Micro-radar Wearable Respiration Monitor

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Motivation: Lack of Portable Breathing Rate Monitors

Portable respiration monitoring devices are required for continuous breathing rate monitoring, which is useful in evaluating breathing disorders symptoms.

- Existing devices:
  - Nasal mask: uncomfortable and intrusive
  - Chest strap: hindering chest wall movement, might cause obstructive breathing problems
  - Radar deployed in room: interfered by environmental noise

Proposed Solution: A Radar-based Wearable System

- Micro radar
- Non-intrusive
- Wireless
- Wearable

System Architecture

- 24 GHz continuous wave Doppler radar sensor
  - Facing toward chest to minimize environmental interference
  - With I/Q channels to discriminate movement direction
- Custom active analog filter circuit
  - Targeted range: 0.2Hz - 0.6Hz (Doppler shift by extreme chest movement)
  - Design: 2.5 Hz bandwidth with a net gain of 50 dB
- Spark Core module: ADC, micro-controller, WiFi

Signal Processing

Raw radar signals of respiration captured in our system:
- Noisy but periodic pattern is visible

Using moving average filter:
- Window size is chosen to be less than or equal to half of desired signal, which typically ranges from 1.5 s to 3.5 s, to avoid losing actual data.

Breathing rate estimation with peak detection:

Frequency analysis of the respiration signal:

Not accurate by looking at the maximum since breathing period vary over time, which might generate multiple peaks

System Evaluation

- Golden standard: Neulog chest band system
- 10 adult subjects
- Subjects are sitting stably in static environment

Breathing rate estimation

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<th>Peak Analysis Based</th>
<th>Golden Standard</th>
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