# *Data formats for EIT*

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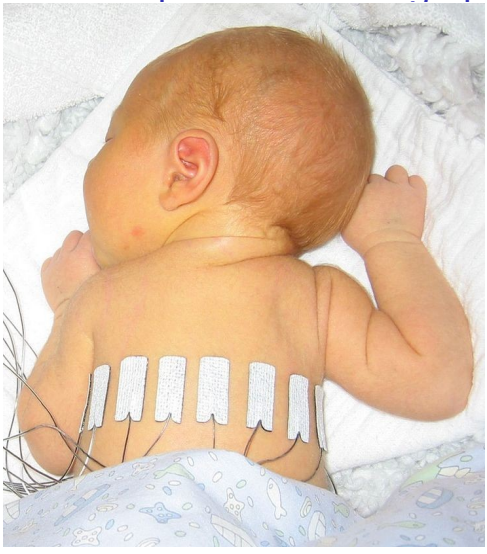
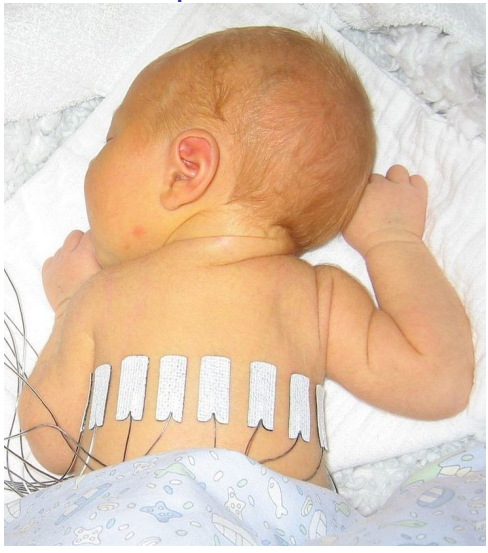
# Electrical Impedance Tomography: Non-invasive

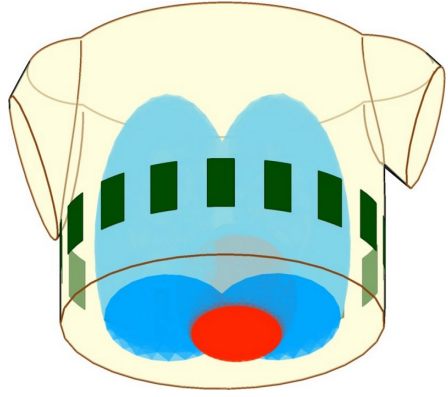


[1]

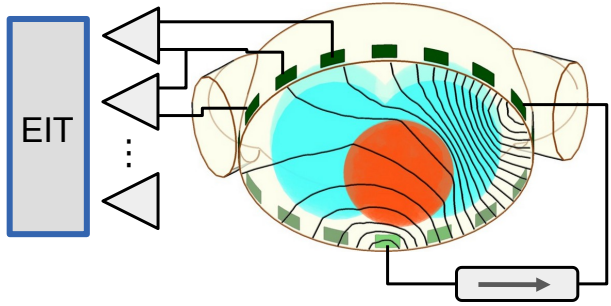
[1] Heinrich *et al* (2006) Body and head position effects on regional lung ventilation in infants ... Int Care Med 32:1392–1398

