The Day-After-Tomorrow: On the Performance of Radio Fingerprinting over Time

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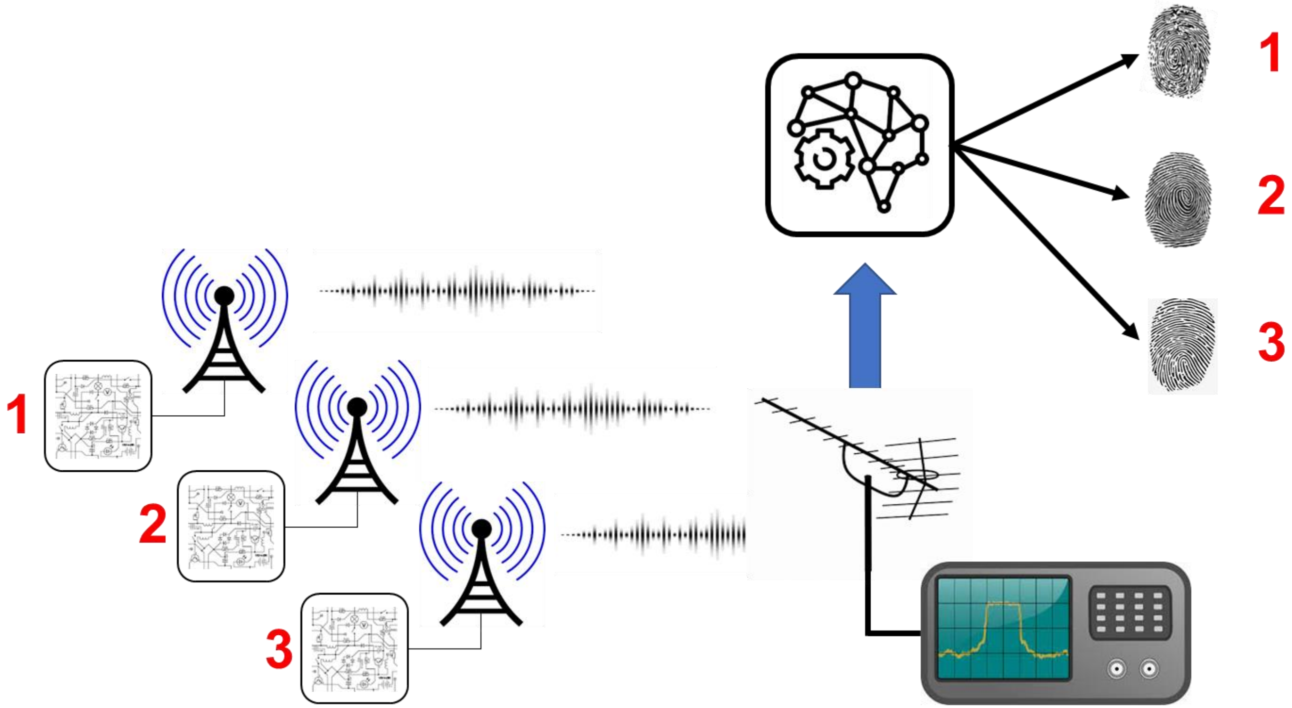
What is Radio Frequency Fingerprinting? (1/2)

Identification of the transmitter at the physical layer

- Two identical transmitters **DO** not exist
- The hardware differences of the transmitters are reflected into the over-the-air signal
- The receiver detects the differences in the signals and identify the transmitter



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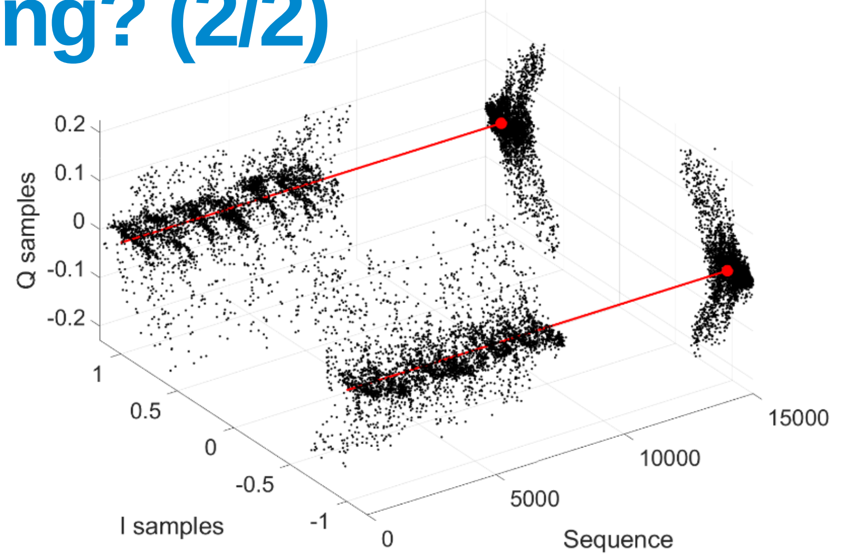
What is Radio Frequency Fingerprinting? (2/2)

