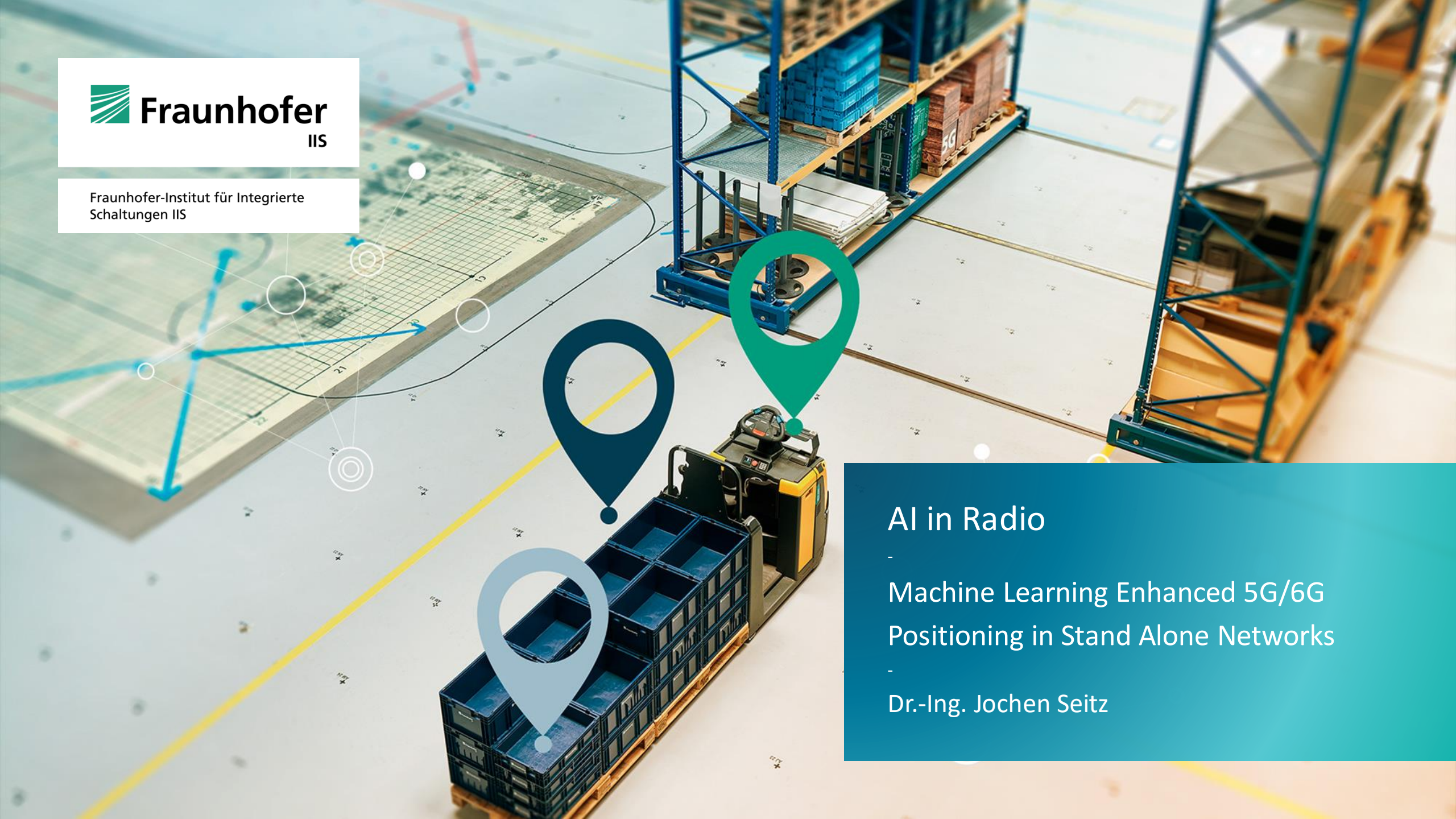

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AI in Radio

-

Machine Learning Enhanced 5G/6G Positioning in Stand Alone Networks

-

Dr.-Ing. Jochen Seitz

Radio based Localization

Limitations and Opportunities

Complex Radio Propagation

- Blockage, reflection, scattering

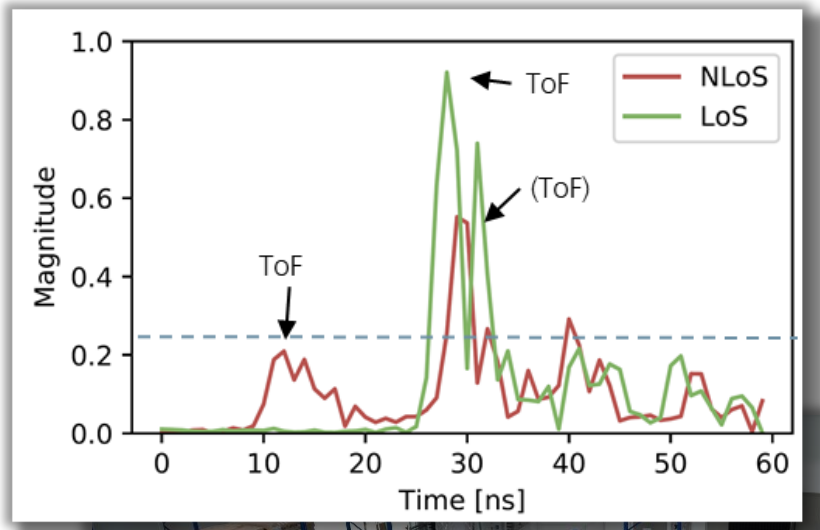
✖ Distance estimation is erroneous!

