Deep Learning for Location Based Beamforming with NLoS Channels

Luc LE MAGOAROU
Taha YASSINE
Stéphane PAQUELET
Matthieu CRUSSIÈRE

CONTEXT

- Massive MIMO systems rely on CSI to determine appropriate precoders.
- CSI acquisition requires sending pilot symbols which induce an important overheard.
- Location based beamforming aims at determining precoders based on estimated user locations.
- Existing approaches rely on LOS path to construct the precoder.
- The proposed approach handles both LOS and NLOS channels.

PROBLEM FORMULATION

Considering a base station equipped with $\mathbf{A}$ antennas and a single subcarrier. We denote $\mathbf{h} \in \mathbb{C}^A$ the downlink channel vector between the base station and any given user, and $\mathbf{l} \in \mathbb{R}^D$, $D \in \{2, 3\}$ its location.

$$\begin{array}{rcccc} \mathcal{P} & : & \mathbb{R}^D & \rightarrow & \mathbb{C}^N \\ & & \mathbf{l} & \mapsto & \mathbf{w} \triangleq \mathcal{P}(\mathbf{l}). \end{array}$$

$\mathbf{w}$ is the preficted precoder.

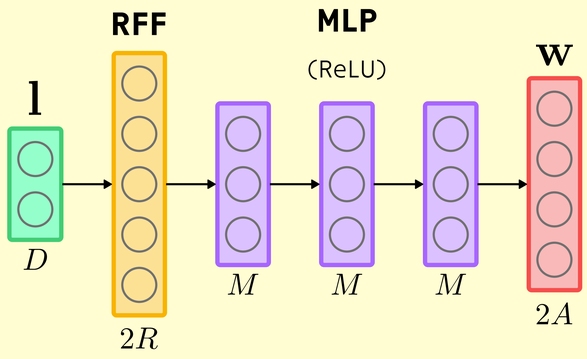
To evaluate performance of the precoding function, the normalized correlation between the precoder $\mathbf{w}$ and the channel $\mathbf{h}$ is used:

$$\eta \triangleq \frac{|\mathbf{w}^H \mathbf{h}|^2}{\|\mathbf{h}\|_2^2}.$$

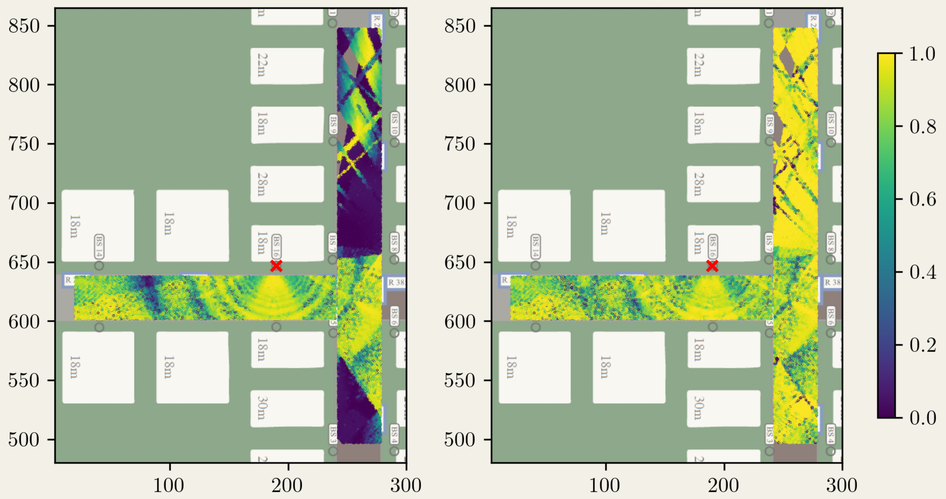
CONCLUSION

- The proposed method allows to extend location based beamforming to NLOS situations.
- It directly learns the location/precoder mapping with the help of a neural network.
- It relies on the use of random Fourier features to learn high spatial frequencies

NEURAL NETWORK



We propose to use a neural network to learn the mapping $\mathcal{P}$ in supervised manner. In particular, we introduce a **random Fourier features (RFF)** [1] layer to allow the network to learn functions containing high spatial frequencies.



References

[1] M. Tancik et al., "Fourier features let networks learn high frequency functions in low dimensional domains," Advances in Neural Information Processing Systems, vol. 33, pp. 7537–7547, 2020.
[2] A. Alkhateeb, "DeepMIMO: A Generic Deep Learning Dataset for Millimeter Wave and Massive MIMO Applications," in Proc. of Information Theory and Applications Workshop (ITA), San Diego, CA, Feb. 2019, pp. 1–8.

EXPERIMENTS

The proposed method is compared to two baselines:

- A classical LBB approach for which the precoder is chosen as the normalized LOS channel in the direction of the user, assuming the azimuth and elevation are perfectly known.
- A deep learning approach using a simple multilayer perceptron (MLP) with the same architecture as the one of the proposed method but where the RFF layer is replaced by a simple fully connected layer.

Evaluation is performed on the DeepMIMO dataset ('O1" scenario) [2]. The neural networks are trained on a set of $N = 10000$ channels for 50 epochs. All methods are evaluated on a training set of unseen channels.

RESULTS

Results show that the proposed method greatly outperforms the baselines. This is shown by the cumulative distribution function (CDF) of the correlation.
In addition, the spatial distribution of the attained correlation reveals how the classical method struggles with NLOS channels (blue areas) while the proposed method performance is not affected.