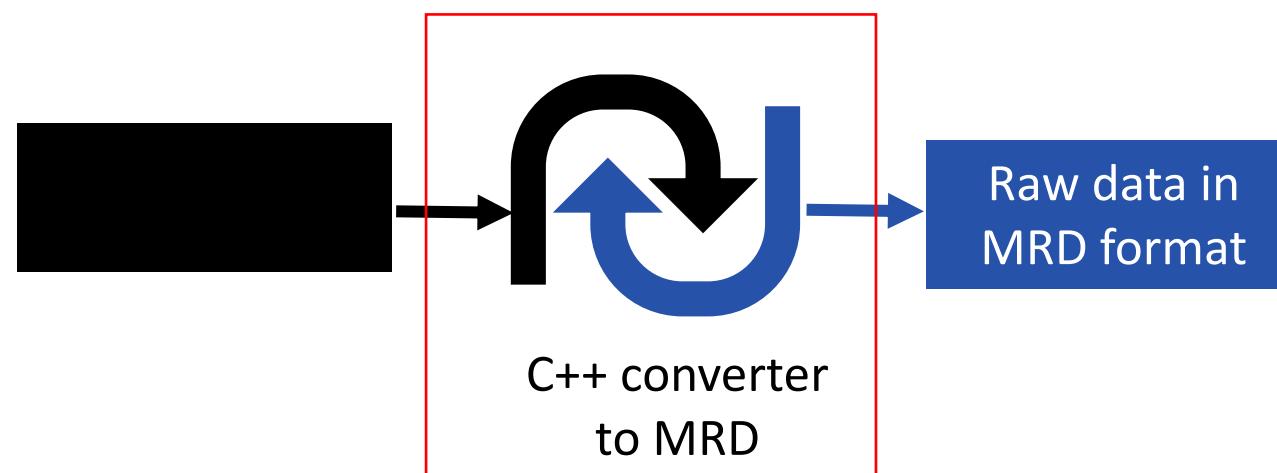
● C++ 4 4 2 0 Updated on Apr 13, 2018

How we use MRD

Inline
Data
Streaming



Offline
Data
Conversion



Data converters maintained
by the community:
Siemens
GE
Bruker
Philips

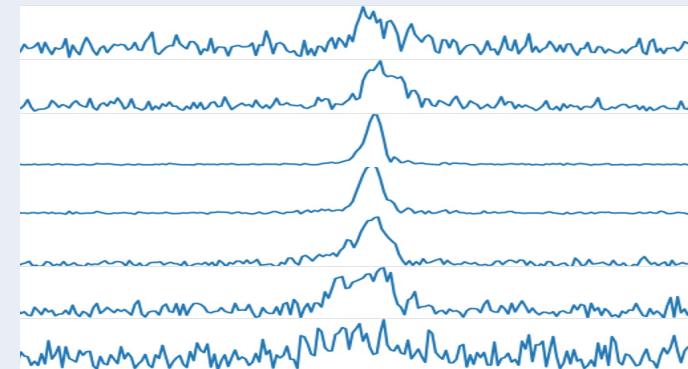
Structure of MRI Raw Data (MRD/ISMRMRD)

ISMRMRD =

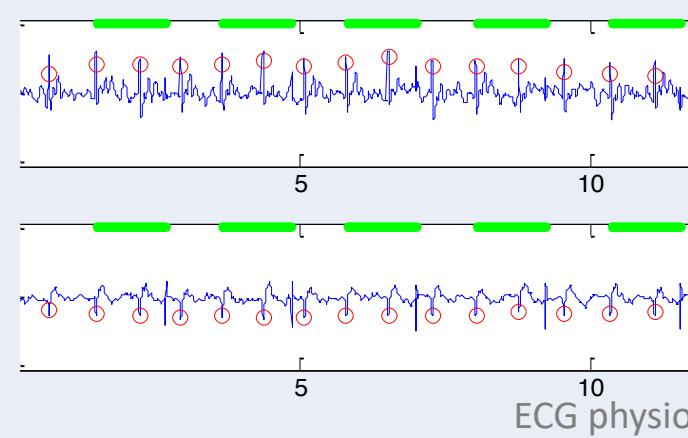
- Experimental Header
- Acquisitions
 - Acquisition Header
 - Data
 - Trajectories (optional)
- Waveforms (optional)
 - ECG, Respiration, Gradients, Field monitoring, more..
- Image

