AI/ML for communication assisted sensing in 802.11 networks

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Outline

- Communication assisted sensing in 802.11
- The role of AI/ML
- Application examples
- Technical challenges and transformations

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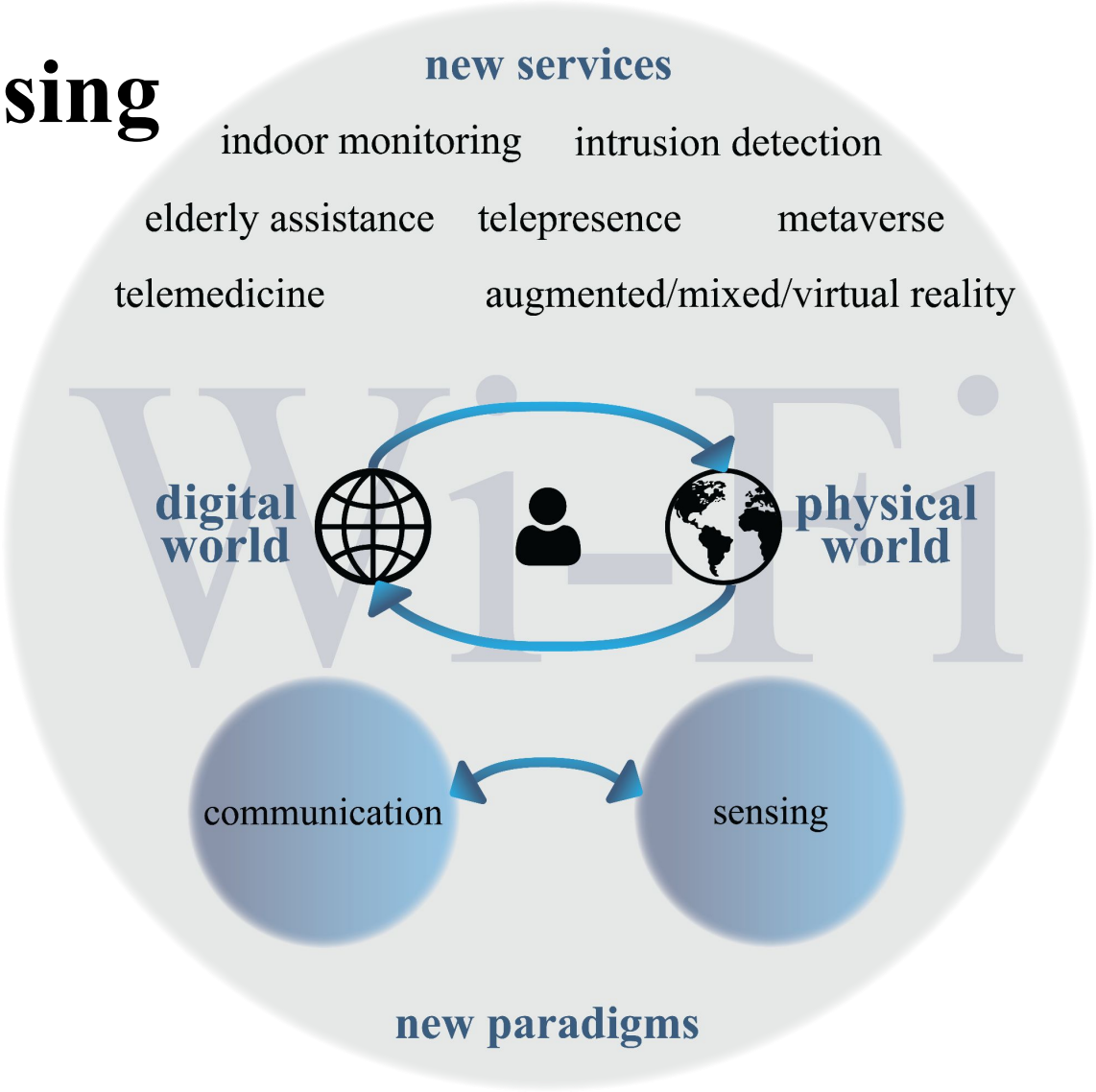
Communication assisted sensing

- IEEE 802.11bf will not define algorithms for sensing → left to implementation and open to research



