# IPIN OFFLINE COMPETITION – CHANNEL IMPULSE RESPONSES

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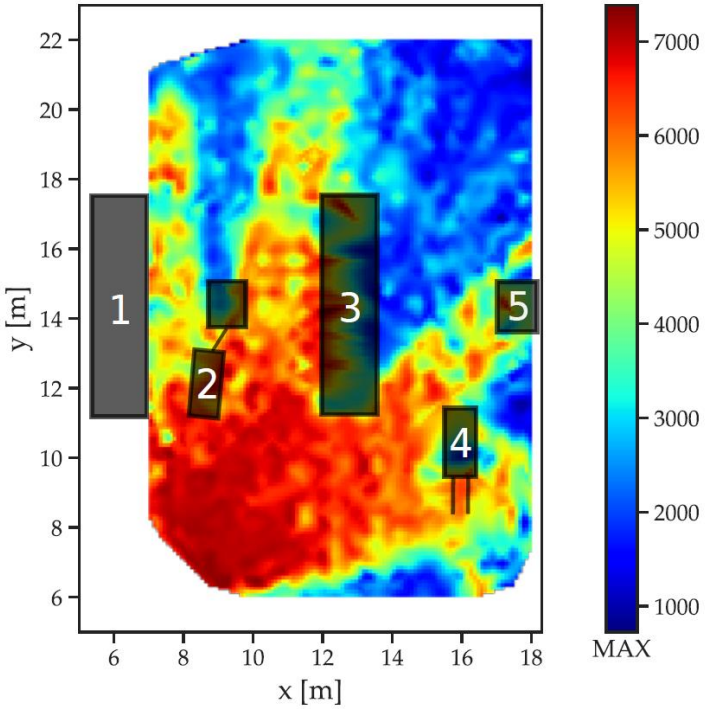




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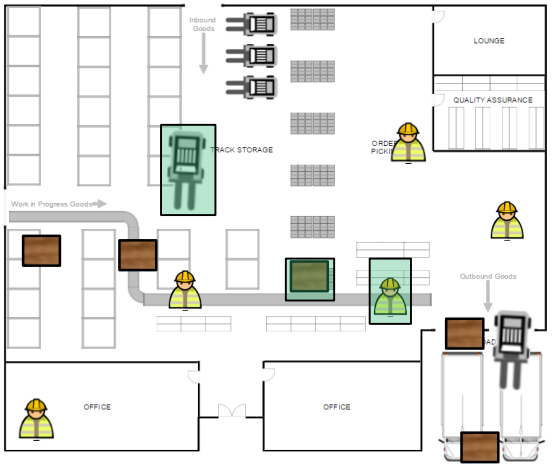
# AGENDA

- Motivation: Tracking in industrial indoor environments
- CIR-based positioning: Model and State-of-the-Art
- Measurement Setup
- Dataset Description
- Competition winner

# Tracking in industrial indoor environments

Tracking of relevant agents provides information for optimization of production efficiency

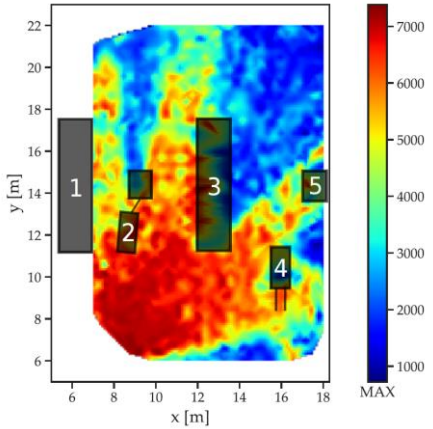


# Tracking in industrial indoor environments

Challenging propagation conditions due to an abundance of metal objects causing diffraction, absorption, reflection and scattering

# Tracking in industrial indoor environments

OR: Spatially characteristic influence of the objects on signal propagation can be exploited for tracking if it can be modelled

