Technische Universität Braunschweig

Institute of Operating Systems and Computer Networks

Accurate and Precise Distance Estimation from Phase-based Ranging Data

IPIN 2018, Nantes, France

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Overview

- Data Acquisition
  → **Phase-based Ranging**

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- Distance Computation
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  $\rightarrow$ **CDE Algorithm**
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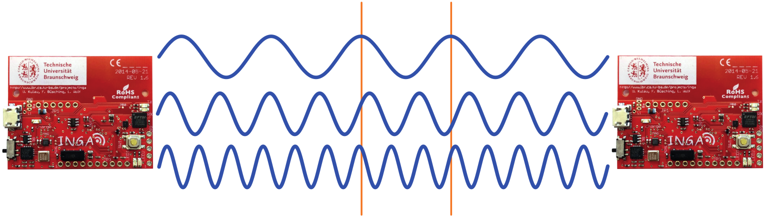
  $\rightarrow$ **Interpolation**
- Comparison to two other algorithms
  $\rightarrow$ **Evaluation**

Phase-based Ranging

- Obtain **distance in meters** between **two wireless sensor nodes**



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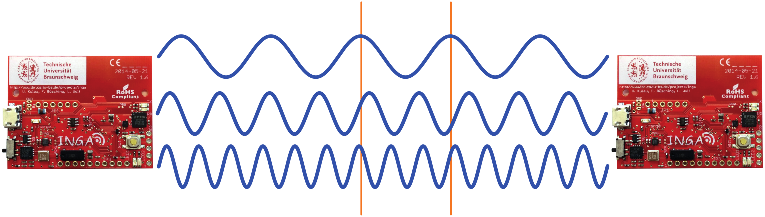

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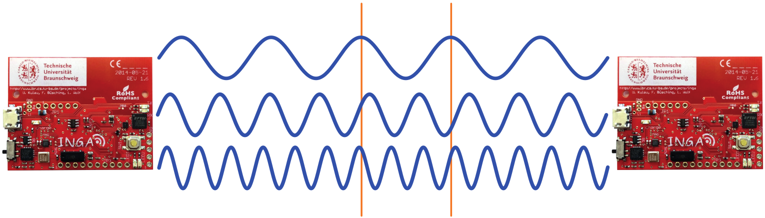

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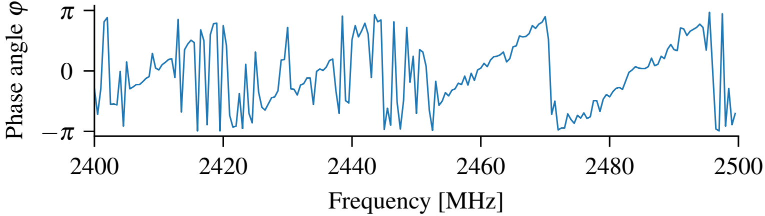

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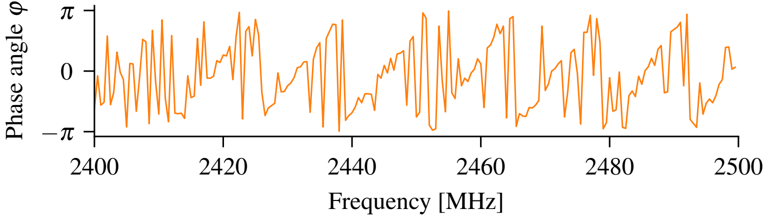

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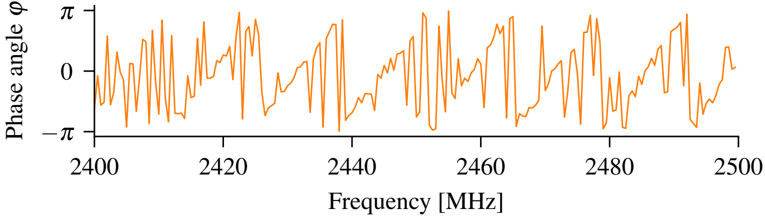

