Seeing With WiFi: Exploring the State and Prospects of WiFi Sensing

An Introduction

Oscar Dahlqivst, Anakha Krishnavilasom Gopalakrishnan, Yuxuan Cui

WiFi Sensing, What is it?

Commercial Interest

Broadcom[1]

Verizon[2]

1 https://aerial.ai/resources/aerial-available-on-broadcom-ap-and-mesh-solutions
2 https://wifinowglobal.com/news-and-blog/verizon-fios-launches-wi-fi-sensing-service-powered-by-origin/

Sensing Uses


Smart Homes


Security


Transportation


Healthcare

Retail Analytics

WiFi sensing vs Cameras

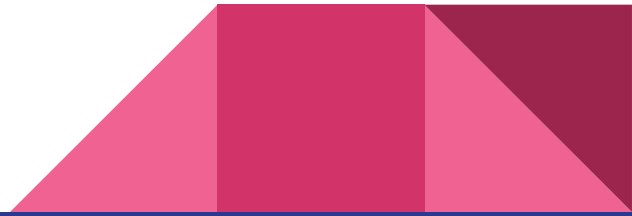
1. Privacy

2. Non Line-Of-Sight

Background

WiFi Frequencies

- WIFI is defined by IEEE 802.11, such as IEEE802.11a, IEEE802.11b……
- WiFi devices only use a specific set of frequency ranges. Most commonly around 2.4 and 5 GHz.



Sensing Metrics

Received Signal Strength Indicator (RSSI)

Channel state information (CSI)

Sometimes Other

Sensing Techniques

Modeling based:

Derived from physical theories or statistical models

Y=f(CSI)

Learning based:

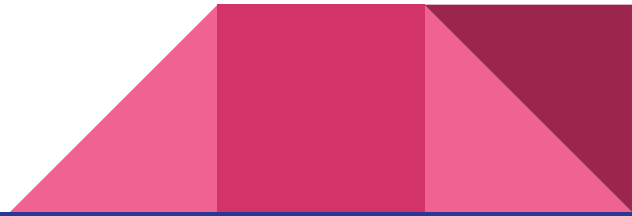
Machine learning

IEEE 802.11 bf

New standard specially provide for WiFi sensing.

Cooperation between devices offers a lot of potential.

But it is still an ongoing project



Findings

Some examples of WiFi sensing tasks

Sensing application	Example
Environment sensing	Temperature
Activity Recognition	Pose
	Gesture
Position & Movement	Localization
	Speed Estimation
	Human Counting
Human Health	Respiration
Food and Agricultural	Fruit Ripeness

Achieve at least 90% accuracy in their desired tasks, even in though-the-wall situations [3].

3) C. CHEN, Z. GANG, and L. YOUFANG, “Cross-domain wifi sensing with channel state information: A survey.” ACM Computing Surveys, vol. 55, no. 11, pp. 1 – 37, 2023

Proposed commercial uses

Smart Homes:

Detect when individuals have arrived home, and when they have left

Power down appliances and devices motion detection accordingly.

Smart Transportation:

Monitor parking spots and detect when they become available.

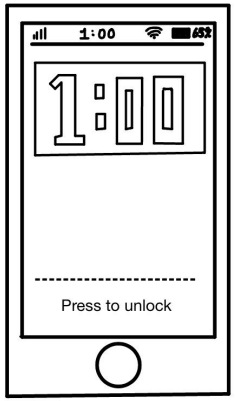
Healthcare:

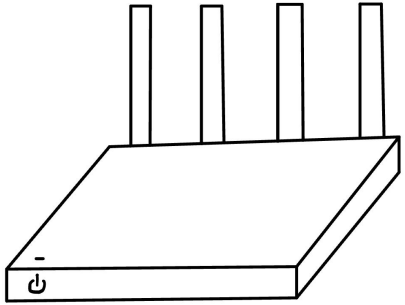
Monitoring the movements of patients and staff.