# EIT and Computational Model

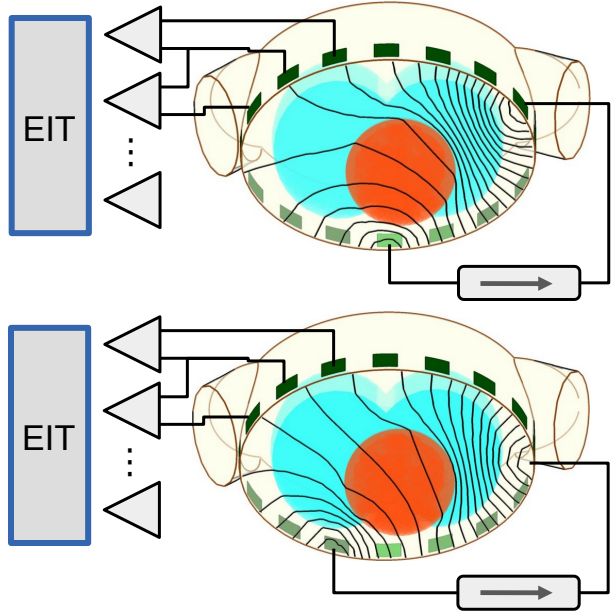




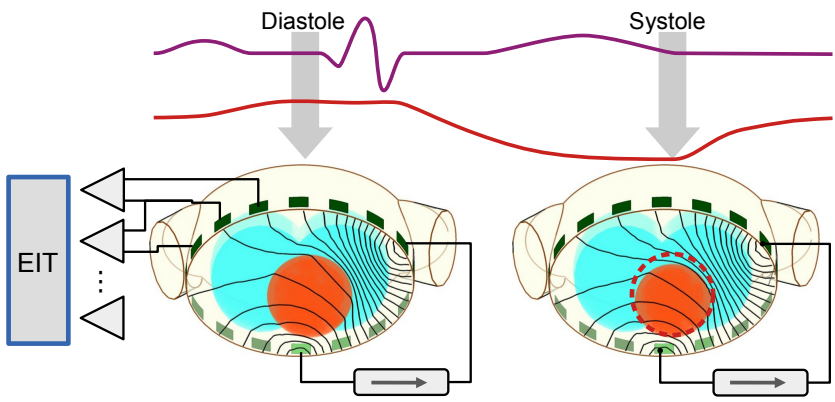
# EIT: apply current and measure voltages



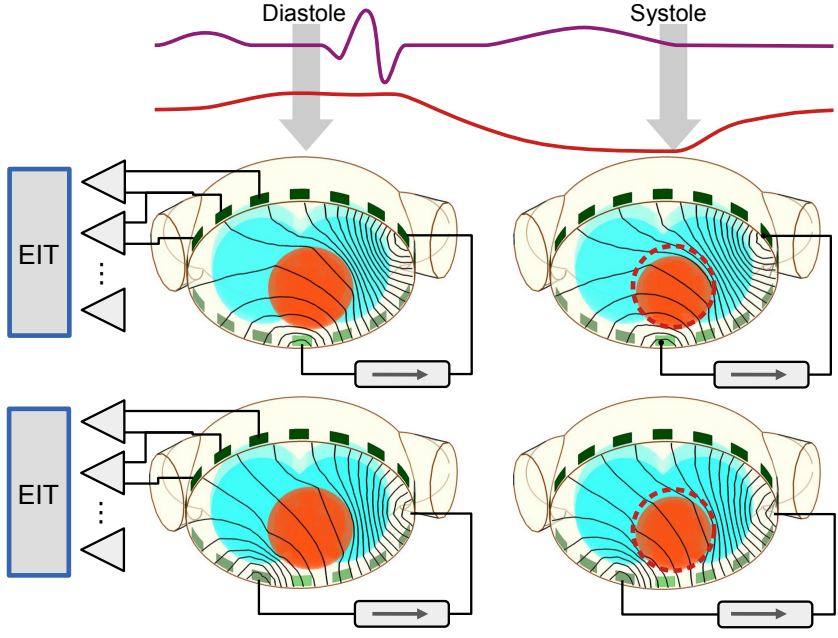
# EIT: apply current and measure *new* voltages