Experimental Header

MR K-space data

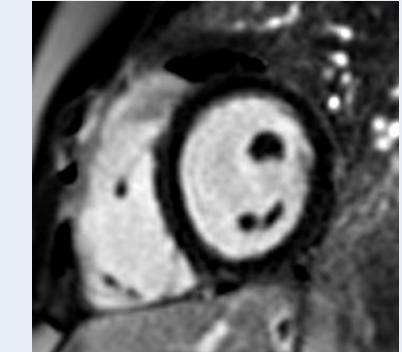


Arbitrary waveforms

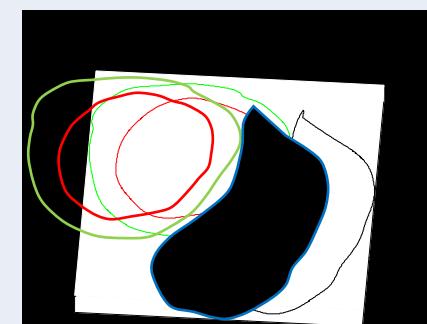


Experimental Header

Image



XML meta data



Contours and landmarks

Structure of MRI Raw Data (MRD/ISMRMRD)

XML Header

```

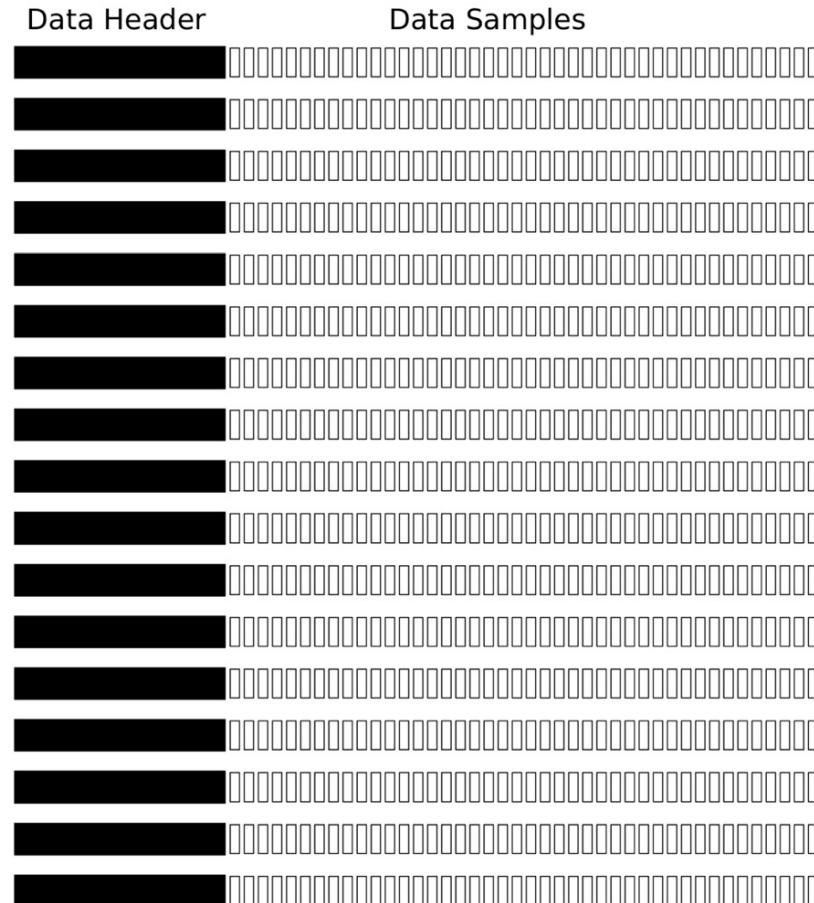
<?xml version="1.0" encoding="UTF-8" standalone="no" ?>
<ismmrHeader xmlns="http://www.ismrm.org/ISMRRMD"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation="http://www.ismrm.org/ISMRRMD ismmrHeader.xsd">

<encoding>
  <encodedSpace>
    <matrixSize>
      <x>512</x><y>256</y><z>1</z>
    </matrixSize>
    <fieldOfView_mm>
      <x>600</x><y>300</y><z>6</z>
    </fieldOfView_mm>
  </encodedSpace>
  <reconSpace>
    <matrixSize>
      <x>256</x><y>256</y><z>1</z>
    </matrixSize>
    <fieldOfView_mm>
      <x>300</x><y>300</y><z>6</z>
    </fieldOfView_mm>
  </reconSpace>
  <encodingLimits>
    <kspc_encoding_step_1>
      <minimum>0</minimum>
      <maximum>255</maximum>
      <center>128</center>
    </kspc_encoding_step_1>
    <repetition>
      <minimum>0</minimum>
      <maximum>1</maximum>
      <center>0</center>
    </repetition>
  </encodingLimits>
  <trajectory>cartesian</trajectory>
