Low-cost biomedical instrumentation: possibilities and applications

Carleton University Life Science Day,
5 May 2017

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Instrumentation = “Smart . . .”

Smart Objects?

- Smart . . . Home / Office / Building
- Smart . . . Watches
- Smart . . . Shirt
- Smart . . . Lights

1 https://en.wikipedia.org/wiki/Smart_objects
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Smart objects properties:\(^1\)

• Awareness
• Representation
• Interaction

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Why instrumentation?

- ↑ reliability  ↓ cost
- New business models
  - rental jet engines, remote coaching
- Customization
  - Taser’s “smart-weapon”
Instrumentation drives new insights

$^3$He images of distribution of ventilation in two COPD patients$^2$.

Instrumentation used to be expensive

1990 My final year undergrad project. We used a 3-axis accelerometer for a μgravity application $10k

2017 Most of you are carrying at least one Biomedical instrumentation...
Instrumentation used to be expensive

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     We used a 3-axis accelerometer for a $\mu$gravity application
     $\sim$10k

2017  3-axis accelerometer. 
     $0.67
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2017  3-axis accelerometer. $0.67$

2017  Most of you are carrying at least one
Example #1: Mobility Trainer

Bungee Mobility Trainer (Neurogym Technologies)³

Example #2: Electrical Imaging

Electrical Impedance Tomography

10-day old healthy baby with EIT electrodes

Source:
eidors3d.sf.net/data_contrib/if-neonate-spontaneous
Medical Applications of EIT

- Monitoring Mechanical Ventilation:

  - Overdistension
  - Collapse

  ![15 hPa](image1)
  ![30 hPa](image2)

Birth
Medical Applications of EIT

- Monitoring Mechanical Ventilation:
  - Overdistension
  - Right heart (pulmonary arterial) Pressure

- **15 hPa**
- **30 hPa**
- **35 hPa**
- **20 hPa**
Medical Applications of EIT

- Monitoring Mechanical Ventilation:
  - Overdistension
    - 15 hPa
    - 30 hPa
    - 35 hPa
    - 20 hPa

- Right heart (pulmonary arterial) Pressure
- Breathing in newborns

Birth
Instrumentation’s challenge . . . analysis

• Information = Data + Interpretation

• Real world challenges:
  • Isolate relevant features
  • Reject “other stuff” which we’re not interested in
  • Data errors
  • Permanence – are features stable over time?
  • Active deception
Instrumentation’s challenge . . . analysis

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Data Quality

Depth Sounder – with analog and digital guages

Problem: With complex algorithms we can get pretty pictures, even when they are irrelevant.
**Idea #1:** Data quality measures using consistency

Images and data quality metric for each stage of the protocol

*A:* EIT images  
*B:* Calculated data quality.
Idea #2: Community

- Open Data
- Open source analysis
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⇒

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We need

- Open Data
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  • Open Data
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We need

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For EIT . . .
For EIT...

EIDORS: Electrical Impedance Tomography and Diffuse Optical Tomography Reconstruction Software

Project Goal

Provide free software algorithms for forward and inverse modelling for Electrical Impedance Tomography (EIT) and Diffusion based Optical Tomography, in medical and industrial settings, and to share data and promote collaboration between groups working these fields.

Requirements

- Matlab (>=7.0) or Octave (>=3.4)
- Netgen Mesher (optional)

Getting Started

To try the EIDORS software, follow these steps:

1. Download the software (release or developer version):
   - Release Version: EIDORS 3.5 (14 Jul 2011)
   - Developer Version:
For EIT...

Contributed EIT Data:

Authors: S. Heinrich, H. Schiffmann, A. Frerichs, A. Klockgether-Radke, I. Frerichs

Date: 2006

Brief Description: 10-day old spontaneously breathing neonate lying in the prone position with the head turned to the left. Data were published in S. Heinrich, H. Schiffmann, A. Frerichs, A. Klockgether-Radke, I. Frerichs, Body and head position effects on regional lung ventilation in infants: an electrical impedance tomography study, Intensive Care Med., 32:1392-1398, 2006.

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Attribution Requirement: Use or presentation of these data must acknowledge Inez Frerichs, and reference this publication.


Format: EIT data were acquired with the Göttingen Goe-MF II device, 220 frames, 13 frames/s. Data are in .GET file format.

Methods: Neonate in prone position, with electrode #1 at the front of the chest, electrode #5 on the left side of the chest, electrode #9 on the back and electrode #13 on the right side of the chest.

Data: Data (zip format)
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