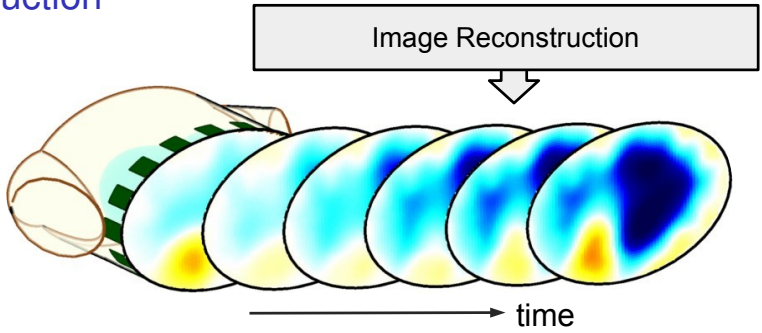
# EIT: Physiology



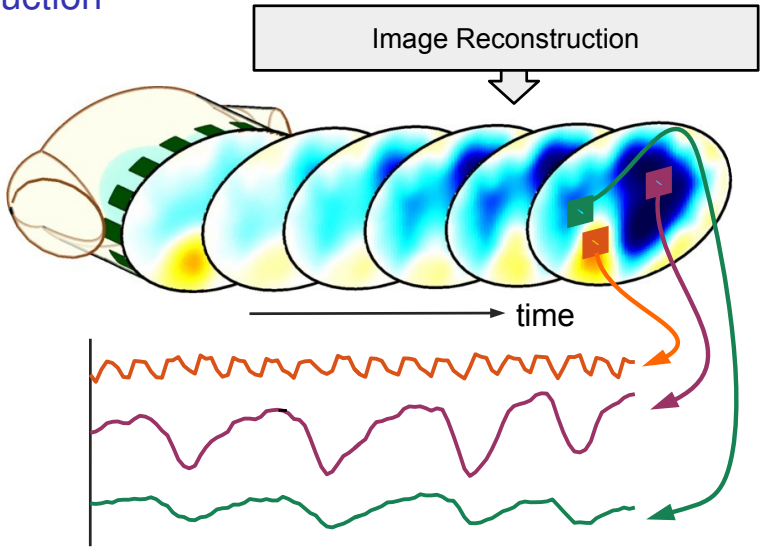
# EIT: Physiology



# EIT: Image Reconstruction

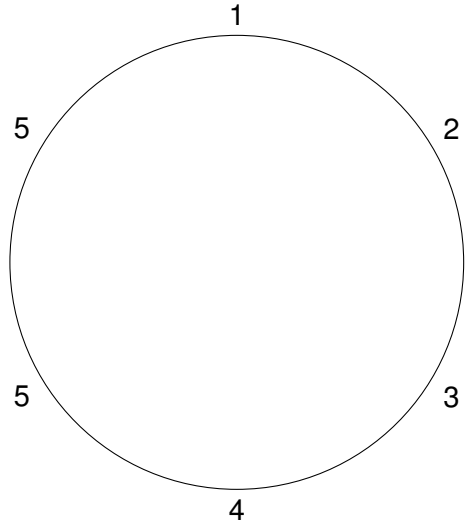


# EIT: Image Reconstruction



# Stimulation & Measurement patterns – 6 electrodes

- EIDORS: mk_stim_patterns()



# Adjacent Stimulation – no_rotate_meas

| Stim | Meas | Meas | Meas | Meas | Meas | Meas |
|---|---|---|---|---|---|---|
| 1→2 | 1→2 | 2→3 | 3→4 | 4→5 | 5→6 | 6→1 |
| 2→3 | 1→2 | 2→3 | 3→4 | 4→5 | 5→6 | 6→1 |
| 3→4 | 1→2 | 2→3 | 3→4 | 4→5 | 5→6 | 6→1 |
| 4→5 | 1→2 | 2→3 | 3→4 | 4→5 | 5→6 | 6→1 |
| 5→6 | 1→2 | 2→3 | 3→4 | 4→5 | 5→6 | 6→1 |
| 6→1 | 1→2 | 2→3 | 3→4 | 4→5 | 5→6 | 6→1 |

# Adjacent Stimulation – no_rotate_meas, no_meas_current

| Stim | Meas | Meas | Meas | Meas | Meas | Meas |
|---|---|---|---|---|---|---|
| 1→2 | 1→2 | 2→3 | 3→4 | 4→5 | 5→6 | 6→1 |
| 2→3 | 1→2 | 2→3 | 3→4 | 4→5 | 5→6 | 6→1 |
| 3→4 | 1→2 | 2→3 | 3→4 | 4→5 | 5→6 | 6→1 |
| 4→5 | 1→2 | 2→3 | 3→4 | 4→5 | 5→6 | 6→1 |
| 5→6 | 1→2 | 2→3 | 3→4 | 4→5 | 5→6 | 6→1 |
| 6→1 | 1→2 | 2→3 | 3→4 | 4→5 | 5→6 | 6→1 |

