Experience: Cross-Technology Radio Respiratory Monitoring Performance Study

Peter Hillyard (Xandem Technology); Anh Luong (Carnegie Mellon University); Alemayehu Solomon Abrar (University of Utah); Neal Patwari (University of Utah, Xandem Technology); Krishna Sundar, Robert Farney, and Jason Burch (Health Sciences Center, University of Utah); Christina A. Porucznik (Department of Family and Preventive Medicine, University of Utah School of Medicine); Sarah Pollard (Department of Surgery, University of Utah School of Medicine)
Background

Need for non-contact respiration monitoring

  In-home Elder Care
  Opioid Monitoring

IoT devices in buildings allow for dual purpose data transfer and sensing
Radio frequency sensing

Goal:
How do these technologies compare to one another?
Do they perform well over long periods of time while in uncontrolled environments?
Purpose of our research

Perform comparison of RF-based respiration monitoring in an extensive side-by-side experimental study

Test on patients in uncontrolled manner

\# patients: 20

\# hours: 160

Professional annotated events

Publish data so that other researchers can develop their own algorithms
Link to data

https://doi.org/10.7910/DVN/X7AYXQ

Downloaded 305 times as of 25 Oct!!!
Current radio sensing hardware

915MHz
Single Channel CW
0.013dB RSS

3.9936 GHz
(Channel 2)
500MHz

802.15.4
2.4GHz
16 channels
1dB RSSI

2x2 MIMO
2.4GHz & 5GHz
114 subcarriers
Experimental Setup
Polysomnography Respiratory Signals

Chest

Nasal

Abs

Thermo
RF-based respiratory signals
Processing Flow Diagram

Pre-Processing → y → Channel Selection → Filtering → Motion Detection → y → Respiration Rate Estimation → \( \hat{f} \)
In the lab, things are great…

<table>
<thead>
<tr>
<th>RF Tech</th>
<th>Median $e$</th>
<th>95th pctl. $e$</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIR</td>
<td>1.32</td>
<td>11.88</td>
</tr>
<tr>
<td>CSI</td>
<td>0.60</td>
<td>11.88</td>
</tr>
<tr>
<td>RSS</td>
<td>1.56</td>
<td>12.84</td>
</tr>
<tr>
<td>SUB</td>
<td>3.36</td>
<td>13.08</td>
</tr>
</tbody>
</table>
But only when patient isn’t moving
How do you remove motion?
Stop moving!

<table>
<thead>
<tr>
<th>Motion Events</th>
<th>CIR</th>
<th>CSI</th>
<th>RSS</th>
<th>SUB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td>0.12</td>
<td>0.12</td>
<td>0.24</td>
<td>0.24</td>
</tr>
<tr>
<td>Between</td>
<td>2.22</td>
<td>3.12</td>
<td>1.0</td>
<td>7.38</td>
</tr>
<tr>
<td>After</td>
<td>0.24</td>
<td>0.12</td>
<td>0.12</td>
<td>0.12</td>
</tr>
</tbody>
</table>
Questions?

Research reported in this publication was supported in part by the National Institute on Drug Abuse of the National Institutes of Health under Award Number #DA041960 and by the U. S. Army Research Office grant #69215CS. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH or the ARO.
BACK UP SLIDES