Wireless User Positioning via Synthetic Data Augmentation and Smart Ensembling

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Dataset

<table>
<thead>
<tr>
<th></th>
<th>Train</th>
<th>Validation</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL</td>
<td>17486</td>
<td>11366</td>
<td>2623</td>
</tr>
</tbody>
</table>

Models

Several models from the literature were tested:
- U-Net [1];
- VGG [2];
- ResNet50 [3];
- DenseNet [custom];
- Others.

The architectures were adjusted to the different nature of our problem, enhancing their performance.

Cyclical Learning Rate (CLR)

- Cyclical Learning Rate can train deep networks faster and better;
- CLR works especially well with Convolutional Layers;
- Regularization is necessary to avoid strong overfitting;
- CLR allows to find better minima;
- One-cycle policy performed best for us.

Autoencoder Pre-training

In the novel framework we proposed, first an autoencoder learns a compressed representation of the channel matrix using the synthetic data, in a completely unsupervised manner. Thus, positions (labels) are not needed during the first phase of the training.

After this phase, only the encoder part of the network is reused and the acquired knowledge is transferred to the real data domain.

We used an implementation of the 3GPP TR 38.901 indoor channel model to obtain a large number of synthetic, unlabeled channel matrices, making it possible for the autoencoder to understand the underlying correlations within a channel matrix.

Ensembling

To exploit the correlation between the received signal power and the RX-TX distance, the following architecture is proposed:
- A deep network, chosen among the best-performing ones, extracts the information from the raw channel matrix;
- A shallower network conveys the power information to the output layers, giving it a higher relevance on determining the position.

The respective outputs are therefore concatenated and fed to a last, dense output layer.

Results

![Fig. Performance of some of the tested networks]

![Fig. Smoothed training curves for VGG-based networks]

![Fig. Visualization of our best model’s errors]

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Mattia Lecci’s activity was financially supported by Fondazione Cassa di Risparmio di Padova e Rovigo under the grant “Dottorati di Ricerca 2018.”