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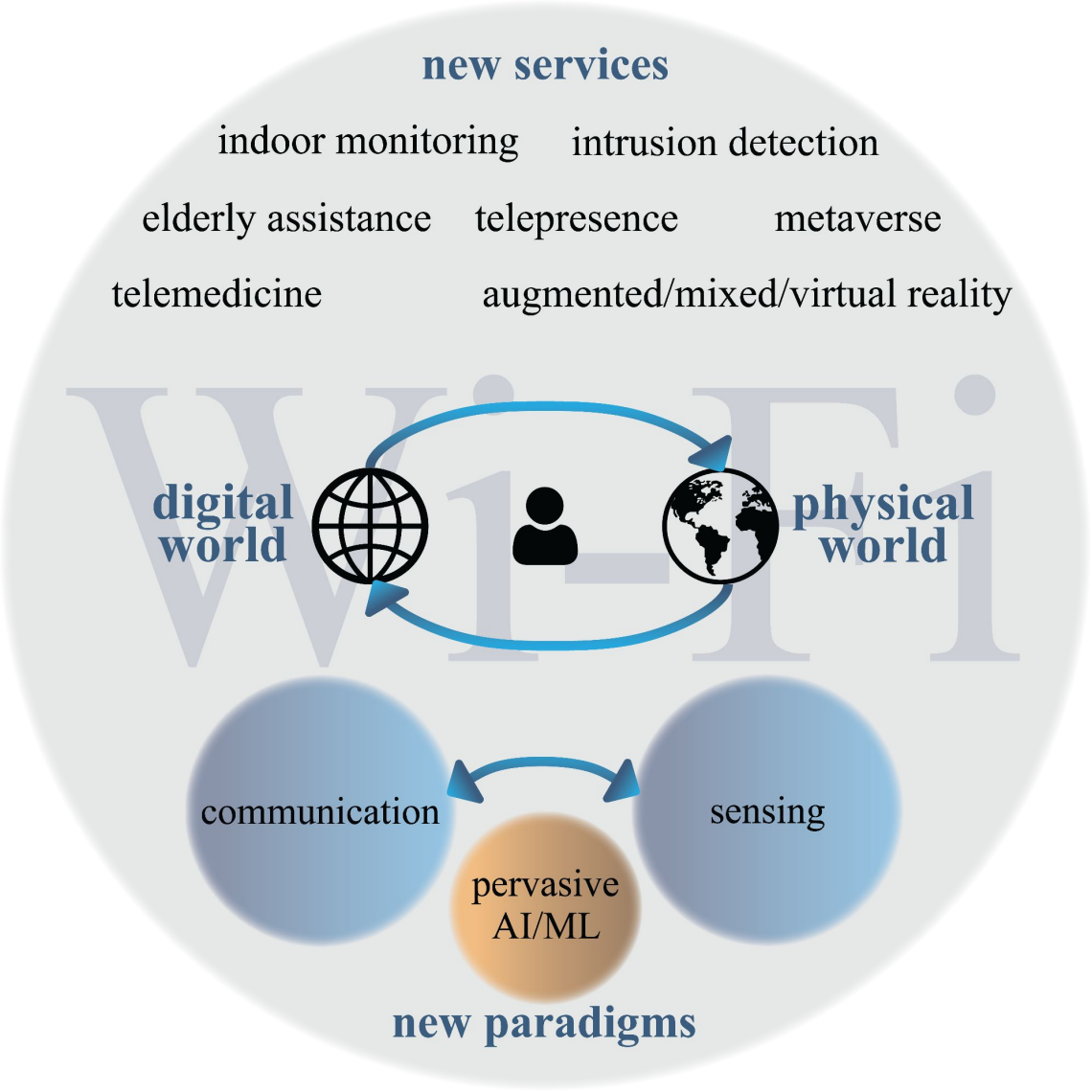
The role of AI/ML

- Complexity sensing tasks
- Complexity of radio signal propagation (multi-path)
- High amount of channel data to be processed
- Plug and play algorithms



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Examples of application - key observations

The **channel frequency response (CFR)** is affected by

- the presence of obstacles – fixed and moving objects and people – in the environment → **SHARP**
- TX / RX hardware imperfections → **DeepCSI**

AI/ML algorithms can be used to capture and classify those features

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Examples of application - 1/2

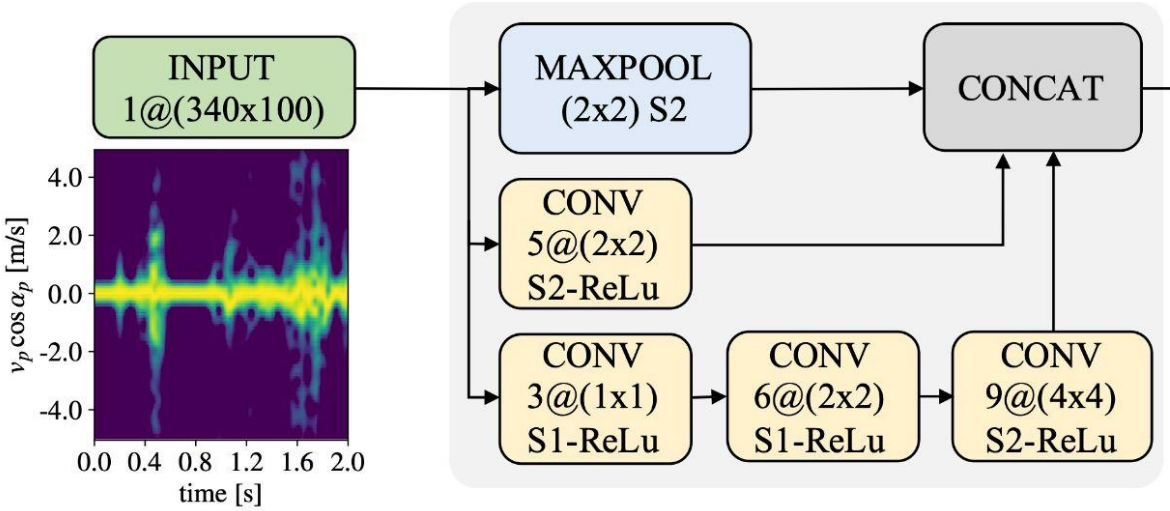
F. Meneghello, D. Garlisi, N. Dal Fabbro, I. Tinnirello and M. Rossi,

"**SHARP**: Environment and Person Independent Activity Recognition with Commodity IEEE 802.11 Access Points"