</encoding>

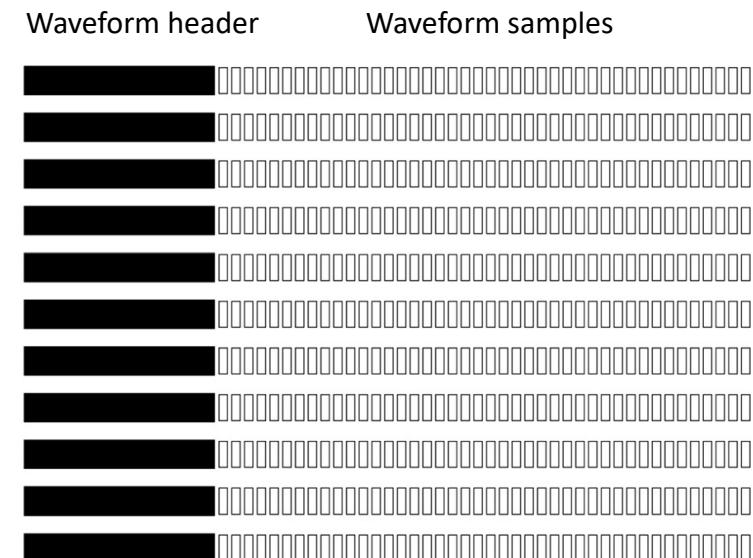
</ismmrHeader>

```

Raw Data



Waveform Data



Let's take a look around!

DEMO: Structure of MRI Raw Data (MRD/ISMRMRD)

The screenshot shows a GitHub repository page for 'ismrmrd / ismrmrdviewer'. The repository is public and contains 2 issues, 2 pull requests, and 51 commits. The commits are listed below, showing changes made by dchansen. The repository also includes files like .gitignore, LICENSE.txt, README.md, requirements.txt, and setup.py.

File	Description	Date
ismrmrdviewer	Fixed an issue where the label on images would not format	19 days ago
res/data	Cleaning up hidden Desktop Services Store files from macOS...	2 years ago
.gitignore	Cleaning up hidden Desktop Services Store files from macOS...	2 years ago
LICENSE.txt	Initial Commit; Main window and open file dialog. Not much e...	3 years ago
README.md	Updated README.md to remove venv instructions	10 months ago
requirements.txt	Fixed minor bugs	10 months ago
setup.py	Fixed minor bugs	10 months ago

README.md

ISMRMRD Viewer

ISMRMRDVIEWER is a python package to view ISMRMRD/MRD (vendor agnostic MRI data format) raw data (including xml, data, waveforms and trajectories) and images.