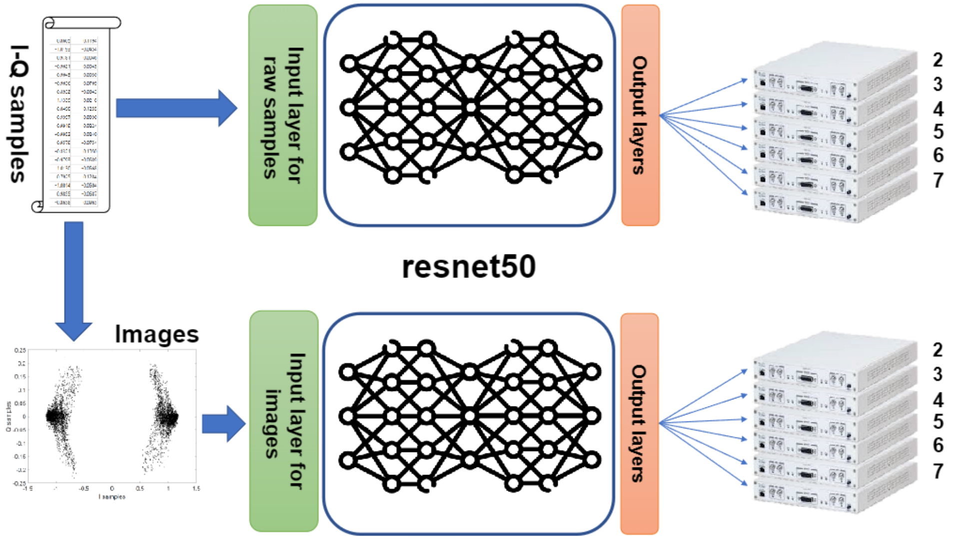


Data collection

- Data from radio spectrum is collected in the form of I-Q samples.

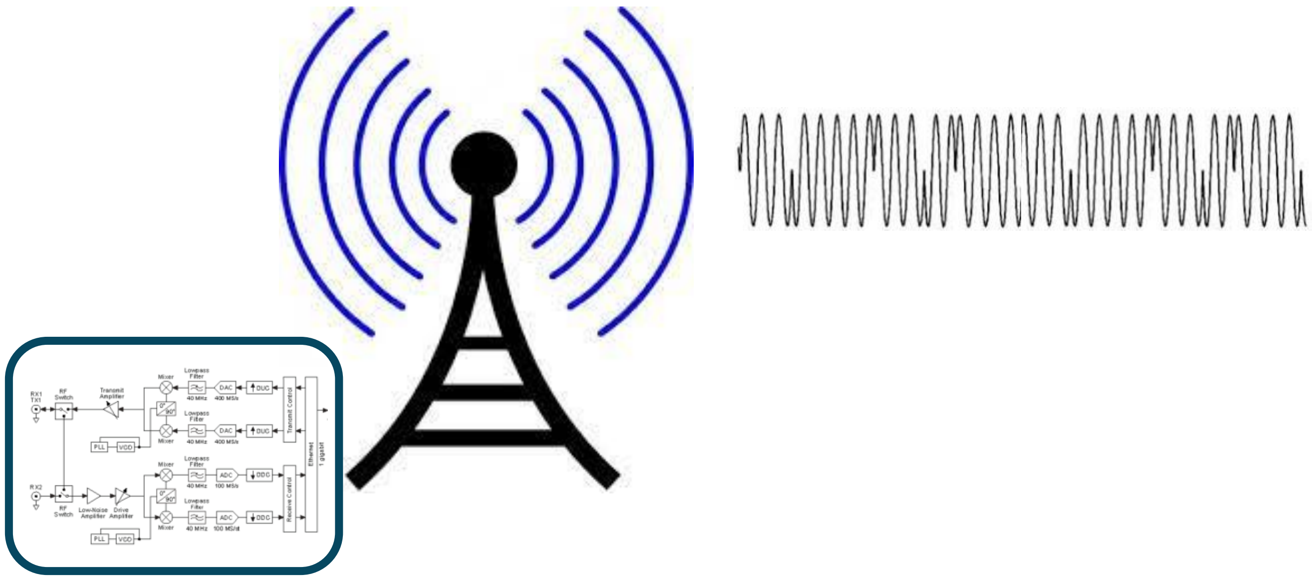
Data processing – Deep learning

- Data preparation
- Training
- Testing



Challenges of Radio Frequency Fingerprinting (1/3)