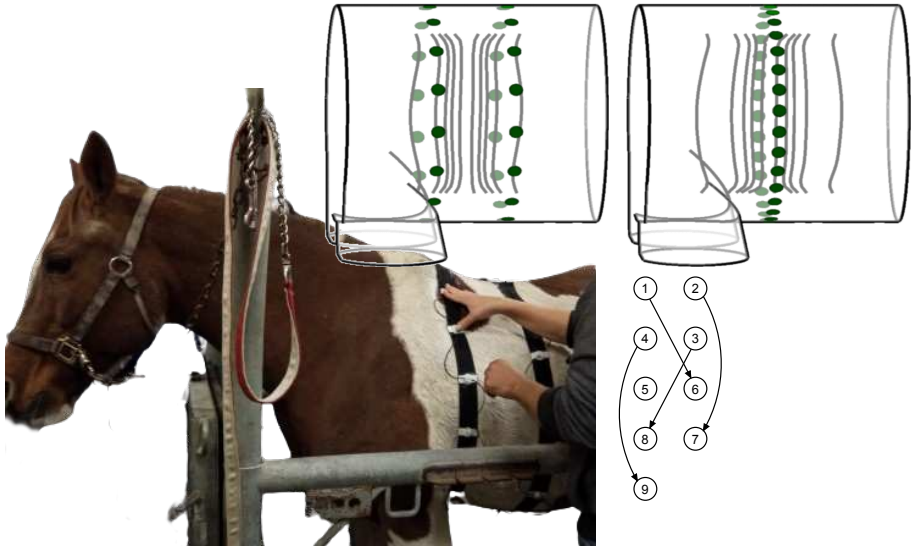
# Adjacent Stimulation – rotate_meas

| Stim | Meas | Meas | Meas | Meas | Meas | Meas |
|---|---|---|---|---|---|---|
| 1→2 | 1→2 | 2→3 | 3→4 | 4→5 | 5→6 | 6→1 |
| 2→3 | 2→3 | 3→4 | 4→5 | 5→6 | 6→1 | 1→2 |
| 3→4 | 3→4 | 4→5 | 5→6 | 6→1 | 1→2 | 2→3 |
| 4→5 | 4→5 | 5→6 | 6→1 | 1→2 | 2→3 | 3→4 |
| 5→6 | 5→6 | 6→1 | 1→2 | 2→3 | 3→4 | 4→5 |
| 6→1 | 6→1 | 1→2 | 2→3 | 3→4 | 4→5 | 5→6 |

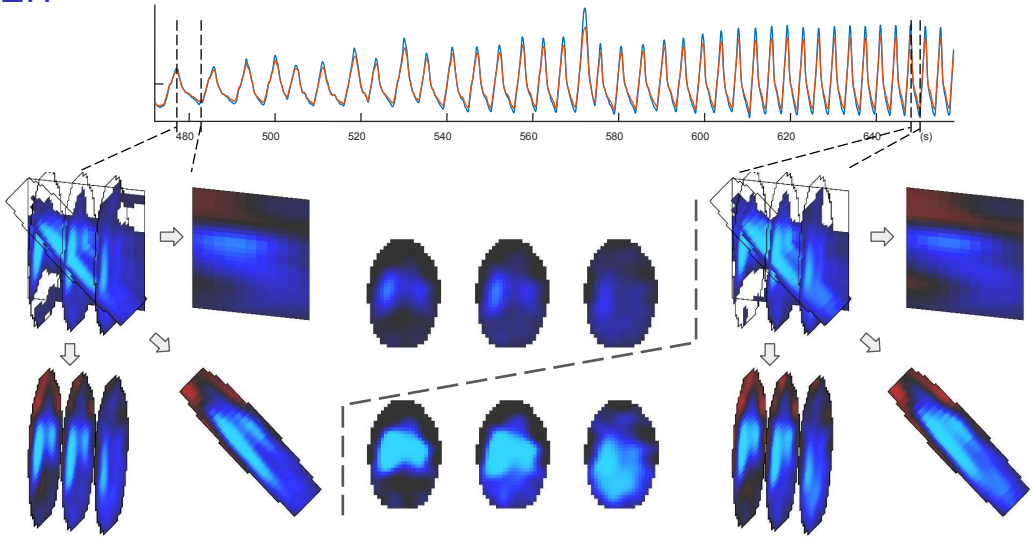
# Adjacent Stimulation – rotate_meas, no_meas_current