<https://github.com/ismrmrd/ismrmrdviewer>

```
>> ismrmrdviewer  
data/converted_siemens_data.h5
```

DEMO: Converting to Siemens MRI Data to MRD

The screenshot shows a GitHub repository page for 'ismrmd / siemens_to_ismrmd'. The repository is public and has 8 watches. It includes tabs for Code, Issues (13), Pull requests (5), Actions, Projects, Wiki, Security, and Insights. The Code tab is selected, displaying the allowed options for the converter script:

```
Allowed options:
-h [ --help ]           Produce HELP message
-v [ --version ]         Prints converter version and ISMRMRD version
-f [ --file ]             <SIEMENS dat file>
-z [ --measNum ]          <Measurement number>
-Z [ --allMeas ]          <All measurements flag>
-M [ --multiMeasFile ]    <Multiple measurements in single file flag>
-m [ --pMap ]              <Parameter map XML>
-x [ --pMapStyle ]         <Parameter stylesheet XSL>
--user-map                <Provide a parameter map XML file>
--user-stylesheet          <Provide a parameter stylesheet XSL file>
-o [ --output ]            <ISMRMRD output file>
-g [ --outputGroup ]       <ISMRMRD output group>
-l [ --list ]               <List embedded files>
-e [ --extract ]            <Extract embedded file>
-X [ --debug ]              <Debug XML flag>
-S [ --attachSpiral ]        <Attach Hargreaves spiral design to acq>
-F [ --flashPatRef ]        <FLASH PAT REF flag>
-H [ --headerOnly ]          <HEADER ONLY flag (create xml header only)>
-B [ --bufferAppend ]        <Append protocol buffers>
--studyDate                 <User can supply study date, in the format of
                           yyyy-mm-dd>
```

