RSS Step Size: 1 dB is not Enough!

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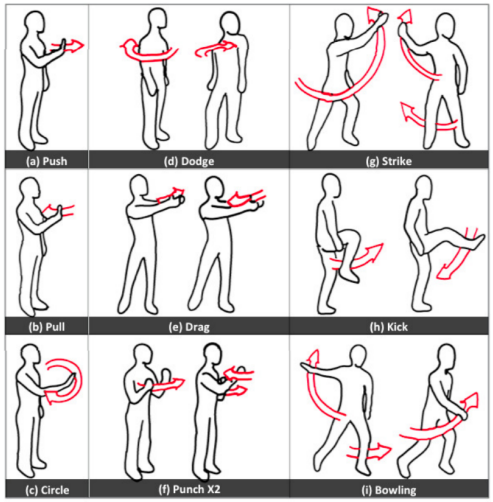
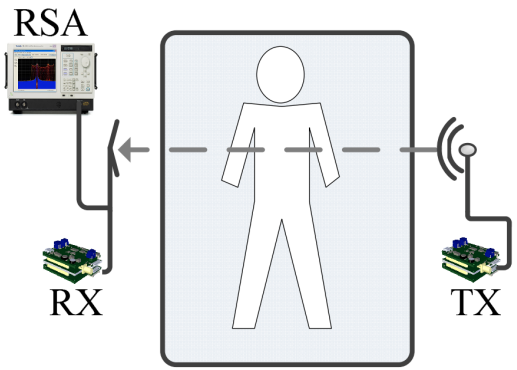
[1]University of Utah, [2]Xandem Technology

HotWireless'16

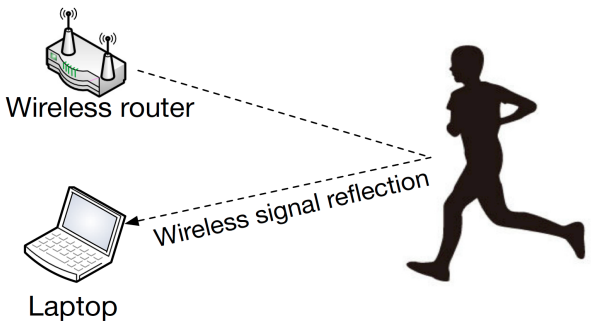
Applications of RF Sensing



Q. Pu et al. "Whole-home gesture recognition using wireless signals", MOBICOM 2013.



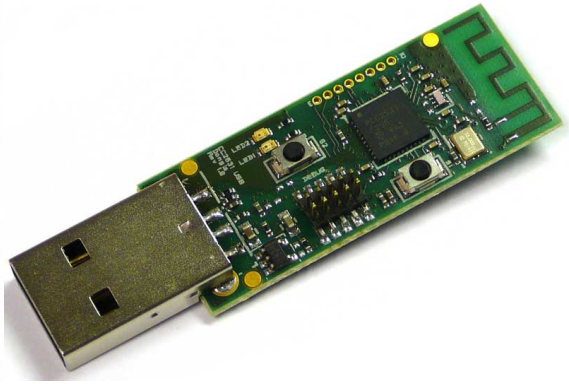
O. Kaltiokallio et al. "Non-invasive respiration rate monitoring using a single COTS TX-RX pair", IPSN 2014.