| Stim | Meas | Meas | Meas | Meas | Meas | Meas |
|---|---|---|---|---|---|---|
| 1→2 | 1→2 | 2→3 | 3→4 | 4→5 | 5→6 | 6→1 |
| 2→3 | 2→3 | 3→4 | 4→5 | 5→6 | 6→1 | 1→2 |
| 3→4 | 3→4 | 4→5 | 5→6 | 6→1 | 1→2 | 2→3 |
| 4→5 | 4→5 | 5→6 | 6→1 | 1→2 | 2→3 | 3→4 |
| 5→6 | 5→6 | 6→1 | 1→2 | 2→3 | 3→4 | 4→5 |
| 6→1 | 6→1 | 1→2 | 2→3 | 3→4 | 4→5 | 5→6 |

# *Skip* stimulation, measurements patterns



# 3D EIT



# Skip-1 Stimulation – no_rotate_meas

| Stim | Meas | Meas | Meas | Meas | Meas | Meas |
|---|---|---|---|---|---|---|
| 1→3 | 1→3 | 2→4 | 3→5 | 4→6 | 5→1 | 6→2 |
| 2→4 | 1→3 | 2→4 | 3→5 | 4→6 | 5→1 | 6→2 |
| 3→5 | 1→3 | 2→4 | 3→5 | 4→6 | 5→1 | 6→2 |
| 4→6 | 1→3 | 2→4 | 3→5 | 4→6 | 5→1 | 6→2 |
| 5→1 | 1→3 | 2→4 | 3→5 | 4→6 | 5→1 | 6→2 |
| 6→2 | 1→3 | 2→4 | 3→5 | 4→6 | 5→1 | 6→2 |

# Skip-1 Stimulation – no_rotate_meas, no_meas_current

| Stim | Meas | Meas | Meas | Meas | Meas | Meas |
|---|---|---|---|---|---|---|
| 1→3 | 1→3 | 2→4 | 3→5 | 4→6 | 5→1 | 6→2 |
| 2→4 | 1→3 | 2→4 | 3→5 | 4→6 | 5→1 | 6→2 |
| 3→5 | 1→3 | 2→4 | 3→5 | 4→6 | 5→1 | 6→2 |
| 4→6 | 1→3 | 2→4 | 3→5 | 4→6 | 5→1 | 6→2 |
| 5→1 | 1→3 | 2→4 | 3→5 | 4→6 | 5→1 | 6→2 |
| 6→2 | 1→3 | 2→4 | 3→5 | 4→6 | 5→1 | 6→2 |

EIDORS

Physiological Measurement

# Uses and abuses of EIDORS: an extensible software base for EIT

Andy Adler and William R B Lionheart

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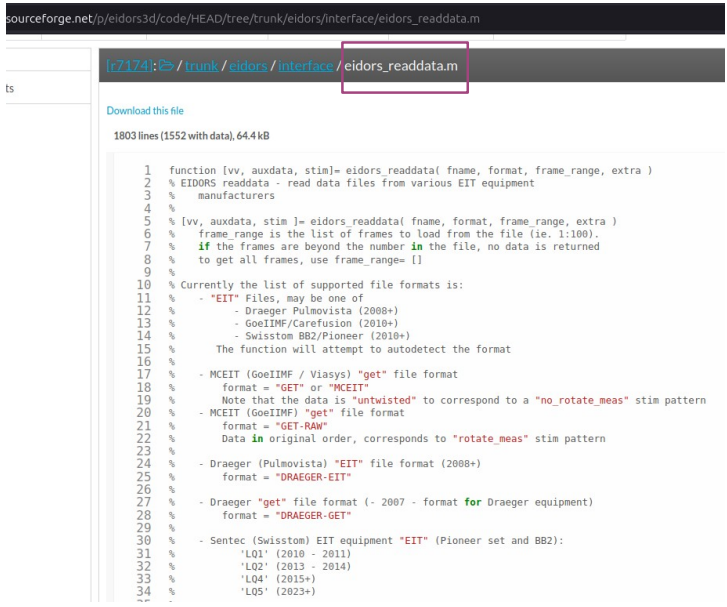
Authors

Article information

## Abstract

EIDORS is an open source software suite for image reconstruction in electrical impedance tomography and diffuse optical tomography, designed to facilitate collaboration, testing and new research in these fields. This paper describes recent work to redesign the software structure in order to simplify its use and provide a uniform interface, permitting easier modification and customization. We describe the key features of this software, followed by examples of its use.