Hardware

Examples of hardware categories

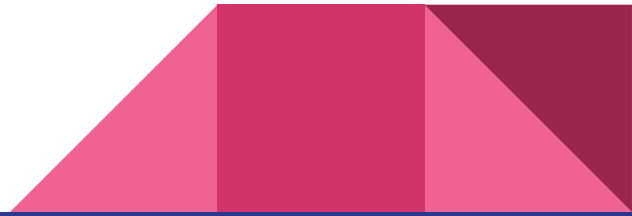
Network Card	Intel 5300 NIC
Mobile Phone	Google Nexus
IoT Device	ESP32
Specialized	Horn Antenna





Product Realisation

There is yet no mature commercial product that uses WiFi sensing.



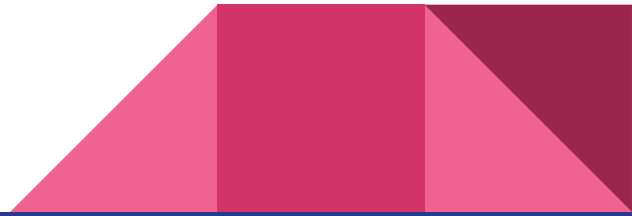
CHALLENGES

1) Cross Domain Adaptability

2) CSI Unavailability

3) Privacy Concerns

4) Costs



Cross Domain Adaptability

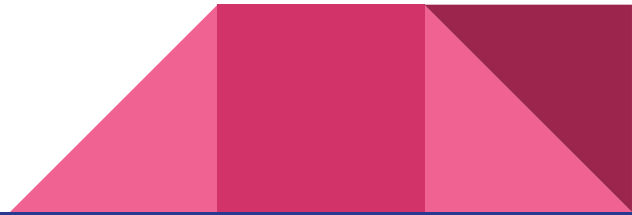
- WiFi sensing needs to adapt to new environments without retraining.
- Challenges include adjusting to new devices, noise, room layout, user size and movement, transmitter positions, and interference.
- Current solutions struggle with even slight changes in the environment.

CSI Unavilability

- CSI is the preferred metric but not always accessible. Since IEEE 802.11ac, which released in 2013, CSI has not been a part of the standard.

- Newer WiFi standards do not provide CSI.

- Research is ongoing to improve models based on beamforming weights, but they have limitations compared to CSI.



Privacy Concerns

- WiFi sensing involves collecting and storing sensitive data about individuals' location, behavior, and identities.
- Data can be used to build detailed profiles without consent or awareness.
- Raises ethical concerns about data collection, transparency, and accountability.

Costs

- Hardware costs
- Infrastructure costs
- Deployment costs
- Integration costs

Summary

- Smart Homes
- Security
- Transportation
- Healthcare
- Retail Analytics

Modeling based:

Algorithms are derived from physical th
on empirical measurements.

Learning based:

WiFi sensing refers to the use of machir
meaningful information from WiFi signa

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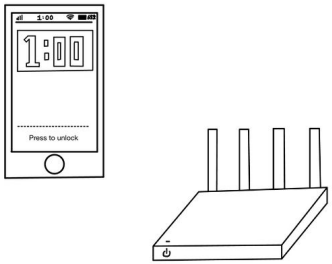

CHALLENGES

1) Cross Domain Adaptability
2) CSI Unavailability
3) Privacy Concerns
4) Costs

Conclusion

- Many Uses
- High Accuracy
- Cross Domain
- Costs
- CSI

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Questions

Sources

1. https://aerial.ai/resources/aerial-available-on-broadcom-ap-and-mesh-solutions
2. https://www.prnewswire.com/news-releases/linksys-introduces-first-to-market-motion-sensing-mesh-wifi-technology-300934025.html
3. C. CHEN, Z. GANG, and L. YOUFANG, “Cross-domain wifi sensing with channel state information: A survey.” ACM Computing Surveys, vol. 55, no. 11, pp. 1 – 37, 2023