Impact of channel noise (multipath) in the RFF process

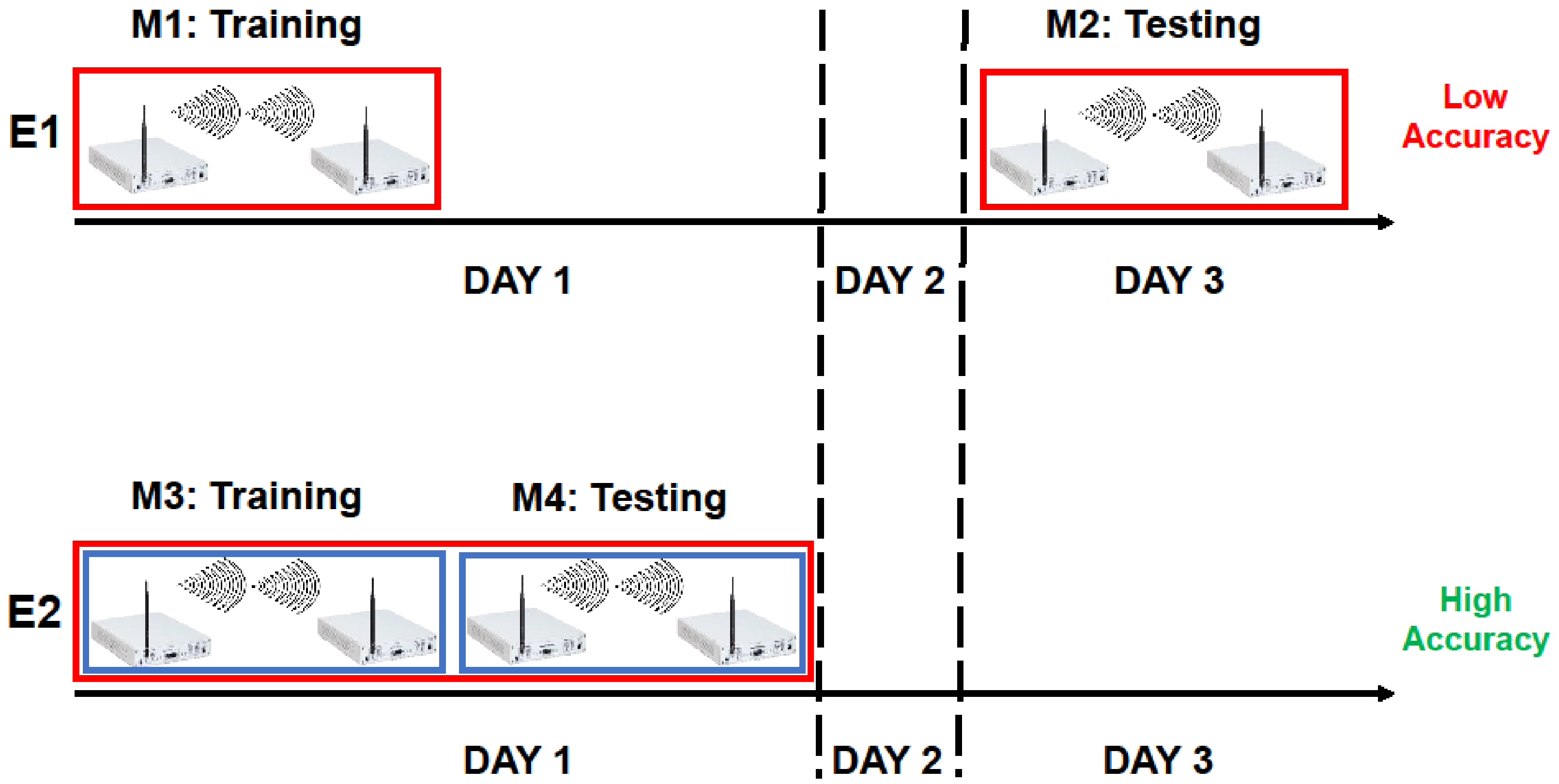


- **Amplitude**
- **Phase**
- **… fingerprint**

Challenges of Radio Frequency Fingerprinting (2/3)

