基于消费级UWB设备的细粒度无线感知

Embracing Consumer-level UWB-equipped Devices for Fine-grained Wireless Sensing

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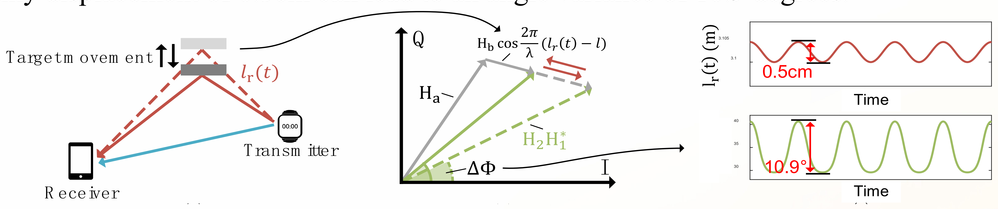
Motivation

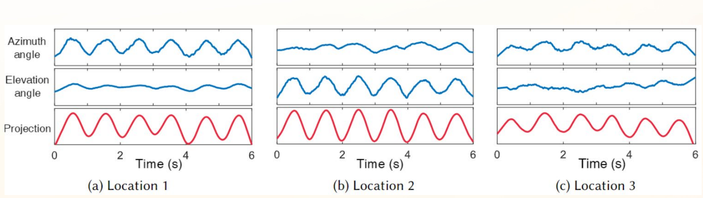
- More and more consumer-level electronics such as smartphones and smart watches are now equipped with **Ultra-Wideband** (UWB) chips. From 2019, UWB chip has been a default component in iPhone. Apple further added UWB chip to Apple Watch, HomePod mini (Apple's smart speaker) and AirTag.
- Following this trend, Samsung and Xiaomi also include UWB chips into their products including **Galaxy Note 20, Note 20 Ultra, Xiaomi MIX 4, Xiaomi sound smart speaker and Mi TV.**

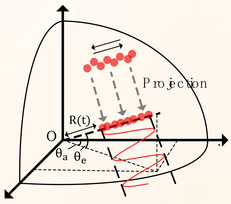
UWB Sensing on Consumer-level Electronics

- We showcase an exciting opportunity to realize RF sensing on consumer-level devices (e.g., smartphones) for the first time.
- However, on consumer-level electronics only the distance and angle information can be extracted. We introduce how to realize RF sensing **without** requiring the raw signal amplitude and phase information.
- **Principle of sensing on consumer-level devices:** There is a **quantitative relationship** between the **target motion** and the **angle change** reported by the UWB device. Even a tiny displacement of 0.5cm can lead to an angle variance of 10.9 degrees.



- **Signal projection in 3D space:** we employ **Principle Component Analysis(PCA)** to project data variations at different directions to 1D space, obtaining the largest signal variation for optimal sensing performance.





Evaluation & Results

- We implement our system on **iPhone** and **Apple Watch** based on Apple's Nearby Interaction API.
- We conduct benchmark experiments to comprehensively study the effect of various factors, including **sensing granularity, device placement, and multi-target sensing**.
- We deploy and test our system in several challenging real-life scenarios. The experimental results show that the accuracies of respiration detection are all above **98%** in these scenarios.