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Forecasting $PM_{2.5}$, PM_{10} & AQI Using TCN: A UAE Case Study

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Desert-dust events in the United Arab Emirates (UAE) frequently cause sharp increases in particulate matter (PM) pollution, posing significant risks to public health and aviation safety.
This study focuses on next-day forecasting of daily $PM_{2.5}$ and PM_{10} concentrations and their corresponding Air Quality Index (AQI) categories across Abu Dhabi Emirate.
We are using five years of air quality data (2015–2019) from ten monitoring stations operated by the Environmental Agency –Abu Dhabi (EAD) as well as meteorological inputs derived from METAR reports—including temperature, relative humidity, wind speed/direction, and atmospheric pressure—available as both daily aggregates and raw hourly data.
We compare traditional statistical models (SARIMA, linear regression) with deep learning approaches (Gated Recurrent Unit [GRU], Temporal Convolutional Network [TCN]). Additionally, we propose a two-tier AQI classification framework that considers both the most likely and second-most likely predicted classes to enhance robustness.
Results show that a multi-station TCN model, integrating hourly meteorological data and station characteristics, achieves superior performance. Specifically, it correctly identifies the $PM_{2.5}$ AQI class in the first or second guess predictions 96% of the time, with errors greater than one class being exceedingly rare.
To our knowledge, this is the first application of TCNs for PM forecasting and AQI classification in the UAE. Our findings demonstrate the TCN model's effectiveness, computational efficiency, and resilience in handling moderate-sized environmental datasets, providing a practical solution for air quality forecasting and public health readiness in arid environments.

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