Enhancing ToA positioning with a hybrid deep learning approach

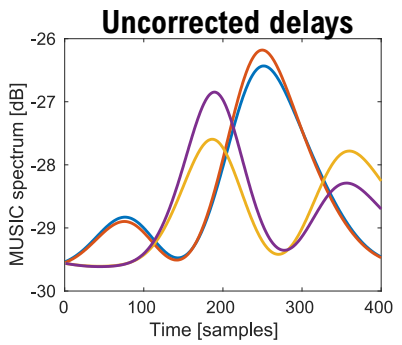
Dolores Garcia, Alejandro Blanco, Héctor Cordobés, Joerg Widmer

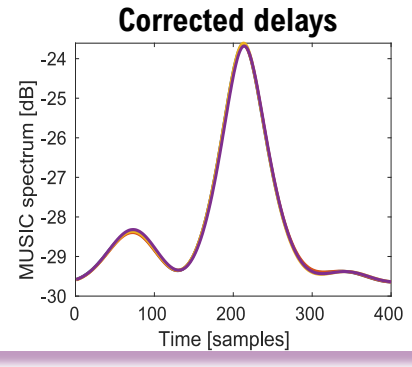
Developing the Science of Networks

institute IMDEA networks

Classical Fingerprinting Algorithm

- Reducing the dimensionality by estimating one Time of Arrival per antenna element with the MUSIC algorithm
- Apply a circular shift to the ToA spectrum as fixed delays are observed for some antenna elements
- Feed the $\{t_i\}_{i=1}^{16}$ real values to the fingerprinting table to obtain a location prediction





Hybrid approach

- Regressor method based on the divergence of the predictions with a threshold to decide
- The Fingerprinting method is used for smaller divergences and CNN for larger ones
- The optimal threshold is obtained through grid search yielding about 0.6m and has less than 8cm of standard deviation

Convolutional Neural Network (CNN)

- Raw data based approach
- Use several 1D convolutional layers to emulate a phase processing along the different carriers over the raw values
- This method presents less outliers, with a MAE of 0.16m

Layer	Size	Filters
Conv1D	9	16
MaxPool1D	2	
Conv1D	9	32
MaxPool1D	2	
Conv1D	7	64
MaxPool1D	2	
Dense	1024	
Dense	1024	
Output	3	

We also evaluate a ML approach, where a regressor is fed with the prediction from both approaches. The best RMSE result was obtained with a Gradient Bosting Machine (XGBoost)

Results

- We evaluate our results with 10-fold cross-validation scheme
- Best RMSE value (0.19m) is obtained with the GBM Hybrid Model, but the threshold-based Hybrid Model and the fingerprinting method set the 80th-percentile on just 2cm error

Model	RSME	MAE	80th-percentil
Fingerprinting	0.66	0.20	**0.02**
CNN	0.24	0.16	0.22
Hybrid (threshold)	0.21	**0.07**	**0.03**
Hybrid (GBM)	**0.19**	0.09	0.11