Design of Multi-Path Traffic Progression for Congested Arterials with Connected Local Progression Bands

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Abstract

- Urban arterials are often plagued by mutual queue blockage between turning and through vehicles, and excessively long delays for both through and turning movements. Key contributors to such bottlenecks include: queue spillback from turning bay, through queue on short links, and ineffective progression for through or turning flows.

- This study proposes a model to construct progression bands for all bandwidths for the selected local paths weighted by each intersection’s volume counts. The proposed model will generate optimal offsets and phase sequences.

- Key information to be estimated in the proposed model includes: the imposed duration within a local path’s progression band due typically to mutual queue blockage, and estimated vehicle volume within each designated progression band.

- This study has proposed a model to construct progression bands for all local paths, based on each intersection’s turning volume counts and geometric features.

- To ensure the progression for each local path on a link between two adjacent intersections, one can formulate the following constraints for local paths (same notation as for MULTIBAND but for paths).

- Maximizing the multi-path progression band due typically to mutual queue blockage, includes: the impeded duration within a local path’s progression band due typically to mutual queue blockage, and estimated vehicle volume within each designated progression band.

- The proposed model constructed local progression bands for vehicles on all local paths and then design the optimal connection between two local through bands for neighboring links under the control objective of maximizing the total weighted progression bands for the entire arterial.

- The proposed model’s embedded functions to minimize the impacts from left-turn spillback on the through queues at the link’s downstream intersection. The turning queue spillback can in turn interrupt the through bands.

Case Study

- The study contains two parts:
  1. Simulation experiments to ensure the effectiveness of the proposed model in a real-world system
  2. Numerical analysis to demonstrate the effectiveness of the formulated constraints

- The proposed model can produce progression for all local and multi-link path flows, as evidenced by the following simulation experiments:

  Experiment 1: Using VISSIM 9, this study has collected the MOEs for the following models for comparison:
  1. MULTIBAND: state-of-the-art model
  2. Proposed model: proposed model with all essential constraints in the formulations.

- Experiment 2: Evaluating the design with turn-in volumes and variable phase sequence. Four levels of volume scenarios (turning volume from high to low) are designed to show benefit from variable phase sequences and accounting for turning-in volumes from side streets.

- Turning volumes may affect the through bandwidths

- Necessity of incorporating the impacts from the potential spillbacks in signal design: reducing the potential interference from the queues with the following logic:

- The effective local bands not interrupted by the queue spillbacks: For a left-turn movement from the arterial to a crossing street, its local band is likely to be impeded by the through queues at the link’s downstream intersection. The turning queue spillback can in turn interrupt the through bands.

- Through or turning flows along each local path flows within the link’s downstream intersection. The above Figure shows an example.

- This study has proposed an MILP model which can provide progression band for various paths along the target arterial.

- The proposed model constructed local progression bands for vehicles on all local paths and then design the optimal connection between two local through bands for neighboring links under the control objective of maximizing the total weighted progression bands for the entire arterial.

- Improved MOE in the simulation experiments comparing to MULTIBAND are due to the proposed model’s embedded functions to minimize the impacts from left-turn spillback on the through paths, as evidenced by the reduction in delay and number of stops by 11.3% and 21.0%, respectively.