Integrated Analysis of Road Texture and Acoustic Emissions in Urban Air Pollution Modeling

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Abstract:
Urban air quality and traffic-related noise are critical factors influencing public health and environmental sustainability. This study investigates the relationship between vehicle-emitted particulate matter (PM) and noise levels across varying frequency bands, emphasizing the role of road texture and driving conditions. By integrating emission and acoustic data, the research reveals frequency-specific patterns and highlights how vehicle type, speed, and traffic behavior shape pollution dynamics. Using a random forest model, the study identifies key correlations but also notes limitations in real-time forecasting due to data volume sensitivity. Practical recommendations include optimizing traffic signal systems, promoting low emission vehicles, and adopting advanced low-noise road materials strategies currently reflected in Hong Kong's urban planning initiatives. The findings underscore the importance of holistic traffic management approaches that simultaneously address air and noise pollution. The predictive models can be refined by incorporating additional environmental variables such as wind speed, humidity, and explore alternative machine learning techniques. This work presents a foundation for data-driven policymaking and the development of integrated frameworks for urban pollution control.

Keywords:
Vertical dispersion, particulate matter (PM), health risks, tire-road noise, random forest, transport infrastructure.