Improved Management of Urinary Incontinence using a Non-Invasive and Safe Monitoring Device

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Motivation

- Toilet training can be a significant challenge for children with Autism Spectrum Disorder (ASD) and Intellectual Disabilities (ID) [Matson 2009]
- Urinary incontinence negatively impacts autonomy and dignity of children
- Enuresis alarm and ultrasound devices used to prompt successful toileting [Leblanc 2005]
- Supportive technologies are lacking [Schlebusch 2013]:
  - Bulky
  - Inaccurate
  - Require professional training to operate
  - Non-continuous monitoring
  - ➢ Reactive not proactive

Electrical Impedance Tomography (EIT)

- Different tissues have different characteristic impedances
- The process:
  1. Electrodes placed around body
  2. Current injected; voltage difference measured
  3. Impedance (conductivity) distribution determined

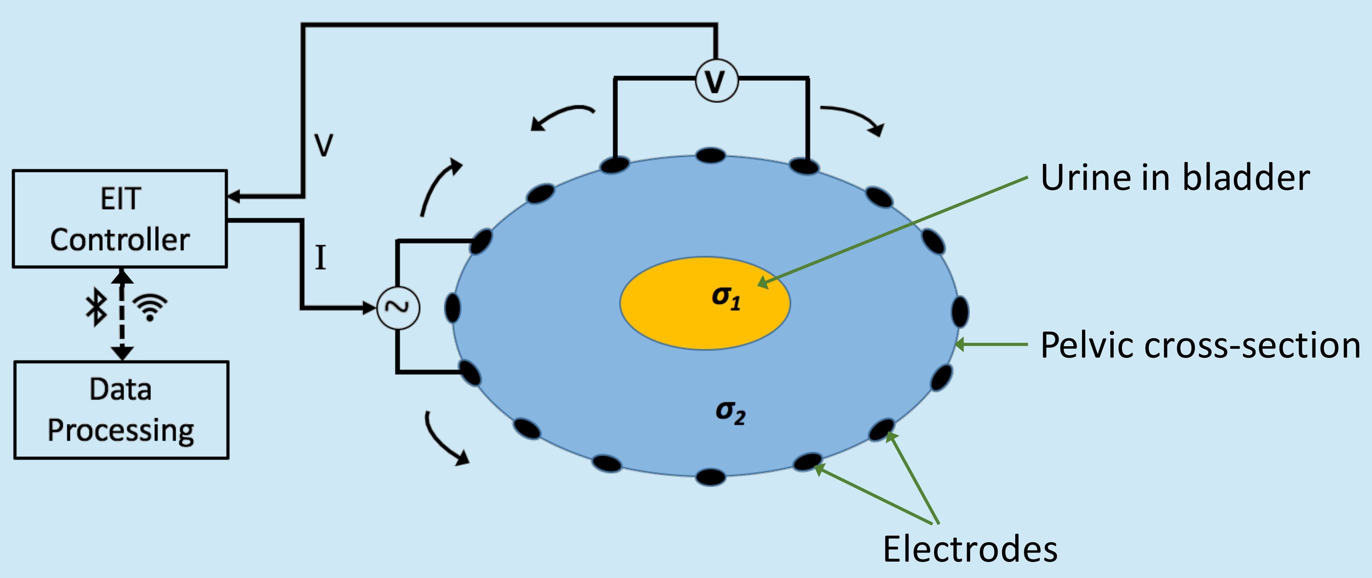

Figure 1. Schematic diagram of EIT bladder monitoring device: 16 electrodes are placed on the skin around the pelvis. Current is applied between a set of electrodes, and the resulting voltage difference is measured between two other electrodes. Data is obtained from all electrode combinations before processing to determine the impedance distribution of the tissues. The conductivity of the urine is σ_1 and the conductivity of the background tissue is σ_2.