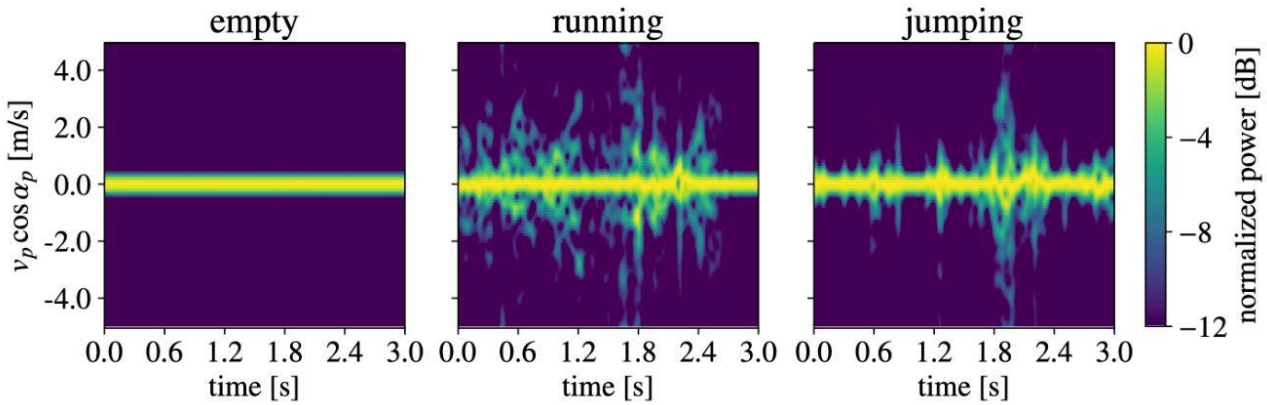
IEEE Transactions on Mobile Computing 2022

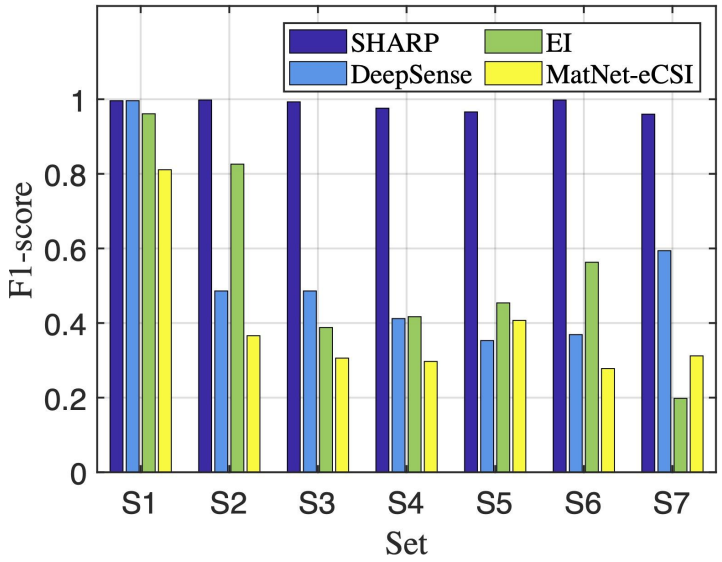
Objective: environment/people independent human activity recognition through 802.11 routers

SHARP main idea: leverage the Doppler effect to remove the contributions of static obstacles



AI/ML challenge: The CFR from commercial devices is affected by a phase offset





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Examples of application - 2/2

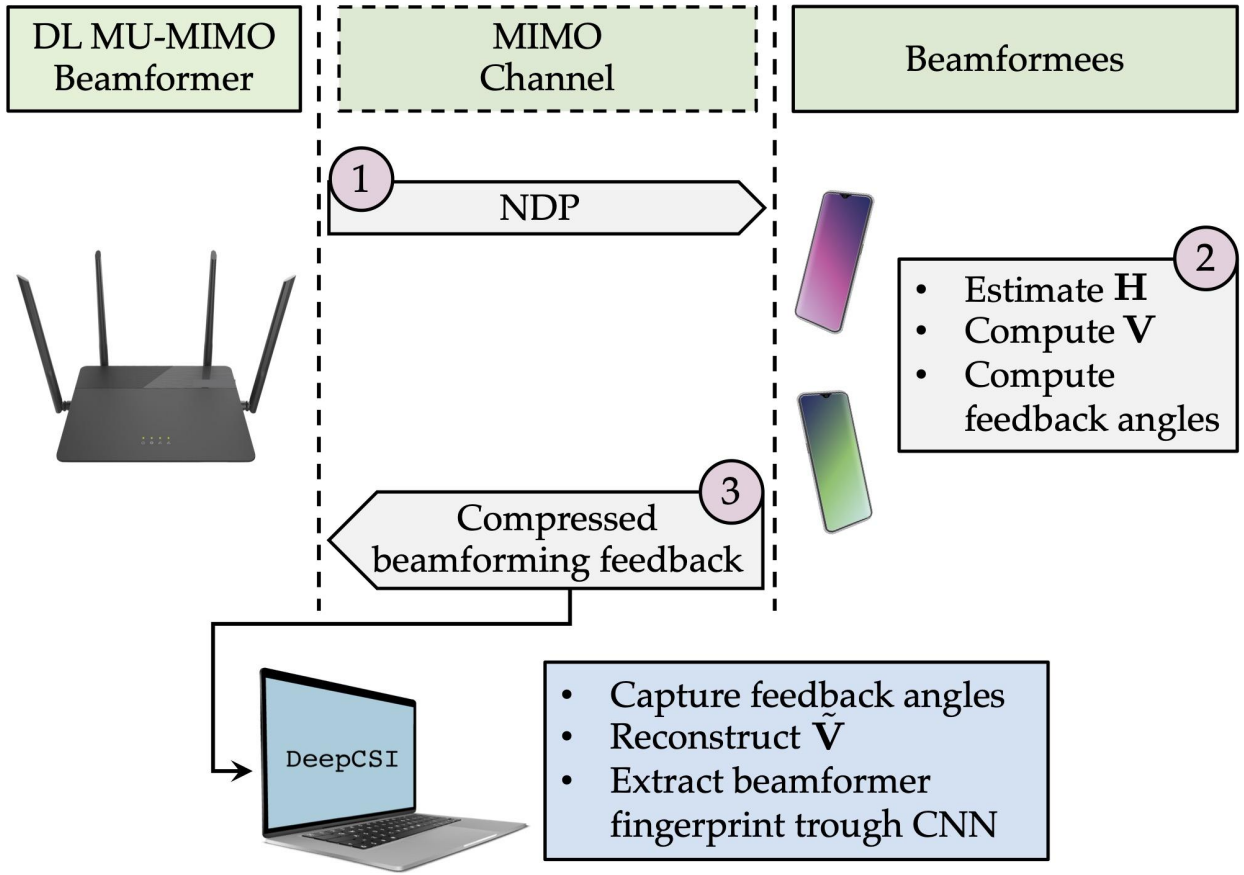
F. Meneghello, M. Rossi and F. Restuccia,

