CNN-S FOR POSITION ESTIMATION IN TDOA-BASED LOCATING SYSTEMS

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Motivation

Object localization and tracking is essential for many applications including logistics and industry. Many local Time-of-Flight (ToF)-based locating systems use synchronized antennas to receive radio signals emitted by mobile tags. The conventional methods are robust, however they are not capable dealing with nonlinear effects such as **attenuation**, **scattering**, **multipath** and delusion of **precision**.

Goal

We want to use convolutional neural networks (CNN) to skip feature engineering of conventional methods and if the model generalizes for the nonlinear effects such as multipath. In order to train CNN-s we need to generate a large dataset which is then used to train and test the CNN model.

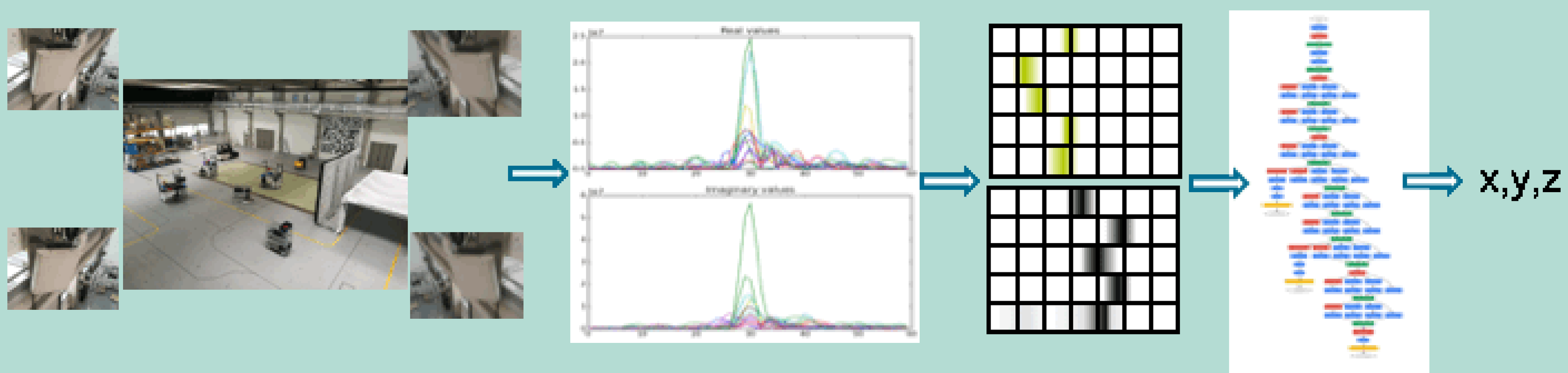

Figure 1: From CIR to position overview.

We use the CIR from the antennas together with ground truth positional data to train a deep CNN. The CNN models both the linear and multipath propagation of the environment.