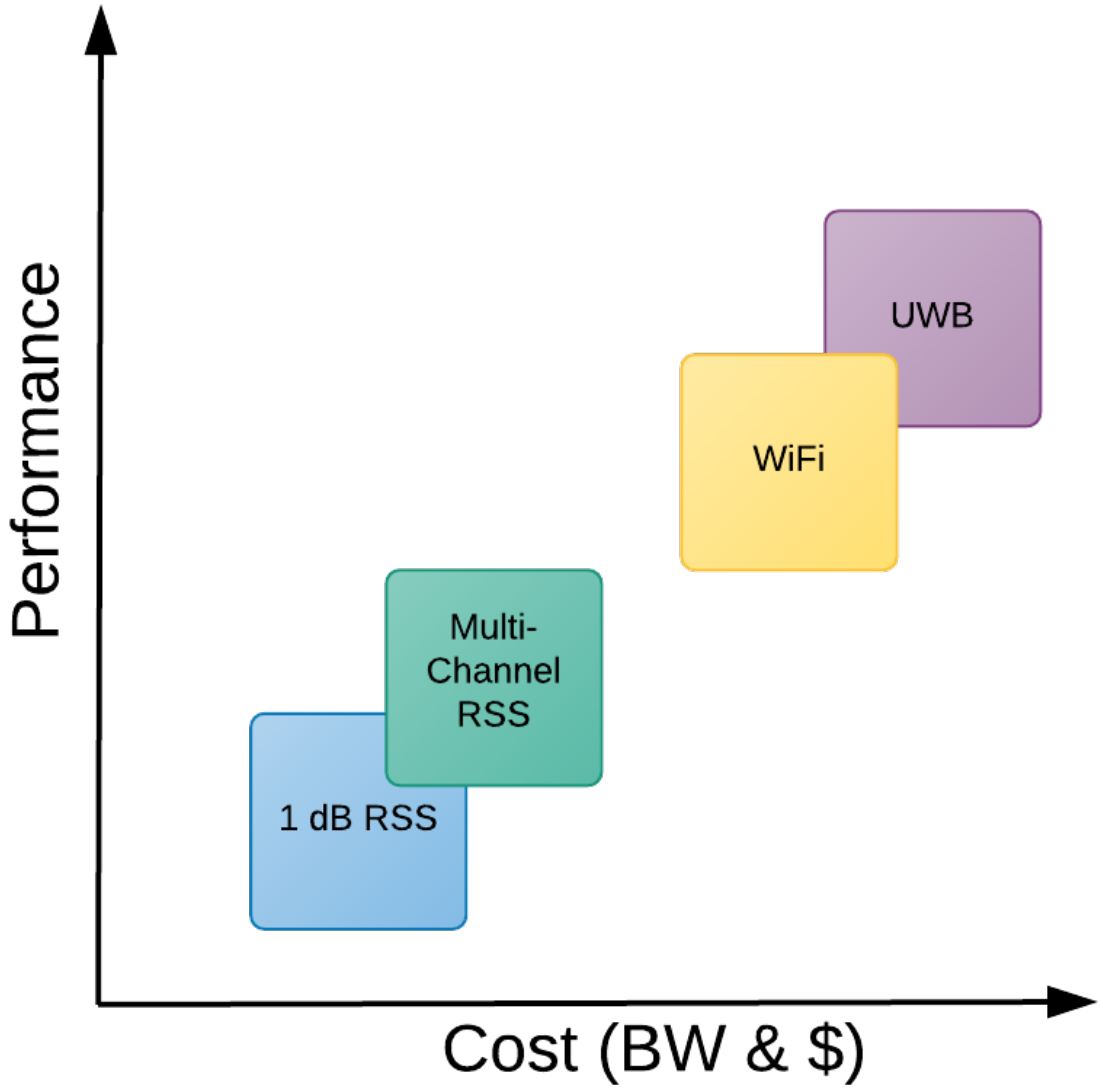
W. Wang et al. "Understanding and modeling of WiFi signal based human activity recognition", MOBICOM 2015.