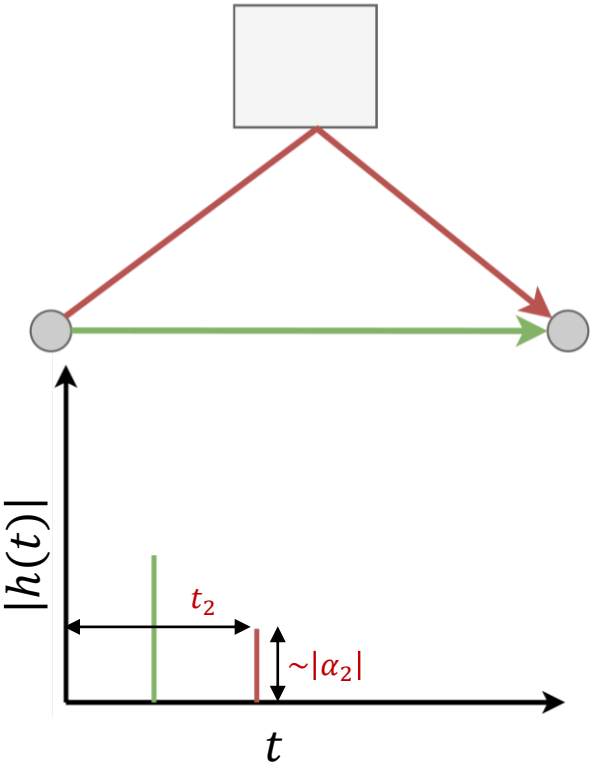



Kram, Sebastian, et al. "UWB Channel Impulse Responses for Positioning in Complex Environments: A Detailed Feature Analysis." *Sensors* 24.5547 (2019).

# CIR-based positioning

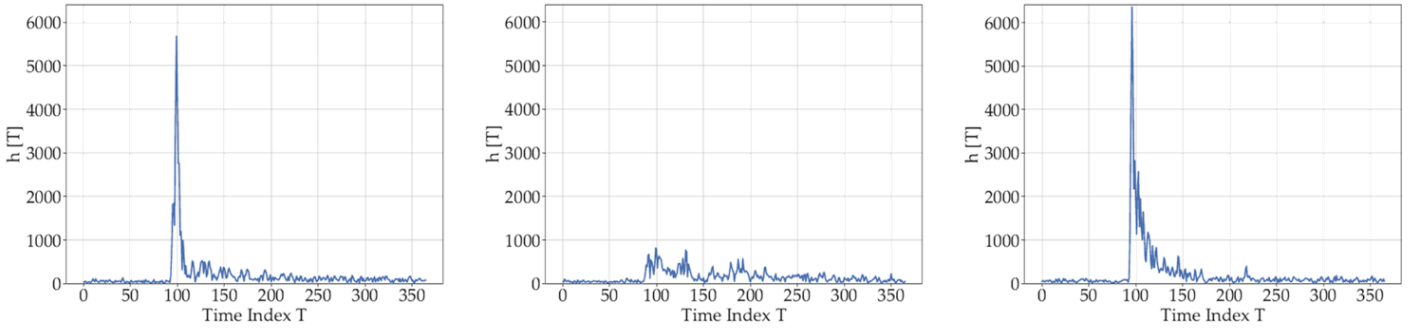
Sum of impulses describing the $N_p$ propagation paths using delay $T_l$ and complex weight $\alpha_l$

$$h(t) = \sum_{l=1}^{N_p} \alpha_l \, \delta(t - t_l)$$




Highly simplified model, additional effects:

- Bandwidth influence
- Sampling and quantization
- Correlation artefacts
- AWGN

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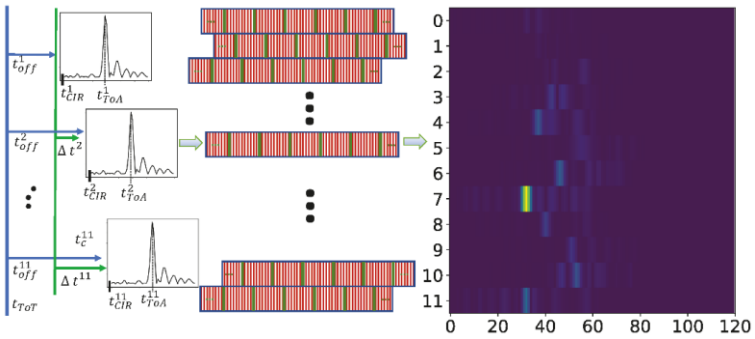
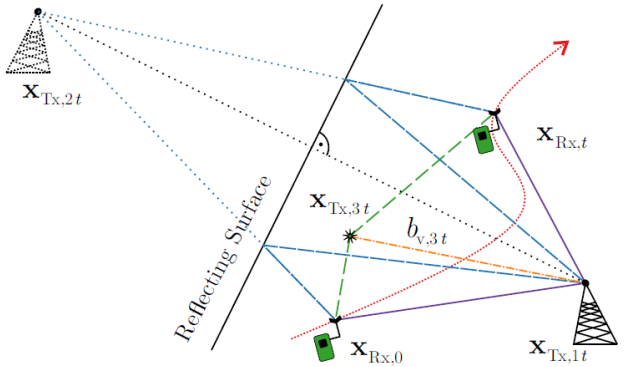
# CIR-based positioning




Niitsoo, Arne et al. "A Deep Learning Approach to Position Estimation from Channel Impulse Responses." Sensors (Basel, Switzerland) 19 (2019)




Leitinger, Erik et al. A Belief Propagation Algorithm for Multipath-Based SLAM. IEEE Transactions on Wireless Communications.