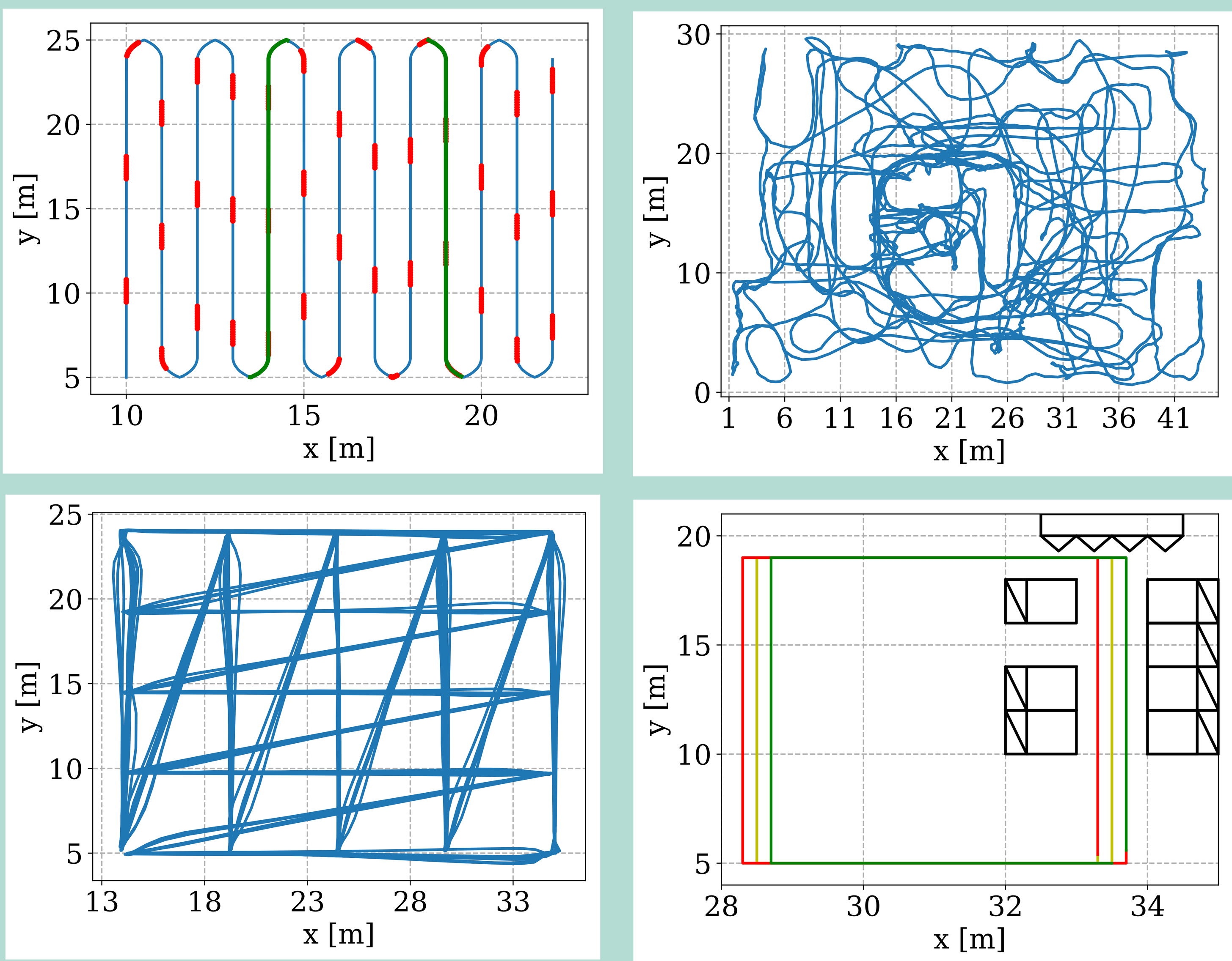

Figure 2: Datasets used in experiments, from top left: Meander, HumanWalk, ZigZag , Displaced Rectangles.

	LM optimizer	Our method
MAE	$80.4cm$	$29.1cm$
CEP	$31.6cm$	$24.1cm$
CE95	$149cm$	$67.3cm$

Table 1: Levenberg-Marquadt Baseline compared to our method on the ZigZag dataset.

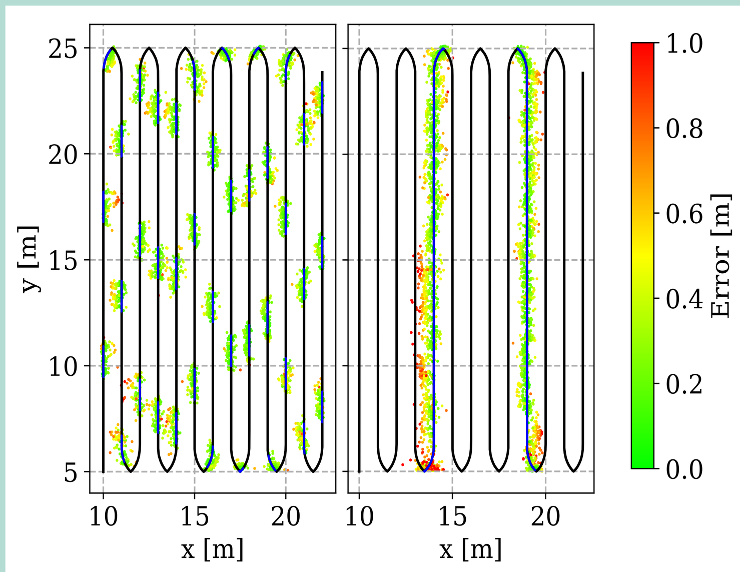

Figure 3: Short and long slice evaluation.

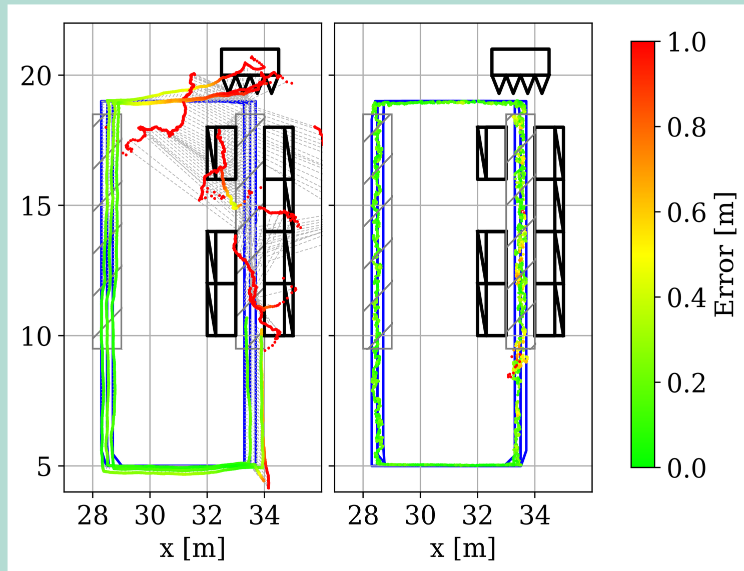

Figure 4: Multipath scenario, EKF on the left, our method on the right.

