Introduction
The task of wet-dry classification using measurements from commercial microwave links (CMLs) is a subject that been studied in depth. In this work, we present, for the first time an empirical study on rain classification using long short-term memory (LSTM) units with a multi-variable time series and CMLs, we demonstrate that LSTM can even be used for rain detection (wet-dry classification).

Background
Commercial Microwave Links (CMLs) for rain detection and estimation

The relation between rain and signal attenuation is given by:

\[ A = aR^bL \]  

CMLs high coverage over land provide more than 4M sensors.

Our main contribution is in:

1. The use of records of errors in CMLs for rain monitoring.
2. The application of RNN techniques on CML data for rain monitoring.

Data description
Our data set based on actual CMLs measurements provided by the cellular company CELLCOM (Israel). Using CMLs static data \( x^{(s)} \) and dynamic data RSL, TSL \( x^{(2)} \) and Error \( x^{(3)} \).

The link error types:

1. BBE (Background Block Error): An errored block not occurring as part of an SES.
2. ES (Errored Second): A one-second period with one or more errored blocks
3. SES (Severely Errored Second): A one-second period which contains \( \geq 30 \) percentage errored blocks.
4. UAS (Unavailable Second): Intervals pertaining to an Unavailable Time.

\[ x^{(s)} = [L, F, R, BW, F_L^{(s)}, F_L^{(s)}] \]
\[ x^{(2)} = [mRSL, MRS, mTSL, MTSL] \]
\[ x^{(3)} = [BBE, ES, SES, UAS] \]
\[ x^{(4)} = [\hat{x}_n^{(3)}, \hat{x}_{n-1}^{(3)}, \hat{x}_{n-2}^{(3)}, \hat{x}_{n-3}^{(3)}, \hat{x}_{n}^{(2)}, \hat{x}_{n-1}^{(2)}, \hat{x}_{n-2}^{(2)}, \hat{x}_{n-3}^{(2)}] \]

Method
The data preprocessing procedure: Normalization, concatenation, sub-sequences splitting and wet / dry sample alignment. The Network Architecture based on LSTM with dynamic and static inputs.

The loss function define via the following equations:

\[ L = \sum_{n=0}^{N-1} \gamma_n \cdot L_n \]  

Where \( L_n \) is standard Cross Entropy Loss

Experiments
We conducted three experiments, where in each case we used different dynamic input data: errors only (Eq. (4)), attenuations only (Eq. (3)), and both errors and attenuations. The confusion matrix results over the three experiments

The experiments accuracy are shown in Table 1.

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Training</th>
<th>Validation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Error</td>
<td>76.7%</td>
<td>74%</td>
</tr>
<tr>
<td>Attenuation</td>
<td>91.5%</td>
<td>90.5%</td>
</tr>
<tr>
<td>Error and</td>
<td>91.9%</td>
<td>90.8%</td>
</tr>
</tbody>
</table>

Acknowledgements
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