- Distance is **proportional to slope/frequency** of phase response

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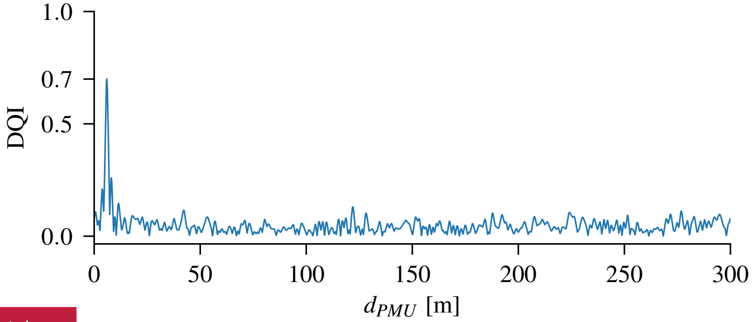

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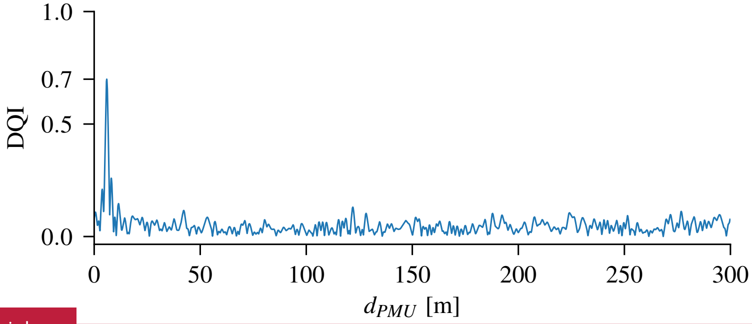

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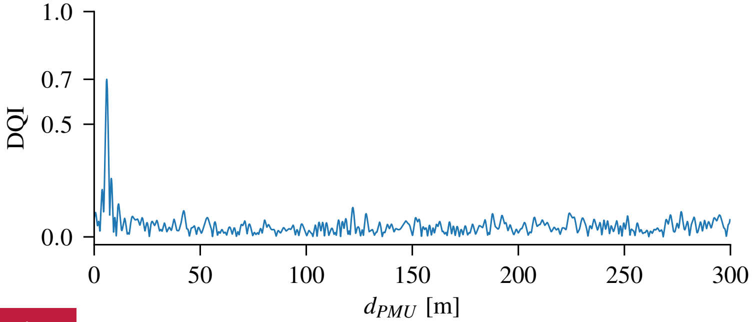

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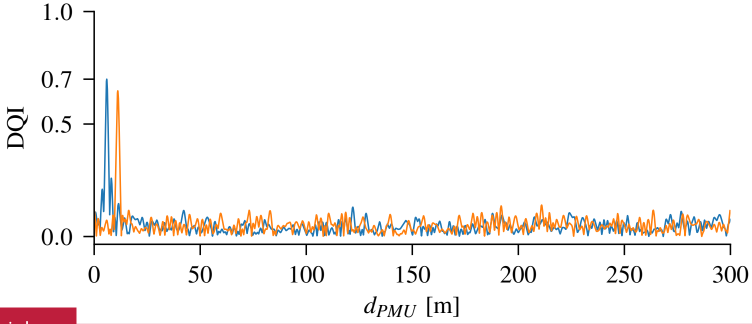

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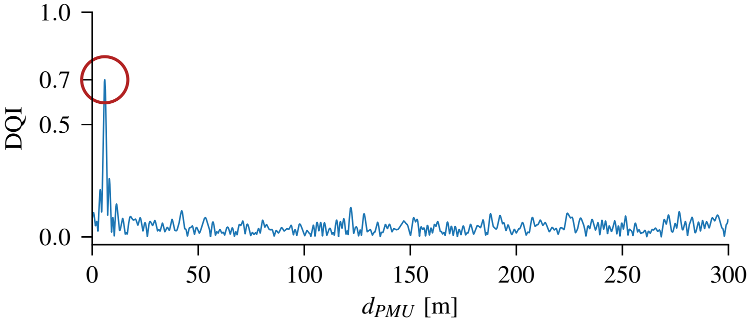