# EIDORS: eidors_readdata.m



# EIDORS: eidors_readdata.m

Main formats:

- Sheffield MKI/MKII
- Goettingen MFII (“get”)
- Dräger Pulmovista (“eit”)
- Sentec BB2 / Pioneerset (“eit”, LQ1 . . . LQ5)

Newer formats

- HDF5

Minor / older formats

- Dixtal, Midas Medical, Sciospec, ITS, IIRC

Looking for formats for other EIT vendors, *please*

- Timpel
- Infivision
- . . .

# File format issues

- Flexibility with Stim/Meas patterns
- Measurement time: serial / parallel / frame rate variations
- Syncronization with other data streams
- Metadata: Hardware settings
- Electrode positions
- Patient data & privacy issues

# HDF5-based format

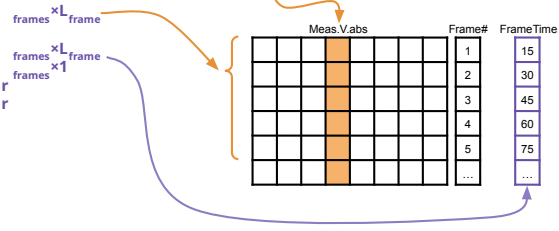
```
/data                 # folder for data
 /dataset1            # this dataset (of several)
  /protocol
```

| | |
|---|---|
| Stim.I.01(A) | Curr elec#01 |
| Stim.I.02(A) | Curr elec#02 |
| Stim.I.freq(Hz) | Injection Freq |
| Meas.V.01(V) | Meas gain elec#01 |
| Meas.V.02(V) | Meas gain elec#02 |
| Meas.V.03(V) | Meas gain elec#03 |
| Meas.V.04(V) | Meas gain elec#04 |
| Meas.V.freq(Hz) | Demodulation Freq |
| Meas.Dtime(s) | Δtime after meas |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| -.01 | -.01 | -.01 | -.01 | ... | 0 | ... | -.01 |
| +.01 | +.01 | +.01 | +.01 | ... | -.01 | ... | 0 |
| 13000 | 13000 | 13000 | 13000 | ... | 13000 | ... | 13000 |
| -10 | 0 | 0 | 0 | ... | -10 | ... | -10 |
| +10 | -10 | 0 | 0 | ... | +10 | ... | -10 |
| 0 | +10 | -10 | 0 | ... | 0 | ... | 0 |
| 0 | 0 | +10 | -10 | ... | 0 | ... | 0 |
| 13000 | 13000 | 13000 | 13000 | ... | 13000 | ... | 13000 |
| 0.001 | 0.001 | 0.001 | 0.001 | ... | 0.001 | ... | 0.001 |

```
 Meas.V.Abs            # data files   N
 Meas.V.Real/.Imag # if available
 Time.Meas(s)          # if available  N
 Time.Frame(s)         # if available  N
 Time.Start(s)         # if available  scalar
 Time.Stop(s)          # if available  scalar

 /initialize           # optional folder
 /finalize             # optional folder
 /dataset2             # more datasets
/patient               # optional folder
/instrument            # optional folder
```



# HDF5-based format

- Allow additional synchronized data
- Allow different stim/meas pattern data
- Allow multifrequency data

- Simplicity: writing data in $< 50$ code lines.
- Self-documenting: core data element is the “frame”.
- Streaming: suitable for large and online data sets.
- Extensibility: easy to add additional data and elements.

# Discussion

- Need more vendor file formats
- Need Repository of data for classic EIT studies
- EIT image formats & DICOM
- File format converters