DEMO:
shell/convert_siemens_data.sh

DEMO: Cartesian Reconstruction with Python

python/cartesian_demo.py

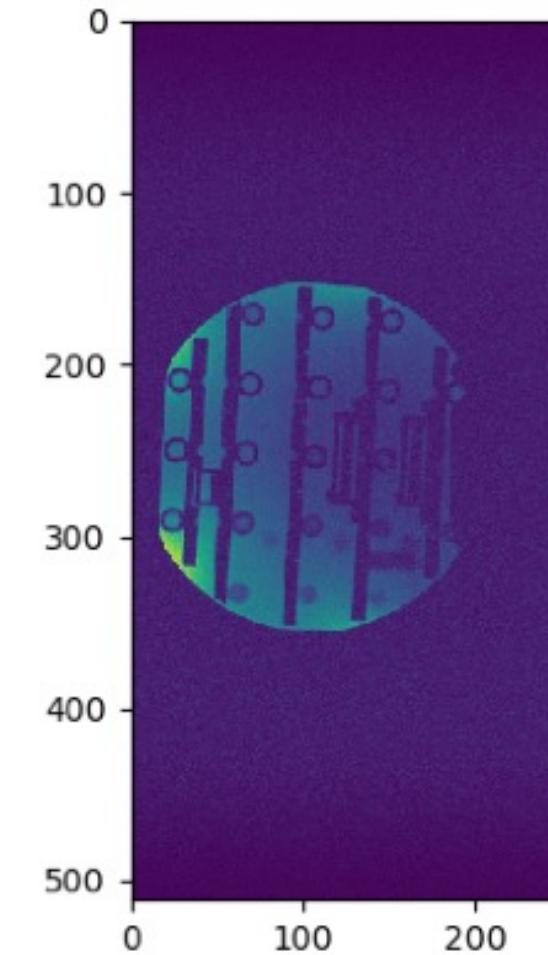
```
# load data and mrd-header

dataset = mrd.Dataset(fname)

exp_header = mrd.xsd.CreateFromDocument(dataset.read_xml_header())

# grab encoding information structure, and extract experiment dimensions
encoding_info = exp_header.encoding[0]

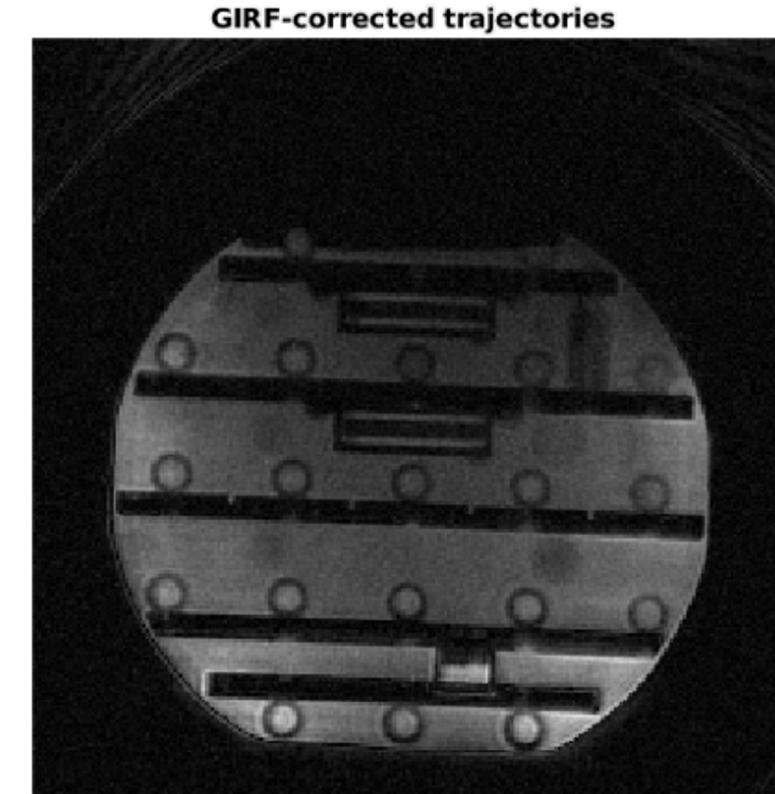
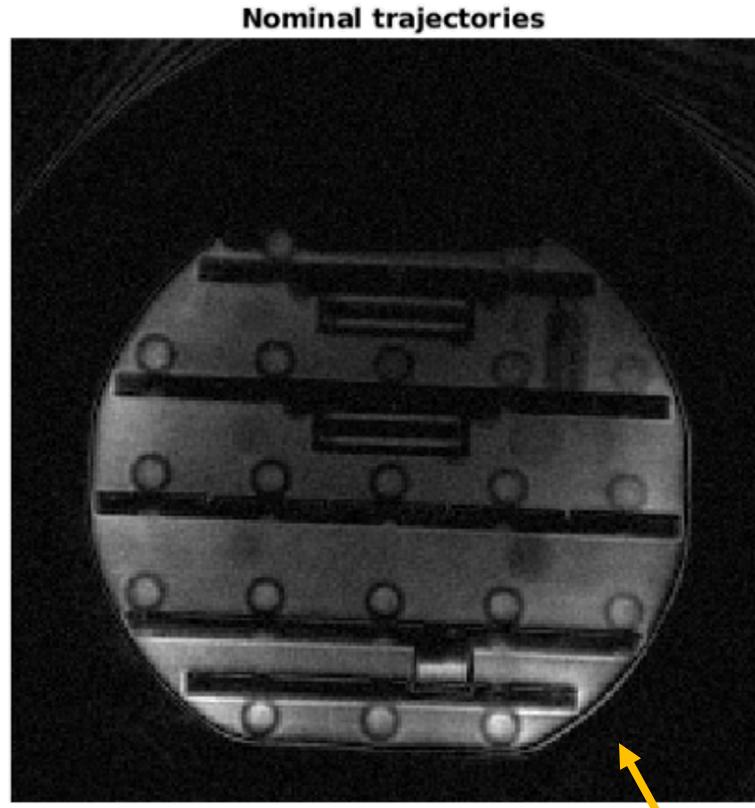
e_1 = encoding_info.encodedSpace.matrixSize.x
e_2 = encoding_info.encodedSpace.matrixSize.y
e_3 = encoding_info.encodedSpace.matrixSize.z
e_4 = encoding_info.encodingLimits.average.maximum + 1
e_5 = encoding_info.encodingLimits.slice.maximum + 1
e_6 = encoding_info.encodingLimits.contrast.maximum + 1
e_7 = encoding_info.encodingLimits.phase.maximum + 1
e_8 = encoding_info.encodingLimits.repetition.maximum + 1
e_9 = encoding_info.encodingLimits.set.maximum + 1
```