Impact of the channel in the RFF process

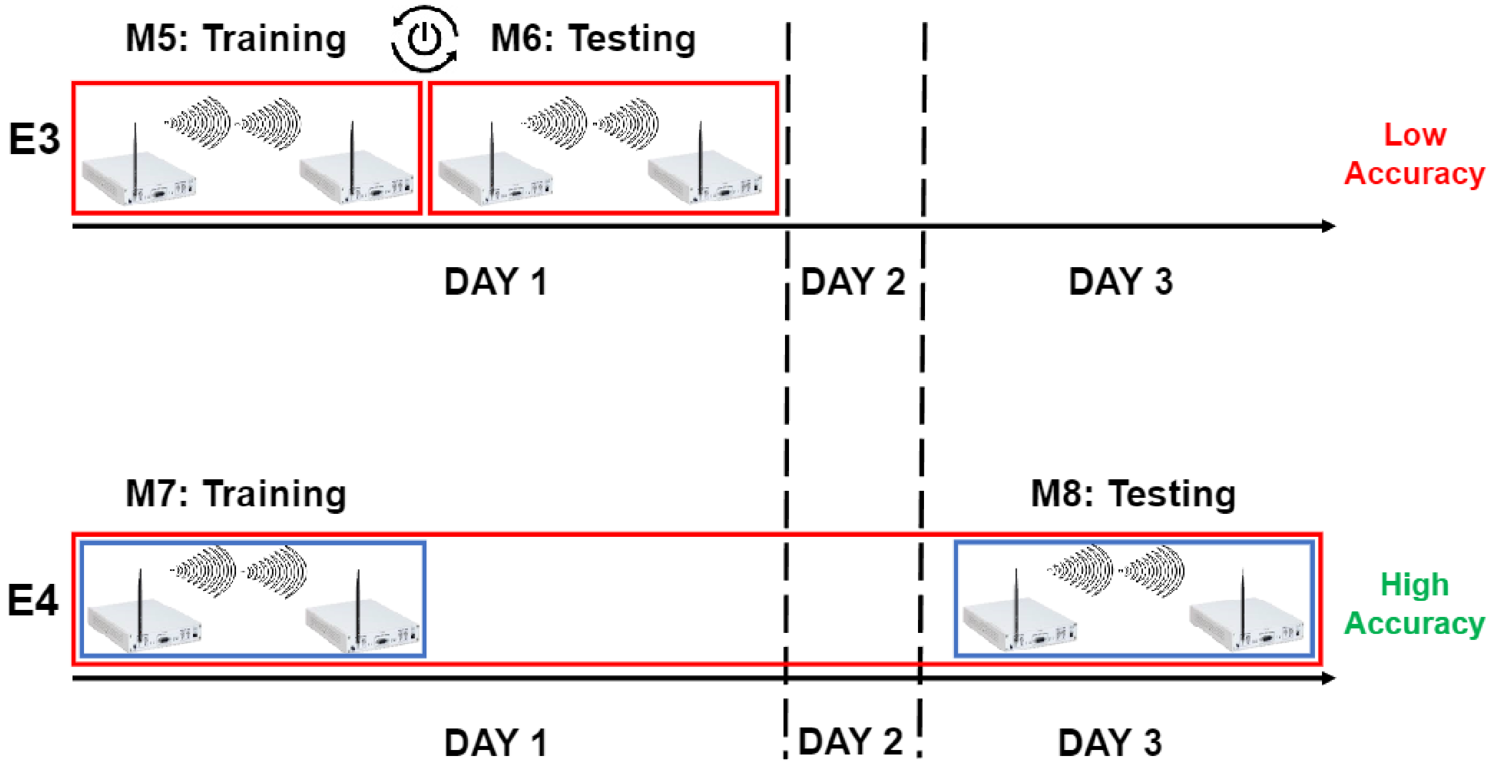
Current state of the art



Challenges of Radio Frequency Fingerprinting (3/3)

One missing important factor

We define **power cycle** as the process involving the software and hardware (re-)initialization of the radio. This takes place by applying the power-off/power-on of the radio.



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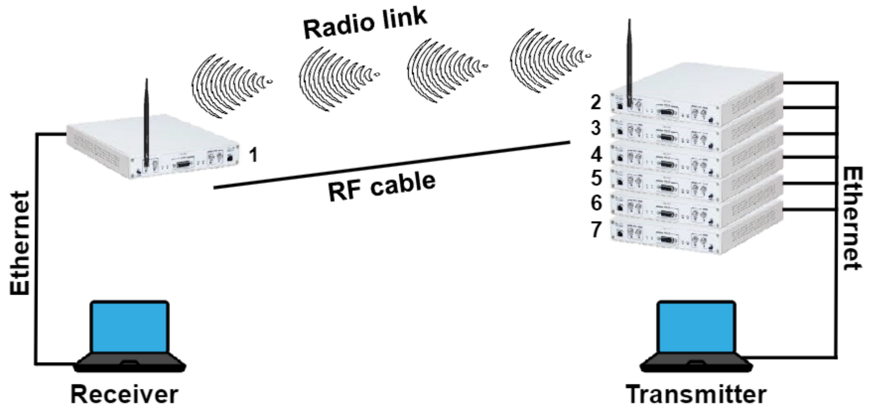
Measurement set-up

The power cycle effect



We tested our assumption against a **wired and wireless link**

We considered 5 transmitters and 1 receiver

- USRP X310

Datasets:

	Link	Sample Rate [Msps]	Duration [Days]	Runs	Samples per Measurement
DS1	Wired	1	3	13	144M+
DS2	Wired	0.256	18	1	33B+
DS3	Radio	1	4	12	144M+

Run: the sequence of 6 consecutive measurements where the receiver is the same while the transmitter changes every time among all the available ones (<u>no power-cycle</u>).