- The use of CIRs has shown to yield results that are superior to other signals for positioning in multipath environments, especially fingerprinting, NLOS/LOS Classification
- CIRs have shown to accurately represent environment features, so that simultaneous localization and mapping (SLAM) on RF signals is a possibility.
- The high complexity of CIR data can be handled by modern Artificial Intelligence (AI) approaches, especially deep learning (DL).

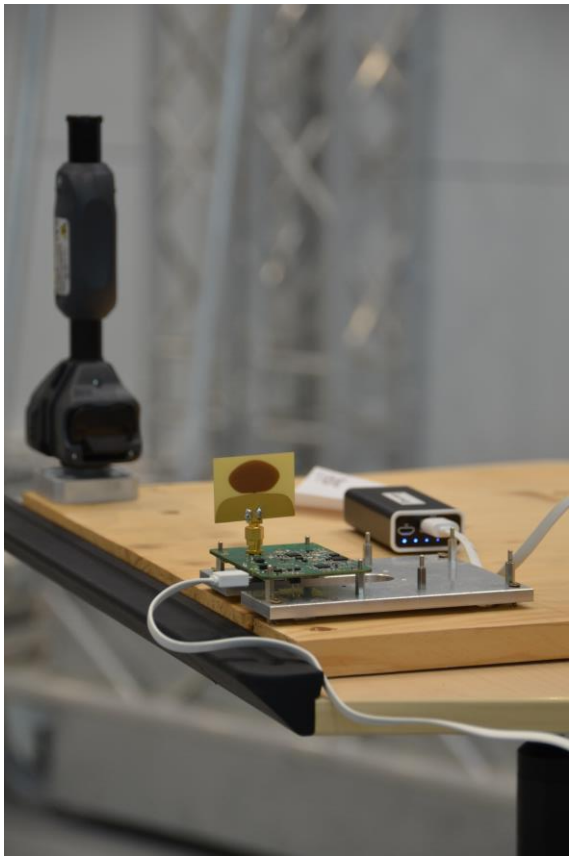
# Dataset Description

## Hardware Platform

8 WiSmIt Sensor Platforms:
6 fixed infrastructure receivers, 1 mobile transmitter,
1 synchronization tag
~ 20 Hz recording frequency
UWB Module Decawave 1000
BW 1 GHz
Center Frequencies 3.5 – 6.5 GHz