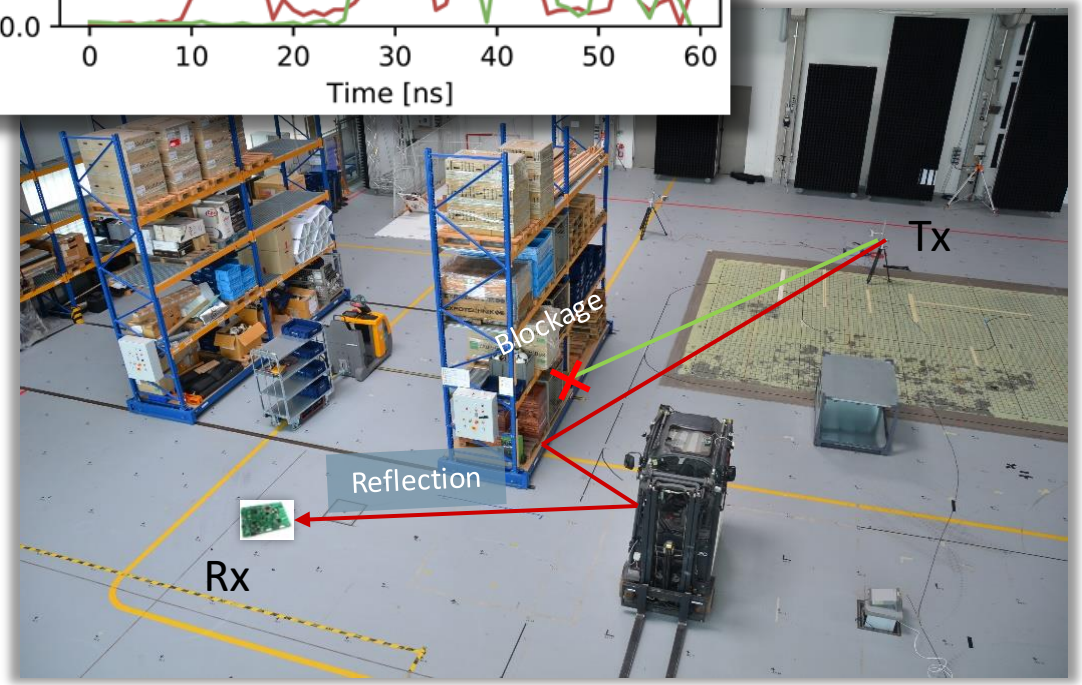
Channel Impulse Response CIR

- Representation of received signals
- Depends on the environment

✔ Contains spatial information

Channel Impulse Responses





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AI assisted Localization

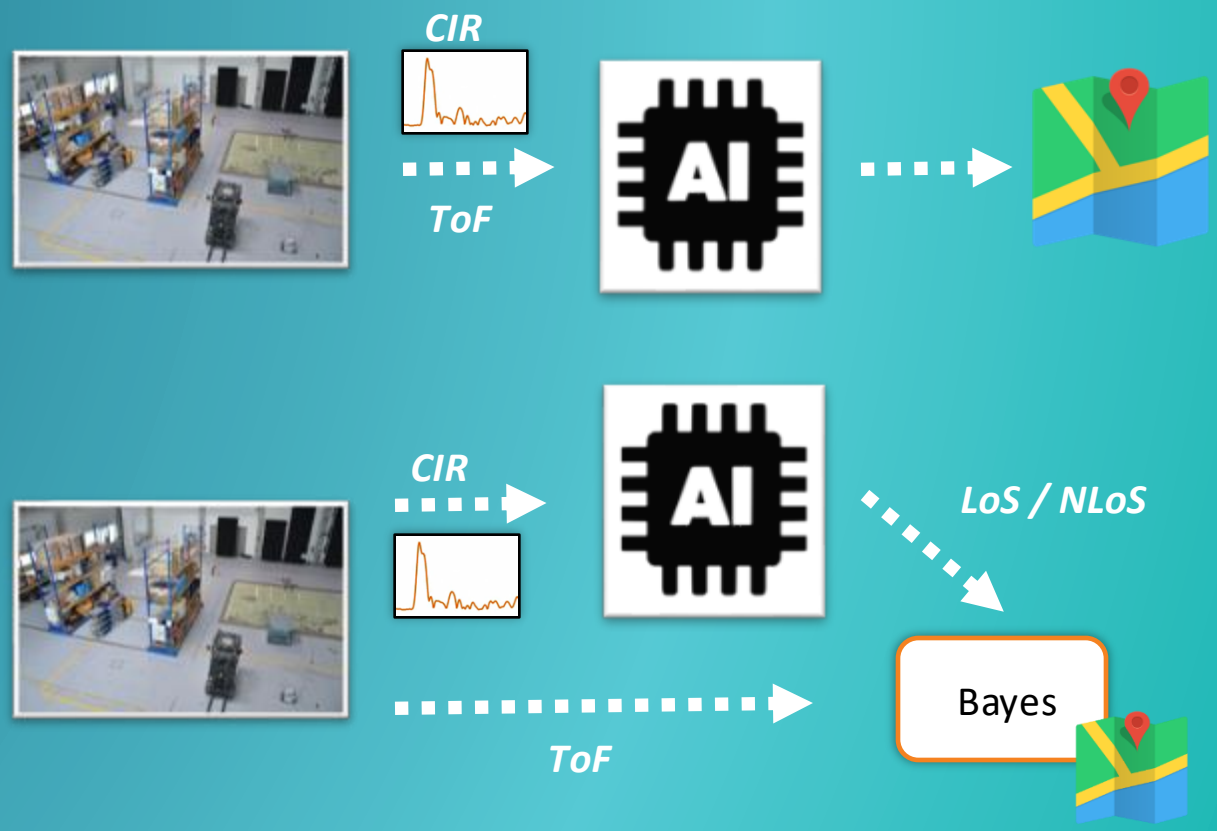
Direct / Hybrid Positioning

Direct Positioning