Future: Ubiquitous RF Sensing

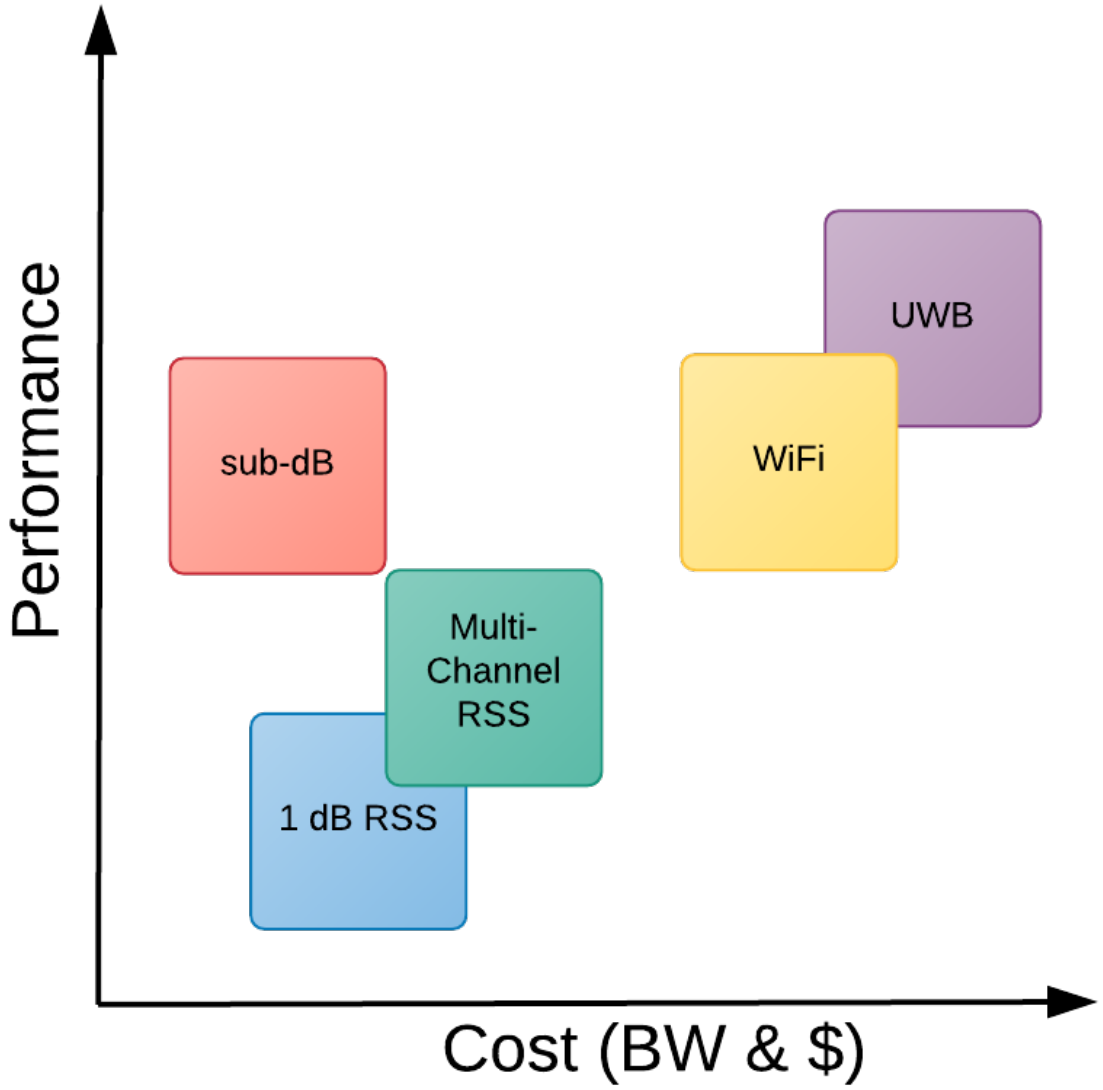
Standard RF Sensors



RF Sensing Tradeoff Space



RF Sensing: sub-dB



Outline

1. sub-dB
2. Breathing Monitoring
3. Gesture Recognition
4. Conclusion

sub-dB CC1200 Prototype

Processor:

- CC1200 Evaluation Board
- Beaglebone Black (BBB)

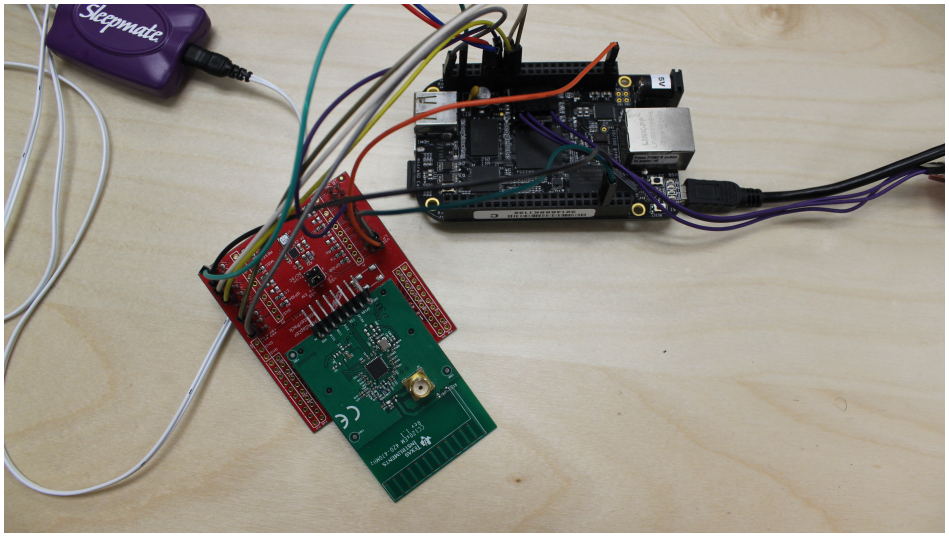
Datasheet:

