Indoor human localization and identification using commodity WiFi

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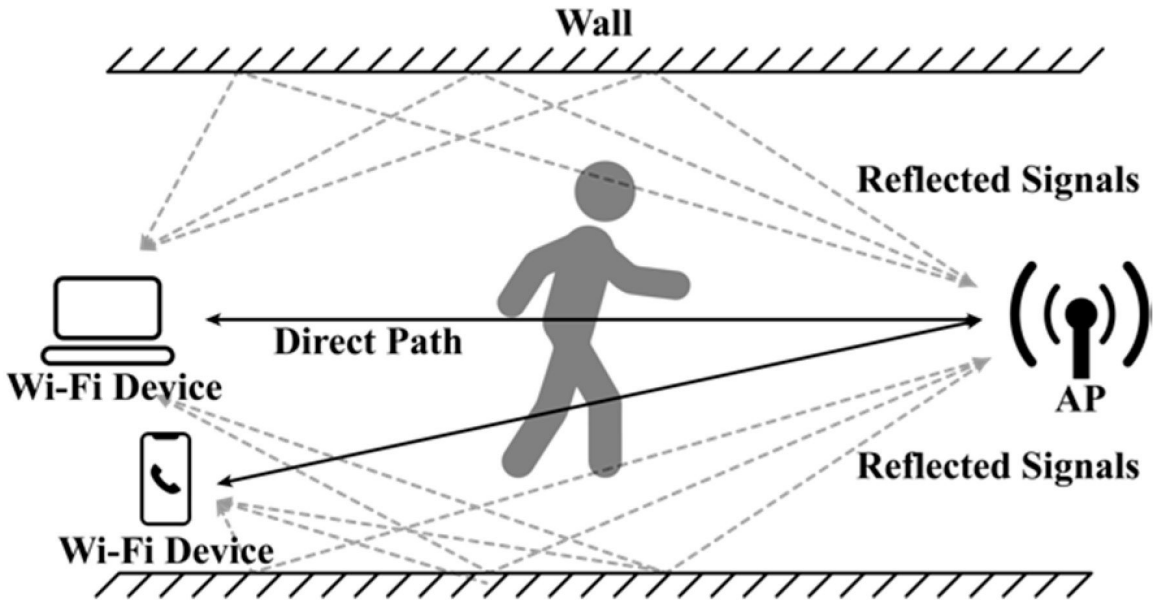
Background

- Radio Frequency, after getting transmitted, it usually got reflected, refracted, diffracted, absorbed, and scattered by objects and people in the environment before being received.
- It leads to the possibility to detect or use radio frequency as a visualization sense to interpret current situations in the physical world.



Background

- WiFi sensing reuses the infrastructure that is used for wireless communication, so it is easy to deploy and has low cost plus it can be considered a passive method in both LoS and NLoS, as users are not required to be mounted with any wearable devices
- Unlike sensor-based and video-based solutions, WiFi sensing is not intrusive or sensitive to lighting conditions.

Purpose

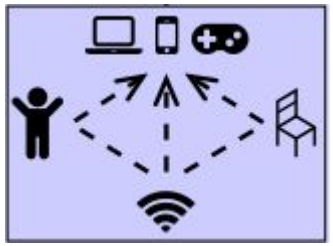
- To build an accurate non-invasive sensing application for localization and identification

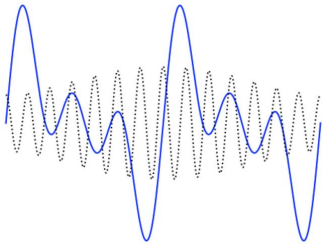
Enabling Technology

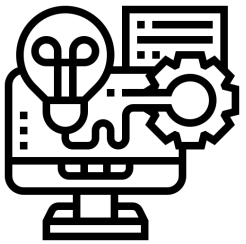
- OFDM, Orthogonal Frequency Division Multiplexing is a form of signal waveform or modulation that provides some significant advantages for data links.
- MIMO (multiple input, multiple output) is an antenna technology for wireless communications in which multiple antennas are used at both the source (transmitter) and the destination (receiver).
- CSI represents how wireless signals propagate from the transmitter to the receiver at certain carrier frequencies along multiple paths.
- A time series of CSI measurements captures how wireless signals travel through surrounding objects and humans in time, frequency, and spatial domains.