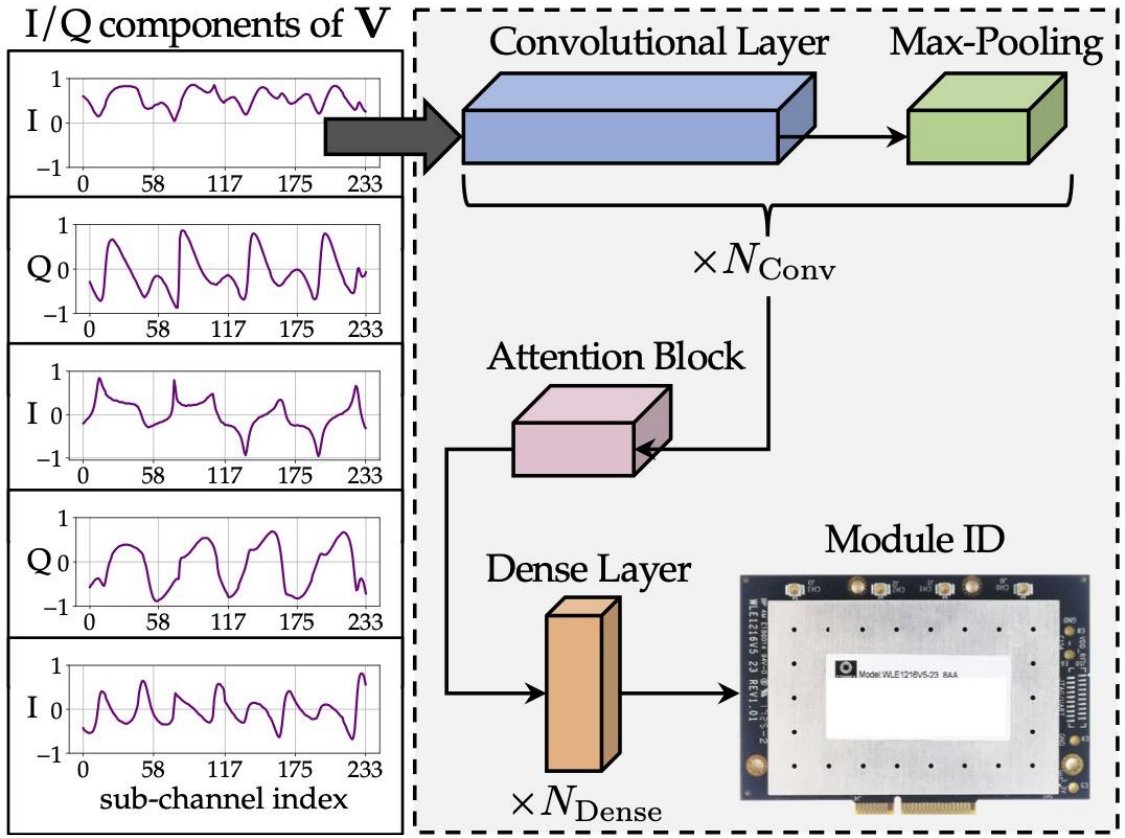
"**DeepCSI**: Rethinking Wi-Fi Radio Fingerprinting Through MU-MIMO CSI Feedback Deep Learning"

IEEE ICDCS 2022

Objective: obtain a **fingerprint of the beamformer** for device authentication

DeepCSI main idea: circuitry imperfections percolate onto the standard compliant 802.11 beamforming feedback