- ➢ Can visualize or quantify urine filling the bladder
- Tracks change in impedance caused by filling bladder
- Alerts the user when bladder needs voiding

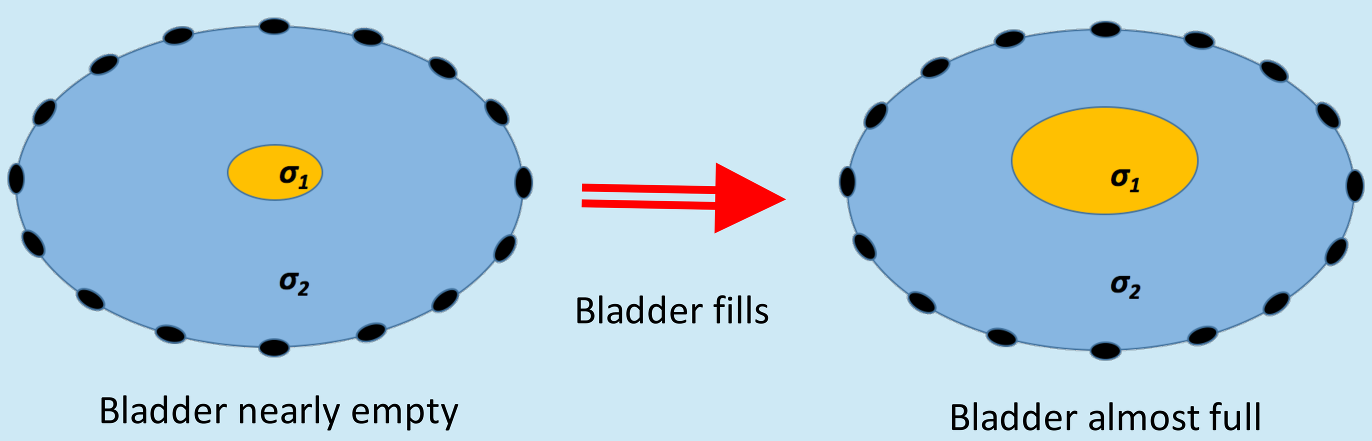

Figure 2. As the bladder fills with urine, the conductivity (impedance) of the bladder region changes. The change in impedance over time is measured using EIT, enabling identification of the point at which the bladder is almost full and voiding is necessary.

- EIT may provide continuous bladder monitoring support for those with incontinence
  - ➢ **Safe**
  - ➢ **Non-invasive**
  - ➢ **Proactive**

Early Results

- Bladder filling tested in simulations:
  - Simplified ellipsoidal pelvic model
  - Spherical bladder model (500 mL)
  - Noise-free test environment

