Analysis of Flow Features in Queued Traffic on a German Freeway

Prospectus for Dissertation Research
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Introduction

- The objective of this research is to study the evolution of traffic from freely flowing to congested conditions at freeway bottlenecks located near off-ramps.
- Preliminary investigations have found that a bottleneck is formed approximately 2000 m upstream of a freeway off-ramp at a location on a German Autobahn.
- This research will contribute to the understanding of congested traffic and may lead to enhanced models and effective real-time freeway management strategies.
Background

- 50 years of freeway bottleneck studies
  - Many studies were limited to manually collected data (direct observation, air photos) with short duration and limited length
  - Others studies were plagued by limitations of the data processing methods (flow vs. time and velocity vs. time plot)
  - Recently, there have been a limited number of successful studies of Canadian, British, and US freeways employing more robust data analysis methods – none on German freeways
Current German Freeway Analyses

- Measured variables (velocity and flow) exhibit statistical variations as well as time-dependent changes.
- This plotting technique makes it difficult to distinguish between the two.
- 3-D plotting technique allows for coarse identification of flow features.
Now, it turns out if the data are processed carefully and properly, key features related to a freeway bottleneck can be diagnosed. An *active* bottleneck exists when upstream traffic is queued and downstream traffic unqueued. Deactivated when there is either a decrease in flow or when a queue spills back from a downstream bottleneck.
Methodology

- Properly transformed curves of vehicle arrival number vs. time and time-averaged velocity vs. time provide the fidelity required to identify key time-dependent traffic features related to bottlenecks.
Construction of cumulative count, $N(x, t)$, plots
Shifted $N(x,t)$

Direction of Travel

$N(x,t)$

$N(x_1,t)$

$N(x_2,t)$

Trip Time

Accumulation

Time, $t$
Data revealed from shifted $N(x,t)$
Study Site
Autobahn A5, Frankfurt am Main, Germany

- A “speed trap” of two inductive loops gives vehicle counts, lengths and speeds
- The study site is a 30 km portion of the A5 north of Frankfurt am Main, Germany
- Research partnership with the Technical University at Dresden
Reveals the general location of the bottleneck
Reveals approximate duration that the bottleneck remains active
Resolution remains coarse, therefore useful only with a high-resolution technique such as cumulative plotting
Shifted $N(x,t)$ constructed from A5 data
Shifted $N(x,t)$ with $q_o$
Oblique $N(x,t)$ & $V(x,t)$
Tracing the queue

\[ N(X,t) - q(t-t), q = 4,800 \text{ vph} \]
Extent of the queue

N(x(t), q(t)), q = 4,520 vph

Time, t @ D17
Queue discharge features

\[ N(D22) = q(t-t_0), \quad q = 4375 \text{ vph} \]

- 4723 vph
- 4166 vph

Time, \( t \) @ D22
Lane-by-Lane Analysis

**LEFT LANE**

- Time of Bottleneck: Activation
- N(x,t) - q(t-t), q = 1,070 vph

**MIDDLE LANE**

- Time of Bottleneck: Activation
- N(x,t) - q(t-t), q = 1,070 vph

**RIGHT LANE**

- Time of Bottleneck: Activation
- N(x,t) - q(t-t), q = 1,070 vph
# Research Schedule

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Preliminary data analysis

- Examine the full 30 km data set
- Describe the evolution of traffic flow for a full day
- Examine the influence of ramp flows, lane-changing, and truck flows on bottleneck formation
Final data analysis

- Examine multiple days’ data to check for reproducibility
- Compare results to Daganzo’s behavioral traffic flow theory and Mauch’s stop-and-go wave findings
- Model the freeway both microscopically and macroscopically and compare model results to empirical data
- Compare to other research findings
- Make data available for other researchers
Contributions

- Add to the understanding of bottleneck features
- Aid to freeway managers ability to predict and the formation of queues
- Allow for testing of traffic flow theories
- Provide an independent assessment of other research (Kerner)