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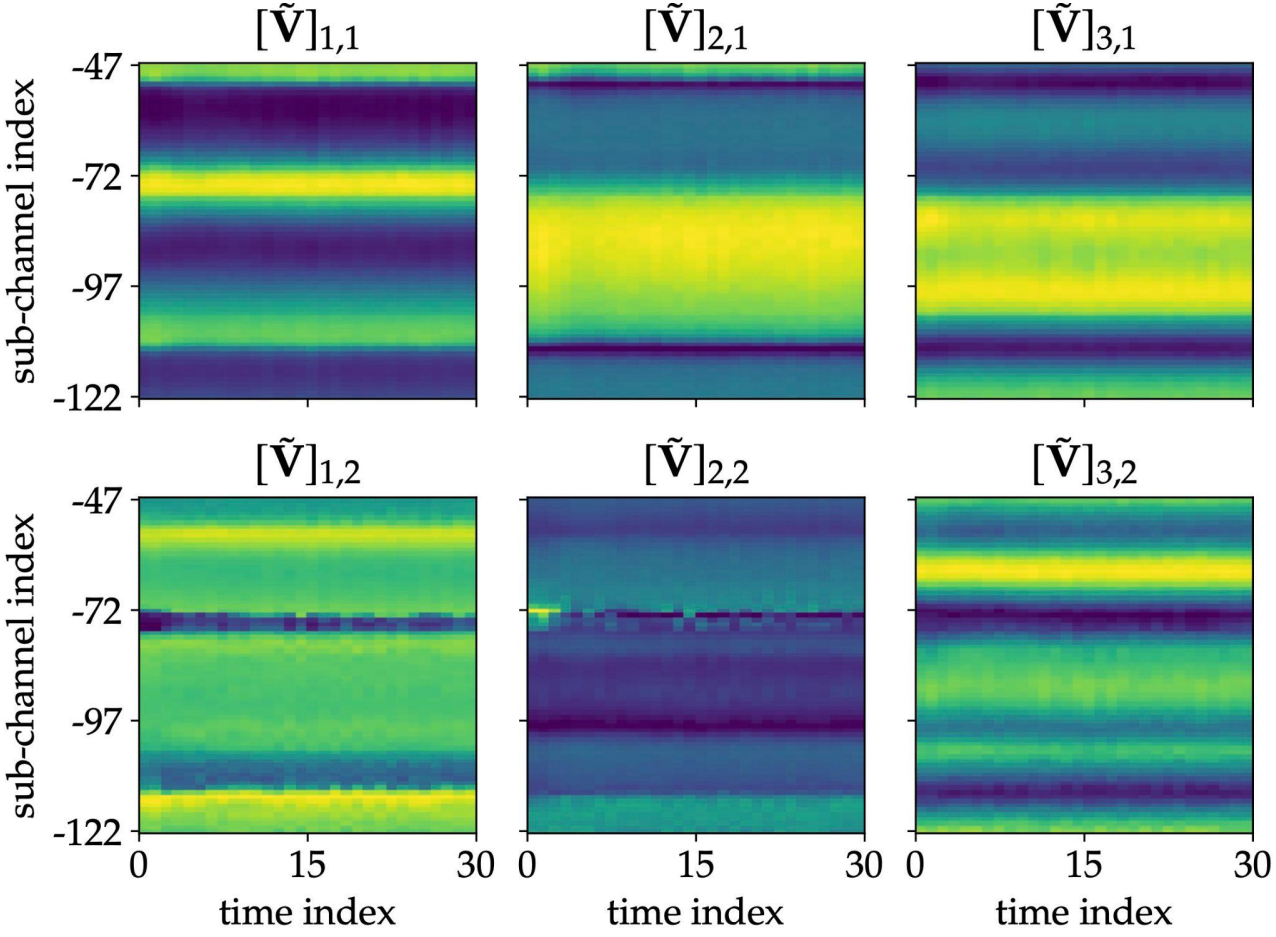
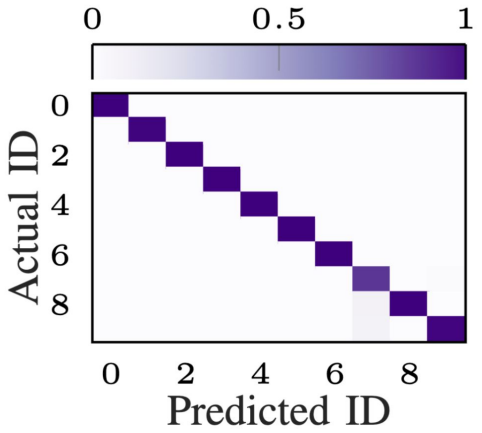
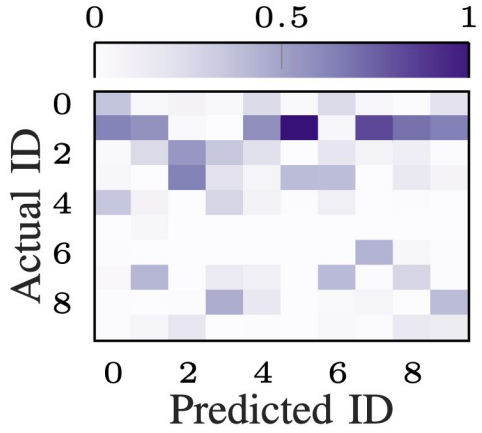
AI/ML challenge: The quantization of the 802.11 beamforming feedback affects the performance of the ML algorithm