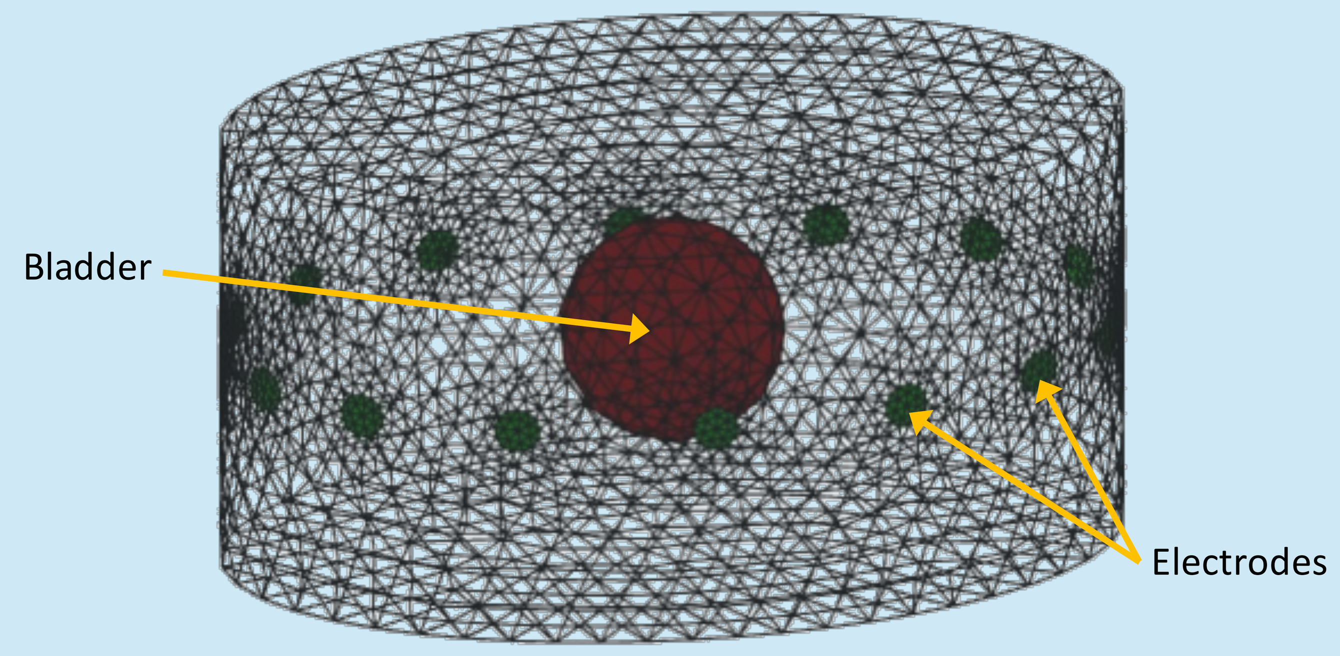

Figure 3. 3D simplified pelvic model in the form of a finite element mesh. The red sphere represents the bladder. The green circles indicate the 16 equally-spaced electrodes placed around the pelvis.

- Image of bladder reconstructed:
  - GREIT reconstruction algorithm used, from Electrical Impedance and Diffuse Optical Tomography Reconstruction Software (EIDORS) [Adler 2009]
  - Mimics real scenario: bladder is empty then fills over time
  - Image produced relative to homogeneous background reference

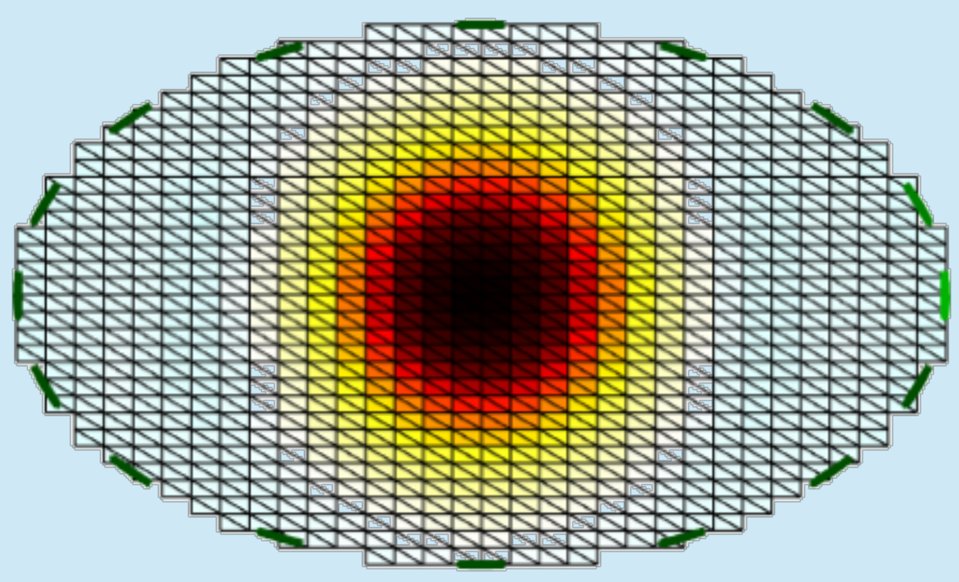

Figure 4. 2D image reconstruction of the impedance distribution of the tissues shown in Figure 3, formed using the GREIT algorithm. The bladder conductivity σ_1 = 1.75 S/m at 50 kHz [Hasgall et al., 2015] and a homogenous reference image with conductivity σ_2 = 0.7 S/m at 50 kHz [Hasgall et al., 2015] were used in this simulation. This image demonstrates that the bladder filled with urine is clearly visible.

Conclusion

- EIT shows promise as a support tool for toilet training through continuous bladder monitoring
  - ➢ Can provide an alert **prior** to voiding
- Promises to accelerate toilet training protocols, promoting independence and maintaining dignity

Acknowledgments

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