A Deep Learning Approach for Remote Sensing Based Estimation of $PM_{2.5}$ in Urban Areas: A case study of Greater Taipei Area

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ABSTRACT

Air pollution remains a threat, with particulate matter being one of the several key indicators of pollution. Numerous studies show that particulate matter of diameter 2.5 µm or smaller ($PM_{2.5}$) impacts public health, hence the need for more accurate models. Traditional numerical methods fail to capture pollutants' spatiotemporal patterns; however, neural networks can learn from environmental data inputs to obtain correlations. In this study, a Temporal Convolution Network – Bi-Long Short-Term Memory (TCN – Bi-LSTM) hybrid model is proposed. TCN-Bi-LSTM is for $PM_{2.5}$ monthly estimation in 2023 using Taiwan's Ministry of Environment air quality historical data from July 2015 to December 2022 – including weather parameters and land use data – to produce a 1km $PM_{2.5}$ map via k nearest neighbors – inverse distance weighting (KNN – IDW). The former model captures causal patterns while the latter handles long range temporal dependencies. The preliminary results compare the proposed model against classical models like Convolution Neural Network and Long Short-Term Memory. The proposed model performs better compared to the others with a metric evaluation of $R^2 = 0.784$ and root mean square error (RMSE) = 2.225 µg/m³ in the GroupKFold cross validation. This study aims to contribute to the bulk of air quality monitoring research and hopefully help mitigate the missing data issue, mainly due to cloud cover on satellite observations during aerosol optical depth retrieval. Future work will evaluate how the model predicts in the 4 common seasons: winter, spring, summer and autumn.

Keywords: Particulate Matter (PM), Spatiotemporal, Temporal Convolutional Network, Long Short-Term Memory