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Improving Precipitation Estimates from Commercial Microwave Links Using Deep Learning: A Comparative Study on OpenMRG Data

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Compared to conventional methods, Commercial Microwave Links (CMLs) offer great spatial and temporal resolution, making them a viable opportunistic sensing technology for precipitation assessment. However, noise, ambiguity, and non-linear connections between signal attenuation and rainfall intensity make it difficult to reliably estimate precipitation using CML-derived attenuation data. In this work, we use the OpenMRG dataset, which contains metadata like frequency, link length, and polarization combined with CML-derived signal attenuation data, to investigate the potential of deep learning (DL) techniques to enhance precipitation estimations.

We assess the performance of various deep learning and machine learning models, such as Random Forest, Quantum Machine Learning (QML), Long Short-Term Memory (LSTM) networks, and Support Vector Regression (SVR). Our findings show that LSTM networks outperform conventional techniques like Random Forest (MAE: 0.530, R2: 0.026) with a Mean Absolute Error (MAE) of 0.529 and an R2 score of 0.074, capturing temporal correlations in the data. Additionally, we investigate the use of quantum-inspired models, demonstrating the potential of hybrid quantum-classical techniques for this job with an MAE of 0.507 and an R2 score of 0.125.

We suggest a novel deep learning framework that combines feature engineering, hyperparameter optimization, and ensemble techniques in order to overcome the shortcomings of current models. According to preliminary tests using polynomial features and sophisticated models like as XGBoost and SVR, performance can be further improved by meticulous preprocessing and model modification. According to our research, precipitation estimations obtained from CML data can be made much more accurate and reliable by using deep learning, especially LSTM and hybrid quantum models.

By showcasing the efficiency of DL approaches for processing CML data, this work adds to the expanding corpus of research on opportunistic sensing. We also highlight the possibilities for combining CML-derived precipitation estimates with conventional remote sensing techniques like radar and satellite data, and we talk about the implications of our findings for operational applications like nowcasting and hydrological modeling. In order to promote the use of CMLs for real-time, high-resolution precipitation monitoring, this work attempts to close the gap between data collection and useful insights.

Are you an Early Career Scientist ?

Yes

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