- 12 bits / 0.0625 dB

Empirical study:
4 least significant bits / 1dB
IQ Sample

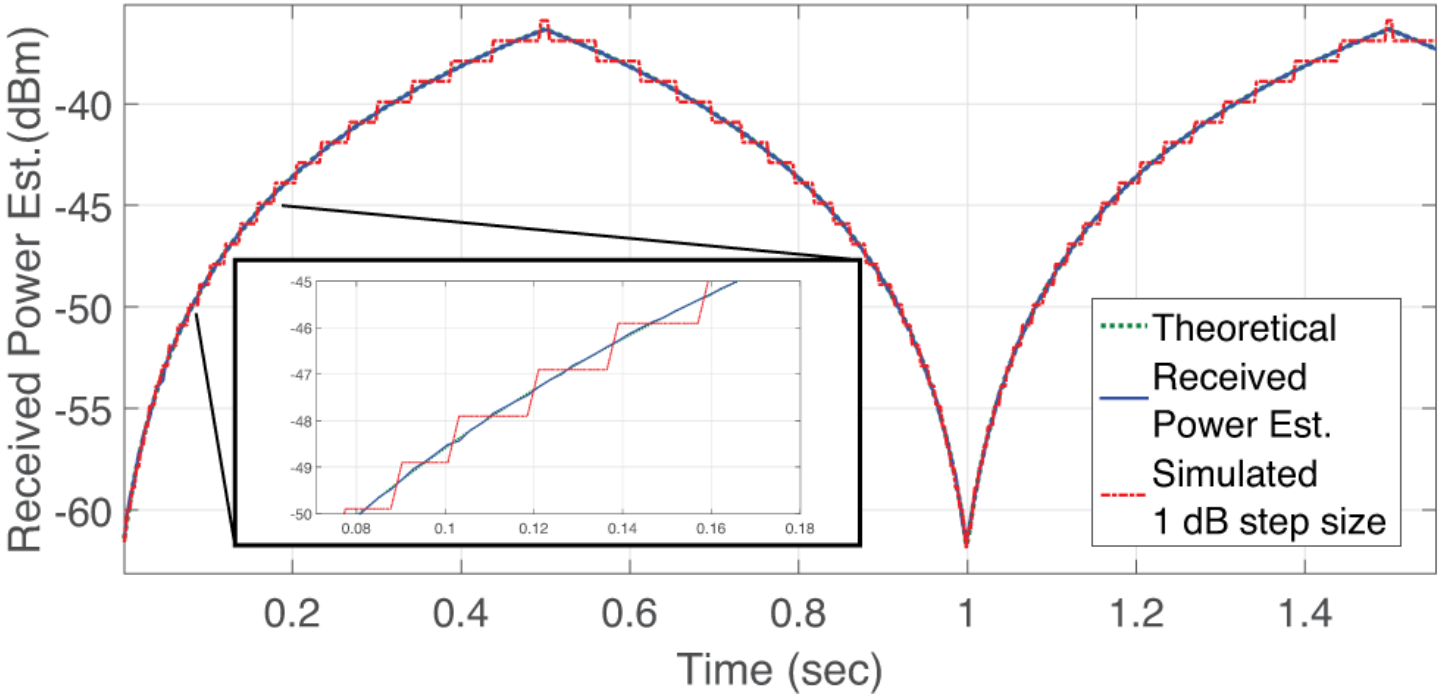
- 17 bits Magnitude

Programable Real-time processing Unit (PRU)
348 samples per sec

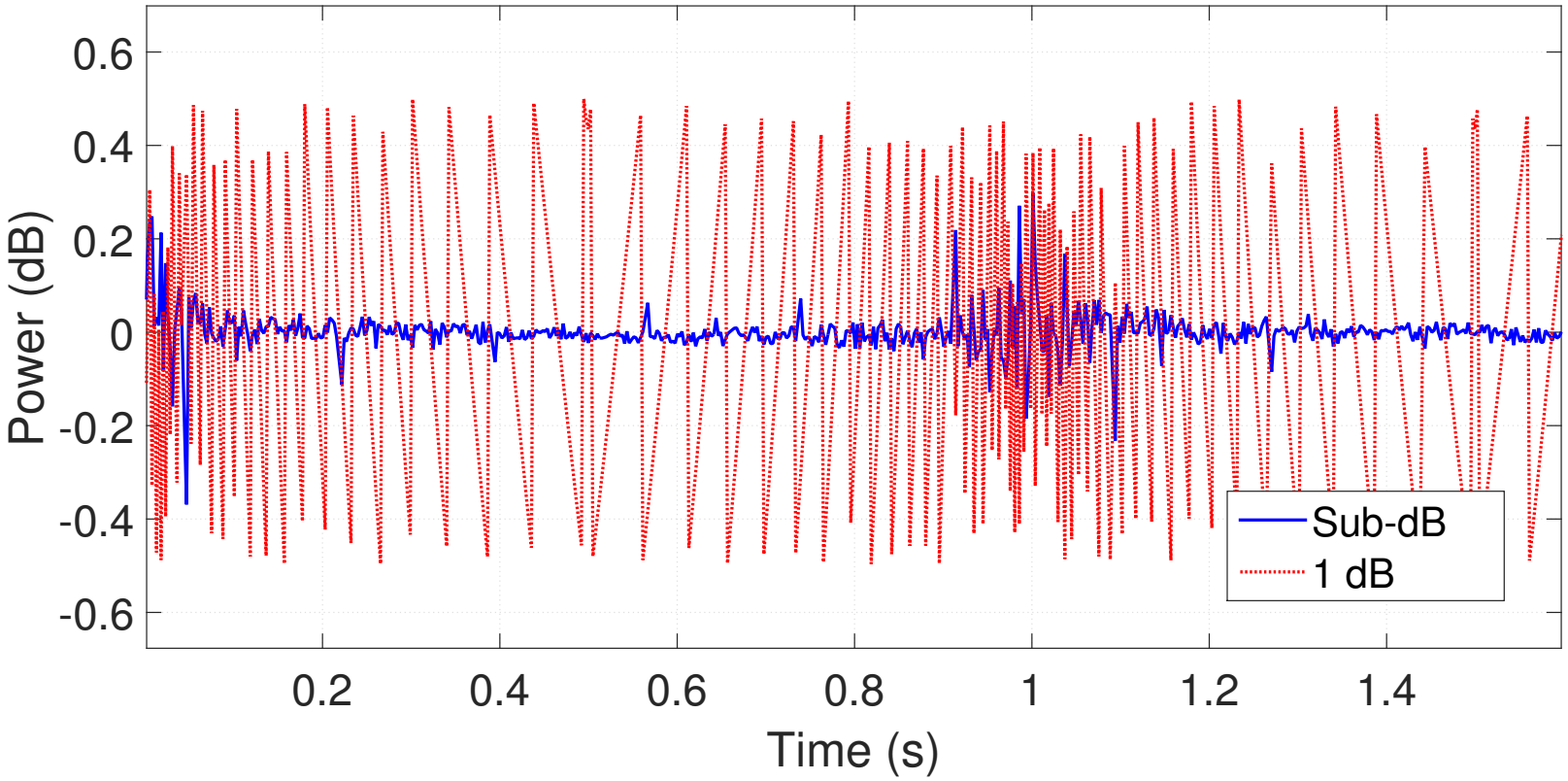


RSS Calculation and Verification