CFR and ML identification performance **first stream**



CFR and ML identification performance **second stream**

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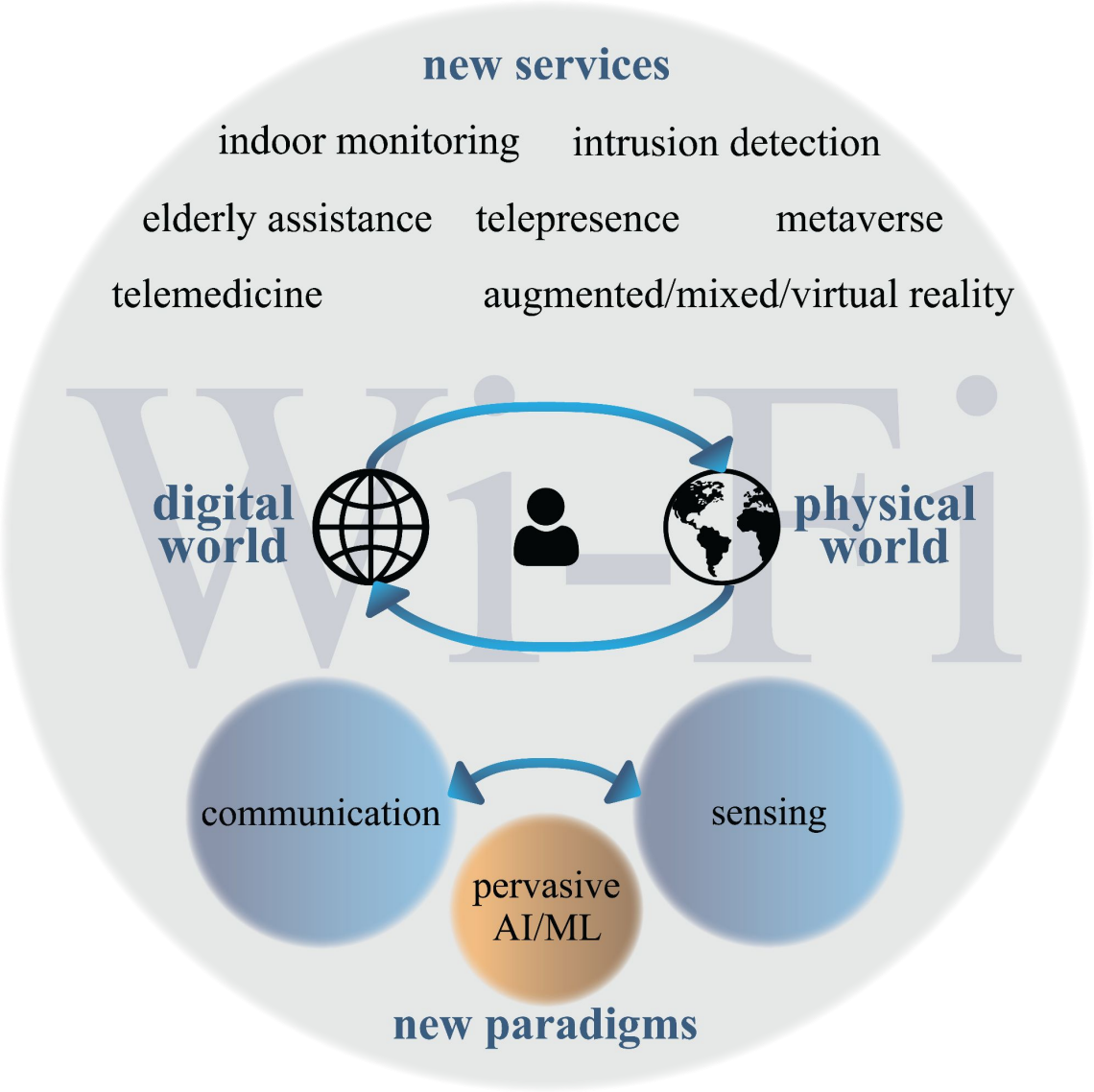
Technical challenges

- How to design AI/ML algorithms that are **robust to undesired hardware imperfections** (CFR offsets)?

- How to obtain a **tradeoff** between the efficiency of feedback transmission and the accuracy of the AI/ML sensing algorithms?



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Technical transformations

Need to consider the **AI/ML requirements for accurate and robust sensing algorithms** within the 802.11 protocol design.
Ideas:

- **transmit reference CFR data** to correct (when needed) phase offsets due to hardware imperfections

- regularly (but sparsely) **transmit uncompressed CFR feedback** for sensing purposes that can be also used to calibrate compressed feedback

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Thanks!
Questions?