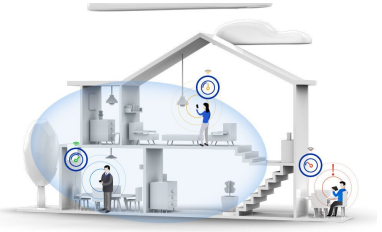
General Method

Input	Signal Processing	Algorithms	Application
Channel State Information	• Noise Reduction • Signal Transform • Signal Extraction	• Modeling-based • Learning-based • Hybrid Model	• Localization • Identification



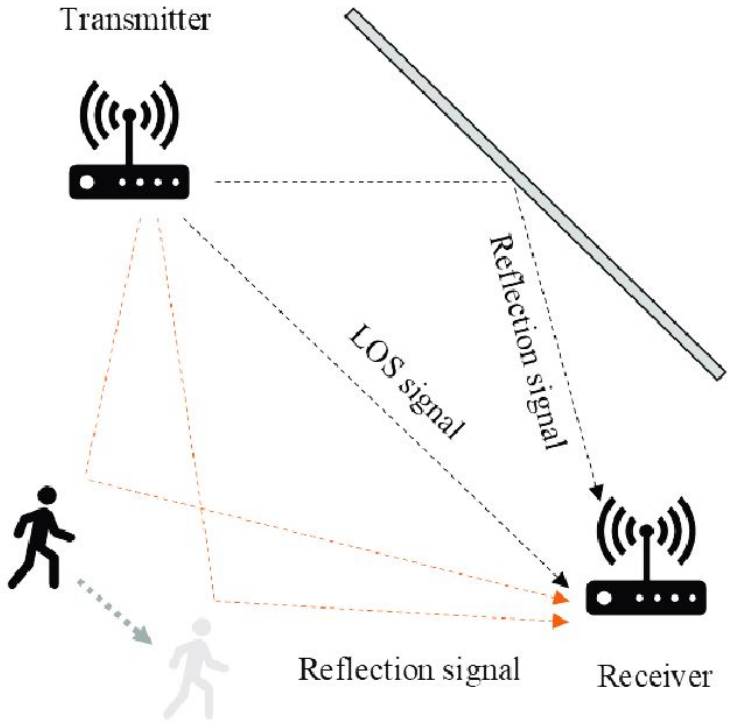






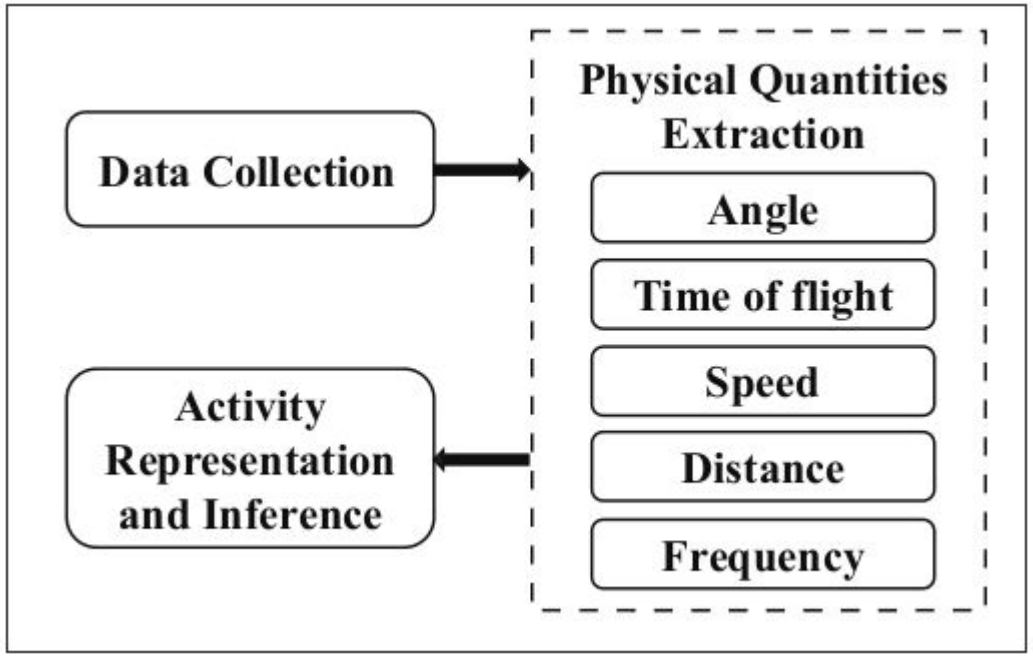
Input Data

- Although CSI is included in WiFi since IEEE 802.11n, it is not reported by all off-the-shelf WiFi cards.
- Two well-known CSI Tool to extract CSI are 802.11n CSI Tool and Atheros CSI Tool which can operate at 2.4GHz and 5GHz



Signal Processing

- **CSI amplitude variations in the time domain** have different patterns for different humans, activities, gestures,and human identification/authentication
- **CSI phase shifts in the spatial and frequency domains**, transmit/receive antennas and carrier frequencies, are related to signal transmission delay and direction, which can be used for human localization and tracking

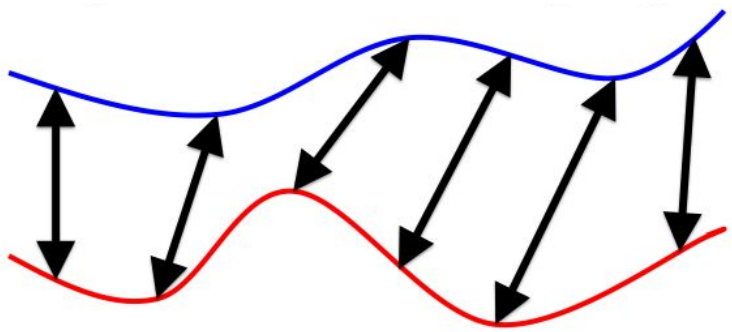


Algorithm for Localization Application

- Modeling-based algorithms are based on physical theories like statistical models
- AoAs and ToFs are two popular models for CSI-based tracking and localization