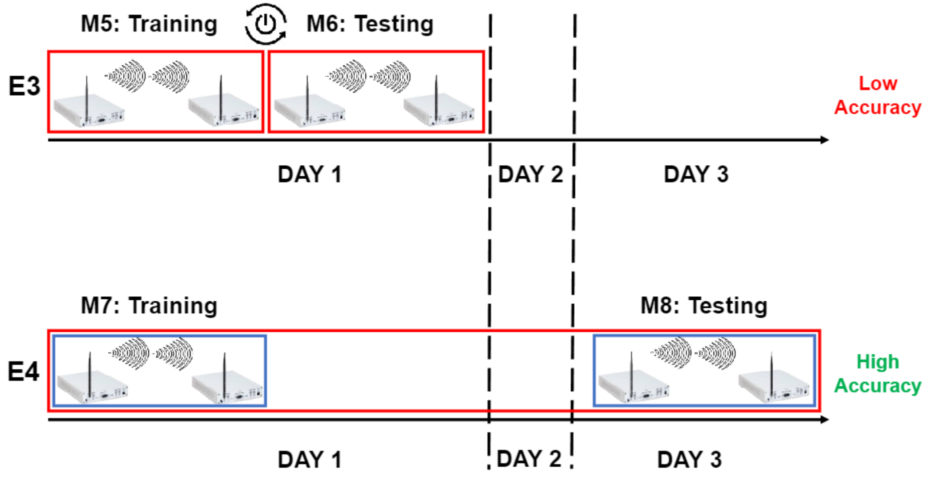
Analysis plan

1. **Experiment E3**
   - Cable link: multipath does not exist
   - Proof that the power cycle affects measurements taken close in time (standard RFF approach)

2. **Experiment E4**
   - Proof that measurements taken in different days (no power cycle) experience high classification accuracy (standard RFF approach)

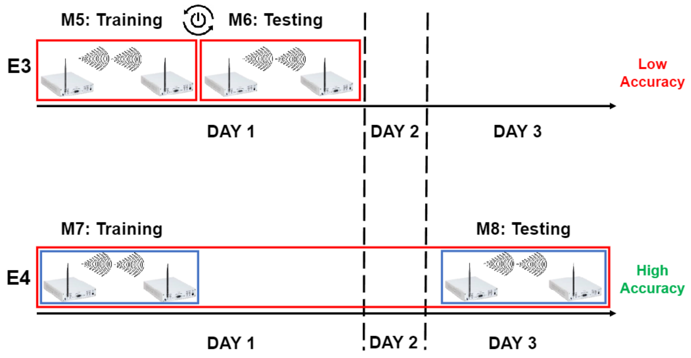
3. **Analysis of E3 to mitigate the power-cycle effect**
   - Finding a mitigation strategy for the power-cycle

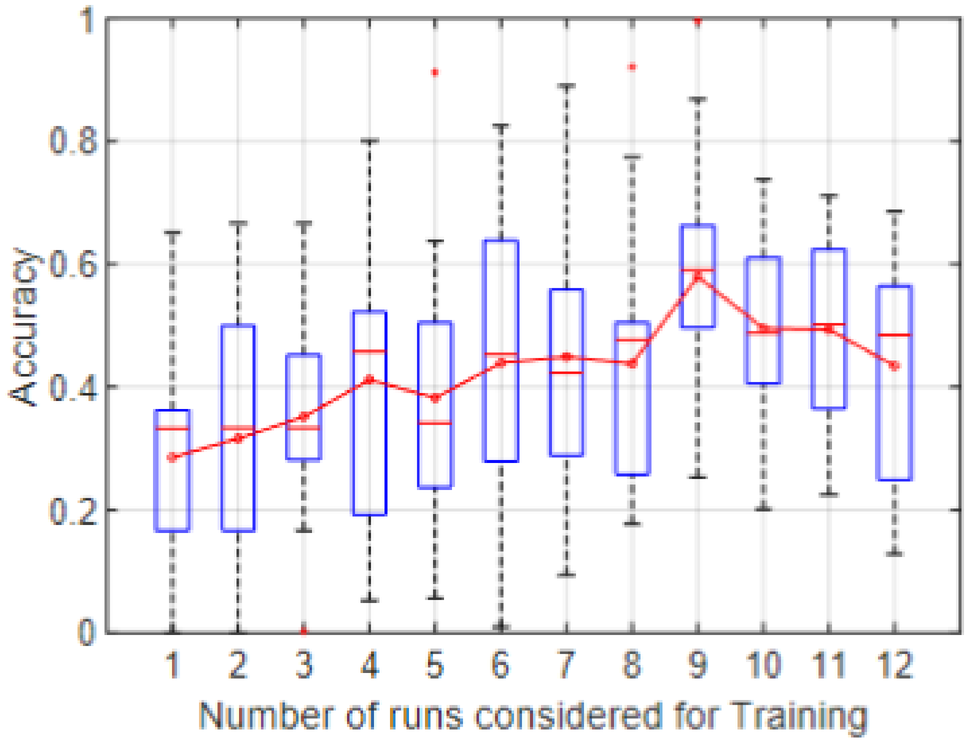
4. **A real case study with the wireless link**



Experiment E3

- Power cycle affects classification accuracy
- Measurements taken one after the other
- Cable: No multipath
- Dataset DS1