- $\text{RSS} = \frac{\sum_{n=0}^{K} |Magnitude_n|^2}{K} - G$
  with K samples, G amp gain
- Test with known generated signal



sub-dB Errors



sub-dB MME: 0.013 dB

1dB: 0.25dB

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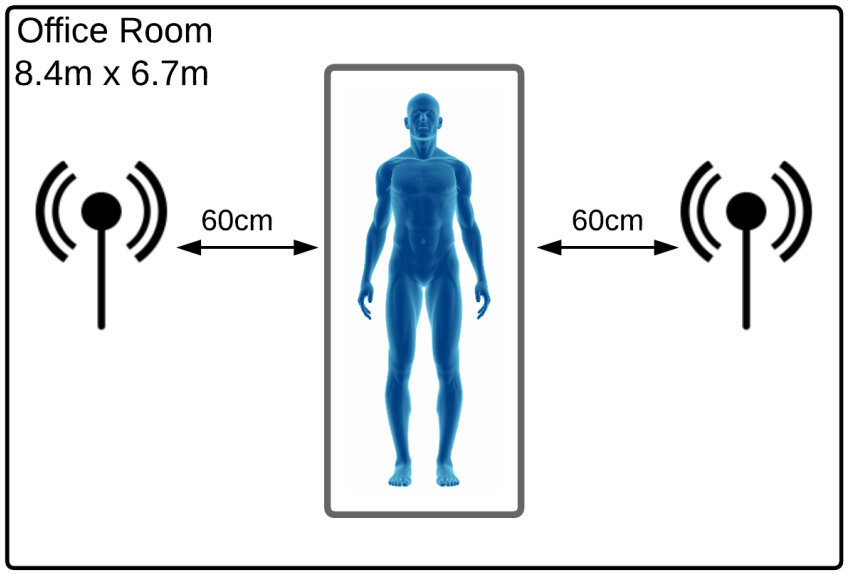
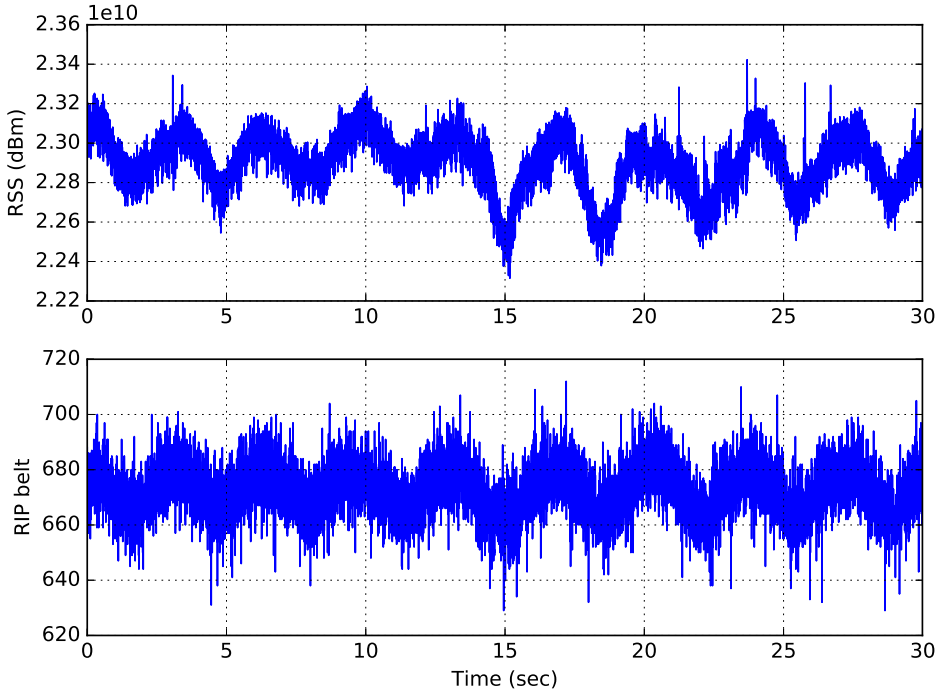
Breathing Monitoring