DEMO: Spiral Reconstruction with MATLAB

Example of how stored trajectory information in MRD can be used: correct non-Cartesian trajectories due to system-specific performance (GIRF)

- Conversion: matlab/README.md
- Recon: matlab/mrd_recon_spiral.m



DEMO: Converting to GE MRI Data to MRD

The screenshot shows a GitHub repository page for 'ismrmd/ge_to_ismrmd'. The repository is public and has 2 issues. The main navigation bar includes links for Pull requests, Issues, Marketplace, and Explore. Below the navigation bar, there are links for Code, Issues (2), Pull requests, Actions, Projects, Wiki, Security, and Insights. The 'Code' link is underlined, indicating it is the active tab.

```
ge2ismrmd [options] <input P- or ScanArchive File>
Options:
Basic Options:
-h [ --help ]                                print help message
-v [ --verbose ]                               enable verbose mode
-p [ --plugin ] arg (=GenericConverter)        class/sequence name in library used for
                                                conversion
-x [ --stylesheet ] arg (/root/local/ge-tools/bin/../share/ge-tools/config/default.xsl) XSL stylesheet file mapping values
                                                provided by Orchestra to those needed
                                                by ISMRMRD
-o [ --output ] arg (=converted_data.h5)        output HDF5 file
-s [ --string ]                                only print the HDF5 XML header
```

Converting to MRD: Parameter maps/stylesheets

GE

Siemens

```
98      <experimentalConditions>
99          <H1resonanceFrequency_Hz><xsl:value-of select="Header/Image/ImagingFrequency * 1000000"/></H1resonanceFrequency_Hz>
100     </experimentalConditions>
101
102     <encoding>
103         <trajectory>epi</trajectory>
104         <trajectoryDescription>
105             <identifier>ConventionalEPI</identifier>
106             <userParameterLong>
107                 <name>etl</name>
108                 <value>
109                     <xsl:value-of select="Header/AcquiredYRes"/>
110                 </value>
111
112             <experimentalConditions>
113                 <H1resonanceFrequency_Hz>
114                     <xsl:value-of select="siemens/DICOM/lFrequency"/>
115                 </H1resonanceFrequency_Hz>
116             </experimentalConditions>
117
118             <encoding>
119                 <trajectory>epi</trajectory>
120                 <trajectoryDescription>
121                     <identifier>ConventionalEPI</identifier>
122                     <userParameterLong>
123                         <name>etl</name>
124                         <value>
125                             <xsl:value-of select="siemens/MEAS/sFastImaging/lEPIFactor"/>
126                         </value>
127                     </userParameterLong>
```

