Contactless Infant Monitoring using White Noise

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CAN SMART SPEAKER MONITOR INFANTS?



Rapidly increased adoption of smart speaker It is estimated that more than 200 million smart speakers get sold by 2019

SMART SPEAKER AS ACTIVE SONAR SYSTEM

Microphone array

Speaker



➢Infants can hear it! High-frequency sound causes headache,

Microphones pick up the reflections, extract the motion and respiration from time-of-arrival

• Infants are small!

nausea, etc.

 Reflections and motion are too weak to be extracted

WHITE NOISE ON SMART SPEAKERS

- Use white noise to help improve infant sleep, as well as monitoring respiration and motion
- Leverage multiple microphones to extract weak respiratory signal









The transformation preserves multipath information so that we can extract time-of-arrival using FMCW decoding algorithms

RECEIVER BEAMFORMING WITH TERNARY SEARCH

> Naïve solution: search every direction and choose the one with best respiratory signal score:

> Power within normal respiratory frequency range, divided by total power

- Ternary search: Reduce searching range by 1/3 every step and shift to higher frequency band
- \succ O(n) \rightarrow O(log(n)), runs on a Raspberry Pi in real time











REFERENCES 8-sp-detail, 2019. [2] Nandakumar, R., Gollakota, S., and Watson, N. Contactless sleep apnea detection on smartphones. MobiSys (2015), ACM, pp. 45–57. [3] Wang, A., Sunshine, J., and Gollakota, S. Contactless infant monitoring using white noise. MobiCom (2019), ACM.

IMPLEMENTATION



\$2 speaker transmitting at up to 59dB

MiniDSP 7-mic array [1]

EVALUATION

> We test different distances, respiratory rate, etc. on a \$25,000 infant simulator





We also tested on five infants in UW Medical Center NICU

Interclass correlation (ICC):0.938



[1] UMA-8-SP USB Microphone Array. https://www.minidsp.com/ products/usb-audio-interface/uma-