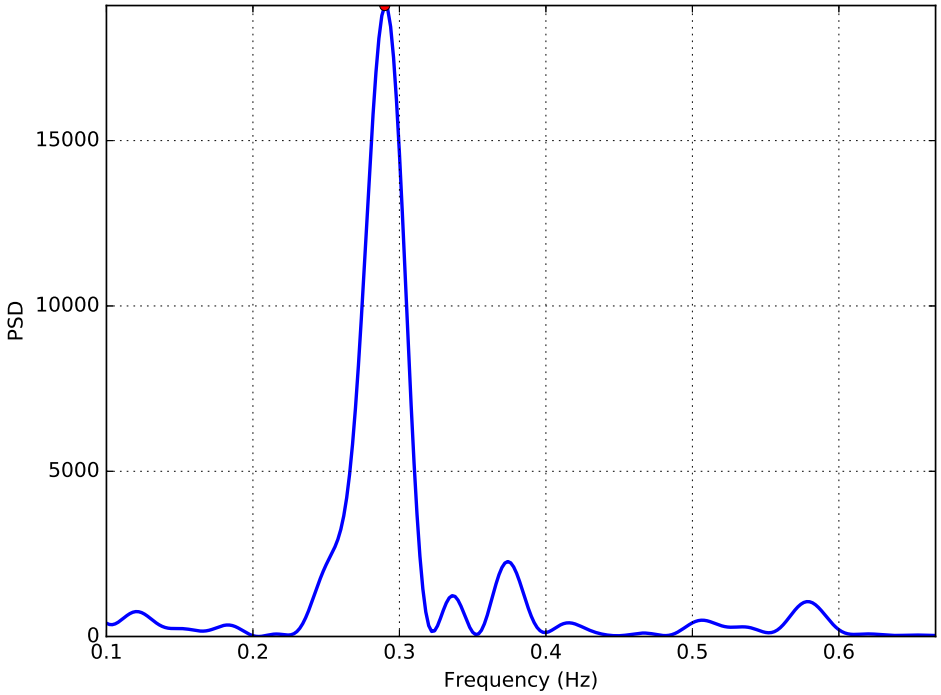




Experimental Setup:

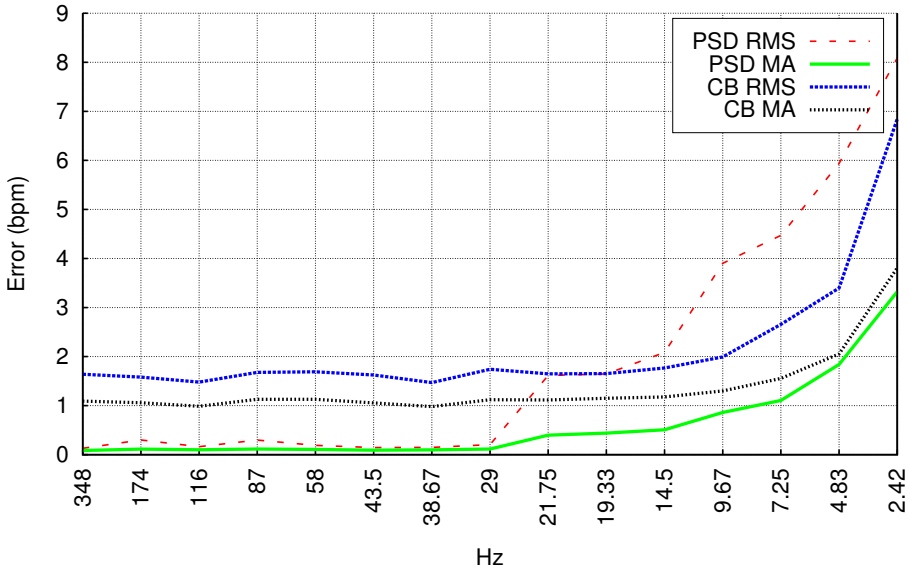
- CC1200 TX 434 MHz, sub-dB RX
- Ground truth via respiratory inductance plethysmography (RIP) belt

