Intrabody Communication: Applications and Practical Issues

Kurt Partridge
University of Washington

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What is Intrabody Communication?

- Low power electrical signals sent through the human body
- Allows ubiquitous and wearable devices to communicate
- The big benefit: signal stays very close to the body
Motivating Ubicomp
Scenario: User Association
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Basic Principles
Principles Applied

transmit receive

\[ V_{out} \]
Our Implementation

- Size: 8cm x 13cm
- Power: 4 9V batteries
- Data rate: 56 kbps
- Data encoding: FSK
- Frequencies: 140 kHz and 180 kHz
- TX voltage swing: 20V peak-to-peak
Basic Experiment Setup
Coupling to the Body

Wrist Strap

Belt

Shoe
Findings

- Minimum signal amplitude for communication: 20 mV
Other Situations
Communication without Touch

- Non-touch communication is undesirable, but it happens
- One trick: reducing transmit voltage
  - Works with the shoe
  - Doesn’t work with wrist and belt because of ground plate impedance variations
Other Experiments

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raising shoe</td>
<td>2-5 times weaker signal</td>
</tr>
<tr>
<td>Changing grounding plate size</td>
<td>large plates roughly similar</td>
</tr>
<tr>
<td>Gloves</td>
<td>1-2 times weaker</td>
</tr>
<tr>
<td>Barefoot</td>
<td>little difference</td>
</tr>
<tr>
<td>Multiple transmitters</td>
<td>distinguished well</td>
</tr>
</tbody>
</table>
Theoretical Maximum BW

- Hartley-Shannon Law: max. error-free capacity:

\[
\text{capacity} = \text{bandwidth} \times \log_2(1 + \text{SNR})
\]
Application Taxonomy

1. Personal Area Networks
2. Collect Data from Environment
3. Customize Environment on per user basis
4. Customize Environment on per user task basis
## Competing Technologies

<table>
<thead>
<tr>
<th>Method</th>
<th>Examples</th>
<th>Features</th>
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<tbody>
<tr>
<td>short-range RF</td>
<td>Bluetooth, RF Monolithics</td>
<td>Ok for PAN, prob w/multiple people, eavesdropping</td>
</tr>
<tr>
<td>infrared</td>
<td>IR badges, Eye-R</td>
<td>Problems outdoors, greater power, less intentional</td>
</tr>
<tr>
<td>ID at physical user-interface</td>
<td>password, iButtons, RFID, fingerprint, barcode</td>
<td>Passive, customization stored with device, privacy issues, administrative and operational overhead, less inconspicuous</td>
</tr>
</tbody>
</table>
Health Concerns

- Short term:
  - Shock – unlikely
  - Pacemakers – may be affected

- Long term:
  - Cancer – difficult to predict, similar to power-line studies
  - Other effects -- unknown
Future Goals

- Achieve touch-only communication
- Increase speed
- Build a deployable board
- Evaluate in practical environment
Conclusions

- Intrabody communication may provide ubicomp with touch-selective communication
- Watch for new results over the next several months

- Visit us on the web at:
  http://portolano.cs.washington.edu/projects/contact
Other Findings

- Using the other hand with the wrist coupler reduced signal strength by 0.5
- A portable PDA has a weaker signal, but was position-dependent
- Grounding or putting a conductive plate down helps a lot
- Touching both xmit plates generates a strong signal w/wrist and belt only
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