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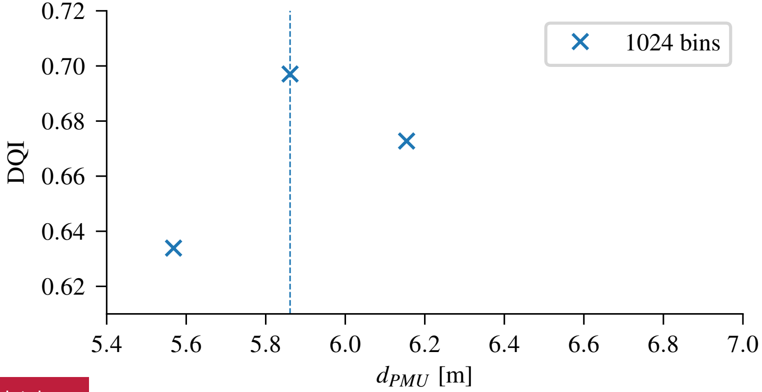

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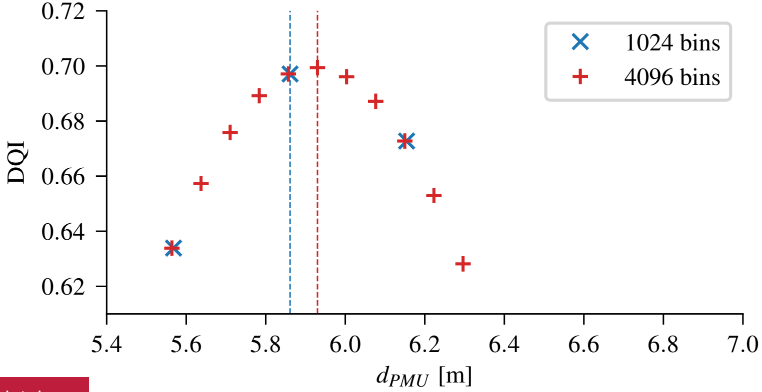

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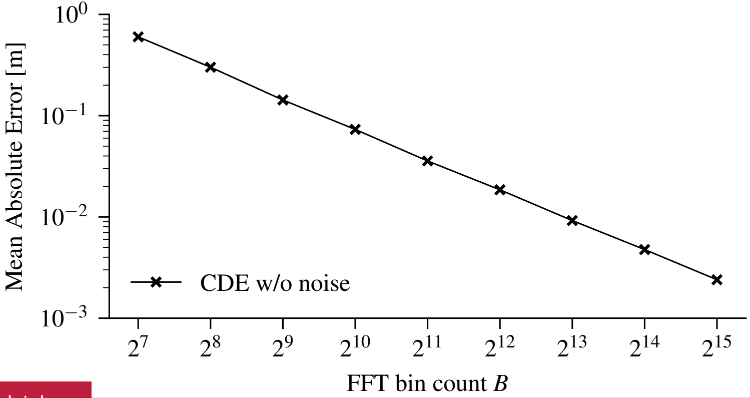

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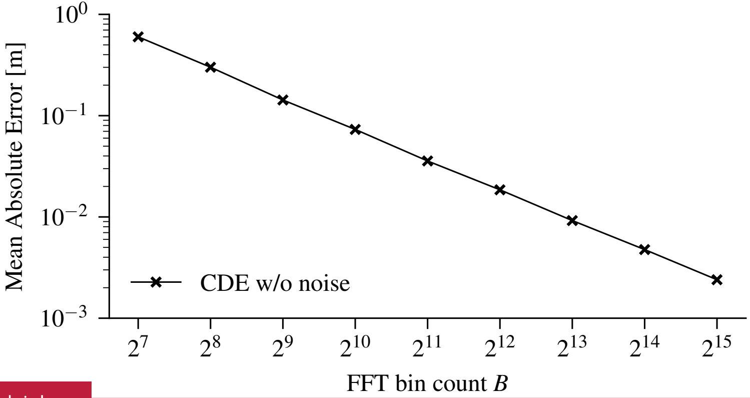