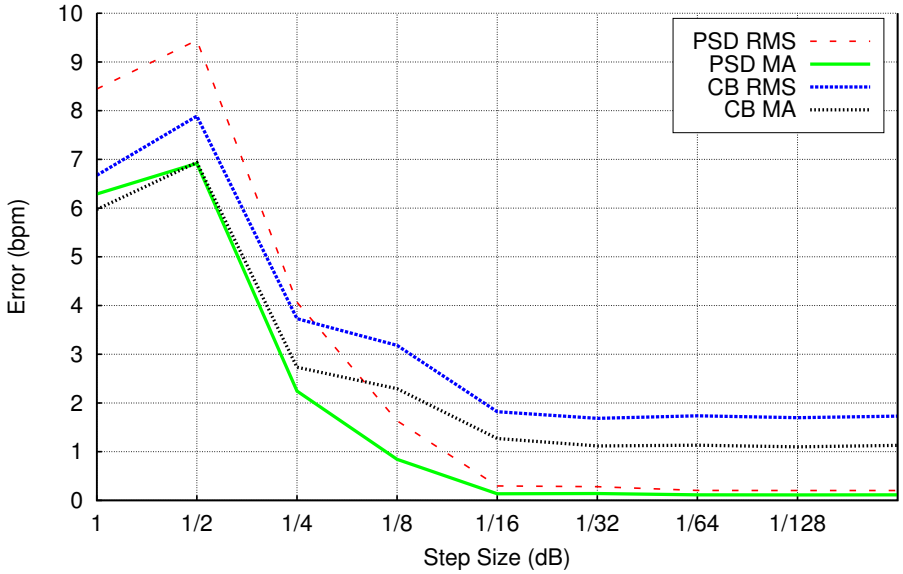
Breathing Monitoring Algorithm



Oversampling & Quantization for Breathing

For breathing monitoring, high accuracy requires:





Sampling rate
$\geq$29 Hz

Quantization step size
$\leq$1/16 dB
($\geq$ 12 bits)

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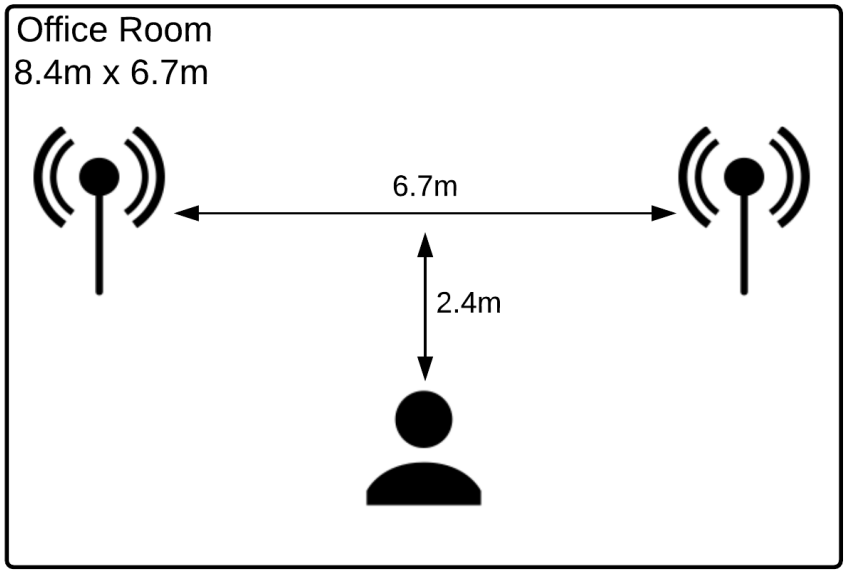
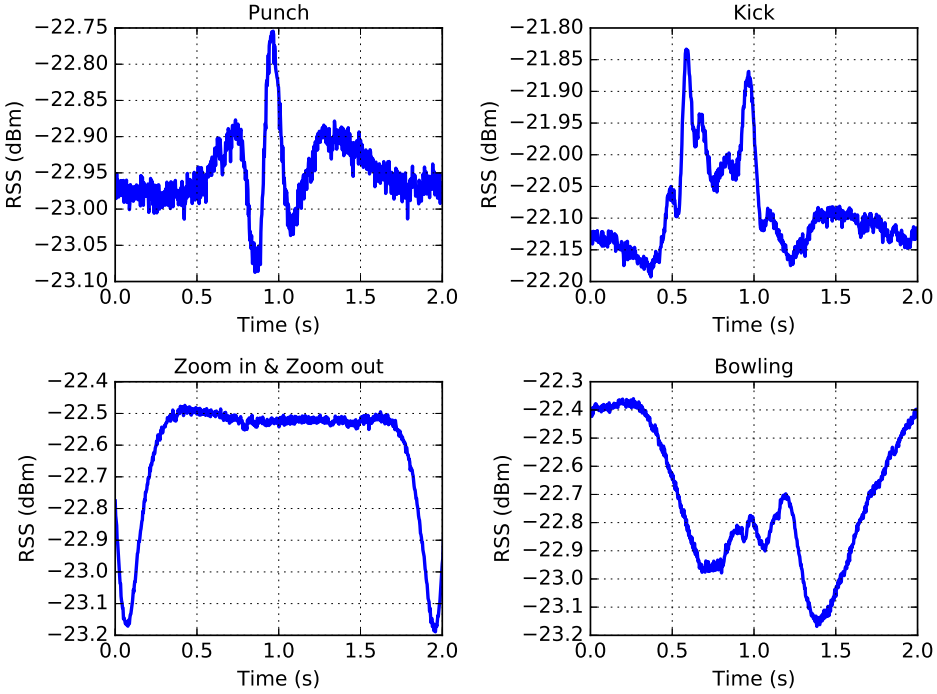
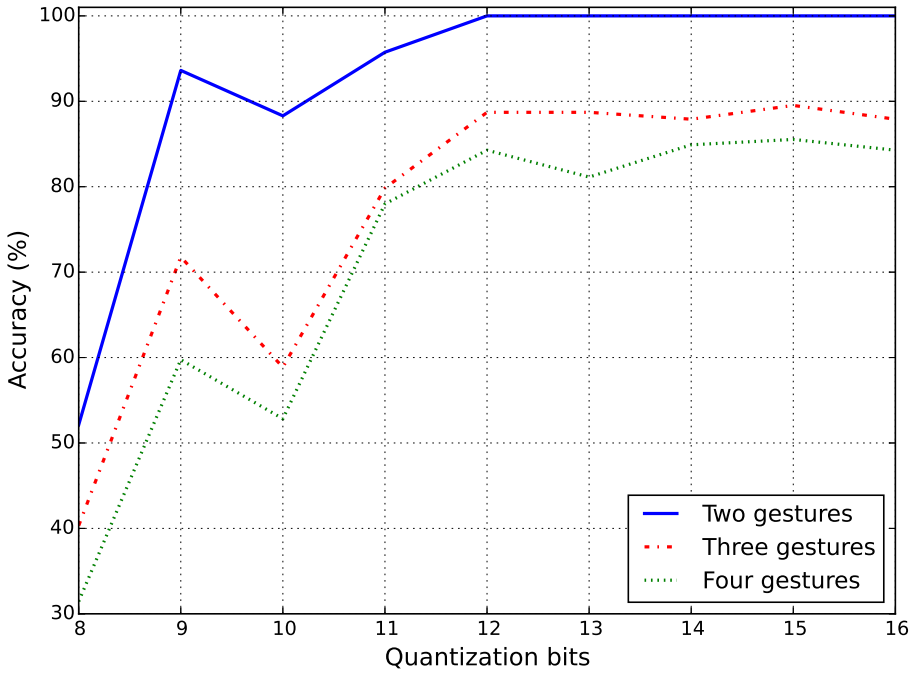
Gesture Recognition