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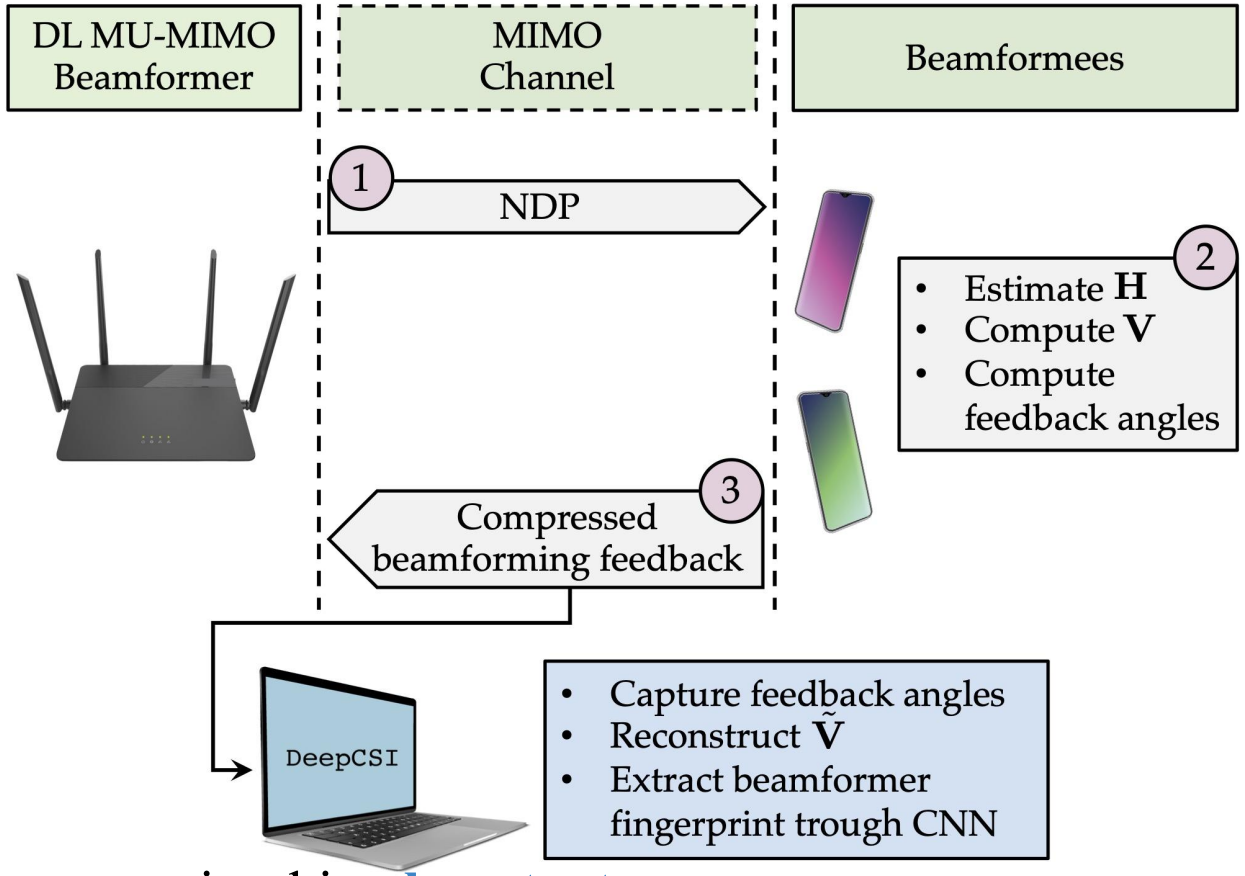
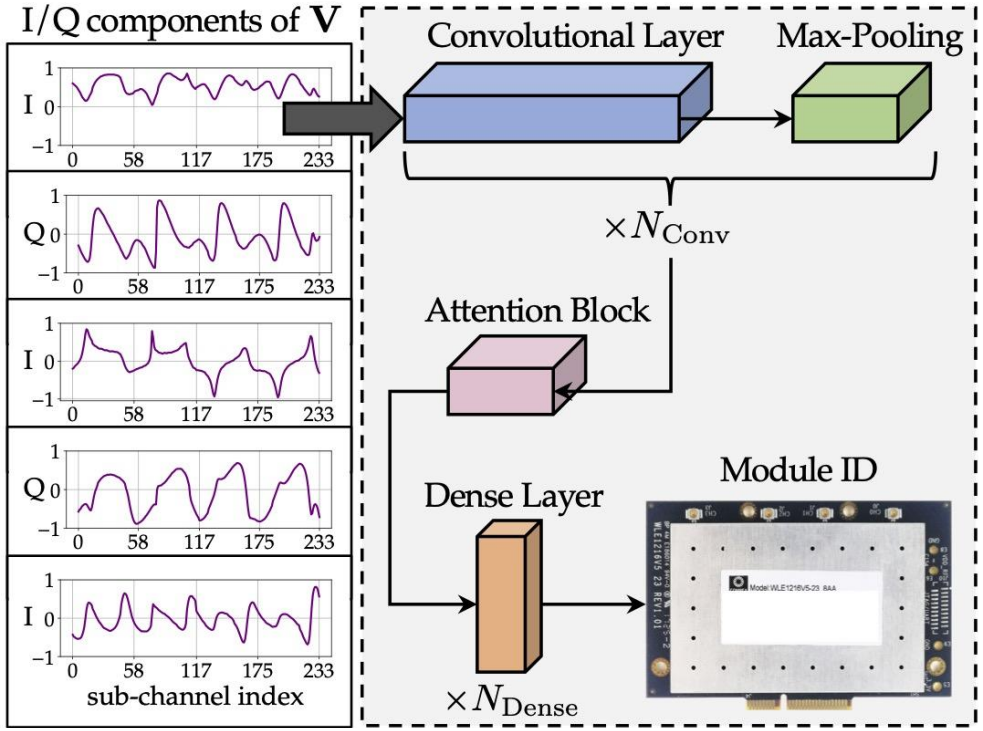
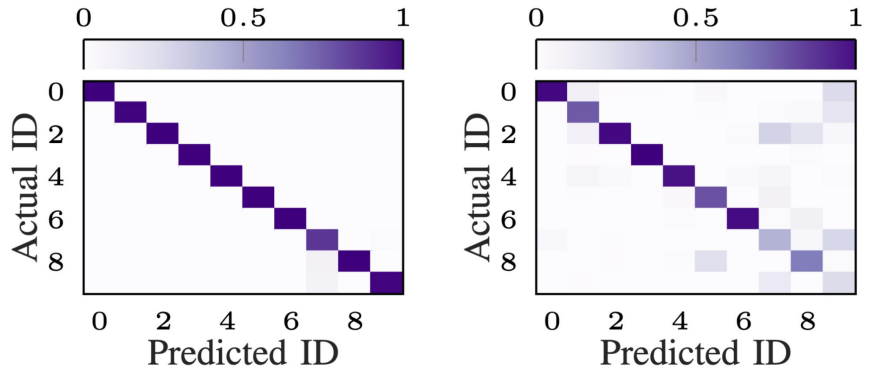
Objective: obtain a **fingerprint of the beamformer**.