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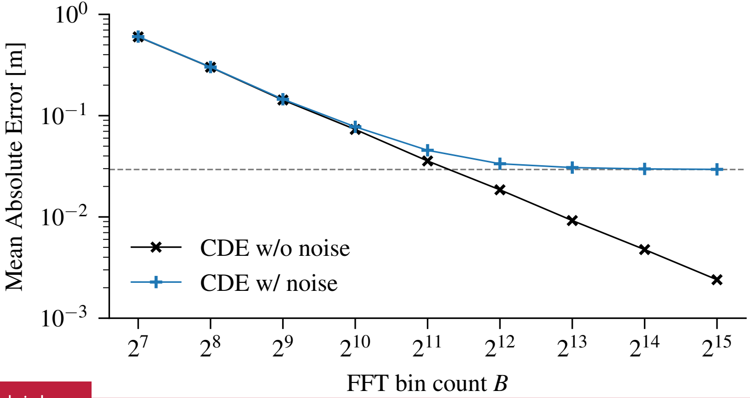

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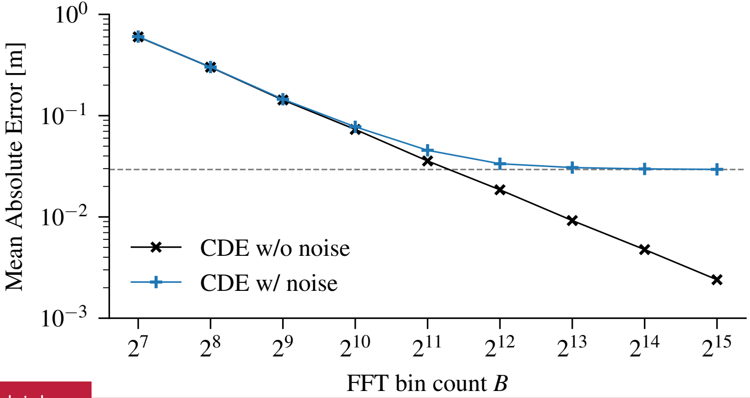
- 2^{12} = **4096 bins** reach **lower bound on accuracy**



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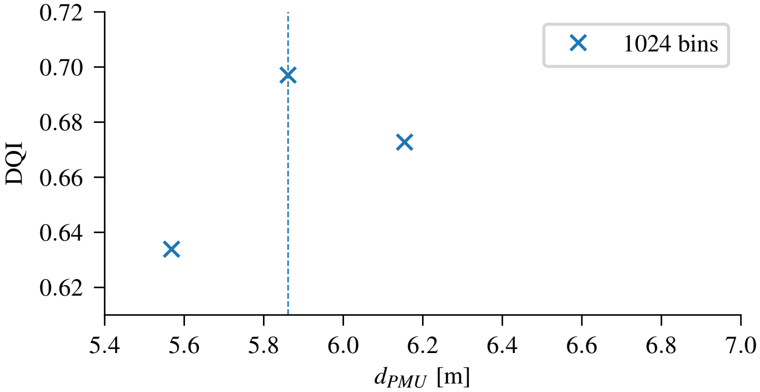

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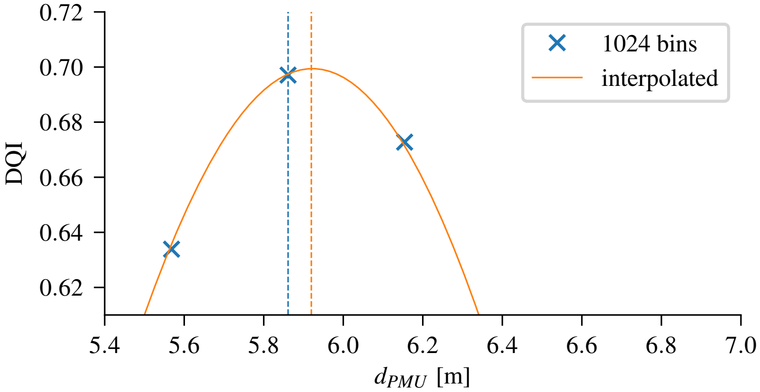

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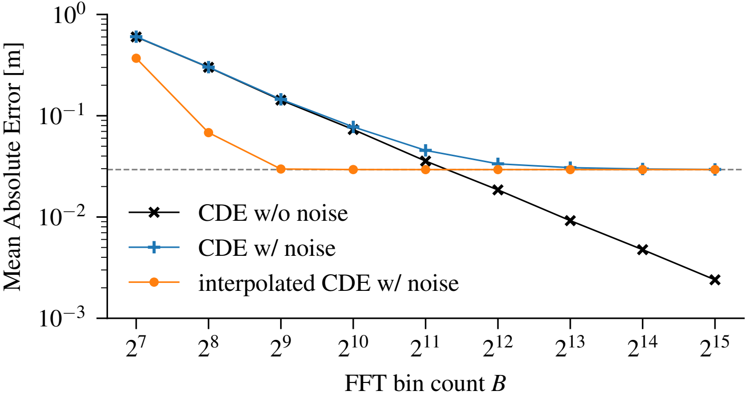