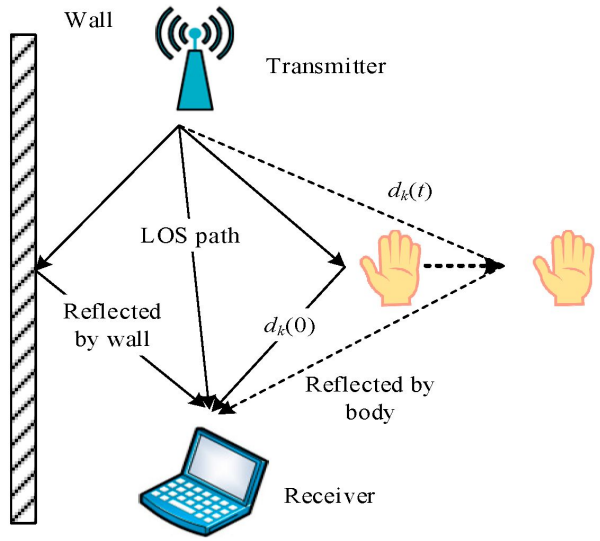
Algorithm for Identification Application

- Binary and multi-class classification applications usually use learning-based algorithms. These algorithms try to learn the mapping function using training samples of CSI measurements and the corresponding ground truth labels.
- Dynamic Time Warping and DNN are most commonly used



Promising Application

- Localization and Authentication Systems - Tracking and Identification System
- Vital Sign Monitoring Systems - Healthcare System
- Gesture Recognition Systems - Human-Computer Interaction
- Human Activity Recognition Systems - Human Computer Interaction



Challenges

- Coexistence of WiFi Sensing and Networking
- Robustness and Resolution
- Privacy and Security

Open Opportunities

- Wireless Sensing for Multi-Person Scenarios
- Wireless Sensing via Multi-Source Data
- Wireless Sensing for other species

Collaboration

- Joint data/signal collection setup (Various Scenario)
- Joint research and publication on resolution enhancement of the sensing application
- Joint development of sensing application using collected data/signal

Thank you for your attention!

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