- Employ raw CIR and ToF in neural network
- Positioning in NLoS areas

Hybrid Positioning

- Estimation of channel conditions
- Use additional information in tracking filter



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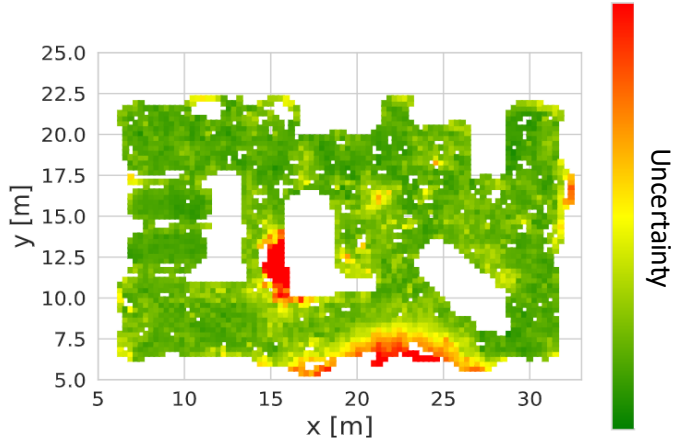
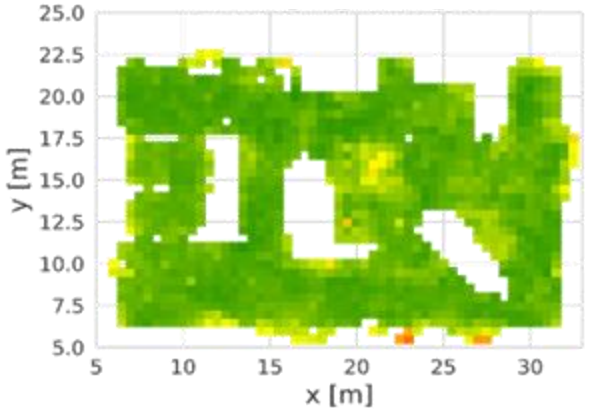
Direct Positioning
Life Cycle Management