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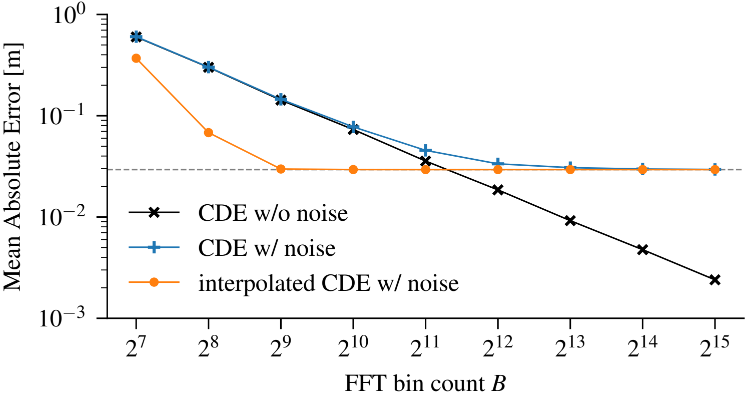
- $2^9 =$ **512 bins suffice** with interpolation



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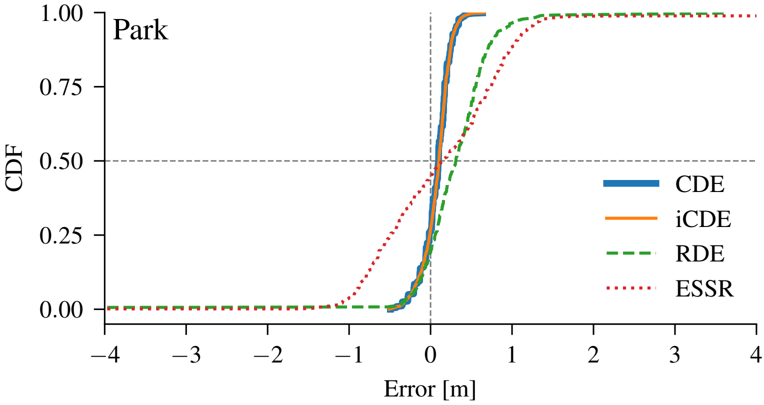
- **All algorithms use the exact same data set**

Park Scenario



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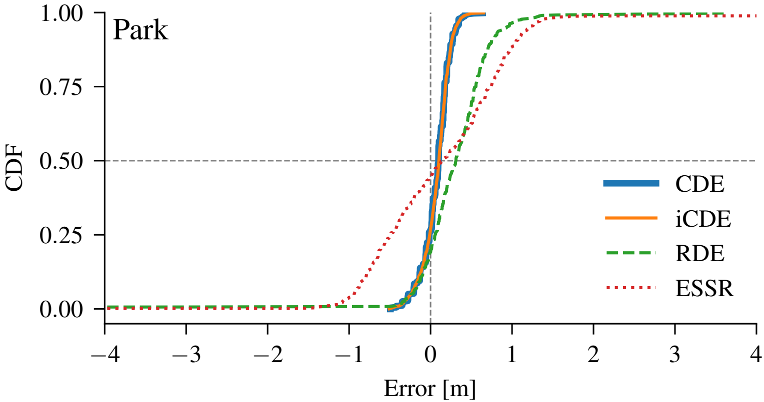

