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Development and Validation of a Representative Driving Cycle for Metro Manila: A Data-Driven Approach to Assess Vehicle Emissions and Inform Emission Reduction Strategies

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Abstract Metro Manila's severe traffic congestion and air pollution demand accurate emission assessment tools. Standard driving cycles often fail to capture unique local conditions, leading to flawed inventories. This paper details the data-driven development and validation of the Metro Manila Driving Cycle (MMDC). Real-world vehicle data (GPS, OBD-II) were processed to construct the MMDC via micro-trip clustering and synthesis. The MMDC features significantly lower average speed (~20.3 km/h) and higher idle time (~29%) than standard cycles (FTP-75, WLTC Class 3b). Validation against field data confirmed its representativeness, with kinematic parameters and speed-acceleration probability distributions showing strong correlation. The MMDC enables more accurate vehicle emission estimations and informs targeted emission reduction strategies for Metro Manila.

Keywords: Driving Cycle, Emissions, Philippines, Urban Mobility, Markov Chain

1. Introduction

Metro Manila faces a transport crisis with severe congestion and air pollution, where mobile sources are dominant. Standard driving cycles, unsuited to Metro Manila's unique stop-start, high-idle conditions, yield inaccurate emission inventories and ineffective policies. Developing a representative, local driving cycle is crucial for accurate assessment, emission quantification, and targeted policy formulation. This paper details the data-driven development and validation of the Metro Manila Driving Cycle (MMDC), highlighting its role in improving emission assessments and informing strategies.

2. Methods

The MMDC development involved data acquisition, preprocessing, cycle construction, and validation. Real-world driving data (speed-time profiles, 1 Hz) were collected via GPS/OBD-II from representative vehicles across diverse Metro Manila routes/conditions. Raw data underwent noise reduction, error correction, and micro-trip segmentation. The MMDC was constructed by clustering micro-trips by kinematic parameters (e.g., average speed, idle duration) and synthesizing representative micro-trips to a target duration (1200-1400s), using methods like K-means clustering and Markov Chain Monte Carlo simulation. Validation compared MMDC's kinematic parameters and speed-acceleration probability distribution (SAPD) against aggregated field data using statistical metrics.

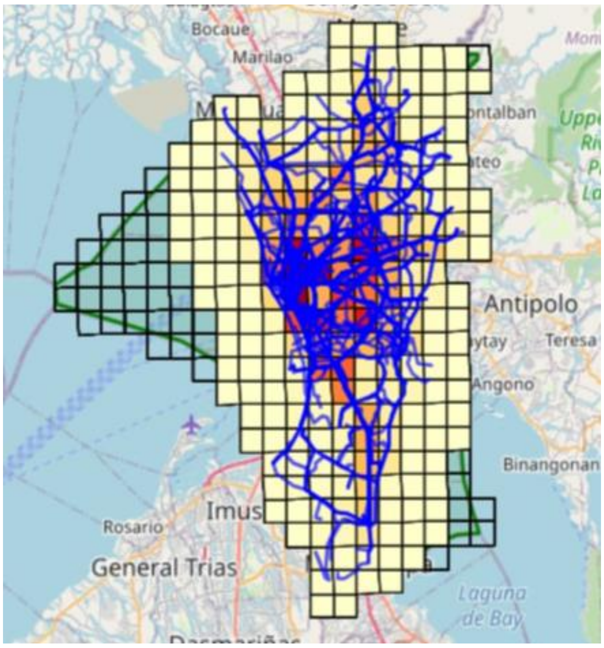

Figure 1. Map of Metro Manila in grids and routes for drive cycle analysis

3. Results

A representative Metro Manila Driving Cycle (MMDC) was developed. Table 1 presents its key kinematic parameters versus standard cycles (FTP-75, WLTC Class 3b). Validation confirmed the MMDC's high representativeness of actual Metro Manila driving. Overall deviation in key kinematic parameters (average speed, idle time, average acceleration) from aggregated field data was under 15%. Crucially, the MMDC's speed-acceleration probability distribution (SAPD) showed high similarity to real-world data, vital for accurate emissions modeling.

