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Abstract:

Urban air pollution remains one of the most pressing environmental challenges of the twenty-first century, particularly in rapidly expanding metropolitan regions. Accurate monitoring of atmospheric pollutants is essential for understanding pollution dynamics and designing effective mitigation strategies. This study presents an integrated framework for monitoring urban air quality by combining satellite observations, ground-based monitoring networks, and artificial intelligence techniques. The approach utilizes multi-sensor satellite datasets, including aerosol optical depth retrievals, nitrogen dioxide column measurements, and land surface temperature observations, to capture spatial patterns of atmospheric pollution. Machine learning algorithms were developed to integrate heterogeneous datasets and estimate near-surface concentrations of key pollutants such as particulate matter (PM_{2.5}), nitrogen dioxide (NO₂), and ozone (O₃). The proposed system was evaluated in several major urban regions characterized by different climatic and emission conditions. Results indicate that the AI-assisted framework significantly improves the accuracy of pollution estimates compared with traditional interpolation methods. The integration of satellite data with machine learning models allows better detection of pollution hotspots and temporal variability associated with traffic activity, industrial emissions, and meteorological conditions. The study also demonstrates the potential of remote sensing technologies to complement ground-based monitoring networks in regions where observational infrastructure is limited. Sensitivity analyses show that incorporating high-resolution satellite imagery improves spatial representation of urban pollution gradients. Furthermore, the framework can support near-real-time environmental monitoring and policy decision-making. Overall, the results highlight the growing importance of artificial intelligence in environmental monitoring and atmospheric research. The integration of multi-sensor satellite observations with advanced data analytics provides a promising pathway toward more accurate and comprehensive urban air quality assessments.

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