DeepCSI main idea: circuitry imperfections percolate onto the standard compliant 802.11 beamforming feedback







(a) S1. Accuracy: 98.02% (b) S2. Accuracy: 75.41%

1. transmitted in **clear-text**
2. **not affected** by inter-stream and inter-user interference

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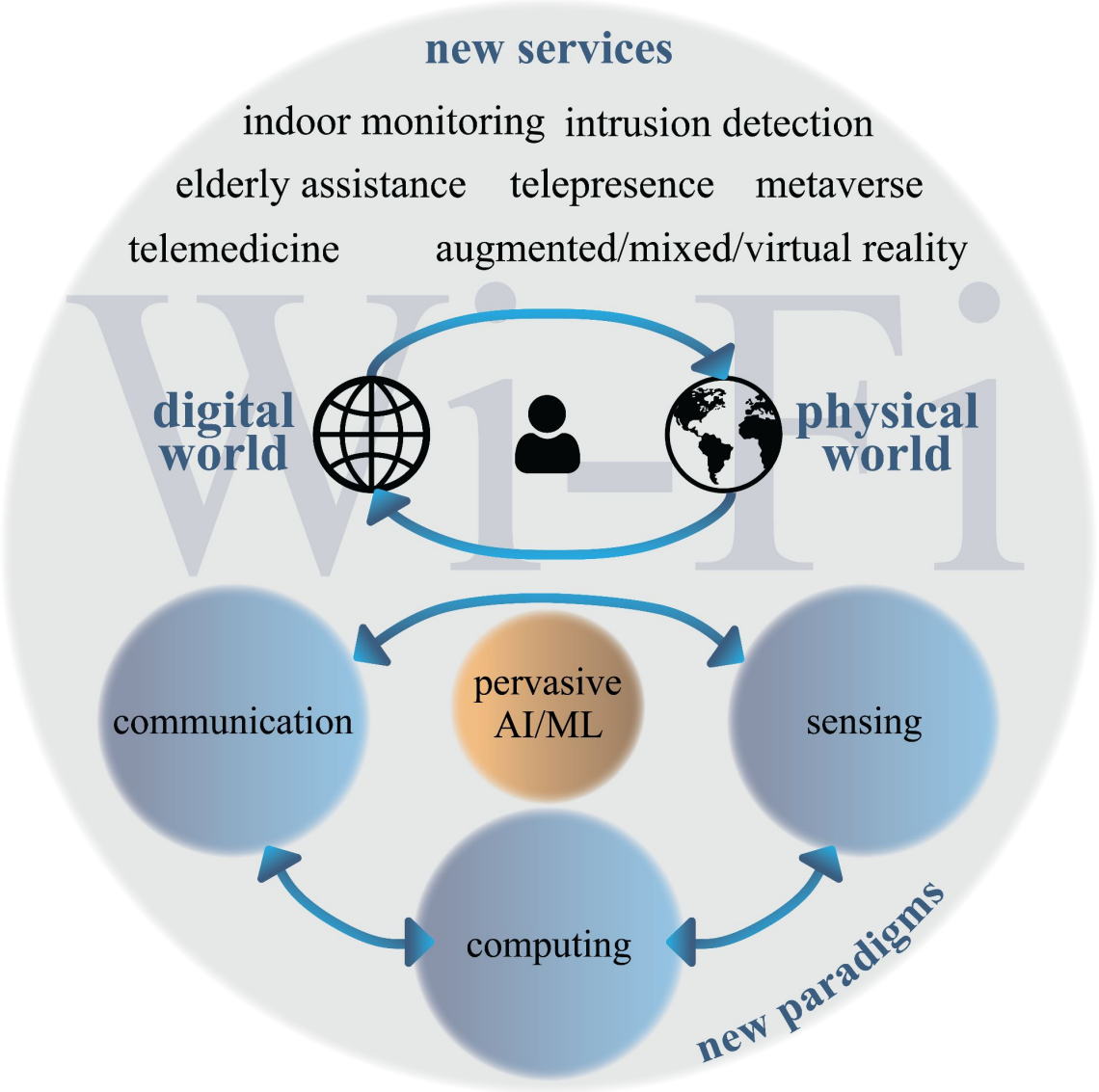
Technical transformations

- **Edge computing facilities** should be considered in the 802.11 networks design to support AI/ML sensing application



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