Uncertainty Estimation
- Env. changes alter radio signals
- Identify changed areas
- Enable new data recording

Transfer Learning
- Repair corrupted model
- Efficient transition from old to new Environment





Stahlke et. al.: „Uncertainty-Based Fingerprinting Model Monitoring for Radio Localization," in *IEEE Journal of Indoor and Seamless Positioning and Navigation*, 2024

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Direct Positioning

Unsupervised Fingerprinting: Channel Charting

Channel Charting

- Exploit manifold of radio signals
- Model the radio geometry
- Only a coordinate transformation is needed

Channel Charting assisted Fingerprinting

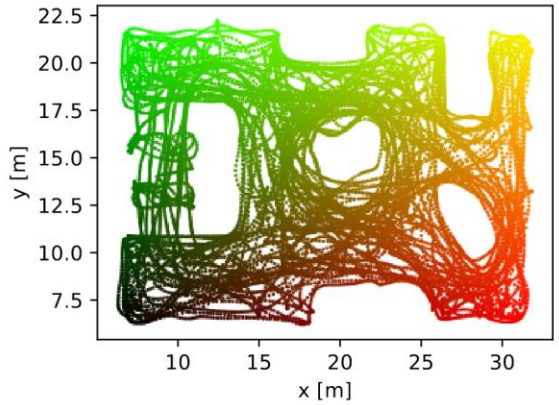
✔ Data collection via crowdsourcing

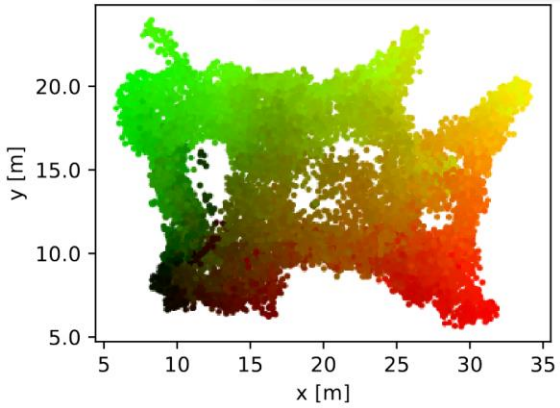
✔ Very few reference positions needed

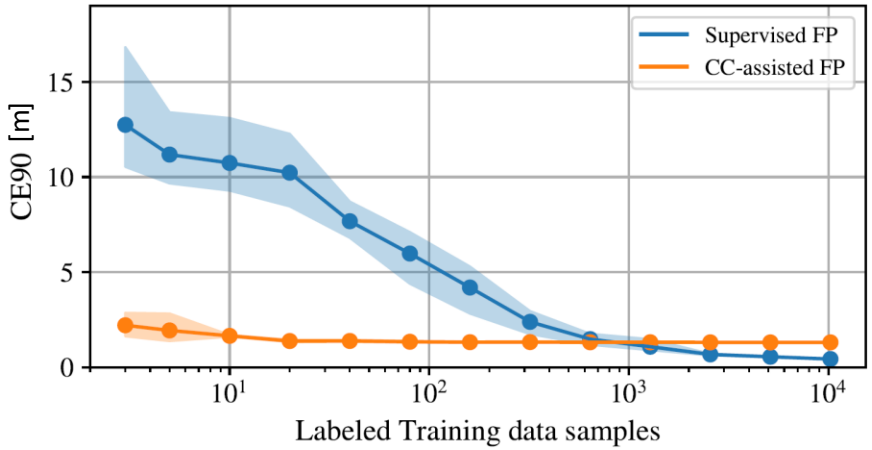
✖ Lower accuracy then supervised fingerprinting

Ground truth

Training







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Stahlke et. al.:"Velocity-Based Channel Charting With Spatial Distribution Map Matching," IEEE Journal of Indoor and Seamless Positioning and Navigation 2024

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Application project example 5GILABB

“5G Industrial Lab Bischheim”