Evaluation

To see whether our model managed to generalized or just overfitted to the dataset, we tested CNN with **short** and **long slices,** which were omitted from the training set, to see whether our model generalizes (**Fig. 3).**

Results

The baseline approach is done with ZigZag dataset in line of sight conditions with LM optimization over the dataset shows us that our CNN method beats the „traditional" approach(**Table 1**.). Further evaluation with the multipath scenario is seen in **Fig. 4** and the results displayed in **Table 2**.

LoS	EKF	CNN	NLOS	EKF	CNN
MAE	$14.8cm$	$15.4cm$	MAE	$211cm$	$29.2cm$
CEP	$14.1cm$	$14.6cm$	CEP	$145cm$	$22.9cm$
CE95	$27.0cm$	$28.3cm$	CE95	$529cm$	$68.3cm$

Table 2: Multipath scenario results between EKF and our method.

We also compared different CNN architectures on the Meander dataset and plotted the cumulative probability distribution on **Fig. 5.**

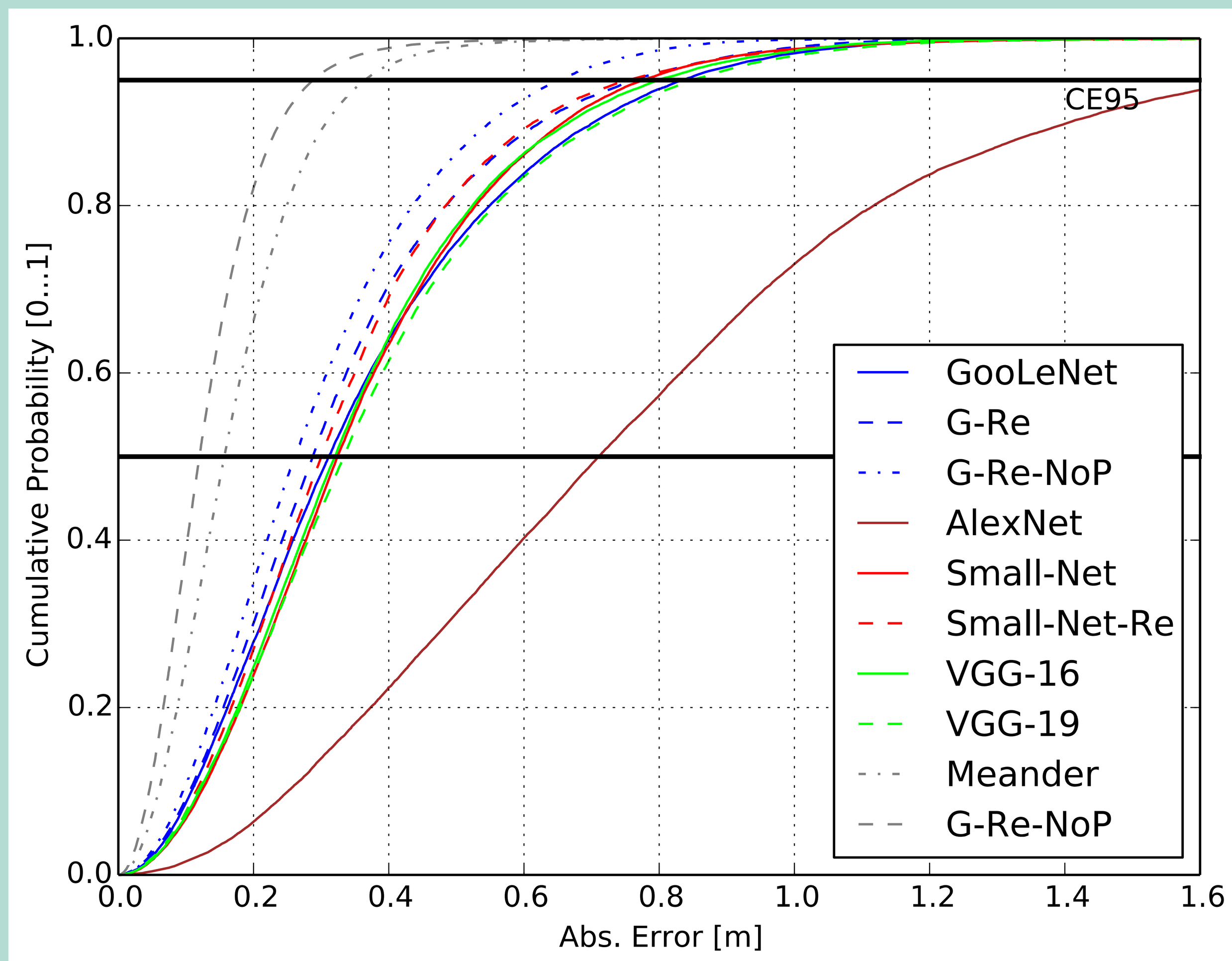

Figure 5: Cumulative probability over the Meander dataset.

Discussion

- It is possible to train CNN-s with CIR-s of TDoA-based locating systems.
- Our method outperforms conventional signal processing approach under heavy multipath propagation.

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