## Positioning Reference System

Nikon iGPS optical system
Accuracy < 1mm



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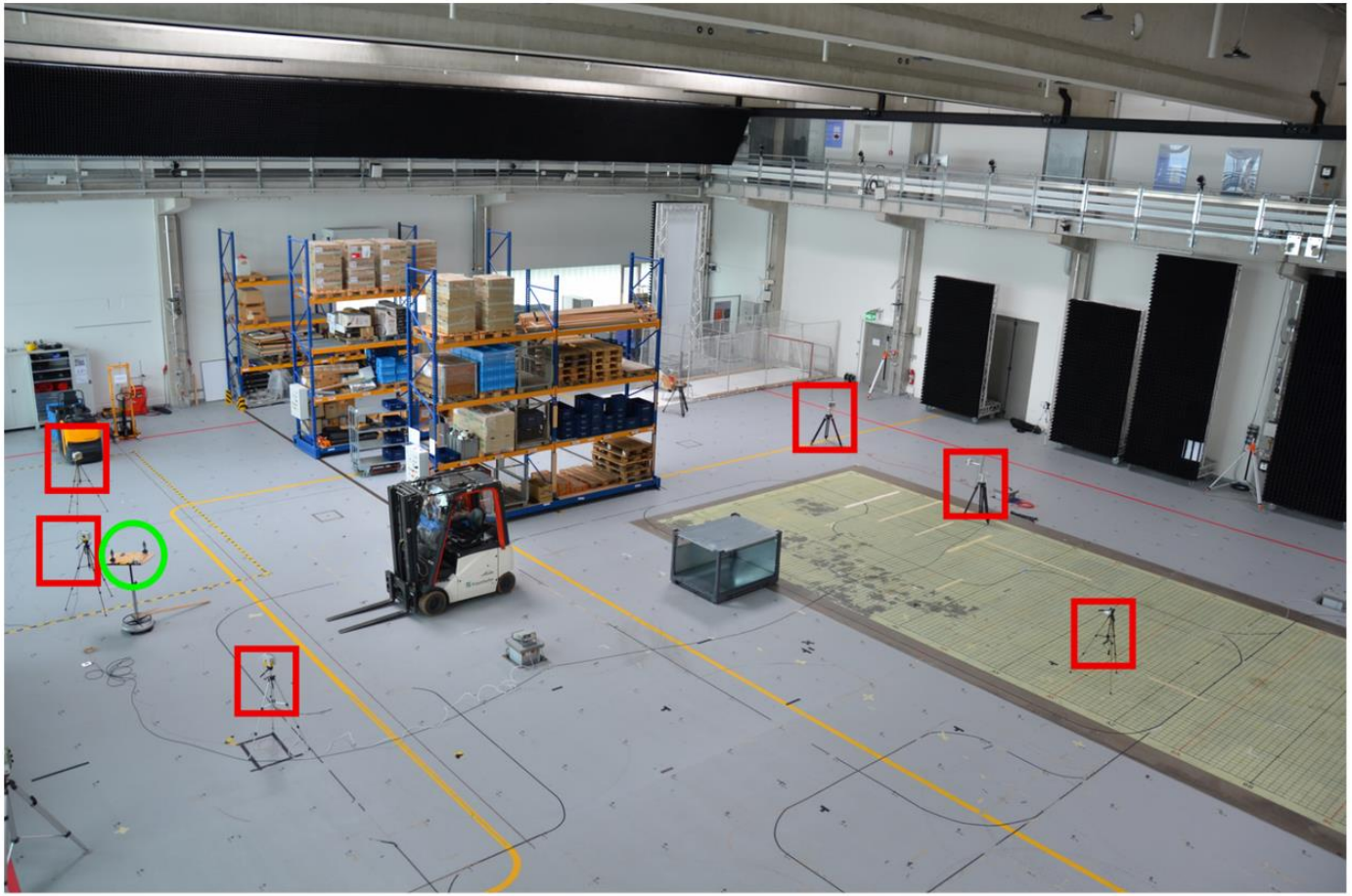

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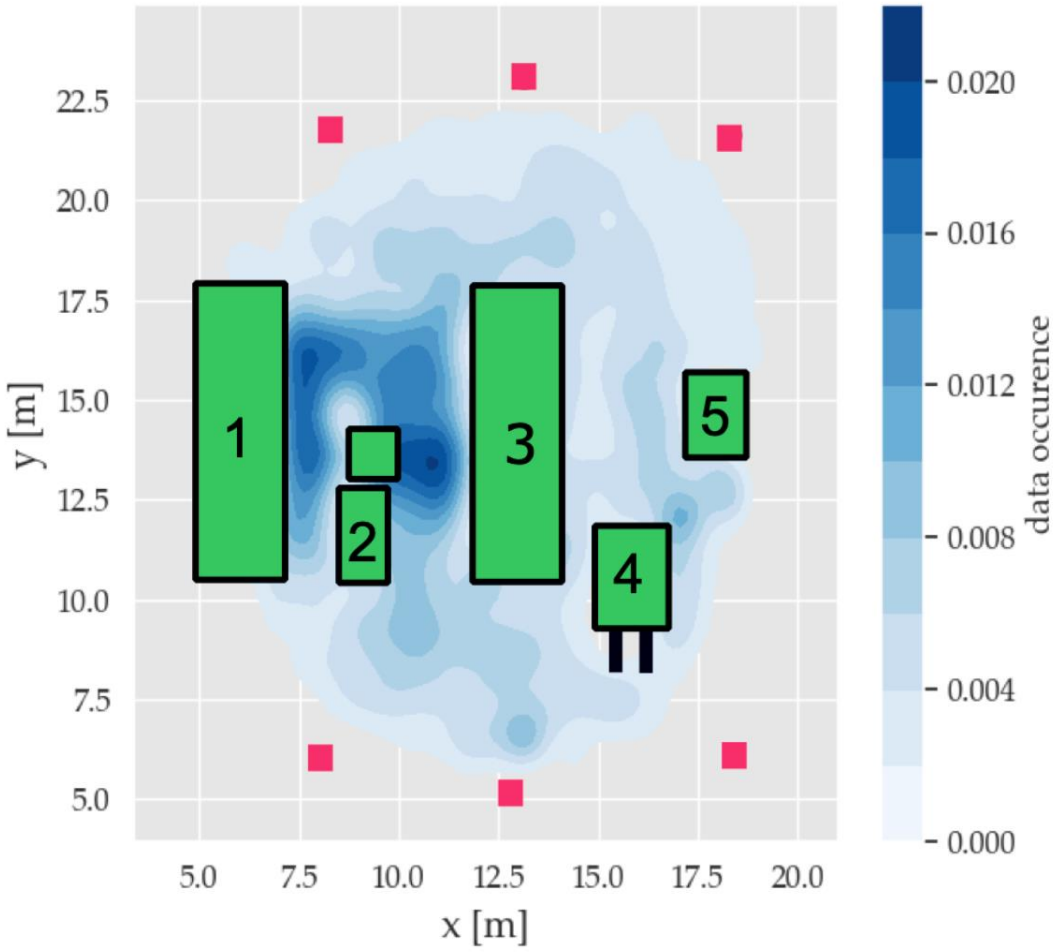






