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From motifs to Lévy flights: modeling urban mobility in Bogotá's public transport system

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Paper published in 2026: we study two years of access card validation records from Bogotá's multimodal public transport system, comprising over 2.3 billion trips across bus rapid transit, feeder buses, dual-service buses, and an aerial cable network. From user trajectories constructed exclusively from access records, we derive motifs that reveal recurrent mobility patterns extending beyond simple two-location visits. This approach enables the construction of an integrated origin–destination (OD) matrix covering 2828 urban zones. Similarity analysis using the Jensen–Shannon divergence confirms the temporal stability of mobility structures across semesters, despite infrastructure changes and fare policy adjustments. From the obtained OD matrices, we derive transition probabilities between zones and uncover a robust power-law relationship with geographical distance, consistent with Lévy flight dynamics. We validate our model using Monte Carlo simulations showing that reproduces both local and long-range displacements, with similar scaling exponents across time. These findings demonstrate that Bogotá's public transport mobility can be effectively modeled through Lévy processes, providing a novel framework for analyzing complex transportation systems based solely on user access records.

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