Gesture Recognition Evaluation



Features:

- Variance
- Skewness
- 8 percentiles (5th to 95th)
- PSD for 3 different bands

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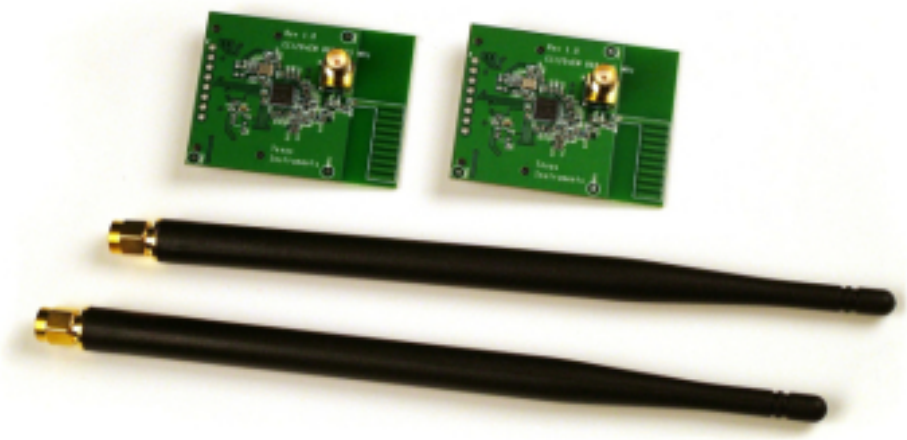
Recommendations

- Chip Designer:
  - smaller step size (1/16 dB or 0.0625dB)
- Application Designer:
  - Pick IC with 12 bits RSSI
  - IQ Sample



Conclusion

Ubiquitous RF Sensing

Thank you

This material is based upon work supported by
the U.S. National Science Foundation
under Grant Nos. #1329755 and #1407949.

Visit `span.ece.utah.edu` for more information

Breathing Monitoring Code is available at:
`https://github.com/SPAN-UofU/rub`

PRU Code is available at:
`https://bitbucket.org/anh_luong/pru`