Nomadic 5G Positioning Testbed

CIR Fingerprinting

IIOT

Channel Charting

AI in radio

Our Goal

- Demonstrate in use cases of SNCF that positioning with sub meter level accuracy is possible in their environments with complex signal propagation

AI Aspects

- Convolutional Neural Networks CNNs trained for an environment to enable precise positioning
- Uncertainty estimation to study changes in the environment
- Active learning to update models
- Channel Charting to reduce labeling efforts

Partner

FR: SNCF, Nokia, CRAN

DE: Fraunhofer IIS, Evocortex GmbH

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https://www.digitale-technologien.de/DT/Navigation/EN/ProgrammeProjekte/Internationale_Kooperationsprojekte/kooperation_frankreich/5g_campusnetze_fra/5GILABB/5gilabb.html

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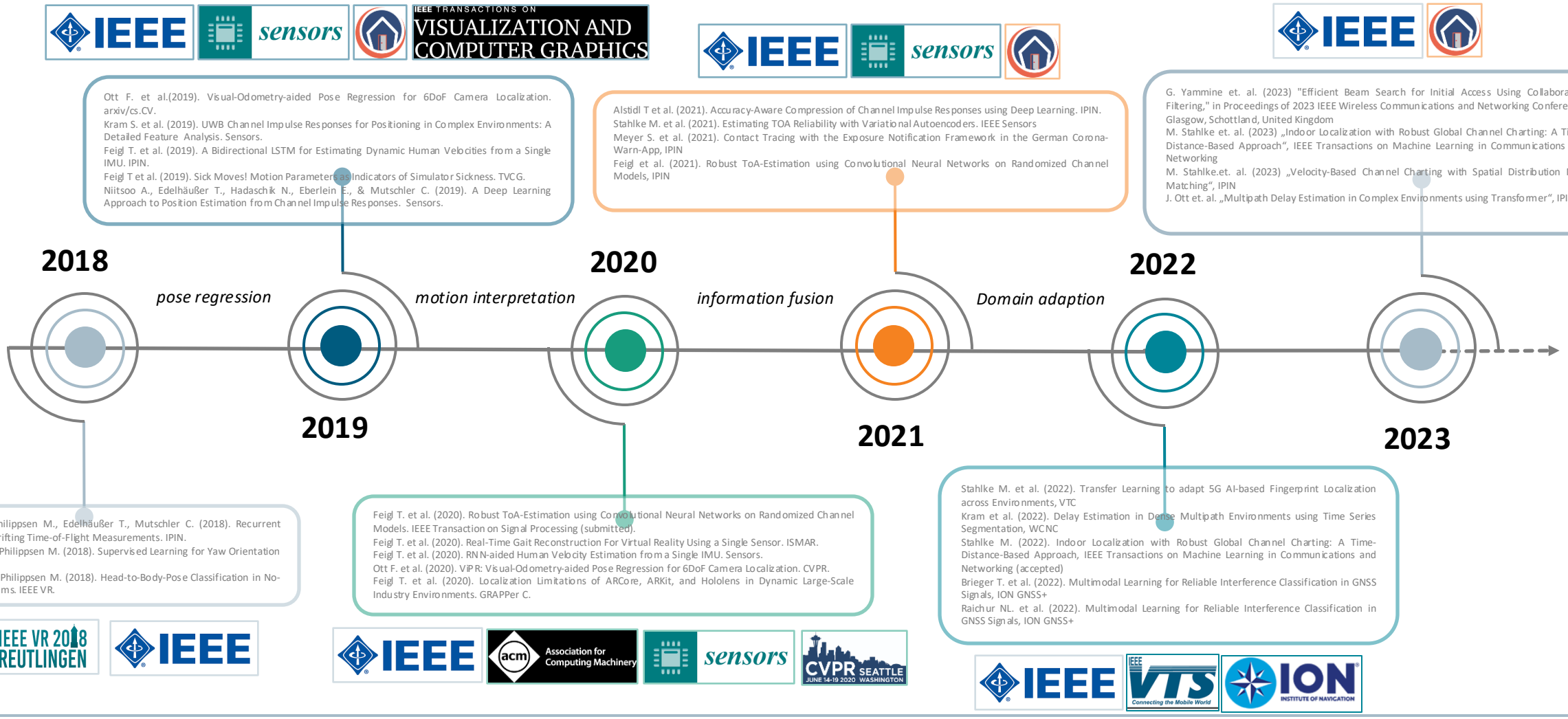

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