Table 1: Key Kinematic Parameters of the Metro Manila Driving Cycle (MMDC) Compared to Standard Driving Cycles (FTP-75 and WLTC Class 3b)

Parameter	**MMDC**	**FTP-75 (UDDS)**	**WLTC Class 3b**
Total Duration (s)	1375	1369	1800
Total Distance (km)	7.76	12.07	23.266
Average Speed (km/h)	20.3	31.5	46.5
Max Speed (km/h)	74.0	91.2	131.3
% Idle Time	29.0%	~19.5%	13.4%
% Acceleration Time	25.5%	(Not explicitly stated)	(Dynamic, not fixed %)
% Deceleration Time	28.0%	(Not explicitly stated)	(Dynamic, not fixed %)
Average Acceleration (m/s^2)	0.55	(Not explicitly stated)	(Not explicitly stated)
Max Acceleration (m/s^2)	1.99	~1.47 (derived)	1.666
Average Deceleration (m/s^2)	-0.60	(Not explicitly stated)	(Not explicitly stated)
Max Deceleration (m/s^2)	-2.01	(Not explicitly stated)	-1.5

4. Discussion

The MMDC's distinct kinematics—lower average speed and significantly higher idle time (Table 1) versus FTP-75 and WLTC Class 3b—quantitatively reflect Metro Manila's severe congestion and the unsuitability of standard cycles for local emission assessment. Using the MMDC will yield more accurate estimations of pollutants like CO, NOx, and PM2.5, especially those sensitive to idling and frequent accelerations, which standard cycles often underestimate. The MMDC is a vital tool for policymakers. It enables evaluation of traffic management schemes , realistic assessment of new vehicle technologies like EVs , refinement of emission standards , and informed infrastructure planning. The MMDC's characteristics also underscore deeper urban planning needs, advocating for systemic changes like mass transit investment. Developing vehicle-specific MMDCs could further target policies. Limitations include sample size and route coverage. Future work could develop distinct MMDCs for various vehicle classes and incorporate road grade effects. Figure 2-3 shows the representative cycles generated from the respective routes.

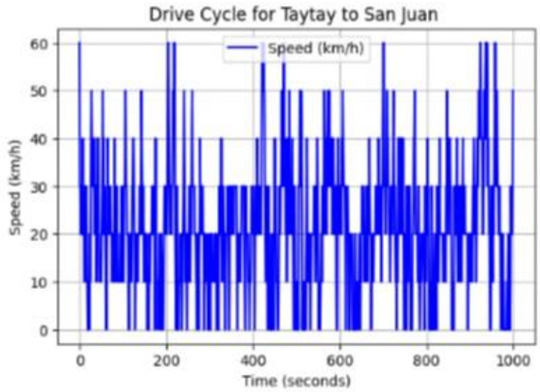

Figure 2. Drive cycle for Taytay to San Juan Route

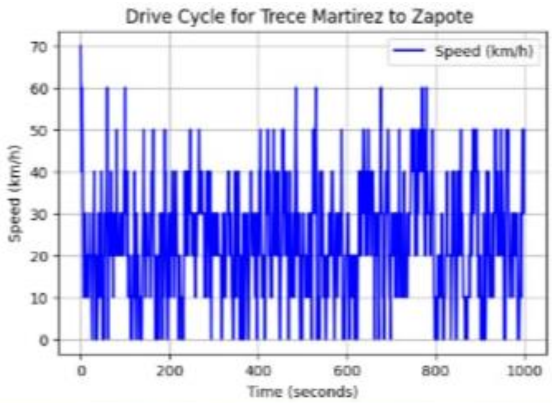

Figure 3. Drive cycle for Trece Martirez to Zapote Route

5. Conclusion

This research successfully developed and validated the Metro Manila Driving Cycle (MMDC). Characterized by lower average speeds and higher idling times than standard cycles, the MMDC accurately reflects Metro Manila's real-world congested driving conditions. It is crucial for facilitating more accurate vehicle emission inventories and serves as a valuable scientific tool for formulating effective, data-driven air pollution mitigation strategies, transportation policies, and sustainable urban planning for the metropolis.

6. References

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