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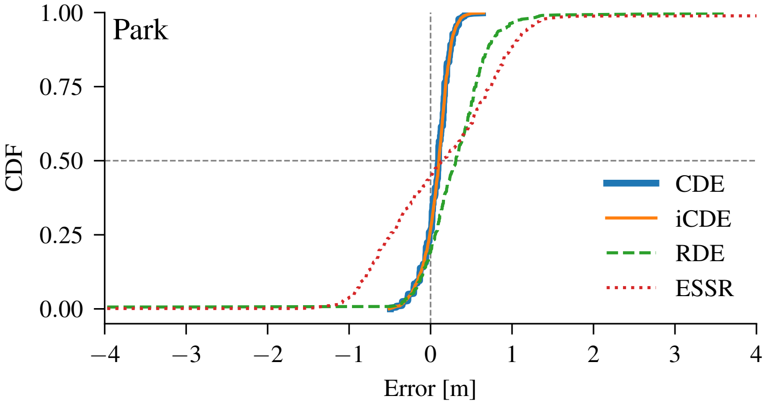

- Interpolation has **no influence** on the result
- RDE and ESSR are accurate but **not precise**

Errors of the Park Scenario

	min. [m]	max. [m]	median [m]	MAE [m]	σ [m]
CDE	-0.493	0.638	0.131	**0.149**	**0.104**
iCDE	-0.507	0.652	0.139	0.151	0.103
RDE	**-69.187**	**3.648**	0.331	0.706	4.292
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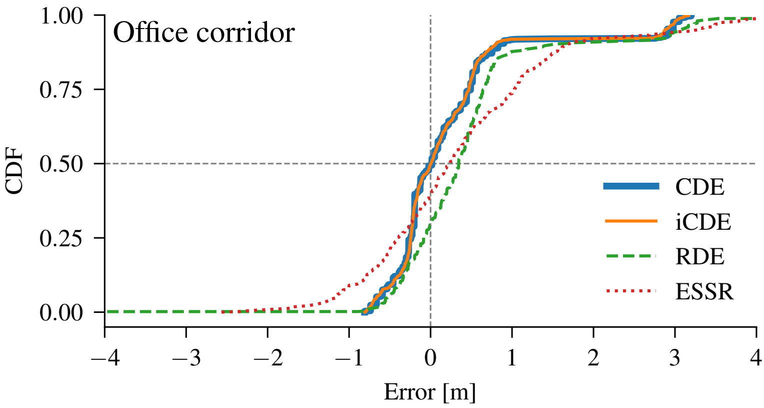
Office corridor Scenario



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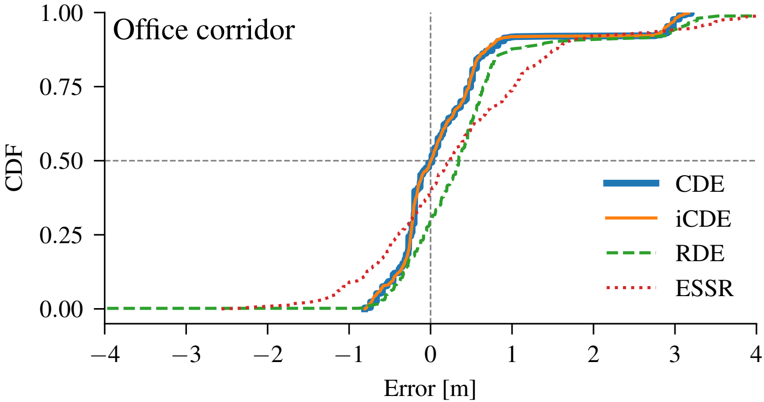

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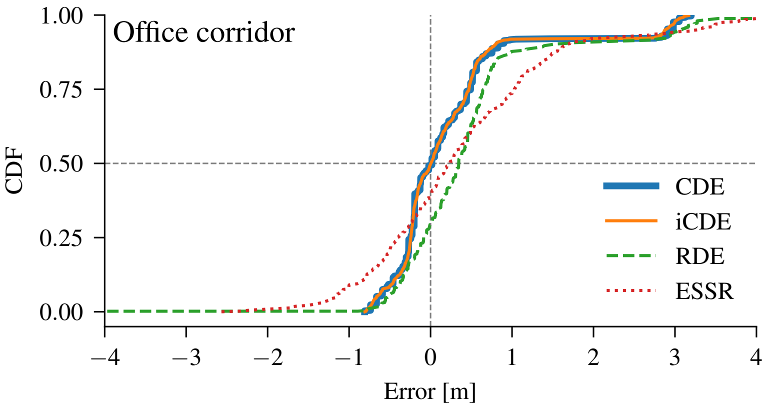