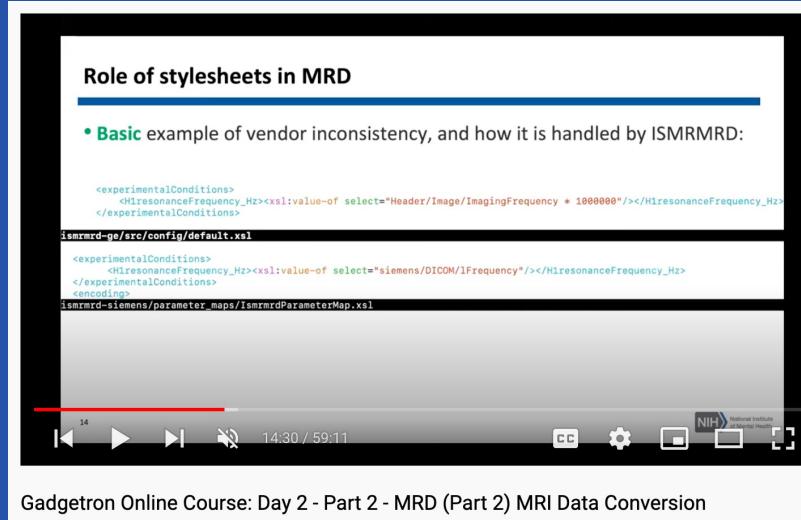
Converting to MRD: Parameter maps/stylesheets

GE

Siemens

98
99
100
101
102
103
104
105
106
107
108
109
110

- A few examples are included:
 - github.com/ismrmrd/ge_to_ismrmrd/src/config/
 - [github.com/ismrmrd /siemens_to_ismrmrd/parameter_maps/](https://github.com/ismrmrd/siemens_to_ismrmrd/parameter_maps/)
- Tutorial

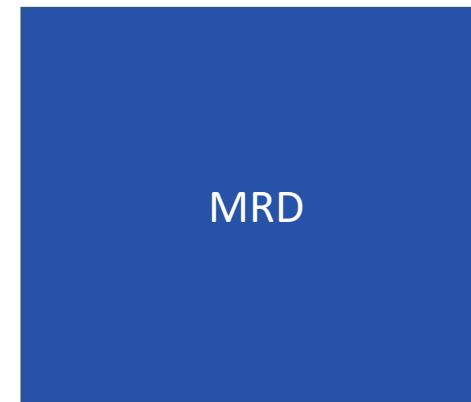


Gadgetron Online Course: Day 2 - Part 2 - MRD (Part 2) MRI Data Conversion

- https://www.youtube.com/watch?v=ggauvF13-OM&list=PL3dITfhovhLW-ySr_KPBS8KKI9tdLjfdR&index=6
- You might need to update them for your application
- Disclaimer:
 - Be careful with vendor proprietary info when sharing the style sheets
 - Specify inclusion or exclusion of PII

DEMO: Bruker Cartesian Data Conversion with Julia & Reconstruction with MATLAB

- Convert data with Julia using MRI-reco
 - matlab/README.md
- Example matlab reconstruction with MRD data
 - matlab/mrd_recon_cartesian_bruker.m



Working with MRI Raw Data (MRD/ISMRMRD)

Conclusion

Flexibility to do what you need!

Upcoming:

Julia support with MRD

“Storage” of same-session scans for shared information across reconstructions

Please see github page for links to resources:

https://github.com/rajramasawmy/mri_together_mrd

Acknowledgements

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Daniel Herzka, PhD

Gadgeteers

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Kristopher Knudson, PhD (Gradient Software)

Vinai Roopchansingh, PhD (NIH)

Oliver Josephs, PhD (UCL)

Maxime Yon, PhD (Lund)

John A Derbyshire, PhD (NIH)

Valery Ozenne, PhD (Bordeaux)

Kelvin Chow, PhD (Siemens Healthcare)

Aurelien Trotier, PhD (CNRS)

Stanislas Rapacchi, PhD (CNRS)

Problems? Join the Gadgetron (and ISMRMRD) call – **Friday's at 4pm UTC**

<https://gadgetron.discourse.group/>