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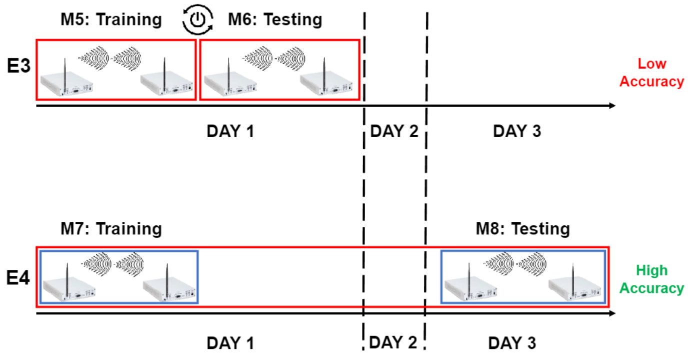
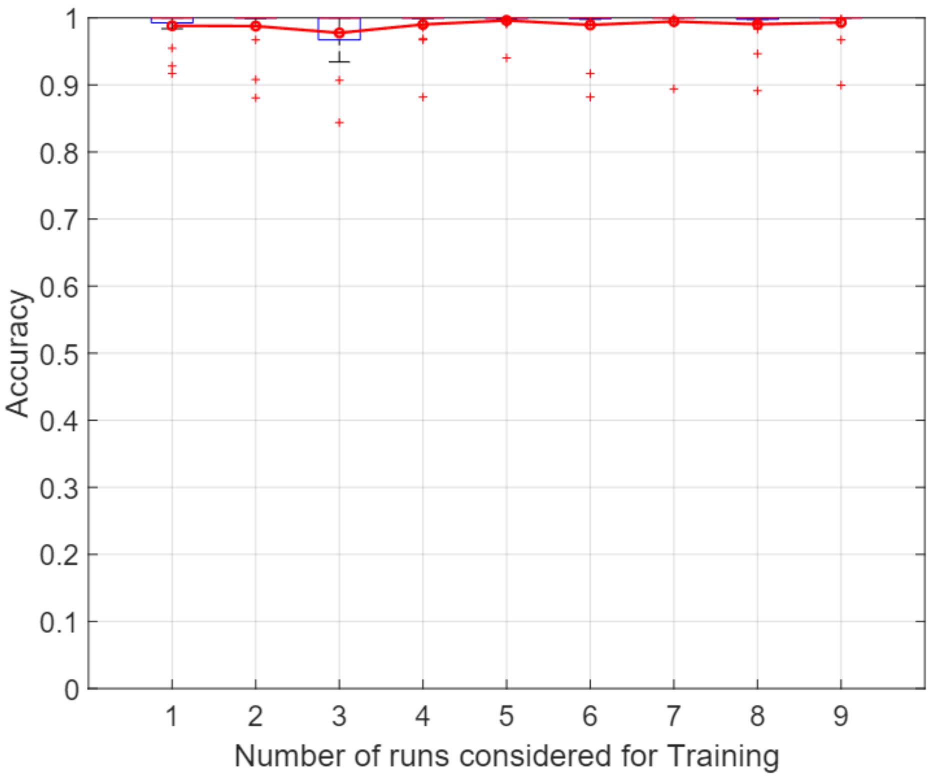
Experiment E4



Measurements taken in different days experience high classification accuracy **when radio are not power-cycled**