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- **Multipath effects** likely lead to wrong measurements (plateaus)

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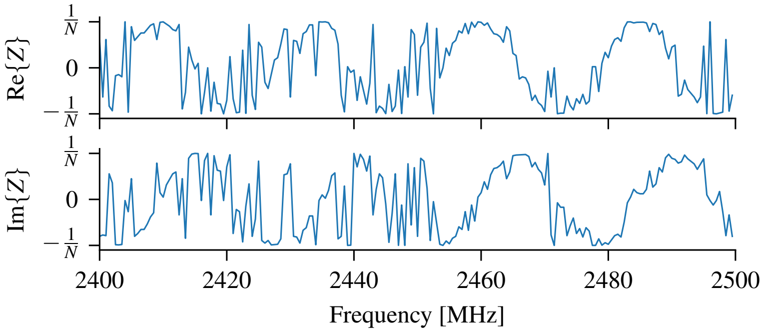
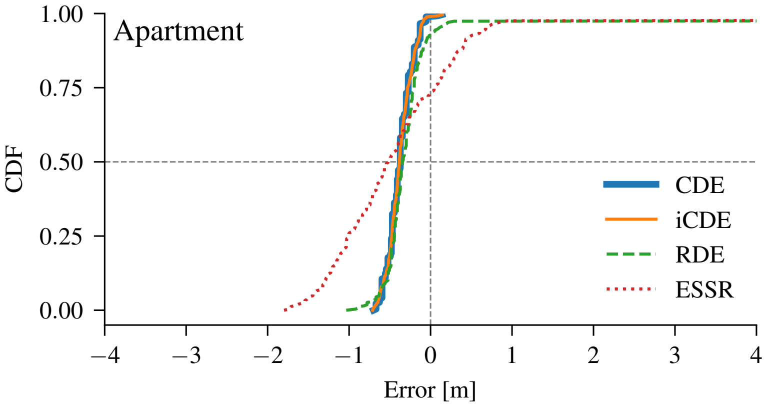
Thank you for your attention!

Complex-valued Distance Estimation

- Compute **complex signal** from phase response
- Assume amplitudes as $\frac{1}{N}$
- Exemplary complex signal for 5 meter distance:



Apartment Scenario



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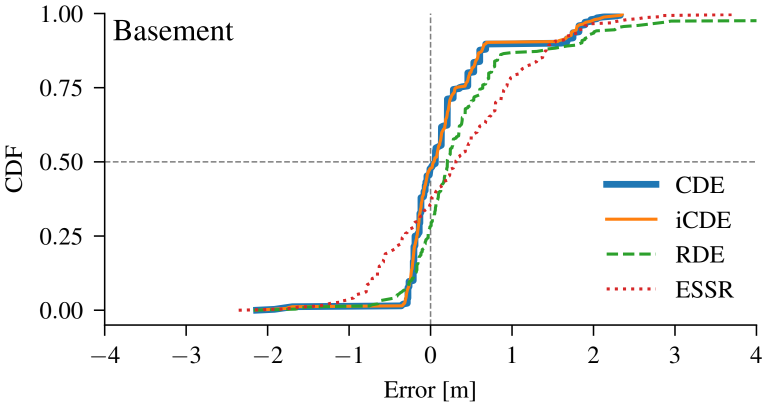
CDE	**-0.701**	**0.140**	**0.372**	**0.376**	**0.146**
iCDE	-0.711	0.145	0.384	0.377	0.147
RDE	-1.035	41.818	0.346	0.862	3.794
ESSR	-1.799	294.078	0.615	3.313	26.353

Basement Scenario



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	min. [m]	max. [m]	median [m]	MAE [m]	σ [m]
CDE	**-2.136**	**2.329**	**0.204**	0.414	0.548
iCDE	-2.144	2.350	0.216	**0.409**	**0.532**
RDE	-2.172	29.598	0.293	0.890	2.850
ESSR	-2.355	3.740	0.652	0.766	0.601

Parameters of the Scenarios

	# meas.	min. dist. [m]	max. dist. [m]
Basement	350	0.5	20.0
Office corridor	650	0.5	49.0
Apartment	350	1.0	7.0
Park	950	0.5	100.0

Interpolation without Noise