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# Dataset Description

Pandas dataframe containing the CIR data:
`rec_time ([int])`: the timestamp in µs at which the CIR was received at the receiver node.
`burst_id ([int])`: the transmitter time index.
`cir_real (array[int])` and `cir_imag (array[int])`: the real and imaginary parts of the CIR as tuples. The CIRS are centered around the peaks and contain 366 samples each.
`anch_ID ([string])`: the anchor id of the receiving anchor.
`ref_x`, `ref_y ([float])`: Reference positions.

Additional pandas dataframe for anchor information:
`anch_ID [string]` the anchor IDs.
`p_x`, `p_y [float]` positions of the anchors.

Length ~

Challenge objectives:
Data: Second dataframe (same structure, without `ref_x`, `ref_y` ), length ~ 20 min.

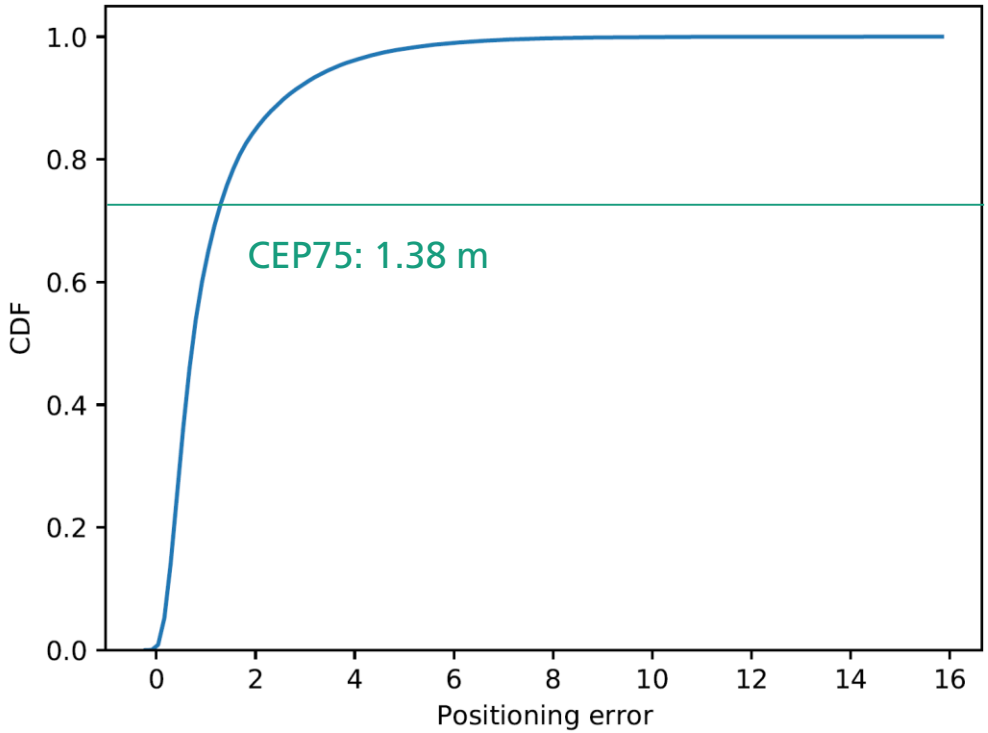
Evaluation interface:
Dataframe containing
the timestamps `t_est ([int])` of the position estimates in µs (starting from 10,000).
the corresponding estimated positions `x_est, y_est ([float])`

# Challenge participation

Unfortunately, only one team contributed results.
Feedback appreciated:

- No interest in CIRs?
- Confusing dataset?
- Uninteresting tracking objective?
- …?

# Challenge results – team YAI



# Thank you for your attention !!!