SMART Belt: A Novel Multi-sensor Device for Seizure Detection

**Team Seize and Assist:** Ethan Leng¹, Mihir Mongia², Charles Park², Tiffany Varughese¹, Andrew Wu¹

¹Dept. of Bioengineering, ²Dept. of Electrical and Computer Engineering, Rice University

---

**Epileptic Seizures**

- Epileptic Seizures: Abnormal electrical activity in brain
  - Affects 2.3 million people in U.S.¹
  - 80% are nonconvulsive²
- Continuous nighttime monitoring crucial to prevent
  - Injury to the patient
  - Sudden Unexpected Death in Epilepsy (SUDEP)

Current standards are insufficient:

- Electroencephalography (EEG)
  - Complex head electrodes
  - Conducted only in hospital
  - Requires physicians’ expertise
- Bed Vibration Sensor
  - Only detects convulsions
  - High false positive rate
- Expensive

**Mission Statement**

Build a device that incorporates respiration and electrodermal activity (EDA) sensors to continuously monitor for physiological signs of seizures at night.

---

**Solution: Portable & Continuous Multi-sensor**

- **Smart Belt**
  - Respiration measured via conductive fabric
  - Unique EDA electrode placement on the T9 vertebral level
  - Wireless data transmission to smartphone + alert of seizure activity
  - Self-contained form factor allows for outpatient seizure monitoring
  - Adjustable belt straps wearable for patients of all ages

**Completed Design Criteria**

- Respiration sensor: 95-100% accuracy of breath detection
- EDA sensor: 80-85% correlation with commercial sensor
- Cost: $65-70
- Comfortable, portable, and easy to affix and remove
- Battery life: 8-12 hours on continuous operation

---

**Seizure Monitoring and Response Transducing (SMART) Belt**

- Detects respiratory and EDA responses reliably
- Required electrodes

---

**Respiration sensor test**

- Patient breaths normally for 20 seconds
- Time (seconds) vs. Voltage (mV)

**EDA sensor test**

- Patient holds breath for 15 seconds (simulating apnea)
- Time (seconds) vs. Voltage (mV)

**Table 1. SMART Belt Statistics of Results**

<table>
<thead>
<tr>
<th></th>
<th>10.2 breaths/second (n=5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average breaths detected</td>
<td>2.9% (0-5.3%) error</td>
</tr>
<tr>
<td>Average breath detection</td>
<td>84% correlated</td>
</tr>
</tbody>
</table>

---

**Results: SMART Belt Matches Established Sensors**

- **Figure 1.** Overview of individual components of the SMART Belt.
- **Figure 2.** SMART Belt sensors and design.
- **Figure 3.** Comparison of SMART Belt respiration sensor vs. commercial sensor shows accuracy in breath detection.
- **Figure 4.** Comparison of SMART Belt EDA sensors vs. commercial sensor shows high correlation of EDA responses.

**SMART Belt Can Monitor Seizures**

- Reliably records respiration and EDA responses
- Comfortable enough for night-time monitoring
- Wirelessly transmits data
- Provides real-time visualization and analysis

**Future Work:**
1. Refine breath detection algorithm to detect events
2. Enhance user interface of smartphone app
3. Clinical testing on patients with epilepsy

**Acknowledgments**

- Dr. Maria Oden, Rice BIOE
- Steve Maschino, Cyberonics
- Dr. Shriram Raghunathan, Cyberonics

This project was funded and supported by the Osland Engineering Design Kitchen at Rice University and Cyberonics, Inc.

**References**

1. CDC 2012. Epilepsy in Adults and Access to Care — United States, 2010. MMWR 61(45):909-913