- Cable: No multipath
- Dataset DS2



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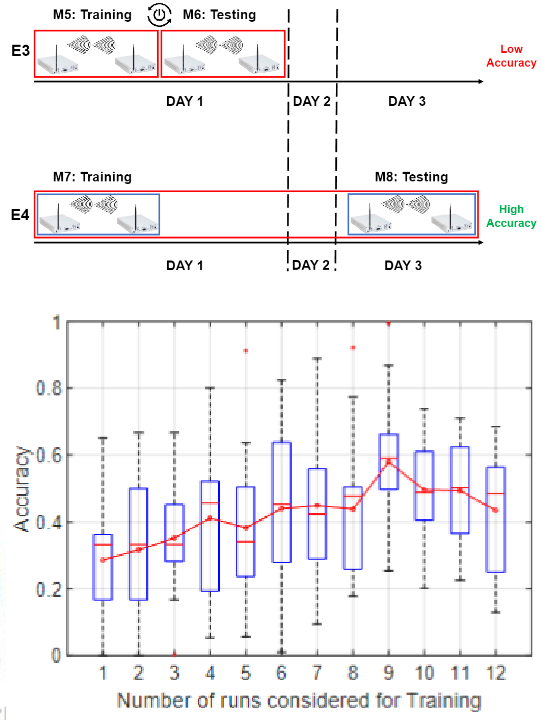
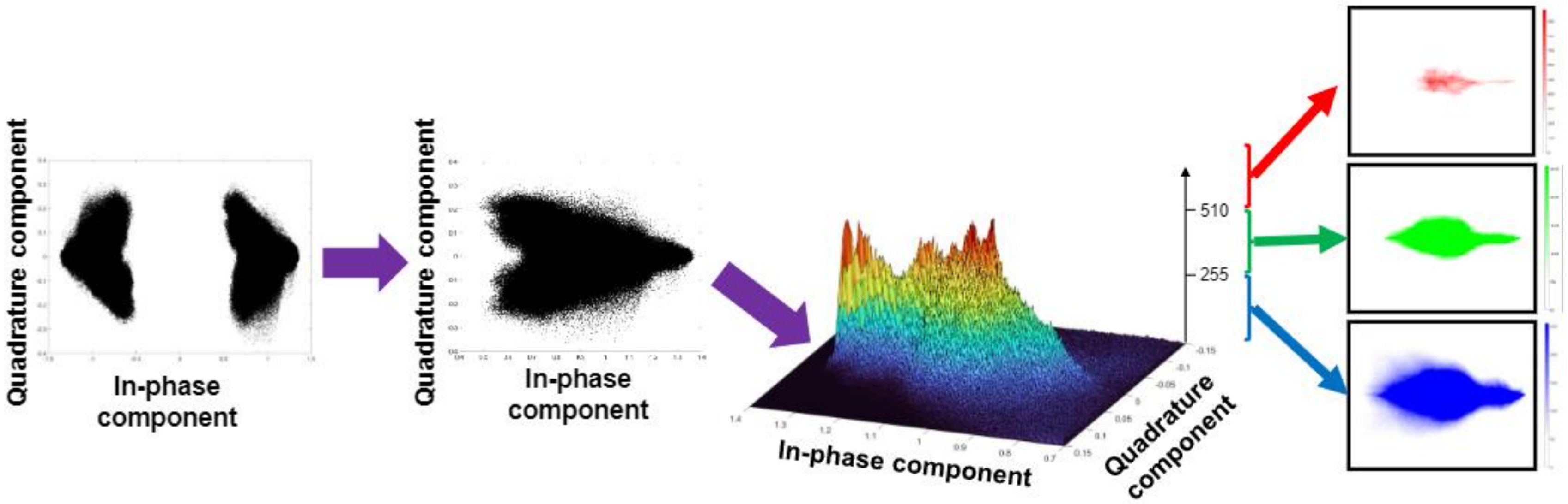
Mitigating the power cycle effect



We propose an alternative technique to classify data:

- Avoid using raw IQ samples (standard RFF approach)
- We generate images from IQ samples
- We use the images as input for Convolutional Neural Networks



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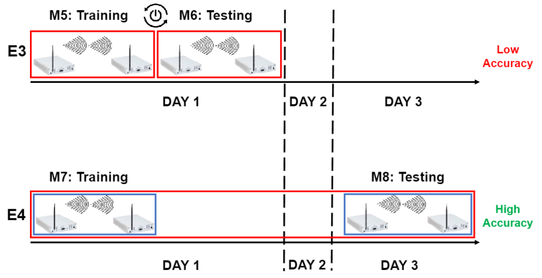
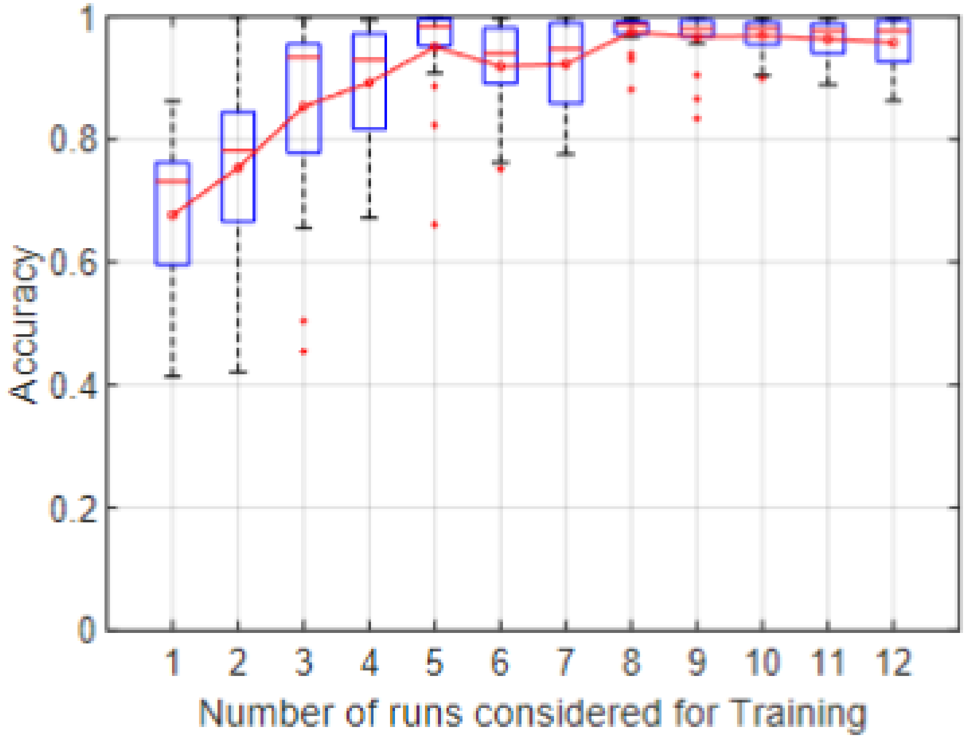
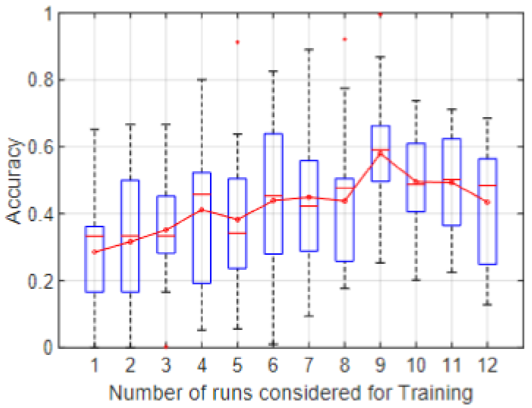
Experiment E3… with mitigation strategy

Translating IQ samples into images boosts the performance

When the number of runs is high enough, our solution reaches accuracy level close to 100%







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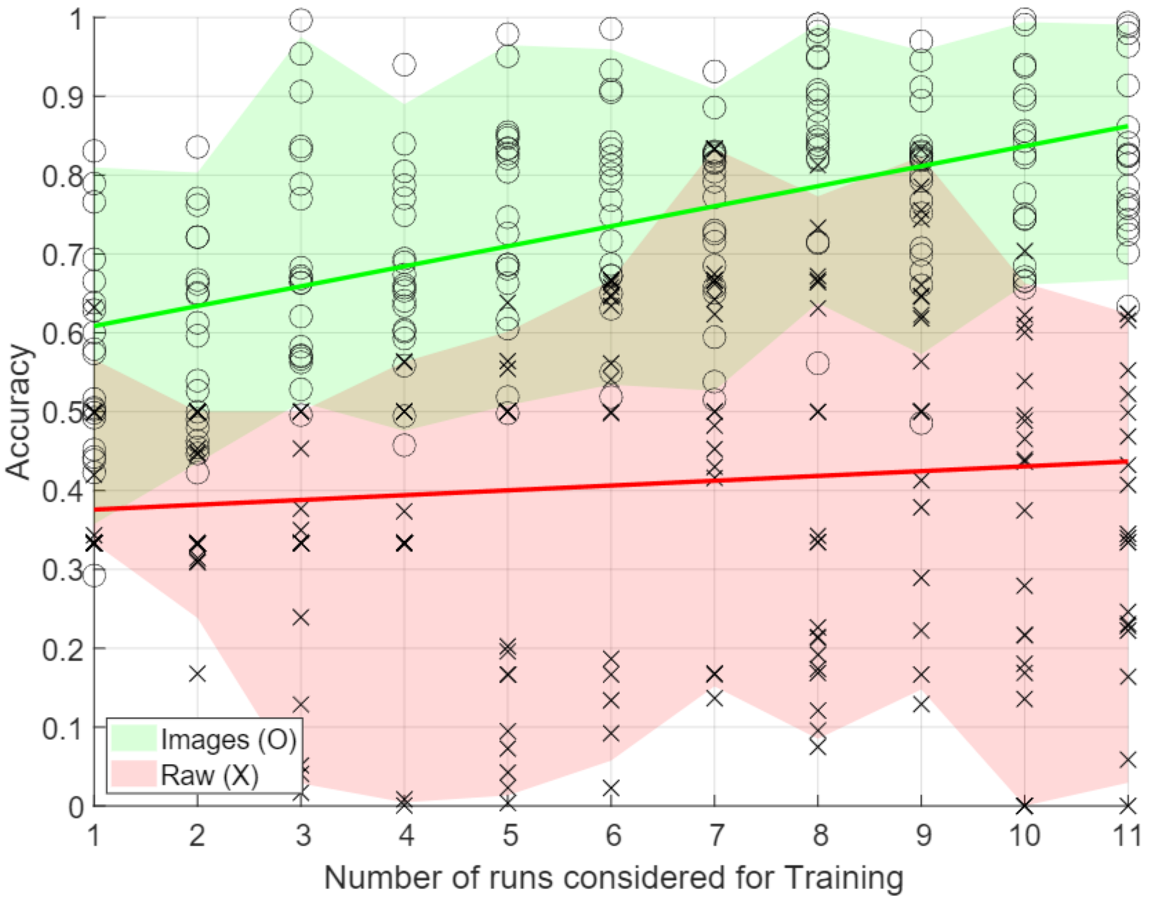
A real case study with the wireless link

Let us consider a real wireless scenario

- TX-RX distance of 10 meters
- No Line of Sight
- Office environment
- People moving around in the close proximity

Image-based classification achieves better performance than raw IQ samples (standard RFF approach)

- ResNet50
- 100,000 samples per image (1/10 of second)



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Conclusions

Power-cycle has major impact in RFF

The problem can be mitigated but there are still open challenges to address

Image-based RFF classification turns out to be effective to boost RFF performance

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